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The Causes and Countermeasures of Soil Erosion of Karst Landform in Guizhou Province

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Abstract. Nowadays, soil erosion has become the focus of social attention. Due to topography, climate, precipitation, human activities, and other factors, this phenomenon is particularly serious in the Karst landform region. Therefore, this paper takes the classic Karst landform region of Guizhou as an example, dividing the karst landform into two different types, namely, the surface karst landform and the underground karst landform, with different positions as variables. Based on the previous data, systematic analysis of the causes of karst, and factors that promote soil erosion and water runoff in corresponding regions. Looking into the future, the issue of soil erosion in the kalandforms still needs to be changed. For the countermeasures, drainage facilities can optimize runoff, and forestry technology could affect vegetation. However for the long run method for generation after generation, people's awareness should be fundamentally raised. Thus, the most economical way to deal with this is to increase the government and relative department limitations.

Keywords: Soil Erosion, Karst Landform, Topography, Precipitation, Drainage Facilities.

1. Introduction

According to the research and analysis, because of the large area of limestone and the steep terrain, the Karst landform has distributed in all parts of China, accounting for about 15% of the country's area. One representative of the karst landscape example is in Guizhou, southwest China. The development of this terrain has made a favorable contribution to tourism in local society, supports the income of the population, and boosts the local economy. However, the special geological landform and climate characteristics of karst mountain lead to the slow development of soil, shallow soil layer, and serious soil erosion. The disorder of human activities easily leads to degradation to form a rocky desertification landscape.

The problems caused by soil erosion, such as land degradation, river siltation, flood disaster, and water pollution, have aroused the wide concern of the whole society and the high attention of the government [1]. Meanwhile, there are complex causes of soil erosion in the Karst region, which makes the corresponding solutions more complicated. Therefore, this study aims to concentrate on the problems and causes of soil erosion and water runoff in the karst area and proposes solutions.

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2. The background of Guizhou

Guizhou province is situated in the hinterland of southwest China, the boundary is 24°37 '~ 29°13' north latitude, 103°36 '~ 109°35' east longitude. The karst area in southwest China is one of the areas suffering most from soil erosion and water runoff, while Guizhou is the province with the widest distribution area and has the highest extent of soil erosion and water runoff in the southwest mountainous area [2]. The landscape of Guizhou belongs to the plateau and mountains in the southwest of the country. From west to east, the terrain in Guizhou falls from high to low, and the middle has the biggest slopes. Its location is in a region of the subtropical humid monsoon climate, which has four distinct seasons, abundant precipitation, and enough sunshine.



Figure 1. Location of Guizhou province.

3. The causes of karst landform

As for the genesis of karst landform, there are four controlling factors.

Firstly, the soluble rock is the fundamental condition of the karst landform. Under the influence of constant disintegration by running water, a significant number of carbonate rocks, sulfate rocks, and halide rocks have developed many unique karst landscapes on the surface and underground. From the analysis of rock structure, the degree of solubility is influenced by the scale of the crystalline rock [3].

The second is the water permeability of rocks. Only when the rocks have a favorable water permeability, can water fully permeate and participate in the formation and evolution of karst landforms. In this case, a larger rock fissure could result in a higher degree of rock permeability and more significant karstification. In karst caves, the karst action and the caves are in a positive relationship, therefore more complete karst landforms are developed via more underground pipelines and the formation of an expanding circulation network.

Thirdly, water is involved in the deformation of different karst landforms. Under the action of water dissolution, the soluble rock dissolves in water to form a solution, which is migrated by water load or scour by water machinery and broken into debris, which is relocated and migrated under the action of hydrodynamic force to form karst landform.

Finally, flowing water can move calcium ions, bicarbonate ions, and other chemical materials away, and can persist in rock dissolution to form karst landforms. If the water is stationary, the solubility of the soluble rock in the water is certain, and when the dissolution reaches an equilibrium balance, the solution is saturated, and finally, the rock is no longer dissolved [4].

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4. Types of Karst

There are different classification criteria for karst landforms. The most common classification criteria are surface karst and underground karst. Additionally, it was separated into bare karst, cover karst, and buried karst depending on the exposure conditions, and it can be classified into tropical karst, subtropical karst, temperate karst, cold karst, and desert karst based on the climate zone. It can also be differentiated into limestone karst, dolomite karst, gypsum karst, and salt karst based on lithology [5].

