

Evaluation of Soil Erosion Using 3S Techniques: A Case Study of Cangxi County in the Jialing River Basin, Yangtze River, China

Yijin Wu^{1,2}, Wenna Tu², Yue Xi², Jing Hu^{1,2,3}, Chang Li^{1,2}

¹Key Laboratory for Geographical Process Analysis & Simulation, Central China Normal University
Hubei Province, Wuhan, China

²College of Urban and Environmental Science, Central China Normal University
Wuhan, China

³Wuhan Branch of China Tourism Academy
Wuhan, China

lcshaka@126.com; lichang@mail.ccnu.edu.cn

Abstract - Soil erosion not only has a negative impact on the ecological environment, but also restricts the sustainable development. Therefore, it's significant to develop green ecology, evaluate soil erosion in large river valley, and propose feasible suggestions of soil and water conservation. This paper uses 3S technology to evaluate soil erosion of Cangxi County in the Jialing River basin, Yangtze River, China. The main steps include: (1)Image pre-processing: using ZY-3 and GF-1 satellite data, both geometric error and radiometric error are corrected so that image accuracy is improved; (2)Field investigation and indoor interpretation of remote sensing: field interpretation marks are established by GPS and RS; mainly image interpretation is carried out by machine learning or image classification, then results are checked by visual interpretation and confirmed by field review to improve interpretation accuracy; (3)Spatial analysis: soil erosion intensity is classified and soil erosion intensity map can be obtained through “standards for classification and gradation of soil erosion”(SL190-2007) based on three factors(land-use types, vegetation coverage and slope); (4)soil erosion evaluation: soil erosion is evaluated by soil erosion intensity map. The results show that: (1)The intensity of soil erosion in the study area is concentrated on slight and moderate soil erosion; the area with severe soil erosion is few; (2)The soil erosion of townships are mainly concentrated on the north and east of the county, while soil erosion is relatively slight in the northwest and southwest; (3)Under the influence of different factors, the soil erosion intensity is quite different and is often affected by many factors(exposed soil, human activities). Finally, this paper proposes some specific measures from the perspective of green ecology, which may provide a view to a certain reference for soil and water conservation in the study area and evaluation of soil erosion in other regions in Yangtze River, China.

Keywords: Soil erosion, Sustainable development, 3S (RS, GIS, GPS) technology, Yangtze River.

1. Introduction

Soil erosion, as an important environmental issue facing the world today, has a more serious negative impact on the ecological environment and social economy, attracting the attention of scholars all over the world and has formed rich research results. In the traditional empirical model, Wischmeier and Smith constructed a universal soil loss equation. It has been rapidly promoted and applied in the United States and even in the world[1]and[2] . Renard proposed to modify the general soil erosion equation[3]. Liu Baoyuan constructed the Chinese soil loss equation[4]. In terms of physical models, representative models include European EU-ROSEMHE[5] and LISEM[6], and Australian GUEST[7]. With the development of RS (Remote sensing) and GIS (Geographic information system) technology, its advantages are also revealed in the study of soil erosion[8] and[9]. Chinese scholars have also done extensive research on this topic[10],[11] and[12]. President Xi Jing Ping emphasized that the Yangtze River is the mother river of the Chinese nation and an important support for the development of the Chinese nation. To promote the development of the Yangtze River Economic Belt, we must take eco-priority and green development roads, so that the mother river will remain viable. Therefore, exploring and applying 3S technology to evaluate and analyze the status of soil erosion has important practical significance.

This article use the “3S” technology to evaluate soil erosion in Cangxi County in the Jialing River Basin, Yangtze River and analyze the spatial distribution characteristics of soil erosion, providing scientific reference for the treatment and decision-making of soil erosion in the region and even other regions.

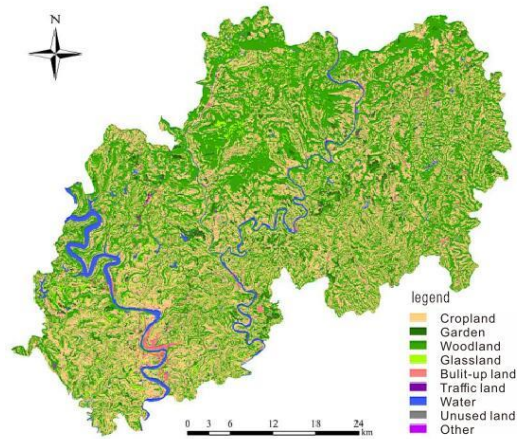


Fig. 2: the map of land use types.

