Analysis of spatial and temporal changes of soil erosion in Anning river basin

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Abstract: Anning River basin as an important soil erosion monitoring and reserve in Sichuan Province. It is of great significance to grasp the temporal and spatial changes of soil erosion in this area in time to realize the comprehensive treatment of regional soil erosion. Based on the revision of the general soil erosion equation (RUSLE), the present situation of soil erosion in 1995-2015 years in this area was monitored, and the classification was completed according to the national grading criteria, and the following results were mainly achieved: (1) Soil erosion in Anning river basin as a whole presents a low gradient change in the eastern High West. (2) The proportion of raster in soil erosion area of each grade also showed different structural differences, which showed that the degree of micro > Mild > Moderate > Strong > Extremely > severe, and the proportion of raster in mild and below intensity erosion area reached more than 80%, and the whole basin was at mildly below erosion level. (3) One-dimensional linear regression analysis shows, within 20 years, about 90% of the raster cell slope in this area is negative, the overall change trend of soil erosion in this area shows a significant improvement

Soil erosion is one of the natural disasters that affect social and economic development and threaten human survival, the innate natural environment of the region determines the severity of soil erosion, at the same time, human activity is an important factor contributing to its change. The frequent occurrence of soil erosion will not only cause environmental problems such as declining land productivity, river blockage and flash flood outbreak, but also aggravate the fragility of regional ecological environment and pose a threat to the sustainable development of human beings.

Experts and scholars at home and abroad have carried out a lot of research on regional soil erosion and obtained many research results. Wischmeier and Smith^[1] put forward that the general equation of soil erosion (USLE) has achieved great benefits and has been widely recognized. Chen Mei Qi and others^[2] used the soil loss equation (CSLE) in China to study the law of soil and water loss in Guizhou province. Yi Kai and others^[3] According to the United States Department of Agriculture revised RUSLE equation on the soil erosion of Chaoyang in Liaoning Province. Cao Sheng^[4] assessment of Ningxiang soil using USLE model. Wang Jiao and others^[5] completed the spatial analysis of soil erosion sensitivity

in Taihang mountain area. Li Dalong and other^[6] to evaluate the soil erosion sensitivity of yili.

Anning River basin plays an important role in ecological environmental protection and construction in the province. However, due to the limitation of natural conditions such as high altitude and complicated geological conditions, etc. In addition, unreasonable exploitation and utilization of natural resources such as land, water and minerals. It has become the key area of ecological protection and soil erosion monitoring in southwest Sichuan. In order to make up for this vacancy, the paper studies the combination of RS, GIS technology and modified general soil erosion (RUSLE) model to monitor the soil and water loss in this area for 1995-2015 years, and explores and analyzes its spatiotemporal variation law in order to provide scientific theoretical reference for the management of regional soil erosion.

1 DATA

According to the RUSLE model, the data of each component factor is obtained, and the data description and source are studied (Table 1).

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Table 1. Research data types and sources

Name	Data sources
Digital Elevation Model (DEM) in watershed area, resolution of 30x30m	The data set is provided by Geospatial Data Cloud site, Computer Network Information Center, Chinese Academy of Sciences. (http://www.gscloud.cn)
1:1000000 soil type vector data, including various sizes of sand grains, powder particles, organic matter content and other information	China Soil Database
Rainfall data for each month and year counted by meteorological stations in and around the study area	China meteorological Data Science sharing network (http://data.cma.cn/)
Watershed Area 1:100,000 Land Use type remote sensing interpretation results data, 1995 and 2000 as vector results, Other issues of raster data for 30x30m	Data for 1995 and 2015 are derived from Cold and Arid Regions Sciences Data Center at Lanzhou (http://westdc.westgis.ac.cn); others from Resource and Environment Data Cloud Platform (http://www.resdc.cn)

2 Research Methods

2.1 USLE Model

Wischmeier and Smith established a general equation of soil erosion (USLE) through a large number of experiments, and later modified to form the RUSLE equation, the model has been widely used in academic circles to calculate the amount of soil erosion in various regions. The model is as follows.

$$A = R \times LS \times K \times C \times P \quad (1)$$

In the formula: A is soil erosion modulus $t/(hm^2 \times a)$, R is rainfall erosion factor $(MJ \cdot mm/hm^2 \cdot a \cdot h)$, LS is slope and slope length factor, K is soil erosive factors, C is vegetation cover factor and P is soil and water conservation factors.

2.2 Rainfall erosion Force factor

Precipitation erosion force is the main external force affecting the degree of soil erosion. and this study selects the classical model proposed by Wischmeier^[1] to calculate. The model is as follows.

$$R = \sum_{i=1}^{12} 1.735 \times 10^{\left(1.5 \times \log \left(\frac{P_i^2}{P} \right) \right) - 0.8188} \quad (2)$$

In the formula: P_i is monthly rainfall, P is annual rainfall. In this study, the model (2) was used to calculate the rainfall erosion force of each site in different years, and its spatial interpolation was accomplished by using the inverse distance weight model.

