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Soil Stability Assessment Based on ArcGIS

-- Taking Daming Palace National Heritage Park as an Example

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Abstract

In recent years, natural disasters such as landslides and debris flows have occurred frequently. In order to reduce the impact of natural disasters, it is necessary to investigate and evaluate the soil stability in specific areas. The traditional assessment of soil stability is generally based on field investigation, which is inefficient and has a great impact on the safety of investigators. Therefore, according to the DEM data and map vector, the ArcGIS software is used to evaluate the soil stability of Daming Palace National site Park in Xincheng District of Xi'an by calculating slope and slope direction. The method can quickly obtain the soil stability of Daming Palace National site Park and determine the unstable range, which has strong practicability.

Keywords

ArcGIS; Soil stability; Assessment.

1. INTRODUCTION

Daming Palace National Heritage Park is located at 108.9° east longitude and 34.3° north latitude. It is located on Longshouyuan in the north of Changan City in Taihua South Road, Xi'an City, Shaanxi Province. It was built in Taizong Zhenguan for eight years and the plane is slightly trapezoidal.It was founded in Taizong Zhenguan eight years, covering an area of about 3.2 square kilometers. The perimeter of the original palace wall is 7.6 km, there are 11 doors on all sides, and there are more than 40 sites such as the temple, platform, building, pavilion and so on. The south of Daming Palace is the former dynasty, from south to north by the Han Yuan Temple, Xuanzheng Temple and Zichen Temple as the center, the north of the inner court center for the Tai liquid pool. Soil stability is the analysis of soil stability in this area, which has a certain reference to the geological conditions of the area, whether there are landslides and debris flows, and is a basis to ensure the safety of the area. Therefore, in order to protect the material and cultural heritage, it is necessary to analyze the geological conditions of the area. The image of Daming Palace National ruins Park is shown in figure 1.

Soil stability assessment is an analysis process of soil stability. There are many factors affecting soil stability, including natural factors and human factors. Natural factors mainly include light, climate and vegetation growth, and human factors mainly include housing construction and farming and other human construction activities. At present, there are few studies on soil stability, especially the evaluation of soil stability [1]. By using ArcGIS software, the soil stability is analyzed according to the slope, slope direction and land use status. The research area includes woodland, grassland, construction land and water area, and the soil stability of the research area is evaluated according to the analysis results.

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Figure 1. Image of Daming Palace National Heritage Park

2. PRINCIPLES AND METHODS

2.1. Principle of Soil Stability Assessment

Soil stability is related to many factors, such as slope, aspect and land use type. Generally, the steeper the slope, the lower the stability, and shady slopes are more stable than sunny slopes [2]. Besides, the soil is also affected by wind erosion, erosion and so on. The influence of erosion on soil is related to slope and aspect [3]. Land use types are divided into woodland, water area, grassland and construction land. The more vegetation, the stronger the soil stability, because the amount of vegetation controls the strength of soil erosion [4], so the soil stability gradually decreases from woodland to construction land. Slope and aspect should be fully considered in the analysis of soil stability. The slope and aspect should be extracted according to the DEM of the study area, and the land use grid map should be obtained according to the vector map of the land use type in the area. Then the soil stability is comprehensively evaluated by the weight method. The weights of slope, aspect and land use type are 0.3, 0.3 and 0.4, respectively.

2.2. Soil Stability Assessment Methodology

The slope, the aspect and the land use type were used to evaluate the soil stability. The slope, the aspect and the stability of the land use type were defined according to the slope reclassification comparison table (as shown in Table 1), the aspect reclassification comparison table (as shown in Table 2) and the land use type reclassification comparison table (as shown in Table 3), respectively.

Table 1. Slope reclassification comparison table

Old values [°]	New values
0 ~ 3	10
3 ~ 6	8
6 ~ 11	7
11 ~ 20	5
20 ~ 30	3
30 ~ 90	1

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Table 2. Aspect reclassification comparison table

Old values [°]	New values
-1	5
0 ~ 90	10
90 ~ 270	1
270 ~ 360	10

Table 3. Land use type reclassification comparison table

Old values	New values
-1	5
0 ~ 90	10
90 ~ 270	1
270 ~ 360	10

3. LAND STABILITY ASSESSMENT OF DAMING PALACE NATIONAL HERITAGE PARK

3.1. Extraction of Vector Data

The extraction of vector data is mainly divided into two parts: vectorization and topology processing. According to the research requirements, the soil types are divided into four categories, so the vectorized types are also four categories, namely, woodland, water area, grassland and construction land. After the end of vectorization, the vectorization results need to be topologically processed to check whether the vectorization results have overlapping pressure, gap errors, through topology verification and topology repair, modify the errors in the vectorization process. The vectorization results after topology processing are shown in figure 2.

