Explicitly Analyze the Soil Erosion in the Karst and Non-Karst Area of Different Morphological Types in Guizhou of China

Anjun Lan
Guizhou Normal University
Zemeng Fan (fanzm@lreis.ac.cn)
Institute of Geographic Sciences and Natural Resources Research, CAS https://orcid.org/0000-0002-0008-2574
Qingsong Zhao
Guizhou Normal University
Xuyang Bai
Institute of Geographic Sciences and Natural Resources Research Chinese Academy of Sciences

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Explicitly analyze the soil erosion in the karst and non-karst area of different morphological types in Guizhou of China

Anjun Lan[1]. Zemeng FAN[1,2,3,4]. Qingsong Zhao[1]. Xuyang Bai[2,3]

Abstract: How to explicitly understanding the soil erosion intensity change in different geomorphological types is one of key issues in the field of soil and water conservation. According to classification criterion of soil erosion intensity of China, the spatial soil erosion data with the resolution of 10 m×10m in Guizhou Province were obtained by combing with the multi-resolution remote sensing data of ALOS, ZY-3, GF-1, Landsat and GDEMV2, and 2762 field sampling data in 2010 and 2015, respectively. a spatial analysis model of soil erosion was improved to analyze the spatiotemporal change of soil erosion intensity in karst and non karst area of Guizhou province, which involved the spatial soil erosion data and different geomorphological type data of Guizhou province. The results show that the soil erosion intensity decreased by 6468.13km^2 in Guizhou Province from 2010 to 2015. The dynamic change intensity in the high-altitude area is larger than in the low-altitude area. The soil change intensity in karst area is higher than in non karst area, especially in the high and middle elevation area in Guizhou province. Moreover, the decreasing ratio of soil erosion intensity in karst area is generally larger than in non karst area, which can be used to explain that the ecological restoration projects and water soil conservation polices carried out in karst area has a good effect, especially in western of Guizhou province from 2010 to 2015, one the other hand, the soil erosion in non karst area should also be focused by local government in the future.

Key words: Soil erosion; karst area; morphological types; spatiotemporal change intensity; quantitative analysis; Guizhou Province

1. Introduction

Soil Erosion and its initiated environmental risk is one of the most serious issue in the world(Borrelli et al. 2017a; Jiang et al. 2014; Fang and Fan, 2021; Zhao et al., 2020）. The interacting relationship between natural environment and human activities is the key component of soil erosion study (Poesen 2018). There is no C layer between soil and it is very serious that bedrock and the soil erosion caused by denudation, dissolution and cross distribution of denudation and dissolution,

Corresponding Author: fanzm@lreis.ac.cn

1. School of geography and environmental sciences, Guizhou Normal University, Guiyang 550025, China;

2.State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China;

3. College of Resources and Environment, University of Chinese Academy of Sciences, Beijing 100049, China;

4. Jiangsu Center for Collaborative Innovation in Geographical Information Resource Development and Application, Nanjing 210023, China

especially in the wide distributed area where karst has characteristic of the vertical development(He et al. 2009).

Guizhou Province is a typical representative area of karst landforms in Southwest China where the landform pattern is complex(Yang et al. 2019). The increasing human activities have caused extremely serious negative interference to this area, which makes the soil erosion particularly serious (Huang and Cai 2007; Wang and Li 2007). At present, a series of studies on soil erosion in Guizhou Province have been carried out by the related scholars. For example, to address the relationship between land use and response of soil erosion, Wang Huan et al. (2019) carried out quantitative attribution on soil erosion in different geomorphic areas of Sanchahe watershed, which showed that land use had the highest explanatory power for soil erosion, and the soil erosion risk of cultivated land was higher than that of other land use types(Borrelli et al. 2017b; Dai et al. 2017; Li et al., 2018). Based on the fixed-point monitoring of slope surface, the influence of different rainfall intensity on soil erosion mode is significant(Fullhart et al. 2020; Wu et al. 2018), and the spatial distribution of soil erosion directly affects the spatial change of soil nutrient loss (Zeng et al. 2018). In addition, relevant researches have been carried out on the mechanism of soil erosion(Li et al. 2017; Peng and Wang 2012; Shen et al. 2008; Wang et al. 2013a) , the construction of soil erosion model (Geissen et al. 2008; Kheir et al. 2010; Liu 2016; Xu et al. 2008) and the temporal and spatial variation of soil erosion(He et al. 2018; Wang et al. 2016). The model for scenario analysis of climate change and land use shows that different response scenarios of land use change to climate change will also cause different soil erosion intensity (Fan et al. 2015; Perović et al. 2019). According to the relationship between soil erosion intensity and terrain characteristics, a model of soil erosion degree was established to reveal the influence of different slope and surface cover types on soil erosion intensity (Bonetti et al. 2019; Vanacker et al. 2019). The MPSIAC model shows that topography is the main factor of soil erosion (Noori et al. 2018). The different type of landforms directly affects the surface water and light intensity, and then affects the spatial and temporal distribution of ecological environmental factors such as soil and vegetation, thus affecting the intensity of regional soil erosion to a certain extent (Cao et al. 2019; Cheng et al. 2009; Feng et al. 2016; Wang et al. 2013b). Thus, different geomorphic types are one of the key factors to analyze the spatial and temporal distribution of soil erosion and its intensity and direction. At present, the research mainly focuses on the driving effect of land use types on soil erosion, as well as soil erosion mechanism or single terrain factor at small watershed scale. However, at the provincial level, especially in karst areas with fragile ecological environment, there is a lack of spatiotemporal variation intensity of soil erosion in different geomorphic types, especially in karst and non karst areas quantitative analysis of driving factors.

Since the 21st century, due to the input and implementation of ecological protection projects and soil and water conservation policies in Guizhou Province, soil erosion has undergone significant spatiotemporal differentiation and change. Therefore, the purpose of this paper is to construct the spatio-temporal analysis model of soil erosion dynamic degree, breadth and relative change rate of different geomorphic types by combining the data of Guizhou landform type with the soil erosion intensity data of 10×10 m resolution. Based on the quantitative analysis of soil erosion change intensity of different geomorphic types and karst and non karst areas, the spatial and temporal variation intensity difference of soil erosion in karst and non karst areas is revealed, and the driving effects of ecological protection projects and soil and water conservation policies on Soil and water erosion changes are comprehensively analyzed, so as to further implement in Guizhou Province.

