Effect evaluation of soil erosion control in Xingguo County

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Abstract: Xingguo county once suffered from serious soil erosion, fragile ecological environment and extreme poverty. After 1980, Xingguo County government adopted a series of measures to control soil erosion, improve people's life and promote economic development. After nearly 40 years of governance, Xingguo has been lifted out of poverty, and the ecological environment has changed greatly. The strategy of Xingguo County Government to control soil erosion has referenced significance. In this study, GIS technology was used to calculate the current situation of soil and water loss in Xingguo County.

1. Introduction
Soil erosion is one of the main causes of land degradation, it is a serious threat to cultivated land resources[1-2]. Unreasonable agricultural activities have drastically increased soil erosion rates[3]. China has always adhered to the road of sustainable development. Cao Shixiong et al put forward a win-win theory of ecological restoration, which believes that poverty alleviation is closely related to environmental protection[4]. The Chinese government always stressed that the economy should not be developed at the cost of destroying the environment. In China, it is widely acknowledged that the environment itself means the economy. Through these years' efforts, the rural environment has been improved and the economy has developed.

In Xingguo County, Jiangxi Province, due to historical human activities such as excessive land reclamation, excessive grazing, and excessive cutting of firewood, soil erosion has been severe, the ecological environment is fragile, and the people's lives are extremely poor. Xingguo government attached great importance to soil and water conservation. After 1980, the county water and soil conservation committee was restored and an office was established. The county water and soil conservation test station, the county water and soil conservation technology extension station, and the Tangbei small watershed test management station have been established successively. The government has trained a number of soil and water conservation professionals. The superiors allocated 6,234,300 yuan, an average of 1.04 million yuan per year. System reform was carried out in 1981, and the forestry property rights reform was carried out throughout the county. The forest rights were assigned to households, and the collective operation of the production team was changed to individual farmers. The rights, responsibilities, and interests of farmers are closely integrated, mobilizing farmers' enthusiasm for forestry management, and combining poverty alleviation with soil erosion management, and
vigorously developing the soil and water conservation industry. At the same time, Xingguo County launched the first comprehensive management of soil erosion in the Tangbei small watershed.

In 2000, the Tangbei small watershed became a national water and soil conservation ecological environment construction demonstration small watershed named by the Ministry of Water Resources. In 2020, Xingguo County meets the national poverty-stricken counties exit criteria and officially exits the poverty-stricken counties sequence. After nearly 40 years of governance, Xingguo County has achieved economic development and environmental improvement, and has found a win-win development path for the economy and ecology. It explains that lucid waters and lush mountains are invaluable assets.

2. Research area, data and methods

2.1. Survey of Research Areas
Xingguo County (26°03'N—26°41’N, 115°01'E—115°51’E) is located in the south-central part of Jiangxi Province and the northeast of Ganzhou City, with a total area of 3,214 square kilometers. The problem of soil erosion in Xingguo County has been around for a long time, and the history books of the Qing Dynasty have described soil erosion. Its climate is subtropical monsoon humid climate with an average annual rainfall of 1,560 mm. The high rainfall and high intensity are important driving factors for soil erosion. The average total runoff for many years is 2.687 billion cubic meters. The runoff depth is deep and the runoff is large, thus losing a lot of soil. The landform is dominated by low mountains and hills, partially distributed in middle mountains and low mountains. The mountain area is large, the terrain is large, the slope is steep, the rock resistance to weathering is weak, and it also promotes soil erosion. The lack of vegetation in the granite mountains makes the soil unprotected. Man-made destruction of vegetation intensified soil erosion. After the end of Qing Dynasty, wars were frequent and soil erosion became more and more serious. After the founding of the People's Republic of China, the government attached great importance to the management of soil erosion, but due to population growth and policy errors, soil erosion was still serious. According to the comprehensive zoning survey of soil and water conservation in 1980, the area of erosion reached about 1899.07, accounting for about 85% of the total mountain area and 60% of the land area of Xingguo County. The total annual soil loss amounts to 11.06 million tons and 132,000 tons of organic matter is lost.

| Loss intensity | mild  | moderate | intense | severe | total |
|----------------|-------|----------|---------|--------|-------|
| Area (km²)     | 938.2 | 291.6    | 502.73  | 166.13 | 1898.66 |
| Proportion in total area(%) | 29.19 | 9.07     | 15.64   | 3.61   | 59.07  |

(Data source: Investigation on Comprehensive Regionalization of soil and water conservation in 1980)

2.2. Data sources
(1) Society and economic data come from the Yearbook
(2) Precipitation data from Meteorological Bureau.
(3) Soil data came from the soil and water conservation monitoring center of Ministry of water resources.
(4) Slope and slope length factors are derived from DEM data of 10m.
(5) Vegetation cover and land use data were obtained from remote sensing interpretation reference and its result checking.
(6) Other information is derived from the work report of the government and the government website.
2.3. Research methods

2.3.1. Chinese Soil Loss Equation

CSLE is a dynamic monitoring method for soil and water loss proposed by Liu Baoyuan, et al[5]. CSLE model has been widely used in China[6-7].