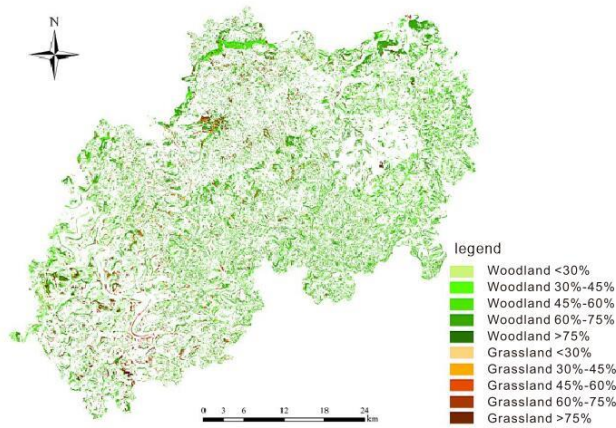


Fig. 3: the map of vegetation coverage rating.

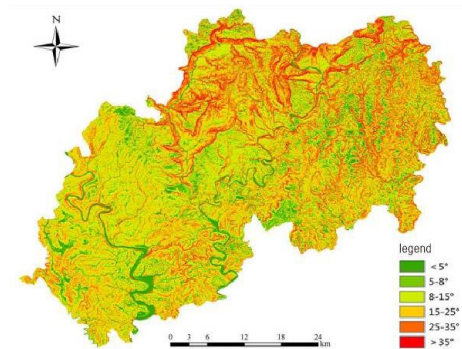


Fig. 4: the map of vegetation coverage rating.

After the above steps, this paper gets the land use classification map of the study area (Fig. 2). Though "Technical specification of soil and water conservation monitoring by remote sensing" (SL592-2012), the vegetation coverage are divided into 5 grades (<30%, 30%-45%, 45%-60%, 60%-75%, and >75%)(Fig. 3). Using DEM as the data source, the slope gradient is divided into 6 grades (<math>< 5^\circ</math>, 5-8°, 8-15°, 15-25°, 25-35°, and >35°) (Fig. 4).

According to requirements in SL592-2012, the number of actual inspection map spot is not less than 1%, and the area is not less than 5%. The area reviewed in this study accounted for 5.05% of the total area, and the number of map spots accounted for 2.19% of the total number of spots. The area verification rate of the sample point is 92.54%, and the spot

verification rate is 91.51%. It can reflect that the interpretation of data is basically in line with the situation on the ground, and the interpretation accuracy can meet the needs of research.

Based on “standards for classification and gradation of soil erosion”(SL190-2007), combined with the analysis of the soil erosion in the study area, this paper determine the classification criteria for soil erosion (Table 1), soil erosion intensity map is obtained (Fig. 5).

Table 1: “standards for classification and gradation of soil erosion” (SL190-2007).

Land use	Forest cover (%)	Slope					
		<5°	5 - 8°	8 - 15°	15 - 25°	25 - 35°	>35°
Woodland and Grassland	> 75	Slight	Slight	Slight	Slight	Slight	Slight
	60 - 75	Slight	Micro	Micro	Micro	Moderate	Moderate
	45 - 60	Slight	Micro	Micro	Moderate	Moderate	Severe
	30 - 45	Slight	Micro	Moderate	Moderate	Severe	Violent
	<30	Slight	Moderate	Moderate	Severe	Violent	Extremely violent
Cropland		Slight	Micro	Moderate	Severe	Violent	Extremely violent
Garden		Slight	Slight	Micro	Moderate	Severe	Violent
Built-up land		Slight	Slight	Slight	Slight	Slight	Slight
Traffic land		Slight	Slight	Slight	Slight	Slight	Slight
Other		Slight	Micro	Moderate	Severe	Violent	Extremely violent

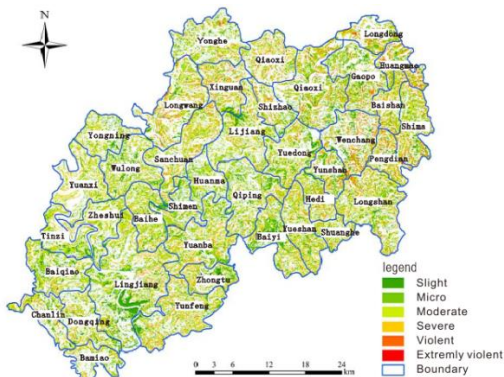


Fig. 5: the map of soil erosion intensity distribution.