4.1 Surface karst

Surface karst has many types, such as karren and clints. Karren is generally formed and created by the continuous erosion of surface water and dissolution along the rock surface and cracks. Clints refers to the stone ridge protruding between the solubilized furrow, which is actually the residue of the formation process of a solubilized furrow. Moreover, a negative karst terrain with a depth and caliber of up to hundreds of meters is called Tiankeng. It has a huge volume and a bottom connected to an underground river and is caused by the continuous collapse of rock layers up to the surface [6]

4.2 Underground karst

In contrast to surface karst, exposed to the outside world, underground karst is below the surface. This underground karst landform resembles an advanced stage of karst, and the construction of the entire landscape was largely influenced by groundwater erosion. Karst cave is a naturally formed underground space that people can enter. Such places are often popular tourist attractions that benefit from their gorgeous stalactites. When atmospheric precipitation on the surface penetrates into the rock along the pores, cracks and planes of the rock, the rock is dissolved and expanded to form underground cavities. As the cavity enlarges, water flows into the cavity to form an underground stream or river. After the formation of the underground river, under the combined influence of gravity's collapse, dissolution, erosion, and transportation of the underground river, the cavity expands even more.

5. The causes of soil erosion

5.1 Natural factors

5.1.1 Topographic factor Geological and geomorphic factors are the basic factors that determine the degree of soil and water loss. Guizhou landform is undulating with steep slopes and shallow soil layers. Karst peak cluster mountain covers a large area, its distribution area is about 109,000 km2, occupying 61.9% of the province's total land area. The frequent activity of geological structures makes the surface soil migrate vertically or laterally along the slope, which makes the surface soil layer thin and scattered, rare and scattered, and prone to soil erosion and even the formation of rocky desertification [7,8]. The Guizhou local government completed data on water and soil loss in Guizhou Province in 2000. The total area of soil erosion and water runoff in Guizhou Province is 73179.01km² or 41.54 percent of the province's total land area. The following was the area of soil erosion and water runoff at various intensity levels: moderate soil erosion and water runoff flow fire area 22424.44 km², moderate soil erosion and water runoff area 41415.30 km², intense soil erosion and water runoff area 8016.86 km², and extreme soil erosion and water runoff area 1322.41 km². The annual soil loss is 252.1538 million t, and the annual soil erosion modulus is 1432t/ (km²·a) [9].

5.1.2 Climate and precipitation Water and climate are also key factors to influence the degree of soil erosion and water runoff. The climate in Guizhou is humid monsoon subtropical. During the year, there is little variation in temperature, and the province's main annual temperature is about 15°C for the most part. July, when is the month that has the highest temperature, typically has an average temperature of 22°C-25°C, and the lowest temperature in January typically has an average temperature of more than 3°C-6°C, which is higher than other areas at the same latitude. Moreover, precipitation is more frequent in other areas, with obvious rainy seasons. More frequent cloudy days with less

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sunshine, are affected by monsoon precipitation in summer. Every region of the territory typically experiences more than 150 cloudy days per year, and the relative humidity stays above 70% throughout the year. [9]. As the main driving force of soil and water loss, precipitation can not only directly strike soil to form erosion, but also easily form surface runoff to cause erosion of soil. Erosive rainfall is characterized by high frequency, large rainfall, long duration, and intensity. The seasonal distribution is mainly from April to September, characterized by high rainfall and rainfall intensity and short rainfall duration, while the other months are on the contrary [10].

At the same time, the difference between rainfall and rain intensity should also be considered to lead to changes in other factors affecting soil and water loss. For example, where rainfall is high, vegetation is often better. Therefore, the same amount of rainfall could produce different soil erosion moduli in different periods and regions. Heavy rainfall does not occur in soil erosion and water runoff or thin soil erosion and water runoff in areas with suitable vegetation, while severe soil erosion and water runoff occur in karst landforms.

5.2 Humanity factors

5.2.1 Over-exploitation

With the rapid development of modern industrial technology, human factors seriously affect soil erosion by establishing different human activities. Account Guizhou is located in a mountainous area, most of the land resources that people rely on for survival are slope farmland, and many people work on slopes above 25°, which aggravates the soil erosion in Guizhou. It can be seen from Table 1 that sloping farmland, especially those larger than 25°, is one of the important factors causing soil erosion and water runoff.

Table 1. Percentage of the field area in different sloping farmland.

Slope	Area (m²)	Percentage of the total area (%)	Paddy field area (m²)	Percentage of the field area (%)	Arid land (m²)	Percentage of arid land (%)
Less than 6	93.67	19.36	59.36	39.65	36.25	12.06
6~15	148.89	32.32	51.36	35.29	96.34	27.41
15~25	150.28	36.31	25.36	16.32	123.54	26.35
25~35	66.32	14.30	9.36	5.34	63.29	15.63
Higher than 35	25.39	5.39	6.35	2.54	36.34	9.35
Total	495.36	120.36	142.35	32.01	362.31	36.29

A large number of industrial production and urbanization construction are easy to create pressure on the natural environment of the region and cause harm to the conservation of soil and water. Therefore, human factors are also a factor that must be paid attention to in the process of curbing soil erosion and water runoff [11].