2. Data and methods

2.1 Data sources

In the study area, ALOS 10 m resolution remote sensing images in 2009 and 2010, and ZY-3 and GF-1 2.5 m resolution remote sensing images in 2014 and 2015 were used to extract two phases of spatial data of land use types in the man-machine interactive mode. Vegetation coverage and bedrock exposure rate were extracted from Landsat 30 m resolution remote sensing image data in 2010 and 2015. Slope data was derived from the 30 m resolution remote sensing image of GDEMV2. The data of lithology classification in karst and non karst areas are from the 1:50000 geological map of Guizhou Province; the geomorphic data are from the agricultural geomorphic division of Guizhou Province.

2.1.2 Data processing

Based on the 1:500000 agricultural geomorphic regionalization map of Guizhou Province as the base map, vectorization is carried out in ArcGIS to generate corresponding vector data. Combined with the research conception of this paper, the soil erosion intensity changes of karst and non-karst areas in different geomorphic areas are analyzed, and the hills subdivided in karst areas in vector data are appropriately merged, and finally low basin, medium basin and high basin are obtained. There are 12 types of land, low hill, medium hill, high hill, low mountain, low middle mountain, middle mountain, high mountain, low platform and high platform (Fig. 1a).

Due to the different sources and scales of soil erosion data, it is necessary to unify the data to form a resolution of 10 × 10 m. The resolution of ZY-3 and GF-1 is resampled for 10 × 10 m, which is consistent with the resolution of ALOS Image. The resolution of vegetation coverage, bedrock exposure rate, slope and other data is increased to 10 × 10 m to ensure the unity of various factors in the process of comprehensive superposition.

Considering the great difference of soil erosion characteristics between karst and non-karst areas in Guizhou, such as soil erosion intensity, the year limitation for soil resistant erosion, risk coefficient of soil erosion, etc., the karst areas refer to the technical standard for comprehensive management of soil erosion in karst areas, and the non-karst areas are based on the classification and classification standards of soil erosion. Combined with land use type, vegetation coverage, bedrock exposure rate, slope and other data, based on a large number of field sampling verification, according to the above standards for karst and non-karst areas, the quantitative discrimination and division of soil erosion grade (Table 1, table 2) are carried out respectively, so as to achieve the 10m × 10m resolution soil in different geomorphological types of Guizhou Province in 2010 and 2015 Soil erosion spatial information data extraction. In the process of processing and analyzing the basic data, in order to ensure the classification accuracy and quality of the data, a large number of field sampling verification were carried out on the above classification results in the field, with a total number of 2762, and the verification accuracy in 2010 and 2015 were 85.44% and 91.07%, respectively (Fig. 1b).

Tab.1 Surface erosion (sheet erosion) classification index of the non-karst area

Land type \ Slope(°)		5～8	8～15	15～25	25～35	>35
Coverage of non cultivated land (%)	60~75					
	45~60		Mild			Intense

	30~45		Moderate		Intense	Extremely Intense
	<30			Intense	Extremely Intense	Violent
Sloping Land		Mild	Moderate			

Tab.2 Sloping Farmland erosion intensity index indirect discrimination of the Karst area

Slope (°)		<5	5～8	8～15	15～25	25～35	>35
Bedrock exposure rate (%)	<5				Intense	Extremely Intense	Violent
	5~30	Mild					
	30~50				Moderate	Intense	Extremely Intense
	50~70						Intense
	>70		Slight				

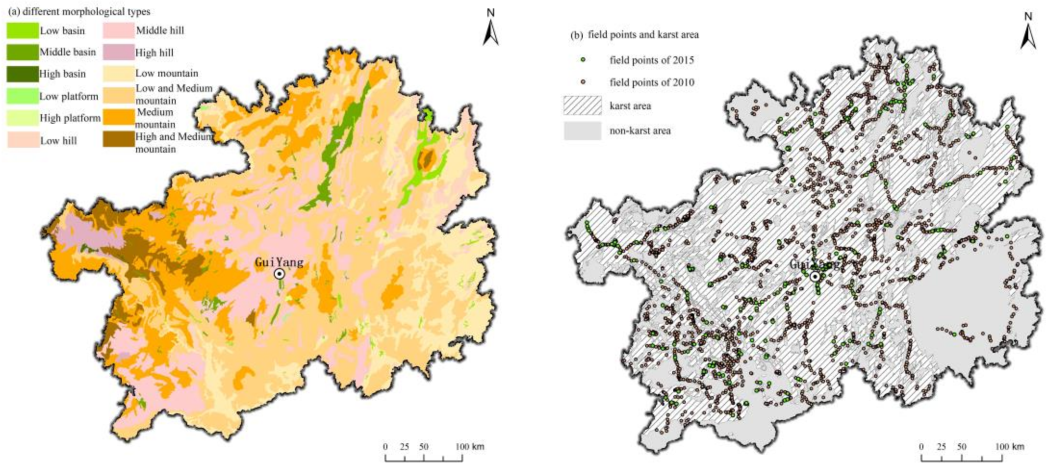


Fig.1 The distribution of different morphological types (a) and field point of karst and non-karst (b) in Guizhou Province

2.2 Spatial analysis model of soil erosion

In order to quantitatively describe and compare the spatial position, main types and regional differences of soil erosion between karst and non-karst areas in Guizhou Province, introducing the existing land use change model and combineing with soil erosion breadth index (Zhu and Li 2003), dynamic degree and other soil erosion characterization indexes, the dynamic degree model, the breadth index model and the relative change rate model of soil erosion are constructed.

For further description of the spatial and temporal dynamic changes of soil erosion in Karst and non-karst regions with different geomorphic types from 2010 to 2015, a spatiotemporal dynamic index model of soil erosion in Guizhou Province was constructed, which can be expressed as:

$$D_i = \left\{\sum_j^n \left(\frac{\Delta S_{i,j}}{S_a}\right)\right\} \times 100\% \qquad (1)$$

Where D_i is the dynamic index of soil erosion, with a value of 0~1, expressed as a percentage; $\Delta S_{i,j}$ A represents the net area of change between soil erosion of grade *i* and soil erosion of grade *j* (km^2); S_a is the area of a geomorphic type area (km^2). The greater the D_i value, the more intense the change in this area; the dynamic degree D_i focuses on the process of soil erosion change rather than its results, which aims to reflect the intensity and overall situation of the change.