4. Results

4.1. Soil Erosion Intensity

(1) General characteristics

In soil erosion intensity, the soil erosion in the study area was serious overall. The proportions of soil erosion with micro, moderate, and severe intensity accounted for 21.31%, 30.52%, and 21.78%, respectively; the violent intensity accounted for 6.17%; the extremely violent intensity accounted for 0.75%. It can be seen that the erosion intensity in the study area is concentrated on the moderate soil erosion, followed by the severe, slight and micro soil erosion, while the ratio of violent and extremely violent soil erosion is relatively low. Therefore, slight, moderate, and severe intensity are the main types of soil erosion in the study area, and their governance can effectively alleviate the serious situation of soil erosion.

Table 2: Soil erosion area statistics.

Soil erosion level	Area (km ²)	Ratio of total area of soil erosion (%)	Ratio of total land area (%)
Slight	235.29	21.31	10.09
Micro	214.97	19.47	9.23
Moderate	337.09	30.52	14.47
Severe	240.61	21.78	10.33
Violent	68.11	6.17	2.92
Extremely violent	8.29	0.75	0.35
Total	1104.36	100	47.39

(2) Spatial distribution characteristics

In terms of spatial distribution, the serious soil erosion of townships is mainly distributed in the north, central and east of the county, while townships in the northwest and southwest have relatively slight soil erosion. In Cangxi County, there are 14 townships where soil erosion rate are all above 50%, such as Baishan, Baiduo, Yueshan, at el. About 8 townships' soil erosion rate are basically around 40% or below. Such as Dongqing, Yongning, Shizao; the remaining other townships have the moderate soil erosion intensity, which is between 40% and 50%.

The causes of soil erosion in the above 14 townships are as follows: the Weihe rivers in the northern and Baishan, Baiduo, Yueshan, Shima, Hedi, Yunshan, Pengdian, Shuanghe, Huangcao and Longshan in southeastern have relatively high altitude, steep slopes and large-scale reclamation of cultivated land and orchards, which cause soil erosion. Baihe, Zhongtu and Yuanba in the central and southern parts of Cangxi country, the three townships are low-lying, but there are many man-made production and construction activities, leading to serious soil erosion in the region.

4.2. Impact Factor Correlation Analysis

(1) Vegetation factors

Vegetation has the function of conserving water source and consolidating soil. Good vegetation coverage can effectively reduce surface runoff, and to some extent inhibit the occurrence of soil erosion. The area with 60%-75% vegetation coverage is the largest, accounting for 41.11% of the total area of soil erosion, followed by the area with 45%-60% vegetation coverage, accounting for 40.65% of the total area of soil erosion. This is due to the fact that the area with both the two vegetation coverage rate accounted for most of the area in the study area. In addition, under the influence of hilly terrain and surface exposed under the vegetation, the area of soil erosion is relatively large. However, in view of the intensity of erosion, erosion intensity is mostly dominated by slight, micro and moderate erosion, and the amount of soil erosion per unit area is small. The soil erosion area with 30%-45% vegetation coverage is relatively small and the soil erosion area with <30% vegetation coverage is the smallest, accounting for only 0.69% of the total soil erosion area. This is due to the fact that the two types of vegetation coverage in the study area are small. And violent and extremely violent erosion are mainly distributed at <30% vegetation coverage level and the amount of soil erosion is large per unit area.

(2) Land use factor

Different types of land use itself lead to greater differences in soil erosion. Soil and water loss in the region mainly occurs in arable land and natural woodland where human activities are strongly negatively affected. The soil erosion area of cropland accounts for 47.92% of the total area of soil erosion in the entire study area, followed by woodland, which is accounting for 29.28%. The main reason is that there are many farmland areas in slope and the soil and water conservation capacity is poor under the influence of human farming activities. Although woodland is better for soil and water conservation due to its vegetation cover and less human interaction, the actual field investigation found that the study area was covered with high vegetation while there were many exposed soils below the woodland. The lack of protection of soil erosion by vegetation shrubs, combined with the topographic effects of mountainous terrain, results in a relatively large area of soil erosion.