2.3 LS is slope and slope length factor

The size of L value has a significant interaction with the rate of surface runoff, typically, the more severe the mild the soil erosion in the long slope area. Slope, as one of the important indexes of terrain change, can objectively characterize the effect of topography on soil erosion. The calculation of slope length in the study adopts the Chinese calculation model proposed by Liu Baoyun and

others^[7]. Slope factor using the calculation model of Southwest Mountain Area proposed by Liu Bintao and others^[8]. The model is as follows.

$$S = \begin{cases} 10.8 \sin \theta + 0.3 & (\theta \leq 5^\circ) \\ 16.8 \sin \theta - 0.5 & (5^\circ < \theta \leq 10^\circ) \\ 20.204 \sin \theta - 0.1204 & (10^\circ < \theta \leq 25^\circ) \\ 29.585 \sin \theta - 5.6079 & (\theta > 25^\circ) \end{cases} \quad (3)$$

In the formula: S is the slope factor, L is the slope length factor, θ is the ground slope, λ is the slope length value, m is the slope factor index.

$$L = \left(\lambda / 22.13 \right)^m = \begin{cases} m = 0.2 & \theta \leq 1^\circ \\ m = 0.3 & 1^\circ < \theta \leq 3^\circ \\ m = 0.4 & 3^\circ < \theta \leq 5^\circ \\ m = 0.5 & \theta > 5^\circ \end{cases} \quad (4)$$

2.4 Soil erosive factors

Soil erosive can reflect the sensitivity of external forces such as precipitation to its stripping. It is one of the important indexes to measure soil erosion in the region, and the data source based on 1:100 million soil data is studied, and the K value is calculated by combining EPIC model^[3,4]. The model is as follows.

$$K = \left\{ \left[0.2 + 0.3e^{-0.0256 \cdot SAN(1 - SIL/100)} \right] \times \left[\frac{SIL}{CLA + SIL} \right]^{0.3} \times \left[1.0 - \frac{0.25C}{C + e^{(3.72 - 2.95C)}} \right] \times 1.0 - \frac{0.7SN1}{SN1 + e^{(-5.51 + 22.9 \cdot SN1)}} \right\} \quad (5)$$

In the formula: K is soil erosive factors $(t/MJ \cdot mm)$, SAN is sand granules, SLA is powder granules, CLA is sticky granules, C is indicates organic matter, $SN1 = 1 - SAN/100$.

2.5 Vegetation and soil and water conservation factors

The research completes the determination of C and P values by referring to the achievements^[8-12] (Table 2)..

Table 2. C and P value determination coefficient

Surface Overlay Name	P	C	Surface Overlay Name	P	C
Paddy	0.01	0.18	Lake	0	0
Dryland	0.4	0.31	Reservoirs, pits and ponds	0	0
Woodland	1	0.003	Permanent Glacial Snow Cover	0	0
Shrubwood	1	0.01	Beach land	0	0
Sparse woodland	1	0.05	Urban construction land	0	0
Other forest land	0.6	0.05	Rural settlements	0	0
Highly Covered Grassland	1	0.002	Other Construction Land	0	0
Moderate Covered Grassland	1	0.03	Sand	0	0
Low Covered Grassland	1	0.1	Bare land	0.4	1
Rivers	0	0			

The research combines RS, GIS technology and RUSLE model to calculate the soil erosion quantity in different periods of the Anning River basin in 1995-2015, and to complete the delimitation of soil erosion grade in different years according to national standards^[12] (Fig. 1).

3. RESULTS AND ANALYSIS

3.1 Spatial Distribution Characteristics

Fig.1 Soil erosion intensity grading in Anning River basin in 1995-2015

According to Figure 5: Soil erosion in the Anning River basin shows a gradient change of West high east and Low, the intensity of soil erosion in the western region is higher and wider than that in the east. In addition, the intensity erosion areas of each level also show obvious distribution differences in spatial distribution. The proportion of extremely strong and Severe soil erosion areas in the whole basin is only about 3%, and is mainly concentrated in the northwest of Mianning County, and in the western region of Xichang. The land landscape in these areas is mainly sparse woodland and dryland, while the geomorphological type is mainly alpine and polar Alpine, the terrain is steep, the topography fluctuation difference is obvious, the slope length and the slope factor data are also larger, the regional soil erosion is relatively serious. Moderate and strongly eroded areas account for about 12% of the entire basin, most of which are concentrated on both sides of the Anning River Valley Plain, where the main geomorphological types and land use patterns are dominated by shrubbery, sparse woodland and cropland, with the highest vegetation cover and the

most complex ecosystem in the region. It is a key buffer area protection zone for regional soil erosion. The proportion of micro and mild erosion areas in the whole basin is about 85%, and most of them are concentrated in the tranquil valley plain, which is the core zone of human activities and social and economic development in the whole basin, and the geomorphology is not obvious in the main terrain of plain and low mountain, which is the area with the most intense soil erosion intensity and area in the whole basin

3.2 Structural differences

An analysis of the proportion of soil erosion zones at all levels contributes to a more comprehensive understanding of the specific conditions of soil erosion in the region (Table 3).

