

# Prediction of Area Vulnerable to Gullying based on Geomorphic Threshold Theory

W J Wang<sup>1</sup> and R X Deng<sup>2,\*</sup>

<sup>1</sup>College of Resources and Environment, Henan University of Economics and Law 450002, Zhengzhou, China

<sup>2</sup>School of Resources and Environment, North China Institute of Water Resources and Electric Power, 450011, Zhengzhou, China

Corresponding author and e-mail: R X Deng, rongxin-001@163.com

**Abstract.** Chosen type Black Soil Area of Northeast China which locates in the Wuyuer river and Nemoer river basin as study area, taken SPOT5 imagery as data source, gully distribution data in 2005 was get. At the same time, taken 1:50000 relief maps as data source, DEM was obtained and then it extracted the slope and accumulation area of headcut. Based on the geomorphic threshold theory  $S=aA^{-b}$ , it acquire the geomorphic threshold model of study area  $S=1.2482A^{-0.0936}$ . By the model, the area vulnerable to gullying was predicted. It showed that the percent of correct prediction gully pixels is 79.43%, and the percent of area vulnerable to gullying is 51.79%. The prediction accuracy is 0.723%. The prediction of area vulnerable to gullying has a acceptable accuracy. The model can discern the area vulnerable to gullying and it can provide scientific suggestion for the erosion control.

## 1. Introduction

Gully erosion is the main research content in the soil erosion, and now geomorphic threshold theory has much more application in the gully erosion research. Based on this theory, gully occurrence can be predicted. Now there are many researches based on this theory in different countries and they get different gully occurrence geomorphic threshold [1-3]. Based on the geomorphic threshold, the areas vulnerable to gullying was predicted in their research area.

At present, for geomorphic threshold theory, the most research used the data slope(S) and accumulation area(A) from the fieldwork, and only a few used the data S and A extracted by DEM. Besides, these researches were often on the small scale to monitor 3 to 5, even decade gullies to obtain the gully parameters using GPS in 3 to 5 years [4-6]. There are little researches on large scale. In this paper, using SPOT5 image as basic data source, gully were obtained and the data S and A extracted by DEM, then the geomorphic threshold model at the 10 thousand km<sup>2</sup> were obtained. Based on the model, the accuracy of model was evaluated and the area vulnerable to gullying was predicted.

## 2. Study area and data source

### 2.1. Study area

Chosen type Black Soil Area of Northeast China which locates in the Wuyuer river and Nemoer river basin as study area, the study area is located in the middle of HeiLongJiang Province in China and its total area is about 23 thousands km<sup>2</sup> where the city of Wudalianchi in the north, and Mingshui county in the South, and the city of Beian in the East ,and Fuyu County in the West. In geomorphology, it is in the transition zone of lesser Hingan Mountains and Songnen plain and the geomorphology characteristic is Rolling Hilly. Slope is much more gentle, often lower 5°. The major agrotype is type black soil, besides meadow soil and bog soils are mainly in the low-lying wetland plain. Black soil has high organic matter, loose texture and big spacing and make it easy to accelerate erosion. The altitude is 150-600m and the altitude in the northeast is 200-500m where is highland, and corresponding, the southwest is rolling hilly plain. The study area falls into a temperate continental monsoon climate. Its mean annual temperature is 0.2 °C -1.5 °C. Its mean annual rainfall is 550mm-600mm and mean depth of runoff is about 75mm. Wuyuer river, Nemoer river, Shuangyang river, Laolai river and Runjin river are the main rivers in this region. The vegetation has the characteristic of interleaving of forest and meadow plain and it belongs the Mongolia vegetation zone.

### 2.2. Data source

Twelve scenes cloud-free 2.5m resolution simulation true color SPOT5 images were as data source. Then according to the image characteristic, such as tone and texture, with the help of expert knowledge and about 20 days field survey, the gully interpretation signs were build. Then, taken ArcView software as platform, combined with expert experience, reference to topographic maps and other related information, the gully distribution data in 2005 were acquired. Then validation work was undertaken from 12 November 2008 to 15 November 2008. At last, according validation results, the gully data were modified, and the final results were get. It suggests that the gully interpretation precision is greater than 95%.

For DEM data: First, contour and elevation spot were obtained by digiting the scale of 1:50 thousands topographic maps. Then with the digital contour and elevation spot, using TOPGRID arithmetic, it created the 5m resolution DEM. Then the S and A were extracted.