To reveal the main conversion types of soil erosion intensity in different geomorphic types, combined with the spatial distribution data of different geomorphic types, a soil erosion breadth index model which can be used to calculate the main conversion types of soil erosion in different geomorphic types was constructed：

$$C_i = S_{i,j}/S \times 100\% \tag{2}$$

Where C_i is the breadth index of soil erosion, the value is 0~1, expressed as a percentage; S_{ij} is the change area from type i soil erosion to type j soil erosion in a certain area from 2010 to 2015 (km^2); S is the total area of various soil erosion changes in the area (km^2). The higher the C_i value, the more dominant the soil erosion from type i to type j in this region. In view of the fact that there are many types of soil erosion conversion among different geomorphic types, in order to analyze the main conversion types of different soil erosion intensities in each geomorphic type area, the cumulative sum of Ci values from large to small is greater than 70%.

On the basis of quantitative analysis of soil erosion extent, in order to reveal the regional differences of different soil erosion intensity changes, the relative change rate model of soil erosion was constructed：

$$K_i = S_{i,j} / S_a \times 100\% \tag{3}$$

Where K_i is the relative change rate of soil erosion, the value is 0~1, expressed as a percentage; the larger K_i value in a certain area indicates that the transition from type i soil erosion to type j soil erosion is more likely to occur than that in other regions.

3 Results

3.1 Comparison of soil erosion intensity between karst and non-karst area

The comparative analysis of different levels of soil erosion intensity in karst and non-karst areas of Guizhou Province shows that: from 2010 to 2015, the overall erosion intensity in Guizhou Province showed a weakening trend, with the proportion of erosion area except slight erosion in the total area of Guizhou Province decreased from 31.37% in 2010 to 27.70% in 2015, and the total weakened area was 6468.13 km^2 (Table 3). Among them, the areas of mild, moderate, strong and severe erosion in karst area are higher than those in non-karst area, which are 566.88 km^2, 794.82 km^2, 265.4 km^2 and 15.17 km^2 more than those in non-karst area. In addition, although the areas of extremely strong and severe erosion have weakened, the weakening extent is the smallest. The weakened areas of soil erosion in karst area and non-karst area only account for 11.03% and 22.42% of the total area of soil erosion weakening in karst area and non-karst area respectively. On the whole, the weakening area of soil erosion intensity in Guizhou karst area is larger than that in non-karst area, but the weakening trend of extremely strong and severe erosion types is contrary to the general trend of soil erosion intensity weakening (the weakening range of karst area is 11.04% and 4.38% lower than that of non-karst area, respectively). The results show that the control of soil erosion in Guizhou karst area has achieved remarkable results, but the treatment of extremely strong and severe erosion types is still severe.

Tab.3 The area of soil erosion intensity in Guizhou Province in 2010 and 2015

Lithology	Soil erosion intensity	2010 Year (km²)	2015 Year (km²)	2015 increased or decreased compared with 2010 (km²)(+/-)	Proportion of increase or decrease in 2010 (%)(+/-)
Non- Karst	E1(Slight erosion)	47110.03	49588.29	+2478.26	+5.26
	E2(Mild erosion)	10023.40	9550.25	-473.15	-4.72
	E3(Moderate erosion)	5739.16	4757.35	-981.81	-17.11
	E4(Strong erosion)	2452.96	1985.37	-467.58	-19.06
	E5(Extremely strong erosion)	1377.36	1132.59	-244.77	-17.77
	E6(Severe erosion)	978.87	667.92	-310.95	-31.77
Karst	E1(Slight erosion)	73772.55	77762.42	+3989.87	+5.41
	E2(Mild erosion)	17591.79	16551.76	-1040.03	-5.91
	E3(Moderate erosion)	10621.68	8844.96	-1776.73	-16.73
	E4(Strong erosion)	3592.39	2859.41	-732.98	-20.40
	E5(Extremely strong erosion)	1695.34	1581.33	-114.02	-6.73
	E6(Severe erosion)	1190.86	864.74	-326.12	-27.39
Total		176146.39	176146.39	0	

3.2 Comparison of soil erosion intensity changes in different geomorphic types

3.2.1 Regional differences of different soil erosion intensity

The dynamic degree (D_i) simulation results of soil erosion intensity change in different geomorphic morphology areas of Guizhou Province from 2010 to 2015 shows that with the rising of altitude, the D_i value of each geomorphic form area increases continuously, but the D_i value of karst area is smaller than that of non-karst area. Therefore, D_i value in high altitude areas such as high basin, high hill and high and middle mountain is higher than that in low altitude areas such as low basin, low hill and low mountain. The D_i value of karst area is lower than that of non-karst area, especially in high basin, with a difference of 9.35% (Fig. 2b). The results show that the dynamic degree of soil erosion in high altitude area is higher than that in low altitude area, and the dynamic degree of soil erosion in karst area is lower than that in non-karst area.

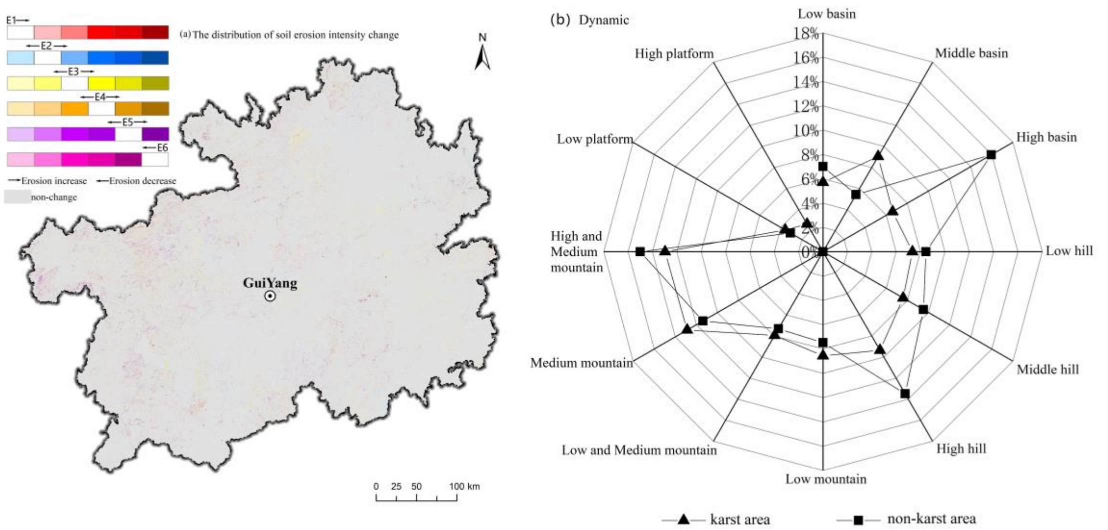


Fig.2 The intensity change of soil erosion distribution (a) in 2010 and 2015 and D_i value in different morphological types (b) of Guizhou Province

