Using Intelligent Remote Sensing Interpretation to Monitor Soil Erosion in Guiyang China

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Abstract: Monitoring soil erosion in large region is not only difficult but also important. We used Intelligent Remote Sensing Interpretation to monitor the soil erosion in Guiyang, China, where the area is 2,400 km^2 and the geographical environment is complex. The study includes (1) making up the knowledge database of soil erosion; (2) digitizing the influent factors of soil erosion; (3) interpreting the message of soil erosion; (4) interpreting the message of soil erosion deteriorated; (5) evaluating the hazard of soil erosion. In the study, it was obtained that the situation of soil erosion and soil erosion deteriorated in study area in 1994 and 1998; the functionary degree of influent factors of soil erosion was analyzed; on the basis of analyzing the message of soil erosion deteriorated, we evaluated the hazard of soil erosion which is important for water and soil conservation in study area. All of these results express that Intelligent Remote Sensing Interpretation is effectual tool to monitor the soil erosion in the large region.
Keywords: soil erosion, remote sensing, expert system, monitor, Guiyang

Soil erosion, which directly effects on the development of human society, is the one of important problems human being faces, so nations in the world pay attention to the soil erosion conservation. Many new methods and techniques of monitoring the soil erosion are widely applied to research on the surveying the soil erosion in deferent scale. Nowadays, it is a light way of monitoring the soil erosion that a series of soil erosion models were combined with Geography Information System(GIS) and Remote Sensing(RS). In our study, intelligent RS interpretation applied the experts knowledge to monitor soil erosion in large region. The results expresses that this method is scientific and effectual.

1 Study area

Guiyang in Guizhou Province, China (106°27'E—107°03'E, 26°11'N—26°55'N) was selected as the study area. The distance from east to west is 56km and from south to north is 79km, and the area, which occupies 1.4 percent of Guizhou Province, is 2,406 km^2. The average altitude is 1,218 meter and the altitude of most of the study area is between 1,000 meter and 1,400 meter. The area of mountain region in the study area is 922 km^2; the middle mountain(365 km^2) where the altitude is higher than 1,400 meter and the height is between 300 and 500 meter occupies 39.6 percent of the area of mountain, and low mountain(557 km^2) where the altitude is lower than 1,400 meter and height is 200 meter—300 meter occupies 60.4 percent of the area of mountain. The precipitation in the study area is much. The average precipitation per year is 1,196.9 mm; but it is storm in May and June, sunshine in July and August, rain from September to November, and rainless in winter. So there are frequently dry and flood in the study area.

2   The procedure of method

Intelligent RS interpretation inspires the soil erosion experts to study the image of Remote Sensing and records experts' knowledge deriving from image of Remote Sensing, and then creates knowledge database and automatically interpreting the message of soil erosion. The flow chart of creating knowledge database is showed in Figure 1. Creating knowledge can be divided into two parts. One is the interaction between man and computer, the purpose of which is to inspire the experts to analyze influent factors of soil erosion; another, which is computer study, records the knowledge of the expert of soil erosion, optimizes them and put them into knowledge database. The regional knowledge database of soil erosion, in final, is made up.

The technological flow chart of intelligent RS interpretation is showed in Figure 2. After knowledge database made up, the data of influent factors of soil erosion from RS or field information is got as pixel unit; on support of the knowledge database, the rule reasoning model is used to interpret the message of soil erosion. While some knowledge is not found in the knowledge database, the new knowledge is supplied through the procedure of creating knowledge database. When the regional knowledge database becomes perfect, the message of soil erosion in the all area can be interpreted.
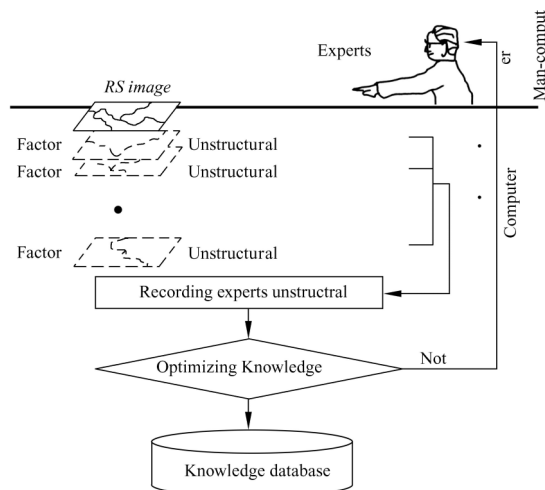