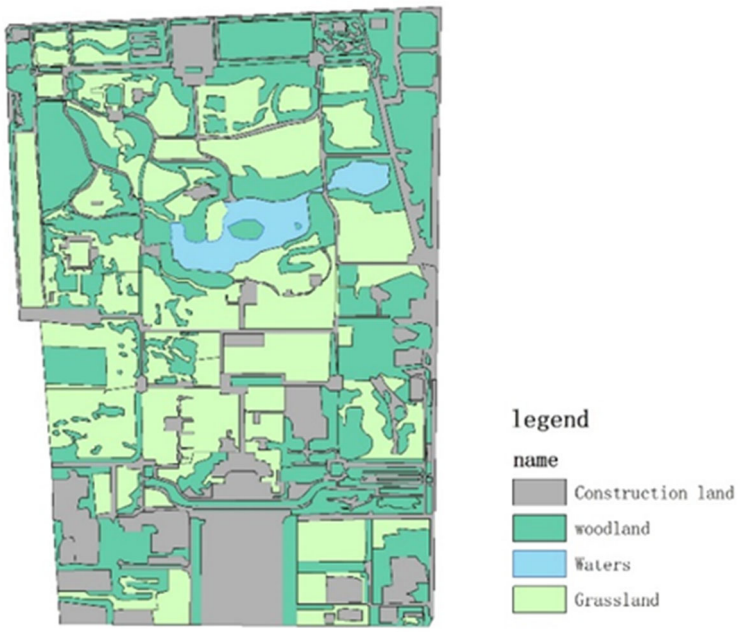

Figure 2. Vector Quantification Results

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3.2. Slope and Aspect Extraction

3.2.1. Slope Extraction

According to the requirements of the study, it is necessary to extract the slope of the DEM map of the research area. According to the principle of soil stability assessment, the steeper the slope, the lower the soil stability. The critical values of stability discrimination according to slope are: 0°, 3°, 6°, 11°, 20°, 30°. Therefore, the stability can be divided into 7 grades according to the slope, and the corresponding values can be given to each grade according to the slope classification comparison table. The step of slope extraction is to start ArcGIS, select the slope under surface analysis in the ArcToolbox Spatial Analyst toolbar. By processing the DEM grid data of Daming Palace National ruins Park, the slope of the research area can be obtained. Then the extracted slope is reclassified according to the reclassification under the Spatial Analyst toolbar. As shown in figure 3, the specific gravity of slope greater than 30° is very large. According to the slope grade, the soil stability in this area is not very good.

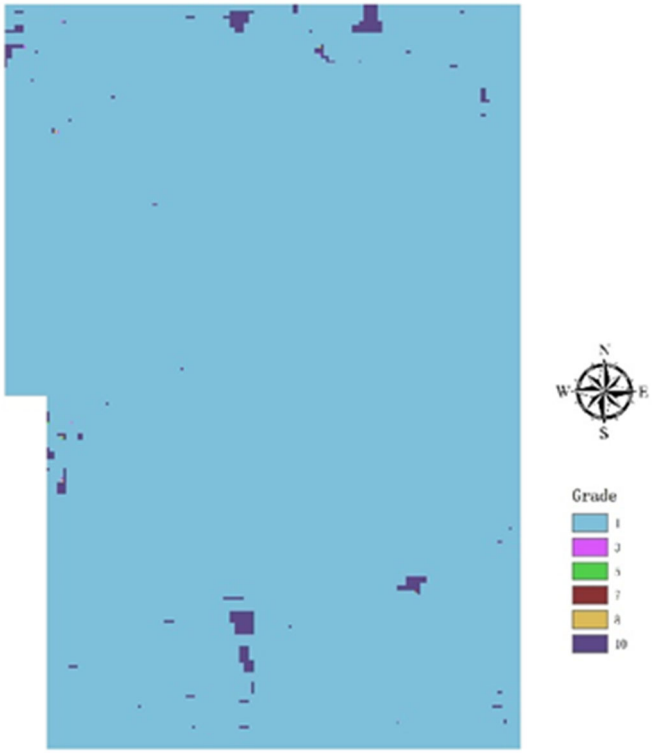

Figure 3. Results of slope grade extraction

3.2.2. Aspect Extraction

The aspect represents the angle between the projection of the diagonal line on the horizontal plane and the normal north direction, generally divided into north slope and south slope and plane, the slope is divided into 0~360°and -1, where -1° is flat ground, 0~90°,270°~360 are north or overcast, 90°~270° are south or sunny. So when grading the slope, The north slope is higher than the south slope. Using ArcGIS to extract the DEM of Daming Palace site park, Select reclassification in the ArcToolbox Spatial Analyst toolbar, divide the slope into three grades, the order is the north slope, the flat slope, the south slope. North slope is the most stable, The south slope is the most unstable. The results of slope extraction in the study area are shown in figure 4, it can be seen that most of the study area is north slope, based on the slope, the soil stability in this area is good.