3.2.2 Analysis on Transformation of soil erosion intensity in different geomorphic types

Based on different geomorphic types, the main conversion types of soil erosion intensity (the sum of C_i values is more than 70%) were statistically analyzed by using the soil erosion breadth index (C_i). The results showed that the average C_i of the main transition types in karst area reached 40.47%, mainly from mild erosion to slight erosion, and the average C_i value of main conversion types in non-karst areas was 33.47%. The extent of soil erosion in karst area is higher than that in non-karst area. In addition to the high basin and high middle mountain, the other areas are mainly transformed from mild erosion to slight erosion (Table 4). The average difference of soil erosion extent in karst area is 10.4% in high basin, high hill and high middle mountain area, and only 1.77% in low basin, low mountains and low hill area. In the area of low basin, low hill and low mountains, the average difference of the first C_i value and the second C_i value between karst area and non-karst area is 25.77% and 23.49% respectively. There are few main conversion types, and the main transformation mode is from mild to slight erosion. In the high basin, high hill, middle mountains and high middle mountain areas, the average difference between the first C_i value and the second C_i value between karst area and non-karst area is 7.36% and 5.63%, and the transformation from mild to slight erosion is not obvious. The main transformation types in non-karst area are more than those in karst area, and the conversion among all levels of erosion occurs. The above analysis shows that mild to slight erosion is the main transition type in all physiognomy areas. With the increase of altitude, the dominance of mild to slight erosion is weakened, and the C_i value of other erosion levels gradually increases, and the conversion types increase. The C_i value of main transition types in karst area is higher than that in non-karst area.

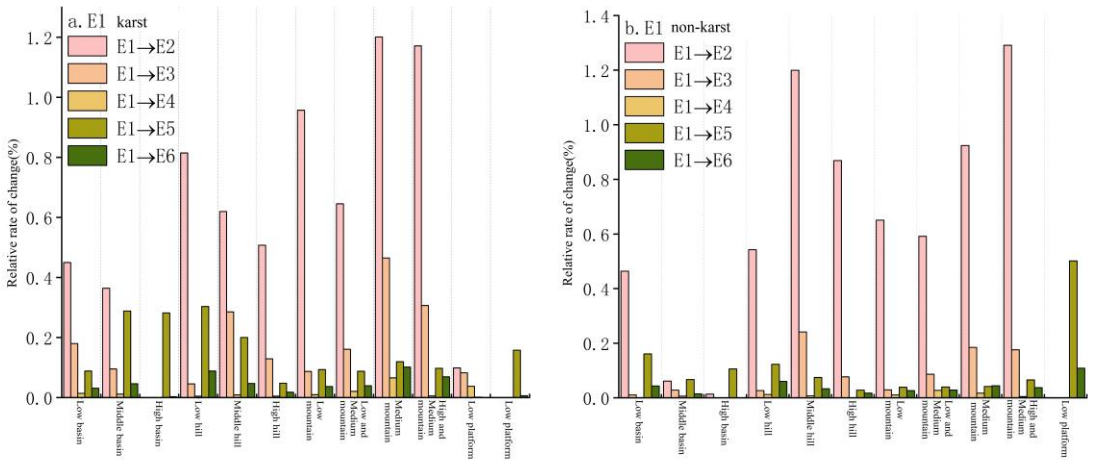
Tab.4 Statistical table of soil erosion intensity conversion types in different morphological types

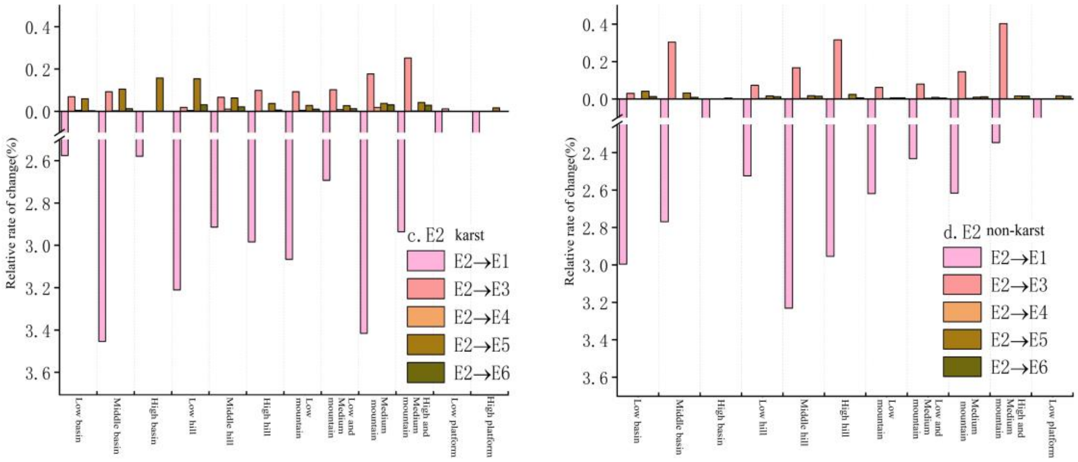
Geomorphic form type	Non- Karst		Karst		Geomorphic form type	Non- Karst		Karst	
	Main conversion type	Ci(%)	Main conversion type	Ci(%)		Main conversion type	Ci(%)	Main conversion type	Ci(%)
Low Basin	E2→E1	42.70	E1→E2	7.89	Low mountain	E1→E2	8.71	E1→E2	11.18
	E3→E1	13.13	E2→E1	45.16		E2→E1	35.03	E2→E1	35.81
	E3→E2	18.74	E3→E1	14.89		E3→E1	14.42	E3→E1	14.08
			E3→E2	9.63		E3→E2	16.89	E3→E2	13.29
Middle basin	E2→E1	51.03	E1→E2	4.02	Low and Medium mountain	E1→E2	8.09	E1→E2	8.12
	E3→E1	9.92	E2→E1	38.15		E2→E1	33.24	E2→E1	33.89
	E3→E2	10.43	E3→E1	15.65		E3→E1	15.62	E3→E1	14.81
			E3→E2	15.99		E3→E2	13.70	E3→E2	14.21
High basin	E3→E1	24.88	E2→E1	39.10	Medium mountain	E1→E2	8.12	E1→E2	9.32
	E3→E2	10.83	E3→E1	29.30		E2→E1	22.99	E2→E1	26.52
	E4→E3	15.54	E3→E2	10.21		E3→E1	11.69	E3→E1	11.69
	E5→E4	11.21				E3→E2	10.79	E3→E2	15.70
	E6→E5	13.30				E4→E3	10.38	E4→E3	8.89
Low hill	E2→E1	41.68	E1→E2	11.10		E5→E4	8.82		
	E3→E1	12.76	E2→E1	43.75	High and Medium mountain	E1→E2	8.60	E1→E2	9.03