Table3 Soil erosion grading in Anning River basin in 199-2015 years

Level	modulus [t/(km ² ·a)]	Proportion of soil erosion zones at all levels				
		1995	2000	2005	2010	2015
Micro	<500	64.26	60.93	60.96	63.42	62.61
Mild	500-2500	20.29	23.53	22.03	22.99	21.87
Moderate	2500-5000	10.10	10.07	10.59	9.54	10.30
Strong	5000-8000	3.75	3.76	4.229	2.88	3.65
Extremely	8000-15000	1.44	1.52	1.914	1.06	1.42
Severe	>15000	0.16	0.19	0.283	0.11	0.15

As can be seen from Table 3, the region's micro and Severe proportions occupy the largest and smallest ends of the entire basin, respectively, the change of proportional relationship in other intensity erosion areas was mild > Moderate > Strong > Extremely. Taking the 2015-year data as an example, the micro erosion zone occupies the largest 62.61%, the rates of mild, moderate, strong and extremely were 20.29%, 10.1%, 3.75% and 1.44%, respectively, and decreased in turn, and only 0.16% of the Severe is minimal. The area of mild and below intensity erosion area in watershed area reached 84.03%, which indicates that the intensity of soil erosion in the whole basin is at a mild level. Similarly, soil erosion in the region in 1995, 2000, 2005 and 2010 was at levels such as light erosion and below.

3.3 Trend changes

Unary linear regression can realize the regression fitting of each variable with time, and and predict its trend change. The model is as follows.

$$X = \frac{n \times \sum_{i=1}^n i \times A_i - \left(\sum_{i=1}^n i \right) \left(\sum_{i=1}^n A_i \right)}{n \times \sum_{i=1}^n i^2 - \left(\sum_{i=1}^n i \right)^2} \quad (6)$$

In the model: X is slope, if X > 0 the value of raster cells increases, Increased amount of soil erosion. Otherwise, on the contrary.

The change of erosion ratio of different grades in 15 years shows that: The proportion of micro-erosion decreased by 1.65%, while the proportion of mild and moderate soil erosion increased by 1.58% and 0.2% respectively. Overall analysis, the proportion of mild and below increased by 0.13%. The raster proportions in strong, extremely strong and Severe erosion zones showed a decreasing state of change, falling by 0.1%, 0.02% and 0.01%, respectively. The raster proportions in strong, extremely strong and Severe erosion zones showed a decreasing state of change, falling by 0.1%, 0.02% and 0.01%, respectively. A comprehensive analysis shows that the increase in mild and below rates is mainly due to a decrease in the intensity and above. At the same time, the analysis of unary linear regression results also showed that the raster ratio of soil erosion increased by 91.67% X < 0 in 15 years. X > 0, the grid ratio of reduced soil erosion was only 8.32%, and the region with a significant reduction in soil erosion accounted for the vast majority of the entire

watershed area.

In summary analysis, the soil erosion in the whole Anning River basin has developed well in 15 years, and the soil erosion condition has been effectively treated, showing a clear trend of improvement.

4 CONCLUSION

Based on the RUSLE model, the temporal and spatial changes of soil erosion in the Anning River basin in the 1995-2015 are analyzed, and the main conclusions are as follows:

(1) From the spatial point of view, the soil erosion in the whole watershed area showed obvious difference of gradient change, and the soil erosion in the western region as a whole was more serious than that in the eastern region. There are also different regional differences in spatial distribution of soil erosion areas at various levels. Extremely strong and sever accounts for the smallest and mainly distributed in the northwest of Mianning and the western region of Xichang. The position of strong and severe erosion zones and is mainly distributed in the middle and alpine regions on both sides of the tranquil valley plain. Mild and Micro eroded areas accounted for the highest proportion, distributed in the middle and low mountain area of the Valley plain.

(2) From the time point of view, the soil erosion area of each grade in the watershed area shows obvious change in the raster proportion over time. The raster ratio in only mild and moderate erosion zones in 1995-2015 years is an increased state of change. The proportion of the erosion zone raster of the remaining levels is reduced to varying degrees. Throughout the period, the situation of soil erosion in this area also showed a significant decrease in the trend of change, and its soil erosion status was effectively treated.

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