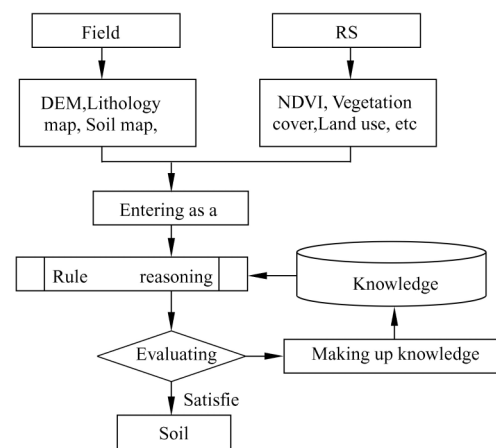**Fig. 1**   Geographical knowledge database   **Fig. 2**   Automatic obtaining soil erosion message

3   Materials

3.1   Obtaining unchanged data

(1) Lithology: The lithology map in Guiyang(1:100000) was digitized into digital vector map using Arc/info, then it was converted into raster data after cleared.

(2) DEM: The relief map in Guiyang(1:100000) was digitized into digital vector map whose contour distance was 20 meter, then it was converted into raster data after cleared and interpolated.

(3) Soil: The soil map in Guiyang(1:100000) was digitized into digital vector map, then it was converted into raster data after cleared.

3.2   Obtaining changed data

(1) Land cover: After doing atmospheric correction to TM data in 1994 and 1998, the regions of interest were selected according to surveying on the field. In order to ensure it was precise to compare between data in 1994 and 1998, the regions of interest in the same location were used to classify the data in 1994 and 1998 with supervised classification. In final, the land cover maps in 1994 and 1998 were obtained after doing post classification.

(2) Vegetation cover: After doing atmospheric correction to TM data in 1994 and 1998, NDVI(Normalized Difference Vegetation Index) was calculated. The same regions of different vegetation cover were selected to calculate the statistic of NDVI in 1994 and 1998, and then NDVI were done density slice according to Mean and Stdev of each vegetation cover class. In final, the vegetation cover maps in 1994 and 1998 were obtained.

4   Result and analysis

4.1   Result

All of digital data were put into the module of intelligent RS interpretation, and the knowledge database of soil erosion in Guiyang was used to interpret the message of soil erosion in 1994 and 1998. Then the soil erosion maps of the study area in 1994 and 1998 were developed (showed in Figure 3).
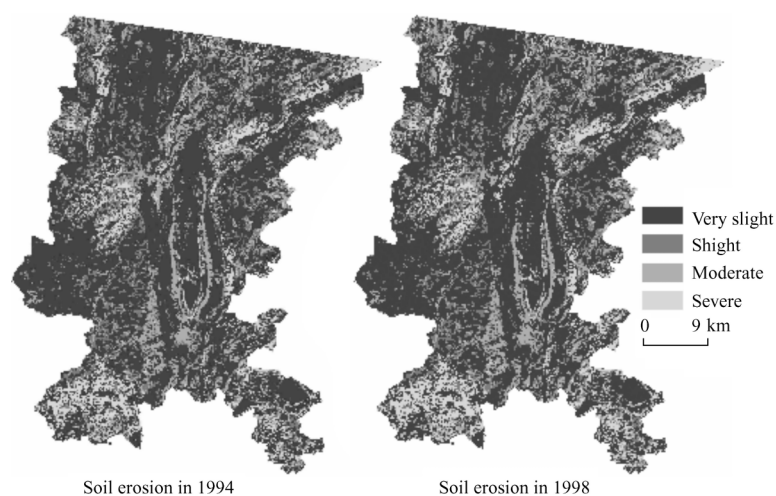

Soil erosion in 1994   Soil erosion in 1998

Fig. 3   The soil erosion maps of the study area in 1994 and 1995

4.2   Analysis

Not only does monitoring the soil erosion in 1994 and 1998 present the information of soil erosion in two years, but also we can obtain the message of soil erosion deteriorated and evaluate the soil erosion hazard while we analyze the change of soil erosion during four years from 1994 to 1998.