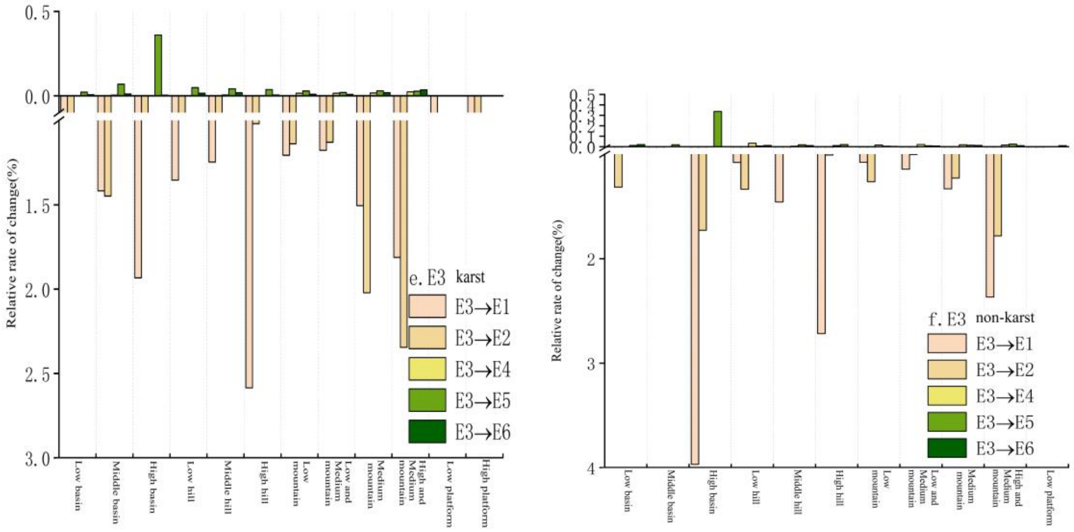
	E3→E2	15.79	E3→E1	18.44		E2→E1	15.64	E2→E1	22.64
Middle hill	E1→E2	12.60	E1→E2	8.14		E3→E1	15.76	E3→E1	13.97
	E2→E1	33.94	E2→E1	38.32		E3→E2	11.87	E3→E2	18.09
	E3→E1	15.31	E3→E1	16.40		E4→E3	10.03	E4→E3	8.88
	E3→E2	8.80	E3→E2	10.07		E5→E4	9.16		
High hill	E1→E2	6.44	E2→E1	31.89	Low platform	E1→E5	16.25	E2→E1	66.66
	E2→E1	21.91	E3→E1	27.63		E2→E1	44.98	E3→E1	18.50
	E3→E1	20.15	E3→E2	10.89		E3→E2	12.59		
	E3→E2	7.47			High platform			E2→E1	63.90
	E4→E2	7.92						E3→E1	9.55
	E4→E3	6.80							

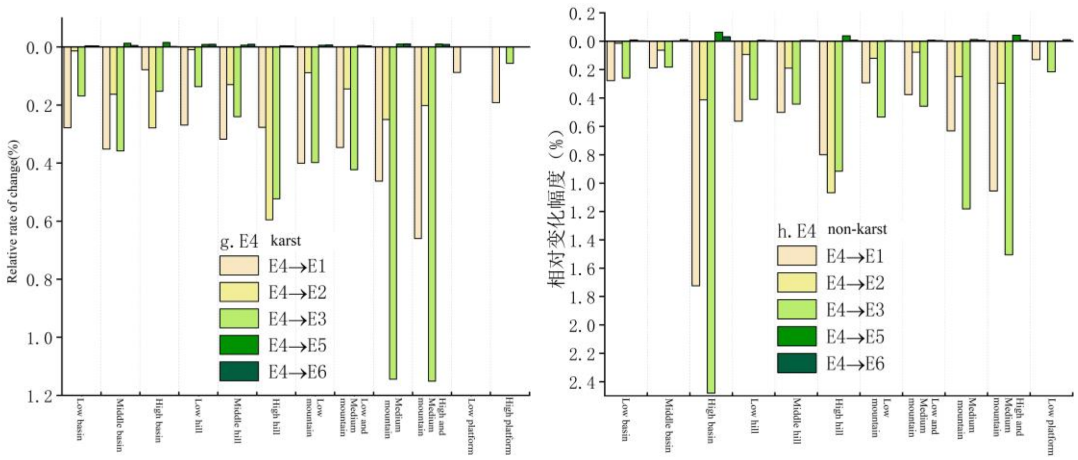
3.2.3 Distribution characteristics of soil erosion intensity in different geomorphic types

Due to the large proportion of low and medium mountains in the whole province, the proportion of basins and platforms is very small. Considering the distribution of the change of soil erosion intensity only from the perspective of area, almost all the areas where the degree of soil erosion is enhanced or weakened are distributed in low and middle mountains. Therefore, in order to further reveal the distribution of soil erosion intensity in different geomorphic types, the relative change rate was used for analysis and comparison. The results show that (Fig. 3), the distribution of decreased soil erosion intensity in karst area is significantly different from that in non-karst area, but the regional difference of enhanced soil erosion intensity is not obvious. Among them, the micro, mild and extremely strong erosion in karst area is further enhanced, and the relative change rate is higher in middle mountain and high mountain area, while in non-karst area, the relative change rate of moderate and strong erosion aggravation in high basin is higher, and the difference between karst area and non-karst area is 0.19% and 0.2%; in karst area, severe, extremely strong and strong erosion is weakened in middle mountain, high and middle mountain and other areas. The relative change rates of high and middle mountains are high, which are 0.63%, 0.66% and 1.15%, respectively. The relative change rates of moderate and mild erosion are higher in high hills and middle basins respectively; in non-karst areas, the relative change rates of severe, extremely strong, strong and moderate erosion are mainly in high basins, with an average of 2.59%; in addition, slight erosion in karst areas and non-karst areas turns to slight erosion in medium The relative change rate of basin and mid hill is high, with an average of 3.19% and 3.0%, and this area is the rapid expansion area of urban construction land.