5.2.2 Growth of population Apart from industrial technology, the rapid growth of population is also the main reason for the aggravation of soil erosion and water runoff and the deterioration of the ecological environment in the karst mountainous areas of Guizhou [12]. As of midnight on November 1, 2020, the number of permanent residents in Guizhou Province was 38,562,100, compared with 34,746,500 in 2010 (the sixth National Population Census of Guizhou Province, the same below), an increase of 3,815,600 in 10 years, an increase of 10.98%, and average annual growth of 1.05%. The scale of permanent residents continued to expand [13]. Therefore, the growing population overall

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continues to increase its demand for land and the daily necessities of crops, while being limited by the poor and unreasonable or excessive use of the land in the karst landform, resulting in the consequences of massive soil erosion.

6. Countermeasures

6.1 Drainage facilities

In comprehensive management, the construction of drainage facilities is a relatively common measure. Adding drainage intercepting facilities in the treatment area can shorten the flow distance of stormwater runoff, weaken its scour force, and thus reduce the soil loss caused by rainwater scour. There are many kinds of drainage facilities, including reservoirs, drains, drains, and so on. During construction, people can plan this measure together with other projects (such as road works and terraced fields) to build a perfect defense and utilization system to solve the problem of soil erosion effectively [14].

In the construction of general drainage facilities, the parameters of the ditch section should be set according to the formula: Q=ACiR, C=(1/n) ×R1/6, R=A/x. Where Q is the maximum flow, A is the area of the water crossing section, C is Xie CAI's coefficient, R is the hydraulic radius, i is the slope, n is the roughness, and x is the wet circumference of the section. When constructing drainage ditches, use existing drainage channels and natural drainage channels as much as possible to reduce the implementation cost of this treatment [15].

6.2 Forestry technical measures

Forestry technology measure is a kind of technology that can effectively control soil and water loss, which has a remarkable effect and high economic benefits. It can maintain the forest environment and restore forest function while reducing the probability of soil erosion and water runoff.

In karst areas prone to soil erosion and water runoff, forestry technology measures to increase forest coverage rate is the main way to prevent it. The local climatic conditions and ecological environment can be improved to realize the regulation of temperature and environmental water and promote the normal growth of vegetation. The local ecosystem can be changed, a perfect ecological environment system can be created through forestry technology, the natural ecotope can be protected and managed, and soil erosion resistance can be effectively enhanced. Through forestry technology measures, the local ecological cycle can be strengthened, the vegetation coverage rate and soil cohesion can be effectively improved, and soil erosion can be further avoided.

Forestry technology measures can build slope protection forests and solid ditch forests. The construction of water resources could conserve trees, especially in the prone to soil erosion problems in the hillside, erosion ditch, and other locations. It can also save water resources and achieve the purpose of surface runoff interception and dispersion. At the same time, afforestation can also reduce surface runoff to a certain extent, realize water savings, and avoid causing gully erosion to the soil environment.

6.3 Raise public awareness

In the comprehensive control of soil erosion and water runoff, raising the consciousness of soil and water conservation is very important. Local publicity efforts can be carried out in a variety of ways to educate the public about the negative effects of soil erosion and the significance of conserving soil and water. At the same time, people should be encouraged to change unreasonable farming methods and adopt more scientific farming methods to reduce the occurrence of damage in the karst region. Moreover, it is necessary to enhance the restriction by the relative department and local government by focusing on monitoring deforestation. It is also suggested to strictly prohibit the cultivation of crops when the slope of the area is above 25° [16]. Other methods, such as setting a tax on the extra use of the land, putting up warning signs, or publicizing the dangers of soil erosion among young children in schools to form ideas, are all efficient ways to use.

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7. Conclusion

The soil erosion of the karst landform in Guizhou province has become a serious problem that needs to be solved. Basically, karst landform is formed by constant erosion of the soluble rocks by the flowing water, distinguished from the different spatial locations. One on the bare side is called surface karst, and the one that hides below the surface is called underground karst. As a whole, two aspects can cause soil erosion. For the natural factors, the karst's characteristics of steep terrain enhance the rate of soil erosion combing with the high frequency and high intensity of rainfall. Moreover, the raise of population and unrestrained cultivation add more burden to soil erosion control. Finally, for the countermeasures, drainage facilities can optimize runoff, and forestry technology could have effects on vegetation, however for the long run method for generation after generation, people's awareness should be fundamentally raised. Thus the most economical way to deal with this is to increase the limitations from the government and relative department.

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