## 3. Method

### 3.1. Model conception

Geomorphic threshold model is as follows:

$$S = aA^b \quad (1)$$

Where S is slope of headcut; A is accumulation area; a,b are coefficient which are no units.

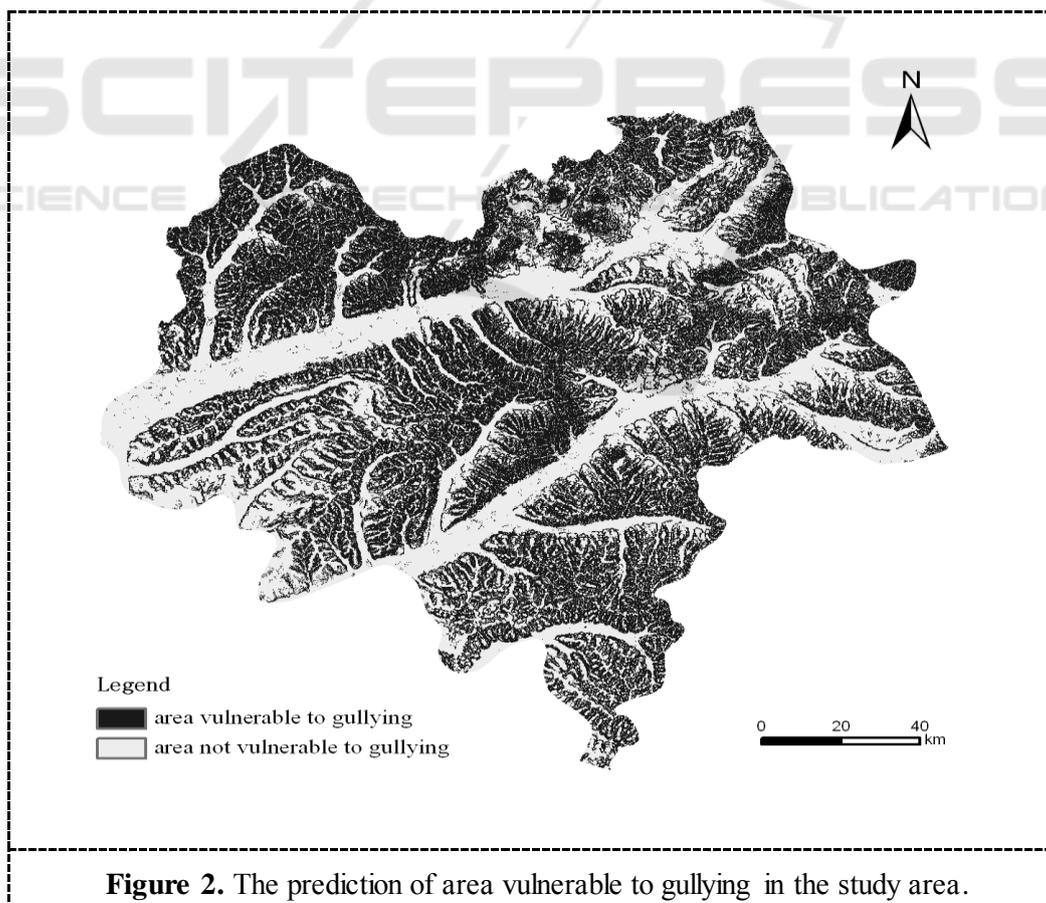
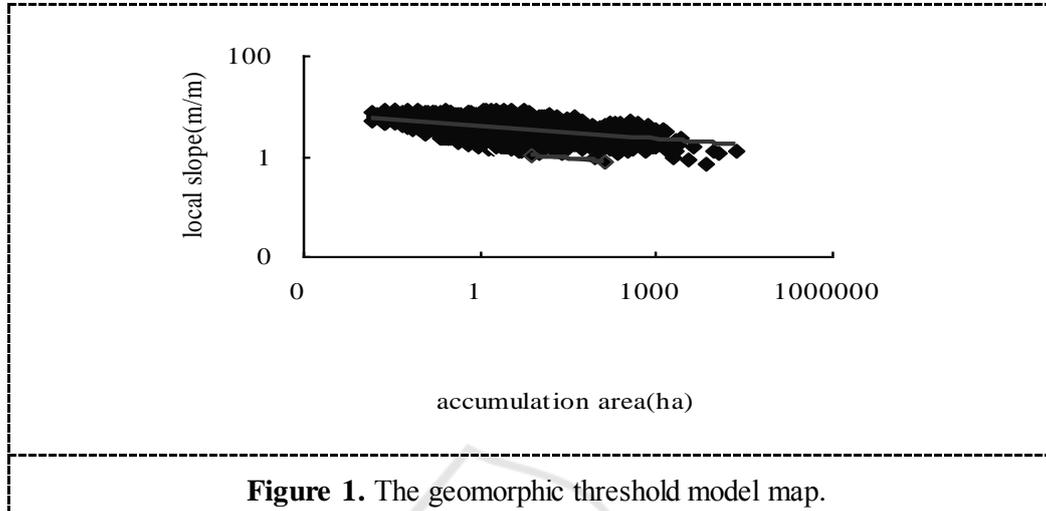
It can confirm the geomorphic threshold model by extracted the S and A .There are two important application. One is that a parallel line below the lower limit of the scatter of the data defines the limit below which valley floors are stable. Another is that the line of best fit through the data represents the mean topographic threshold conditions for gullying. The first application is mainly used to gully prediction and the other is used to the analysis of dominant gully process.

