THE APPLICATION OF SPATIAL ANALYSIS IN REGIONAL SOIL AND WATER CONSERVATION AND DISASTER PREVENTION AND CONDUCTION

Ming YU [a,b,] *, Guo-rui ZHU[a] , Hui-zhen LI[b] , Zhi-biao CHEN[b]

[a] School of Resources and Environment Science, Wuhan University, Wuhan, Hubei， 430072,PR China - yumingfz@vip.sina.com; zhugr123@sohu.com ;

[b] Department of Geography, Fujian Normal University, Fuzhou, Fujian, 350007,PR China-myu@fjnu.edu.cn

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ABSTRACT:

Taken 1:10000 Scale topographic map in the small watershed of Genxi River as an example, under the support of ARCVIEW and ARC/INFO software of GIS, through digitizing topographic map and other special maps to set up a spatial geodatabase. This paper forms a digital elevation model and has an analysis of slope and aspect, also discovered knowledge referenced for soil and water conservation. The results show that slopes of most of the soil and water losing region are between 15° to 25°, and 45° to 90° for the landslip region, the aspect of which is almost to the south or around the south. At last, the basic measures for fathering soil and water loss has been brought forward on the base of data mining and knowledge discovering.

1. INTRODUCTION

Slump gullies is the most serious type of soil erosion in granite region in south China, which is a special physiognomy erosion type formed by the integrated action of gravitation and waterpower to the rock and soil. Someone (Tang Ke-li, 2004) think that it's also the highly phase of the development of sloping field and gullies. Slump gullies distribute in Guangdong, Fujian, Jiangxi and Anhui provinces in China (Niu De-kui, etc. 2000). Some people (Yu Ming, 2002; De Kai-chang, 2001; Tang Guo-an, 2001) have discussed the concrete application of GIS and Data mining and knowledge discovery before. For the sake of providing references to the regional actuality of slump gullies, conservation of soil and water, prevention and conduction of the disaster, this paper takes the small watershed of Genxi River for example to link between data and the information kept in data, using spatial analysis and displaying data in many dimensions through information visualization flat roof.

2. EXPERIMENT METHODS

2.1 Computer System and Software

To build up a system basing on spatial data, this experiment requires two components mainly, the computer system and the GIS softwares.

2.2 Building DEM and Data Mining

There are so many methods to build a DEM Special interpolation measurement on the base of vector data, such as contour, terrain characteristic points etc, which is the one used in this experiment. First, a spatial geodatabase is to be set up by the GIS softwares. It consists of several atlases, of course including the topographic map with contour field. Secondly, TIN will be built on the topographic map, using the ARCTOOLBOX module. This TIN can be viewed in 3D SCENE and navigated in ARCSCENE. Also in ARCTOOLBOX, the TIN will be converted to a grid by sampling on the data, and then to a USGS DEM at last.

The ability of GIS to handle and process geographically referenced data establishes GIS as a technology, which is important to a wide variety of applications. The spatial analysis method is often used as a pretreatment and characteristic extracting technique, which can be combined with other data mining methods to discover knowledge from spatial database. Especially, the extraction of terrain characteristic includes the calculation of basic terrain genes (slope, aspect, terrain roughness, channel consistency) and the extraction of complex terrain characteristic.

3. DATA AND THEIR PROCESS

3.1 The General Situation of the Study Region

The small watershed of Genxi River, 25°37 N ~25°43′ N, 116°18′ E ~116°27′ E , locates in the western of Changting County, Fujian, which has an area of 2272.94 hm^2. Most of the physiognomy is low mountains and hills. There is profound red weathering crust that is developed by biotite with bulky minerals in wet and hot climate environment, generally it is 10~20m deep, and the deepest reaching 50~60m. The red weathering crust is intensively eroded directly under glide because of the destruction of vegetation. There are too many gullies on the ground, and the slope surface is intensively eroded, that leads to seriously filling up in the vale and river. It is middle subtropical monsoon climate here. According to the data from the county weather station (1961-2000a), the average temperature is 18.3℃, the highest temperature appears in month of July, which reaches 27.1℃ in average, and the lowest is in