c. E2 karst
E2→E1
E2→E3
E2→E4
E2→E5
E2→E6
Relative rate of change(%)
d. E2 non-karst
E2→E1
E2→E3
E2→E4
E2→E5
E2→E6
Relative rate of change(%)
Low basin
Middle basin
High basin
Low hill
Middle hill
High hill
Low mountain
Low and Medium mountain
Medium mountain
High and Medium mountain
Low platform
High platform


e. E3 karst
E3→E1
E3→E2
E3→E4
E3→E5
E3→E6
Relative rate of change(%)
f. E3 non-karst
E3→E1
E3→E2
E3→E4
E3→E5
E3→E6
Relative rate of change(%)
Low basin
Middle basin
High basin
Low hill
Middle hill
High hill
Low mountain
Low and Medium mountain
Medium mountain
High and Medium mountain
Low platform
High platform


g. E4 karst
E4→E1
E4→E2
E4→E3
E4→E5
E4→E6
Relative rate of change(%)
h. E4 non-karst
E4→E1
E4→E2
E4→E3
E4→E5
E4→E6
相对变化幅度（%）
Low basin
Middle basin
High basin
Low hill
Middle hill
High hill
Low mountain
Low and Medium mountain
Medium mountain
High and Medium mountain
Low platform
High platform

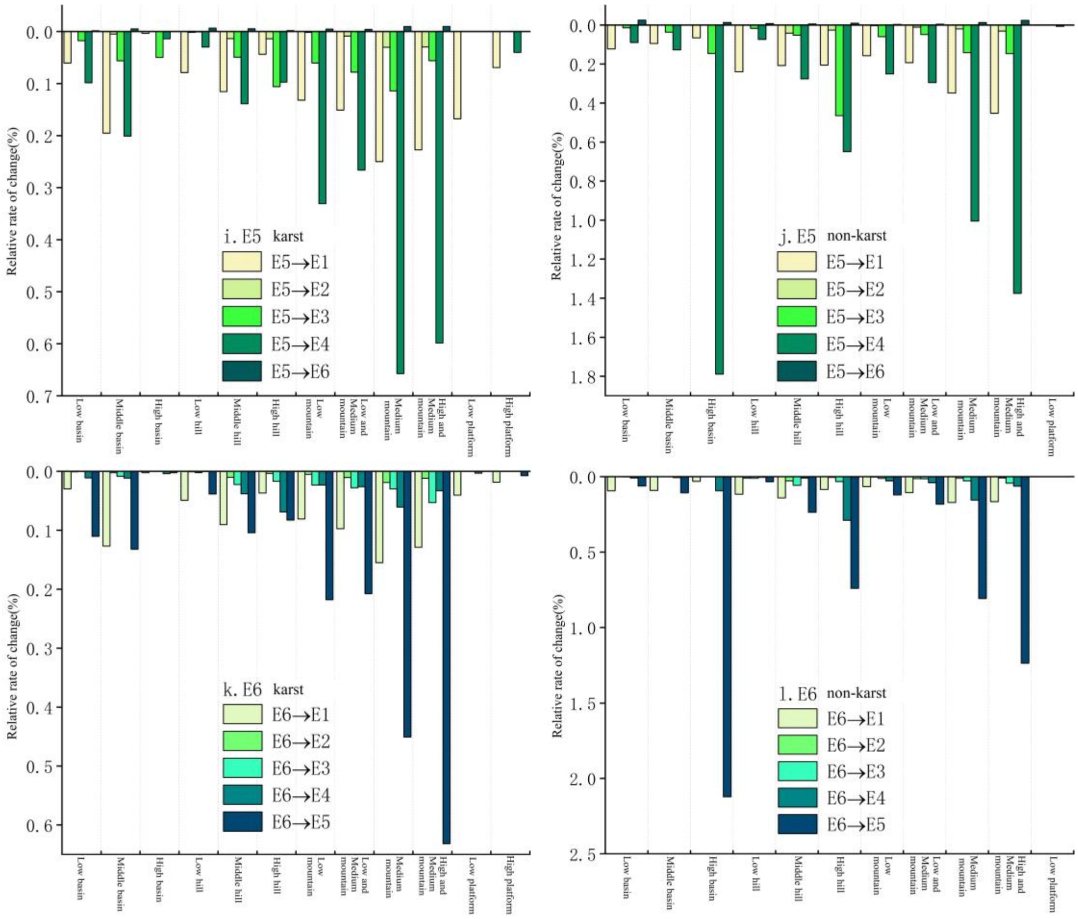


Fig.3 The intensity changes of soil erosion between karst and no-karst area in different morphological types

4 Discussion and conclusions

4.1 Discussion

The driving forces of soil erosion are directly or indirectly controlled by different geomorphic types. Different altitudes affect the vertical difference distribution of heat and moisture, and then affect vegetation types and land use patterns; the greater the surface relief, the stronger the terrain cutting, soil erosion is prone to occur; slope and aspect directly affect the intensity and direction of soil erosion. Different soil erosion intensity is the result of the synthesis of various factors. This paper analyzes the geomorphic differences of different soil erosion intensity changes, which has a certain indication for the changes of various factors.