4.3   Obtaining the message of soil erosion deteriorated

The region of soil erosion deteriorated is the place where the grade of soil erosion is worse than before. The formula of obtaining the message of soil erosion deteriorated is as fellow:

$$P = SE\,98 - SE\,94 \qquad (\text{where } P > 0)$$

where P is the message of soil erosion deteriorated, $SE\,98$ and $SE\,94$ are respectively matrix of soil erosion data in 1998 and 1994. The statistic of the message of soil erosion deteriorated (showed in Figure 4) was calculated in according to the class of land cover in 1998, the class of lithology, the grade of gradient, the class of soil, the grade of vegetation cover degree in 1998 and the grade of altitude. It is known from the results as fellow.

4.4   Evaluating the hazard of soil erosion

According to the percentage of the area of soil erosion deteriorated occupying in each class or grade, the hazardous degree of soil erosion is determined for each class or grade. The greater is the percentage of

the area of soil erosion deteriorated occupying in each class or grade, the higher is the hazardous grade of soil erosion (showed in Table 1).
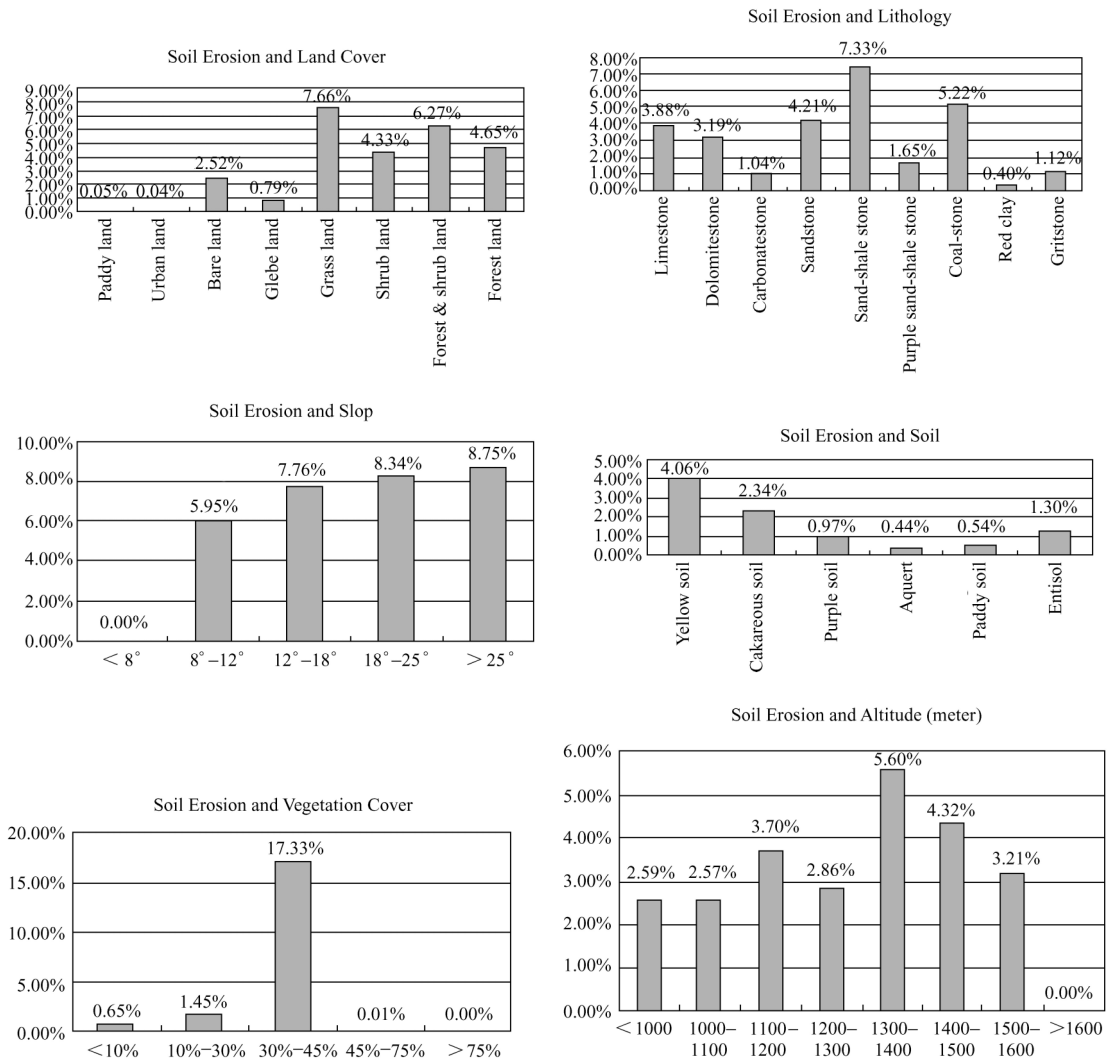
Soil Erosion and Land Cover