* Corresponding author. Ming Yu , E-mail:yumingfz@vip.sina.com

January, which has an average temperature of 7.9 ℃. Historically, the highest temperature in this county is 39.4℃, and the lowest is -8.0℃. The average rainfall is 1730.4mm, which has two apexes in one year. Most of the rainfall is from March to April with a gross of 1318.3 mm; it accounts for about 76.18% of the total amount of the rainfall in the whole years. The intensity here is great, the direction of wind changes significantly, it prevails south wind in summer and northwest wind in winter. Before actualizing soil and water conservation, most of the region almost vegetated nothing except for a few 1m high pines massonianas. Only about 5-10% of the ground is covered with plants, but they grow very slowly. In the near future, although the vegetation here has changed appearances, the soil and water conservation is still shoulder heavy responsibilities.

3.2 Building up a Spatial Geodatabase

According to the method mentioned above in 2.2, a spatial geodatabase is to be set up firstly. This geodatabase consists of vector data, including map covers: contour.shp (Figure 1), liushi.shp, land-slip.shp, cuoshi.shp; the TIN (Figure 2) ,also the grid and the USGS DEM (Figure 3) basing on it. These mps will be the basic maps for spatial analysis and data collecting below.

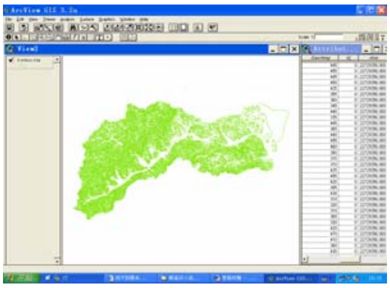

Figure 1 Topologied contour.shp with attribute

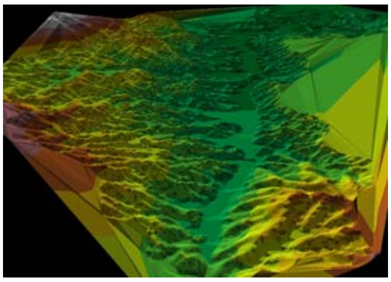

Figure 2 3D view of TIN in 3D SCENE

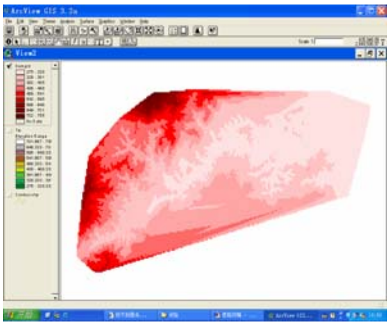

Figure 3 The grid view of DEM in ARCVIEW

Figure 2 and Figure 3 can simulate the geographic sight of the whole watershed straightly. The altitude in this region is 270.0~690.2 m and there're vales and basins near Tingjiang River and its anabranches. The area of slump gullies is large and most of them locate

on the slope surfaces of low and fleet hills in the middle and backward of the river. This complexion corresponds with the review on the spot, so that the error of describing DEM terrain can be ignored. Figure 4 is the 2D view of terrain .The distributing actuality of slump gullies can be viewed on Figure 5, and the statistical characteristics of them are showed in Table 6.

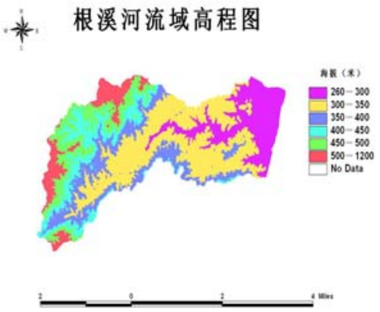

Figure 4 2D view of terrain

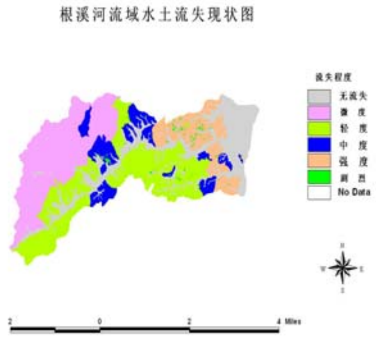

Figure 5 The distributing actuality of slump gullies

Items	Total area of Land （hm^2）	Total area of slump gully （hm^2）	Numbers of slump gully	Densities of slump gully
Total	2272.94	24.51	131	1.08