The intensity of soil erosion in Guizhou Province showed a decreasing trend. Among them, the dynamic degree of soil erosion in the high-altitude area in the west is higher than that in the low-altitude area in the East. This result reflects the ecological effect of the project of returning farmland to forest (grass). From 2010 to 2015, the cultivated land in the middle mountain and high and middle mountain areas converted to woodland and grassland by 13.83 km^2(Han et al., 2015). Due to the large-scale plantation and the implementation of rocky desertification ecological project in the west of Guizhou Province (Yan et al. 2018; Zhang et al. 2017), the overall trend of soil erosion in Guizhou Province has become better, showing a dynamic change pattern of soil erosion in the western part of Guizhou Province, which changes violently in the west and relatively stable in the east (Fig. 2a). On the one hand, due to the main distribution of forest land and cultivated land in karst area, under the drive of ecological and environmental protection policies, slope cultivated land is gradually reduced, so that the breadth of soil erosion in karst area is higher than that in non-karst area, and the conversion is mostly to weak first-order erosion. On the other hand, the severe, extremely strong and intense soil erosion in karst area is mainly concentrated in the middle and high mountains areas, and the relative change rate of soil erosion in these areas is relatively high, which reflects that the ecological restoration project has achieved good ecological effect in karst area. In addition, due to the rapid development of urbanization in the central basin and hilly areas along the Zunyi-Guiyang-Anshun line, the construction land has expanded greatly (increased by 1029.86 km^2 from 2010 to 2015), mainly from cultivated land (Cheng et al. 2019; Cheng et al. 2018), which makes the relative change rate of soil erosion from mild to slight erosion in this area is in a high state. From the overall situation, because the slopes of middle mountains and middle and high mountains areas in Guizhou Province are basically above 25 ° and the terrain fluctuates greatly, coupled with the implementation of ecological restoration projects such as slope farmland conversion and rocky desertification control, the dynamic degree of soil erosion intensity change in this area is the strongest.

Due to the difficulty in obtaining the refined spatial information of soil erosion, the spatial-temporal variation trend and regional difference of soil erosion intensity in karst and non- karst areas of Guizhou Province from 2010 to 2015 are only revealed at the resolution of 10m × 10m. In the further work, we will continue to obtain more refined spatial information data of soil erosion, and then realize the dynamic detection and fine identification of spatial and temporal variation patterns and regional differences of soil erosion intensity in Karst and non-karst areas of Guizhou Province, and further implement soil and water loss prevention measures and control measures in karst and non-karst areas in Guizhou Province Rocky desertification ecological restoration project provides dynamic and refined spatial data and method support.

4.2 Conclusions

In view of the lack of quantitative analysis of soil erosion intensity in different geomorphic types, this paper takes Guizhou Province as an example to study the spatiotemporal variation intensity of soil erosion and its driving factors in karst and non-karst regions of different geomorphic types. The spatial and temporal variation intensity of soil erosion in karst and non- karst regions was revealed by constructing spatiotemporal analysis models of soil erosion in different geomorphic types. This study can provide method support and data support for the refined study of soil erosion change intensity in complex geomorphic type area.

The results showed that: 1) from 2010 to 2015, the soil erosion intensity in Guizhou Province showed a decreasing trend, with a total area of 6468.13 km^2. The total area of soil erosion intensity weakening in karst area is larger than that in non-karst area, but the weakening extent of soil erosion intensity of extremely strong and severe erosion in karst area is less than that in non-karst area, which indicates that the soil erosion restoration difficulty of extremely strong and severe erosion area in karst area is higher than that in non-karst area; 2) with the increase of altitude, the dynamics of various geomorphic types are also discussed. The average D_i value increased from 6% in low altitude area to 13.61% in high altitude area, and the increase of D_i value in karst area was less than that in non-karst area; 3) the main conversion type of soil erosion in each geomorphic form type area was from mild to slight erosion, and the conversion breadth index of soil erosion in karst area was higher than that in non-karst area, although C_i value in low altitude area was only 1.77%; 4) The results showed that the average effect of the project was 10.4% higher than that of the other areas in Guizhou Province.

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Figures

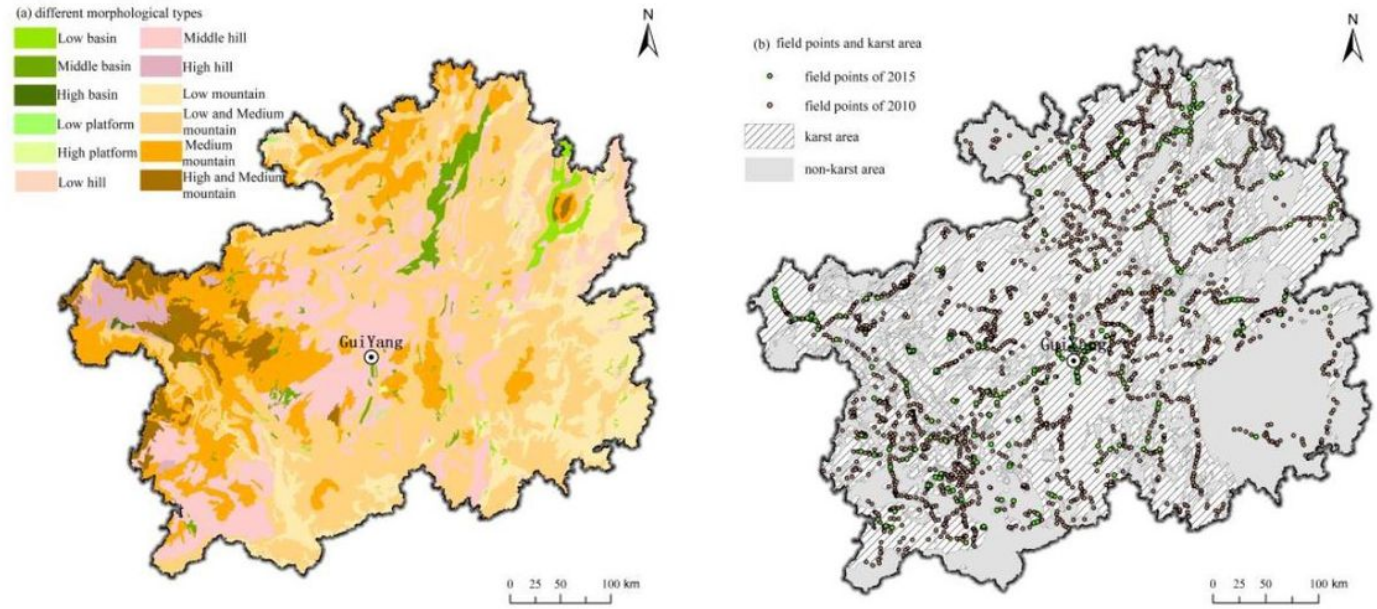

Figure 1

The distribution of different morphological types (a) and field point of karst and non-karst (b) in Guizhou Province. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