Paddy land 0.05%, Urban land 0.04%, Bare land 2.52%, Glebe land 0.79%, Grass land 7.66%, Shrub land 4.33%, Forest & shrub land 6.27%, Forest land 4.65%

Soil Erosion and Lithology

Limestone 3.88%, Dolomitestone 3.19%, Carbonatestone 1.04%, Sandstone 4.21%, Sand-shale stone 7.33%, Purple sand-shale stone 1.65%, Coal-stone 5.22%, Red clay 0.40%, Gritstone 1.12%

Soil Erosion and Slop

< 8° 0.00%, 8°−12° 5.95%, 12°−18° 7.76%, 18°−25° 8.34%, > 25° 8.75%

Soil Erosion and Soil

Yellow soil 4.06%, Cakareous soil 2.34%, Purple soil 0.97%, Aquert 0.44%, Paddy soil 0.54%, Entisol 1.30%

Soil Erosion and Vegetation Cover

<10% 0.65%, 10%−30% 1.45%, 30%−45% 17.33%, 45%−75% 0.01%, >75% 0.00%

Soil Erosion and Altitude (meter)

<1000 2.59%, 1000−1100 2.57%, 1100−1200 3.70%, 1200−1300 2.86%, 1300−1400 5.60%, 1400−1500 4.32%, 1500−1600 3.21%, >1600 0.00%

Fig.4　The statistic of relationship of the deteriorated soil erosion and the influent factors

Table 1　The table of the hazardous grade of soil erosion

hazardous grade	1	2	3	4	5	6	7	8	9
Land cover	Grass	Forest &Shrub	Forest	Shrub	Bare	Glebe	Paddy	Urban	
Lithology	Sand-Shale Stone	Coal-Stone	SandStone	Limestone	Dolomitestone	Purple Sand-Shale Stone	Gritstone	Carbonatestone	Red Clay
Slop(degree)	<8	8—12	12—18	18—25	>25				
Soil	Aquert	Paddy Soil	Entisol	Purple Soil	Cakareous Soil	Yellow Soil			
Vegetation Cover(%)	>75	45—75	<10	10—30	30—45				
Altitude(meter)	>1,600	1,000—1,100	<1,000	1,200—1,300	15,00—1,600	1,100—1,200	1,400—1,500	1,300—1,400	

The model of evaluating the hazard of soil erosion is:

$$SEV = \sum_{i}^{n} \frac{R}{M_i} \times SED_i$$

where *SEV* is the value of hazardous degree of soil erosion. *SED* is the index of hazardous degree of soil erosion in each class or grade. *n* is the total number of classes or grades. *i* is the index of class or grade. M_i is the maximum index of No.i class or grade. *R* is the maximum index of the class or the grade which has the least number of the hazardous degree.