(3) Terrain Factors

The differences in elevation, slope, etc. have a great impact on the speed and intensity of soil erosion. From the aspect of soil erosion and terrain correlation analysis, the area of soil erosion in the study area is mainly distributed in mountainous

regions with altitudes of 450-600m and 600-750m, accounting for 65.42% of the total area of soil erosion; the topography of the area is mainly mountainous. Due to the main production activities in study area are ploughing agriculture, the slope is large in this elevation range, in addition, there are many disturbances to the surface by human activities, and the intensity of land use development is relatively large, results in a large area of soil erosion.

Soil erosion is severe and erosion intensity is mainly based on severe, violent and extremely violent, where the slopes are mainly concentrated in the areas within the range of 8-15°, 15-25°, and 25-35°, accounting for 39.57%, 28.59%, and 13.54% of the total area of soil erosion, respectively. Therefore, in the future, the focus of soil and water conservation should be on the areas with an altitude of 450m-750m and a slope of 8-35°.

5. Prevention Measures

Based on the analysis of the above evaluation results, there are several specific measures:

1) To control soil erosion comprehensively according to local conditions

Cangxi County should seize the opportunity of prevention and control as a key treatment area for soil erosion at the national level. Actively implement the return of farmland to forests, slope change ladder, accelerate the adjustment of industrial structure so as to achieve the unity of ecological, economic, and social benefits.

2) Unified planning, implementation of partition prevention

Based on the status quo of soil erosion, geographical distribution and spatial distribution of the soil erosion in the study area, combined with the natural socio-economic development of Cangxi County, the prevention and control of soil erosion in the study area is planned and divided into three grades to take appropriate measures to focus on the purpose of governance.

3) Strengthen rural energy development and optimize energy structure

Cangxi County has a large area of mountainous area and has a large rural population. It has been burning firewood as the main energy source, resulting in excessive cutting of trees and serious soil erosion. Therefore, we should actively guide farmers in areas with severe soil erosion to take advantage of rural crop stalks, livestock and manure, and vigorously develop biogas digesters. In addition, when developing and utilizing the abundant natural gas resources of Cangxi County, it actively covers the vast rural areas and provides clean energy and a good living environment for the majority of farmers.

4) Establish sound water and soil conservation monitoring and forecasting system

Strengthen the construction of soil and water conservation monitoring facilities, actively promote the application of “3S” technology in soil and water conservation monitoring, and establish soil and water conservation monitoring information system. Provide scientific reference for the planning and management of soil and water conservation in Cangxi County.

6. Conclusion

(1) This study gives full play to the advantages of integrated application of 3S technology, uses 3S technology to carry out field investigations to establish interpretation marks and verification, and completes the main tasks of indoor interpretation.

(2) The monitoring results show that, the proportions of soil erosion with slight, moderate, severe intensity accounted for 21.31%, 30.52%, and 21.78%, respectively; the violent intensity accounted for 6.17%; the extremely violent intensity accounted for 0.75%. Therefore, slight, moderate, and severe erosion are the main types of soil erosion in the study area, and their governance can effectively alleviate the serious situation of soil erosion, which is of great significance for the soil and water conservation in the study area.

(3) From the perspective of spatial distribution, there is a certain difference in soil erosion intensity in the study area. Townships with more serious losses are mainly distributed in the northern, central and eastern, while townships in the northwest and southwest have relatively less soil erosion. The rate of soil erosion in 14 townships in the southeast is above 50%. Western townships have relatively small soil erosion, and the loss rate is basically around 40% and below. The loss rate of the rest of the other townships is between 40% and 50%.

(4) According to the correlation analysis of soil erosion and vegetation coverage, the soil erosion in the study area is mainly concentrated in the vegetation coverage range of 60%-75% and 45%-60%, and the resulting soil erosion area is relatively large, but the erosion intensity is mostly slight, micro and moderate, and the amount of soil erosion per unit area was relatively small. It is the key treatment area for soil erosion afterwards.

(5) According to the correlation analysis of soil erosion and land use, the soil erosion in the region mainly occurs in the arable land and natural woodland where human activities are strongly disturbed. The soil erosion area of cultivated land accounted for 47.92% of all the lost areas, followed by forest land, accounting for 29.28%, accounting for 77.20% of the total.

(6) According to the correlation analysis of soil erosion and topography, the area of soil erosion is mainly distributed in mountainous regions with an altitude of 450-600,600-750m, accounting for 65.42% of the total; The areas mainly concentrated in the regions of 8-15°, 15-25°, 25-35°, which accounted for 39.57%, 28.59%, and 13.54% of the total, respectively, and the erosion level is concentrated on severe, violent and extremely violent intensity.

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