Based on the calculated values of soil erosion factors, Chinese Soil Loss Equation (CSLE) was used to measure soil erosion in Xingguo County in 2018.

\[ A = R \times K \times L \times S \times B \times E \times T \]  \hspace{1cm} (1)

- \( A \) is the annual soil erosion amount (t·hm\(^{-2}\)·a\(^{-1}\));
- \( R \) is the rain fall erosivity (MJ·hm\(^{-2}\)·h\(^{-1}\)·a\(^{-1}\));
- \[ \bar{R} = \frac{\sum_{m=1}^{24} R_m}{24} \]  \hspace{1cm} (2)
  - Where \( \bar{R} \) is the average annual rainfall erosivity (MJ·hm\(^{-2}\)·h\(^{-1}\)·a\(^{-1}\));
- \( M \) takes 1, 2,..., 24, which means dividing a year into 24 half months; \( R_m \) is the rainfall erosivity of the mth half month (MJ·hm\(^{-2}\)·h\(^{-1}\)·a\(^{-1}\)).
- \( K \) is the soil erodibility factor (t·h·MJ\(^{-1}\)mm\(^{-1}\));
  - It represents the ability of soil to resist raindrop and runoff erosion. \( K \) is related to soil physical and chemical properties.
- \( L \) is the slope length factor, dimensionless;
  - It refers to the ratio of soil loss on a slope with a slope length of 22.13 m under the same other conditions (rainfall, soil, slope, land use and soil and water conservation engineering measures), which reflects the impact of slope length on soil erosion.
- \( S \) is the slope steepness factor, dimensionless;
  - It refers to the ratio of soil loss on a slope to that on a slope of 5.14 ° when other conditions (rainfall, soil, slope length, land use and soil and water conservation engineering measures) are consistent, which reflects the impact of slope on soil erosion.
- \( B \) is the vegetation cover and Biological measure factor, dimensionless;
  - It refers to the ratio of soil loss of vegetation covered slope to that of non vegetation covered land under the same conditions (rainfall, soil, slope length, land use and soil and water conservation measures are consistent), which reflects the impact of vegetation cover on soil erosion. Through the collection of 23 Landsat and MODIS within the monitoring area in the first three years Image, fusion method or parameter correction method were used to calculate 24.5 months of 30 m resolution NDVI data.
- \( E \) is the Engineering protection practice factor, dimensionless;
  - It refers to the ratio of the soil loss on the slope with some engineering measures and without engineering measures under the same conditions, which reflects the role of soil and water conservation engineering measures.
- \( T \) is tillage measures factor.
  - It refers to the ratio of the amount of soil loss on the slope surface by taking some tillage measures to that by traditional tillage under the same conditions. Traditional tillage refers to flat farming or ridge farming along the slope. \( T \) reflects the effect of Tillage Measures on Soil and water conservation.

When the land use type is cultivated land, \( t \) factor is selected to multiply the other five factor layers in \( B \) factor and \( T \) factor; when the land use type is non cultivated land, \( B \) factor is selected to multiply with other 5 factor layers. Get the grid layer of soil erosion modulus calculation value.
2.3.2. T-test
Based on the soil and water loss data of 32 small watersheds in Xingguo County in 1980 and 1992, t-test was used to test the effect of property right reform and soil erosion control.

3. Research results

3.1. The results of Chinese Soil Loss Equation
The total area of soil erosion in Xingguo County in 2018 was 80.52% less than in 1980. Among them, only 14.83 km² of soil erosion area is left at a moderate level or above, which is 98.46% less than in 1980.

Table 2: Soil erosion grades in Xingguo County in 2018

| Soil erosion grade | slight | moderate | intense | extremely intense | severe | Total |
|-------------------|--------|----------|---------|------------------|--------|-------|
| Area (km²)        | 355.11 | 5.11     | 2.85    | 3.39             | 3.48   | 369.94|
| Proportion (%)    | 95.99  | 1.38     | 0.77    | 0.91             | 0.94   | 100   |

Figure 2: Intensity and distribution of soil and water loss in Xingguo County in 2018
3.2. The results of T test

Table 3: T-test of soil and water loss area change in small watershed of Xingguo County in 1980 and 1992

| Variable   | Obs | Mean     | Std. Err. | Std. Dev. | [95% Conf. Interval] |
|------------|-----|----------|-----------|-----------|----------------------|
| X<sub>1</sub> | 32  | 3543.197 | 457.7385  | 2589.36   | 2609.633 - 4476.761 |
| X<sub>2</sub> | 32  | 5961.138 | 562.7336  | 3183.302  | 4813.435 - 7108.84  |
| Diff(X<sub>1</sub>-X<sub>2</sub>) | 32  | -2417.941| 332.4756  | 1880.766  | -3096.029 - 1739.852|

(X<sub>1</sub> is the area of soil erosion in 1992, X<sub>2</sub> is the area of soil erosion in 1980.)

The results show that after the property right reform and the first stage of soil and water conservation project in Xingguo County, the effect of soil erosion control in Xingguo County is obvious (the significance level <0.0001).

4. Conclusion

Through the reform of property rights, the construction of soil and water conservation projects and the development of soil and water conservation industry, Xingguo County has achieved remarkable results in soil and water conservation. Xingguo County has achieved poverty alleviation while improving the environment. In 2018, the per capita disposable income of rural residents in the county was 10712 yuan, 25 times higher than that in 1986, and the per capita disposable income of urban residents was 28172 yuan, 11 times higher than that in 1986. It proves that the environment itself means the economy.

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