The *SEV* was calculated using the model and it was divided into five grades with the same gap. Then the map of evaluating hazard of soil erosion in Guiyang was developed(showed in Figure 5).
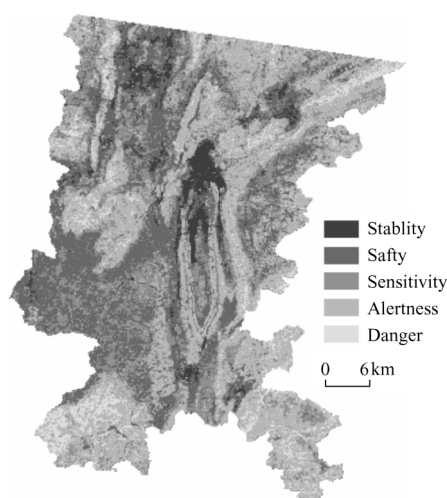

Fig. 5   The map of evaluating soil erosion hazard in the study area

5   Conclusion

Monitoring soil erosion plays a role part in the soil and water conservation. Intelligent RS interpretation is an effectual tool to monitor soil erosion. It can survey soil erosion simply, quickly, scientifically and reliably. After monitoring the soil erosion in Guiyang, not only does the result prove this method to be effectual, but also it shows the situation of soil erosion change in Guiyang from 1994 to 1998. The soil erosion in Guiyang became bad step by step with economic improved. During the period from 1994 to 1998, the area of soil erosion increased 1.46% and every grade of soil erosion was deteriorated. The area of slight increased 0.64%; the area of the moderate increased 0.24%; the area of the severe increased 0.56%. After analyzing the message of soil erosion deteriorated, it is concluded that unreasonably developing is still the main factor aggravating soil erosion. There are a series of measurements in the urban land, industry land and agriculture land where there are more human being activities, so the soil erosion is controlled effectually. There is better vegetation cover in the place where there is few human being activities, so the soil erosion is protected. So soil erosion is severe in the place between these two kind lands, in which, especially, sand-shale stone, thick yellow soil and steep gradient aggravate the soil erosion in Guiyang. Evaluating the hazard of soil erosion based on the message of soil erosion deteriorated in Guiyang synthesizes the function of factors above, so it presents the degree of the hazard of the soil erosion in the study area. Spatially analyzing the hazard of the soil erosion shows that there is 33.3 percent of area of the study area where the soil erosion easily happen, therefore, more attention must be paid to these regions.

References

Bu Zhahong, Sun Jinzhuang, etc. 1997. A study on quantitative remote sensing method of soil erosion and its application. ACTA Pedologica Sinica. **34**(3):235-245.

Chen Yibing, K.O. Trouwborst. 1997. Study of Applying ANSWERS and the Geographical Information System ARC/INFO in Soil Erosion Modelling. Journal of Soil Erosion and Water Conservation. **3**(2):1-13.

Jurgens, C.,M.Fander.1993. Soil erosion assessment by means of landsat TM and ancillary digital data in relation to water quality. Soil Technol. 6:215-223

Li Rui, Yang Qinke, etc. 1998, Application of Spatial Information Technology in Soil and Water Conservation of China. Bulletin of Soil and Water Conservation. **18**(5):1-5.

Savibi, M., R., D. C. Flanagan, etc, 1995, Application of WEPP and GIS-Grass to a small watershed in Indinana, J. Soil Water Conserv. 50:323-328

Tim, U.S. and R. Jolly. 1994. Evaluating agricultural nonpoint source pollution using integrated geographic information systems and hydrology/water quality models, J. Environ. Qual. 23:25-35

Wang Mintang. 1990. Applying USLE in the research on soil erosion using remote sensing in Loess Plateau. The proceeding of research on Loess Plateau using remote sensing. Peking University Press.

You Songcai, Li Wenqing. 1999. Estimation of soil erosion supported by GIS—A case study in Guanji Township, Taihe, Jiangxi. **14**(1):62-67

Yu Fang, Gan Dayong, Zhu Qijiang. 1990. The research on the GIS of small watershed in Loess Plateau. The proceeding of research on Loess Plateau using remote sensing. Peking University Press.

Zhang Zengxiang, Zhao Xiaoli, etc. 1998. Numerical Analysis of soil erosion in Mountain Area Using Remote Sensing and GIS. Transactions of the Chinese Society of Agricultural Engineering. **3**(3):14-18

Zhao Xiaoli, Zhang Zengxiang, etc. 1999. Dynamic Monitoring of Soil Erosion Based on RS and GIS in Central Tibet. Journal of Soil erosion and Water Conservation. **5**(2):44-50.

Zhu Qijiang, Gan Dayong, Yu Fang. 1990. The model of soil erosion entropy and realization using SEIS. The proceeding of research on Loess Plateau using remote sensing. Peking University Press.