Table 6 Characteristics of slump gullies in small watershed of Genxi River

CF	Scoop	Strip	Arc	Claw	Dustpan	Mix	Total
Area （hm^2）	5.183	4.386	1.053	10.587	1.523	1.780	24.512
Rate （%）	21.14	17.89	4.30	43.19	6.21	7.26	100
Numeral	30	48	10	27	12	4	131
Rate （%）	22.90	36.64	7.63	20.61	9.16	3.05	100

CF Stand for Classification

Table 7 The area and ratios of each type of slump gullies in small watershed of Genxi River

The configuration of slump gullies is complex, which correlates with the part of terrain it locates, the area of catchments, the thickness of the weathering crust and the cranny characteristics and so on. According to the appearance of the slope surface, the slump gullies can be divided into six types (Ding Guang-min, 2001; Xu Peng, Lin Wei-lie, 1991): scoop shape, strip shape,, arc shape, claw shape, dustpan shape, mix shape .The configuration characteristics of the slump gullies of the whole watershed are showed in Table 7. As we seen from the table, the area of the claw shape ones and the amount of the bar shape ones is the largest.

3.3 Extracting Slope and Aspect Information and Spatial Analysis

3.3.1 Building Slope Information Model (Basing on TIN and DEM)

On one hand, because TIN itself has the slope attribute, so the slope classification of the watershed can be showed in solid view by changing the legend to “SLOPE” (Figure 8). On the other hand, the slope attribute can be derived from the DEM using “SURFACE>DERIVE SLOPE” in ARCVIEW. And the slope classification thematic map that is suitable for soil and water conservation can be drawn.(Figure 9).Both of the nine classes in Figure 8 and Figure9 are divided according to the critical slope classification standard, which is adopted at large in soil and water conservation. (0º-3º`，3º-5º，5º-8º，8º-15º，15º-25º，25º-35º，35º-45º，45º-60º，60º-90º)

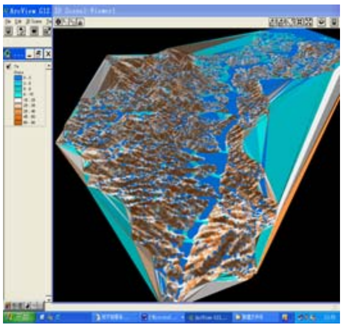

Figure 8 The TIN model showed in slope

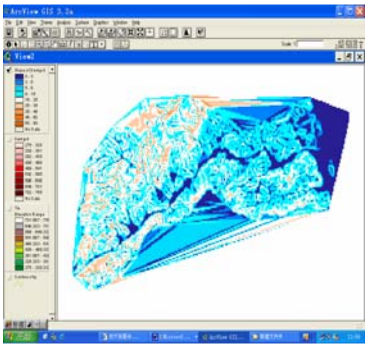

Figure 9 The slope model derived from DEM

3.3.2 The Relation between the Slump Gullies and Slope

The movement of the slump gullies relates to the slope. Some people (Ding Guang-min, 2001) differentiate it into two types: activity and stabilization type. But we often catch sight of another type that interposes between the two types in actual survey. So in this paper the slump gullies are differentiated into three types. (1) Activity (A): These slump gullies are still dilapidation, there are few plants covered on the wall of gullies and accumulation of slump, the heads of gullies dilapidation flourishingly when it meets rainstorm. That leads to the fresh earth of the precipitous walls there coming out. This is the activated phase of the slump gullies; every year there’re fresh earth comes out on the walls of the slump gullies; (2) Stabilization (S): There’re some plants covered on the walls of gullies and accumulation of slump. When it meets rainstorm, the heads of gullies does not dilapidation, nor comes out the fresh earth of the precipitous walls of the heads of gullies. They keep the steady states; (3) Half—Stabilization (Half-S) : It’s a type between activity and stabilization. Among the slump gullies in this experiment, 50% of them are half—stabilization type. Table 10 reveals the statistics.

