Assessment of wind erosion hazard using the RBFN model and GIS technique—A case study of Inner Mongolia, China

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ABSTRACT

Soil wind erosion is the primary process and the main driving force for land desertification and sand-dust storms in arid and semi-arid areas of Northern China. Many researchers have paid more attention to this issue. This paper select Inner Mongolia autonomous region as the research area, quantify the various indicators affecting the soil wind erosion, using the GIS technology to extract the spatial data, and construct the RBFN (Radial Basis Function Network) model for assessment of wind erosion hazard. After training the sample data of the different levels of wind erosion hazard, we get the parameters of the model, and then assess the wind erosion hazard. The result shows that in the Southern parts of Inner Mongolia wind erosion hazard are very severe, counties in the middle regions of Inner Mongolia vary from moderate to severe, and in eastern are slight. The comparison of the result with other researches shows that the result is in conformity with actual conditions, proving the reasonability and applicability of the RBFN model.

Key Words: wind erosion hazard, Radial Basis Function Network (RBFN), assessment, Inner Mongolia, China

1. INTRODUCTION

Wind erosion is one of the most principal processes and mechanisms of land degradation and dust storm in arid and semiarid regions, also including partial sub-humid regions. Over the last 50 years in China, about 9.1×107 ha of farmland have been damaged by wind erosion each year, and 6.7×106 ha of farmland have been buried by mobile dunes, mostly in the sandy rain-fed agricultural regions of Inner Mongolia, northern China. Many researches have been done on the wind erosion in northern China, Yet how to assess wind erosion risk is still difficult, particularly at regional scales. Wind erosion hazard in this research is the susceptibility of a landscape to wind erosion which depends on atmospheric conditions, and the factors of land surface characteristics such as vegetation, soil moisture, pedology and land use.

2. STUDY AREA

The study area, Inner Mongolia Autonomous Region, is located in the southeast part of Mongolia Plateau with approximately 36º-54ºN and 97º-126ºE. Besides hills, plains, deserts, rivers and lakes, Inner Mongolia has plateau landforms, mostly over 1,000 meters above sea level. It has a complex and diverse climate with temperate continental and seasonal climates as the main features. The total annual precipitation is between 100 mm to 500 mm, and the region is frost-free for between 80 to 150 days. This area was selected for study because it is the province that the most serious land desertification and dust storm token place and it has become a serious concern here. Assessment of wind erosion hazard may help the local government to make relevant regional development policies..

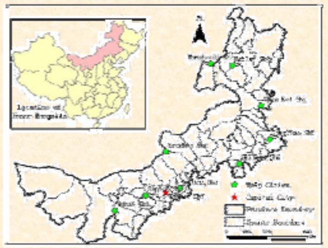


Fig. 1. Location map of study area .

3. METHODOLOGY

3.1 Structure of radial basis function network

The RBFN, which is multi-layer and feed-forward, is often used for classification. The basic architecture of a three-layered neural network is shown in Figure 2. An RBFN has three layers including input layer, hidden layer and output layer. The input layer is composed of input data. The hidden layer transforms the data from the input space to the hidden space using a non-linear function. The output layer, which is linear, yields the response of the network. The argument of the activation function of each hidden unit in an RBFN computes the Euclidean distance between the input vector and the center of that unit. The network has a better accuracy only when the early stop technique is appropriately used.

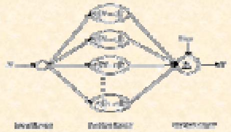


Fig.2. The structure of RBFN

3.2 Main factors forming wind erosion hazard

Vegetation cover: using MODIS NDVI to represent the percentage of vegetation cover.

Soil types: taking the contents of fine sand as index to study the soil erodibility.

Percentage of sandy land area: Usually the bigger the area of sandy land area in a region, the more erosive the soil is.

Average relief degree of land surface: the Relief Degree of Land Surface is extracted from national 1:50000 DEM by using the GRID module of ARCGIS.

The degree of soil dryness: The dryness index is usually computed by the ratio of regional rainfall and heat, the formula for the degree of soil dryness of land surface is

$$D = 0.16 \cdot \sum T_{>10℃} / P$$

D is the degree of soil dryness, P is the annual precipitation, T>10℃ is the annually cumulated temperature which is higher than 10℃.

The intensity of wind energy: we adopt the wind energy equation of RWEQ created by USDA.

$$W = \frac{n}{500} \cdot \sum_{i=1}^{n} U \cdot (U - U_c)^2$$

W is the intensity of wind energy and the unit is m3/s3, U is the wind velocity 2m above the ground surface, Uc is the threshold wind velocity 2m above the ground surface and is always computed with 5m/s.).

3.3 Train sample data

some typical counties with different hazard of wind erosion were selected based on the former work and export knowledge. Furthermore four erodible landscape types were used, that is "slight wind erosion hazard county"(Ⅰ)、"moderate wind erosion hazard county"(Ⅱ)、"severe wind erosion hazard county"(Ⅲ)、"very severe wind erosion hazard county" (Ⅳ). 12 typical counties as train samples with different hazardous levels were selected to drive the RBFN model, they are Eerguna, Keerqinyouyiqian Banner,Yakeshi, Balin Right Banner, Dongwuzhumuqin Banner, Keerqinzuoyizhong Banner, Otog banner, Sonid right Banner, Wulatezhong Banner, Alxa Left Banner, Alxa Right Banner, Ejin Banner.

4.RESULTS

The GIS was used to extract the spatial data from the basic data. Figure 3 shows maps of the standard value of the relevant factors. Different gray degree means the different scores of standard value, the darker the county, the relative score is higher.

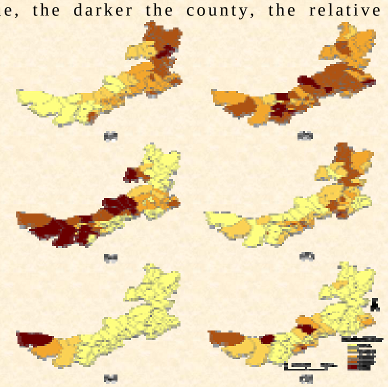
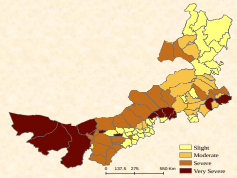


Fig. 4. Maps of standard value of the affecting factors of wind erosion hazard in Inner Mongolia (**a.** Percentage of vegetation; **b.** the contents of fine sand; c. percentage of sandy land; **d.** Average relief degree of land surface; **e.** The degree of soil dryness; **f.** The intensity of wind energy)



Tab. 2. Map of different levels of wind erosion hazard

5. CONCLUSIONS

The results of the model show that in counties of western Inner Mongolia, the wind erosion hazard is very severe, and in eastern Inner Mongolia is slight. The level of wind erosion hazard varies from moderate to severe in the middle part of Inner Mongolia of which the northern part is more serious than the southern counterpart. The assessment result provides a scientific foundation for land resource plan, controlling soil wind erosion and eco-environmental protection.The combination of GIS—RBFN may effectively solve problems of the management and visualization of spatial data in the wind erosion assessment. The research demonstrates the feasibility of using GIS and RBFN to assess wind erosion hazard. if with more relevant data sources, a more mature model could be establish.

6. ACKNOWLEDGEMENTS

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