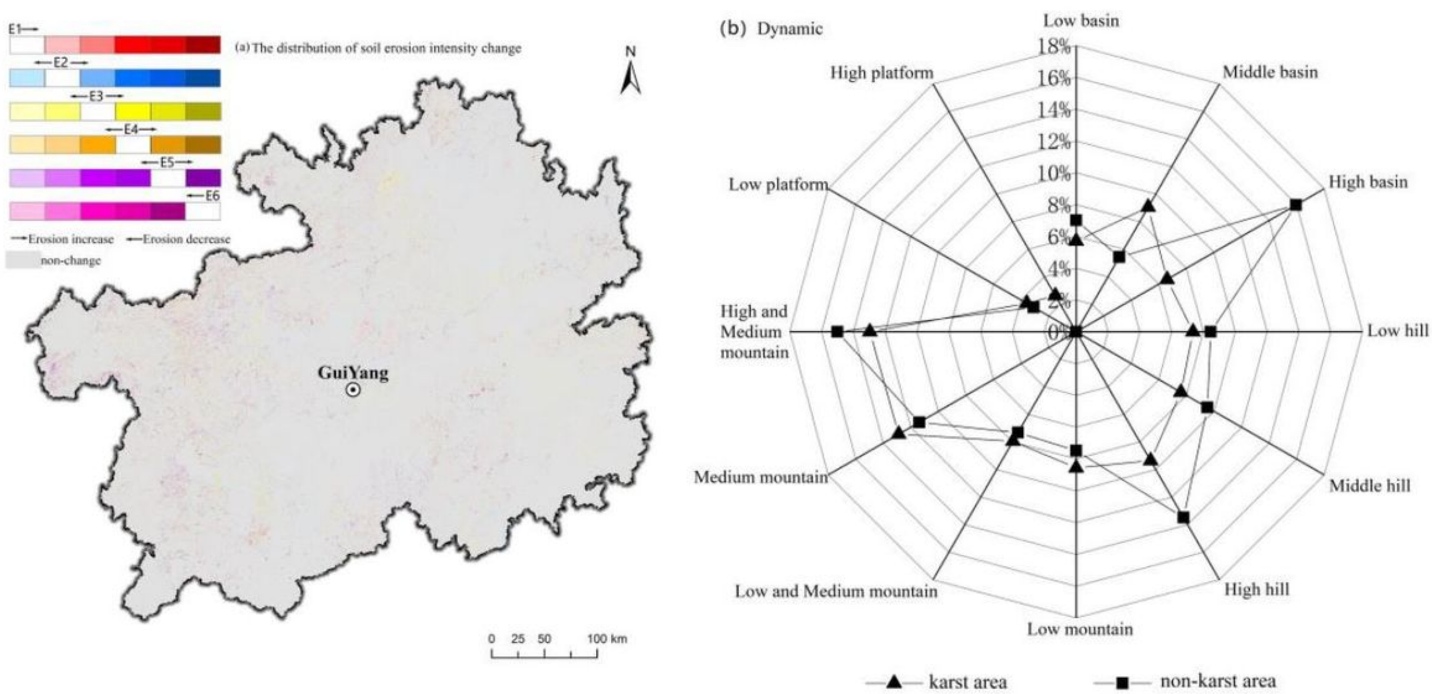

Figure 2

The intensity change of soil erosion distribution (a) in 2010 and 2015 and Di value in different morphological types (b) of Guizhou Province. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

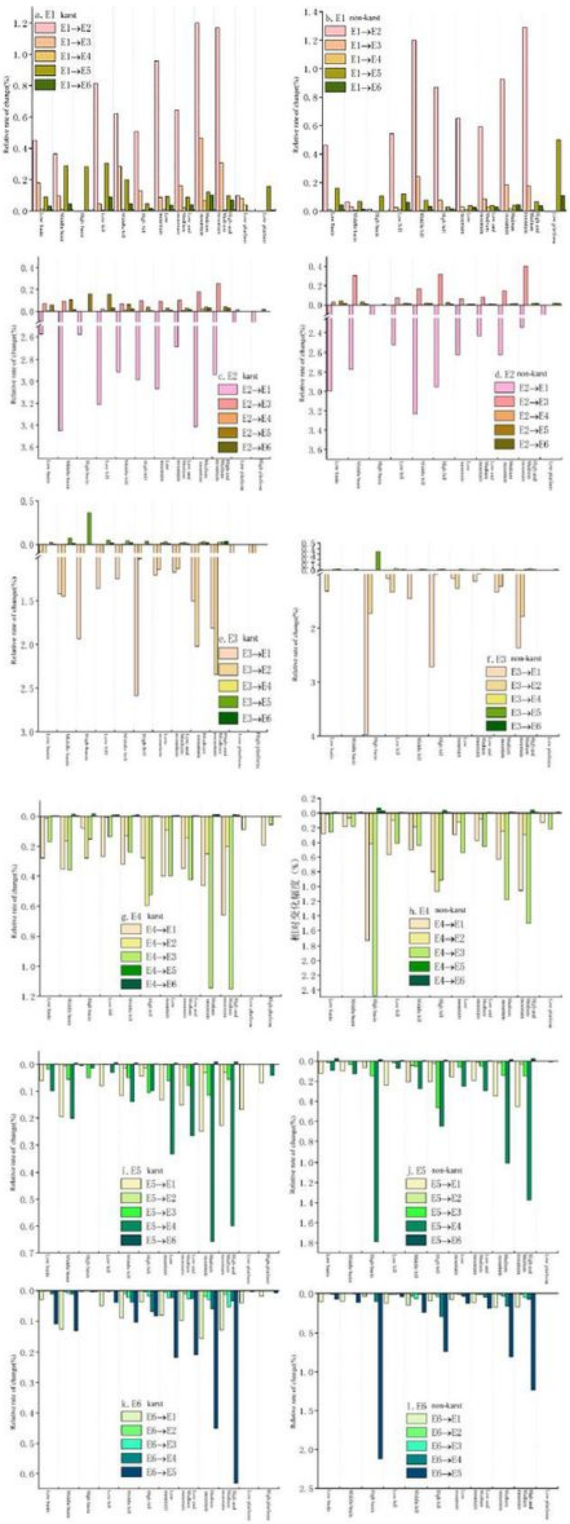

Figure 3

The intensity changes of soil erosion between karst and no-karst area in different morphological types