Situation	A	S	Half -S	Total
Area（hm^2）	10.273	2.501	11.739	24.513
Rate（%）	41.91	10.20	47.89	100
Numeral	25	36	70	131
Rate（%）	19.08	27.48	53.44	100

Table 10 Analysis of active situation of slump gullies

3.3.3 The Relation between the Soil and Water Loss Region and Slope

In this section, the distributing actuality of slump gullies in soil and water loss region thematic map (Figure5) and the slope classification thematic map (Figure8) are carried through map overlaying. The new map is still use “SLOPE” as the classification field, from which new knowledge can be discovered (Figure 11). Figure11 is not only good at displaying; it can also realize the directly mutual query and extraction from attribute information on the map, through using “MAP QUERY” in ARCVIEW. On the base of that the statistics of the slope proportion of the soil and water region is shown in Table 12. It indicates that in the soil and water loss region, the area with 8º-60º slope accounts for 61% in this region, among them the area with 15º-25º slope accounts for 23.09%, whose proportion is the largest. Figure 5 and Figure8 indicate that most of the seriously eroded types of soil and water loss and slump gullies locate in the middle

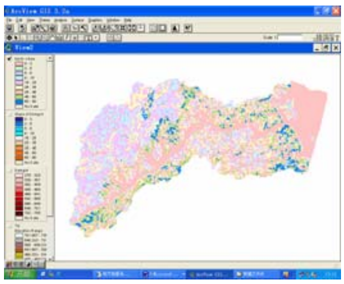

Figure 11The classification map of slope in the disaster region

Slope	0º-3º	3º-5º	5º-8º	8º-15º	15º-25º
Proportion（%）	0.73	0.87	2.52	10.38	23.09
Slope	25º-35º	35º-45º	45º-60º	60º-90º	
Proportion（%）	17.45	10.06	8.92	3.74	

Table 12 the statistics of slope in the soil and water loss region (area proportion %)

3.3.4 Extracting Aspect Information

In ARCVIEW, choosing SURFACE> DERIVE ASPECT and backward position of the watershed can draw the aspect thematic map (Figure13). From Figure 13, we can see that the aspect of the disaster region is mostly to the south or close to the south, which conforms to the wind direction in July with plenty precipitation. One of the main reason is that, the frequency of south wind is high in monsoon, so the windward. South slope is prone to be intruded by rainwater and rainfall kinetic energy. The other reason is of the incidence obliquity of the sun radiation, the sun radiation accepted by the south slope is evidently more than the north one in a year and it leads to the greater degree of air slaking on granite on the south slopes than the north ones. So the former is more prone to form sump gullies than the latter one.

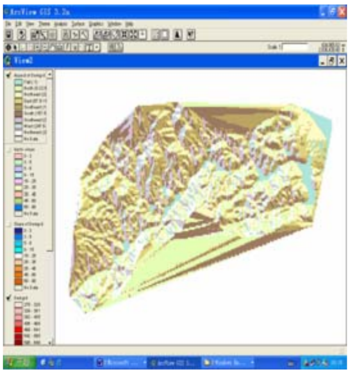

Figure 13 The display of aspect model

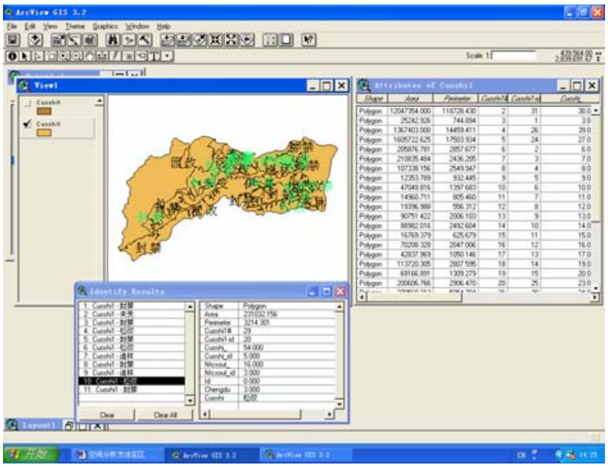

Figure 14 The mutual querying layout between figure and attribute data of measurement of soil and water conservation