### 3.2. Model application

By the gully data and DEM , it get the S and A of the headcut. Then, it used the parallel line below the lower limit of the scatter of the data to get the geomorphic threshold model (Figure 1). The model was as follows:

$$S = 1.2482A^{0.0936} \quad (2)$$

By the above model, it counted the critical slope ( $S_a$ ), then let critical slope ( $S_a$ ) compare with the slope ( $S$ ) of study area. If  $S - S_a \geq 0$ , it shows the possibility of gully occurrence and the area vulnerable to gully. Vice versa, the result is opposite. Then it used the model and the geomorphic map, it get the prediction map of area vulnerable to gully in the study area (Figure 2).



## 4. Results and analysis

### 4.1. Spatial distribution of area vulnerable to gullying

According to the figure 2, the area not vulnerable to gullying was mainly in the water, alluvial flat and ridge, but the area vulnerable to gullying was located in all the part of the study area. In a word, the prediction is much more better. Most of gully formed in the area vulnerable to gullying, but there were little region not correct. The main reason was that the seasonal river was mistook by gully, so it brought the mistake. Otherwise, for some gully, it existed in the area not vulnerable to gullying, and it maybe cause by the headward erosion and gullywall extension.

### 4.2. Accuracy analysis

From the table1, the percent of correct prediction gully pixels is 79.43%, and the percent of area vulnerable to gullying is 51.79%. The prediction accuracy is 0.723%. It can conclude that the percent of correct prediction gully pixels is very high, but the prediction accuracy is low. However the low prediction accuracy caused not by the model, and the main reason is that most of the region is no gully at present. For the geomorphic threshold model, it predicts all the area vulnerable to gullying, so it is only a conservative evaluation and its prediction is maximum. Otherwise, the mode of land use and the environment condition do not reach the threshold value. As a whole, with the geomorphic threshold model, the prediction of area vulnerable to gullying has a acceptable accuracy. By the conservative evaluation, it can help the land managers to better understand the area vulnerable to gullying and make the appropriate soil protect strategy.

**Table 1.** Gully prediction accuracy.

total pixels in study area	186346602	pixels of gully in study area	879035
<b>prediction equation</b>	total prediction gully pixels	correct prediction gully pixels	percent of prediction pixels in the study area (%)
<b>S=1.2482A<sup>-0.0936</sup></b>	96507467	698183	51.79
			79.43
			0.723

Remark: prediction accuracy = correct prediction gully pixels/ pixels of gully in study area

## 5. Conclusions

Based on the geomorphic threshold theory, with the gully data, it build the geomorphic threshold model fit for the study area and by this model the area vulnerable to gullying was predicted. In a word, the prediction of area vulnerable to gullying has a acceptable accuracy. The model can discern the area vulnerable to gullying and it can provide scientific suggestion for the erosion control. Besides, this is only a conservative evaluation, the area vulnerable to gullying is not the region which must form gully. Because vegetation, landuse and other natural and human factors all affect the gully form beside of the terrain. So how to combine with above factors, then further analyze the area vulnerable to gullying, such high danger region, much high region is very critical.

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