3.3.5 The Measures of Soil and Water Conservation

From the system we can obtain information for the mutual querying between spatial data and attribute data (Figure14). Basing on this system data and the knowledge discovered above, that's the different measures (close, garden changing, afforestation and fruit planting) should be taken in different soil and water conservation regions, the layout of the measures on soil and water conservation can be built. And then we can overlay Figure 5 and Figure 11 on the layout and analyze it, which can make the measures more pertinent. The integrate fathering of sump gullies should be from up to down, from slope to channel, from head to bottom of sump gullies from accumulation of slump to alluvium, disposing overall and setting up successive lines of defence.

Firstly, fathering the catchments slope: reducing the surface slope on the sloping field and abstaining the falling water from the head of sump gullies is the core ink of fathering the sump gullies. The catchments slope upon the head of sump gullies, it should be fathered by biology measurement and engineering renovate, mostly by digging well and filling channels. We should do our best not to let the water flowing out from the slope radically controlling the driving condition of the development of sump gullies.

Secondly, fathering the accumulation of slump: The mud falling from the head of gully and the wall of gully (accumulation of slump) accumulates at the foot of cliff, that would decrease the height of the empty surface before and it's propitious to the stabilization of the head of gully and the wall of gully. But the earth of the accumulation of slump is loosened and is easier to be eroded. While the accumulation of slump is eroded, the height of the empty surface would increase again. So controlling the anew erosion of the accumulation of slump is the important component of preventing the tracing to source erosion of the wall of gully.

Thirdly, fathering the bottom channel of sump gullies: The channels of sump gullies locate between the accumulation of slump and the alluvium, it's the access of the erosion of sump gullies, the mainly function of which is to transfer water and mud in the catchments. Accumulation and declination appear here, and its moisture condition is good. Most of the declinations of the bottom of gullies tend to markdown in this part and it should be fathered by biology measurement.

4 CONCLUSION

Spatial analysis is often used in data mining and knowledge discovering from spatial database. But data mining is not equal to knowledge discovering. The new thematic maps mentioned in the experiment reflect a kind of knowledge discovering. Because sump gullies distribute largely in the small watershed of Genxi River and water and soil there is seriously losing, this experiment, basing on DEM and spatial analysis of slope and aspect, has great meaning for improving the environment in the disaster region. At the same time it can be a reference for the decision-making department to put the father measures in practice（seeing about figures and tables in this article）.

The sump gullies is a complicated system that consists of a few subsystems: catchments slope, wall of gully, accumulation of slump, gully bottom of sump gullies (including channels), and alluvium. Among the subsystems there're complicated import and output substance process. The mud from the catchments slope influxes into the sump gullies channels, bringing into falling water. This accelerates the erosion on the bottom of gully and the unstabilization of side slope. The mud falling from the head of gully and the wall of gully (accumulation of slump) accumulates at the foot of cliff, which can strengthen the stabilization of the wall of gully. Because of the erosion by the water, most of the loose substance from landslip can be quickly brought to the jaw and then they accumulate into alluvium, some are brought to the lower reaches of the river. The particularity of slope and aspect in the watershed of Genxi River can leads to the formation of sump gullies, while the man-made factor should not be ignored. Basing on the analysis of the sump gullies system, the sump gullies of Genxi River can be fathered in the following ways: (1) controlling the driving condition of falling water from catchments slope; (2) reducing the erosion of the accumulation of slump; (3) combining the fathering measurement of sump gullies with the economy.

With the technique of data mining and knowledge discovering, the degree of automation and intelligence has been improved when we apply spatial analysis in solving actual problems. This can help us observe and understand the geographic states and its intension in a region fleetly from various angles. Moreover, we can make the best of the characteristics of terrain and constitute corresponding plan to adapt to the modern times development.

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