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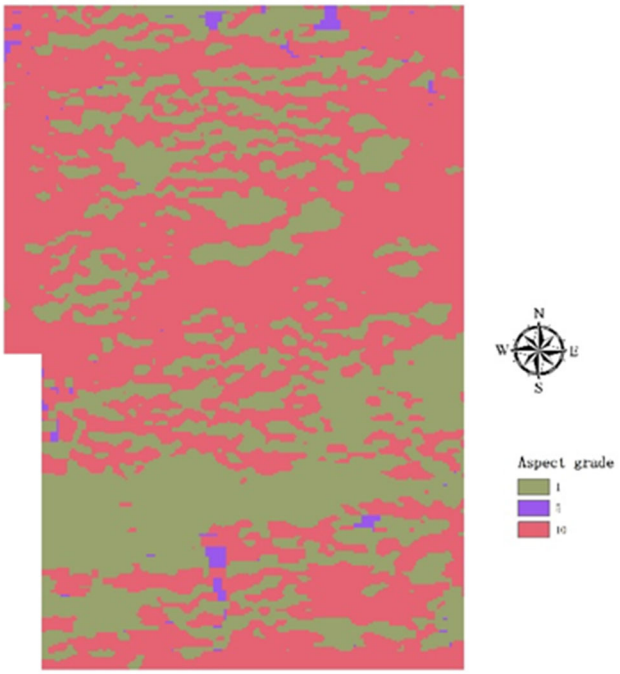

Figure 4. Extraction of Slope Level

3.3. Land Use Type Extraction

According to the research requirements, the soil types are divided into four categories: woodland, water area, grassland and construction land. According to the vectorized results, the distribution of land use types in this area can be obtained. For the final weighted calculation, the vector data needs to be converted to raster data, and the grid data is selected by ArcToolbox the conversion tool in the toolbar. Finally, the obtained grid data is reclassified. The result is the highest grade of woodland, followed by water, grassland and construction land. The results are shown in figure 5. It can be seen that the forest land occupies a large range and the soil stability is better.

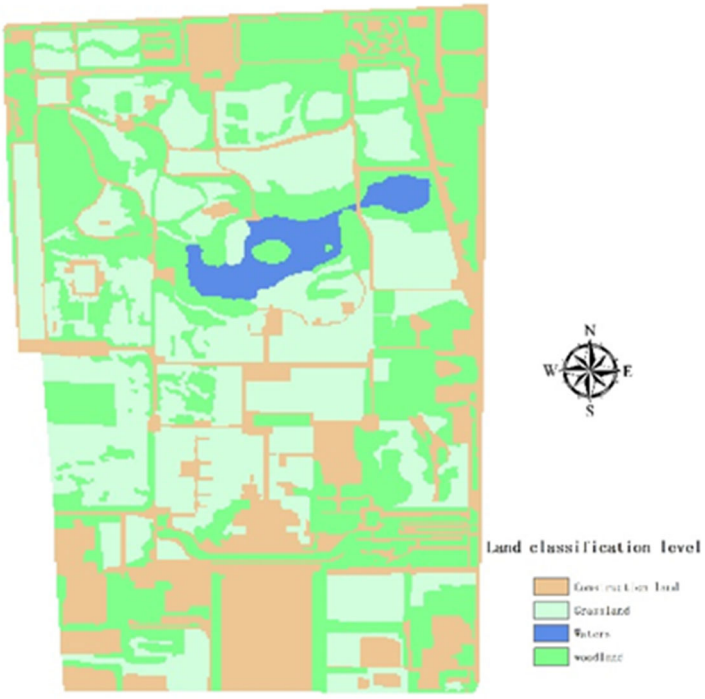

Figure 5. Extraction of land use type grades

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3.4. Assessment of Soil Stability

The assessment of soil stability is based on slope, slope direction and type of land use, the results of soil stability evaluation were obtained by weight calculation. In the weighting process, the weights of slope, slope direction and land use type are 0.3, 0.3 and 0.4 respectively. Participation in the weighted calculation is the result of slope grade extraction, the results of slope grade extraction and land use type grade extraction, the grid calculator under Spatial Analyst map algebra in the ArcToolbox toolbar is used for weighted calculation. Re-mark the results, open the properties window of the layer, under the symbol system, then the results are divided into three categories, the demarcation points are 3.78 and 6.09, less than 3 is unstable, 3.78 to 6.09 are more stable, more than 6.09 is very stable. Make the classification and annotation results into a thematic map as shown in figure 6. According to the thematic map, the unstable areas are mainly concentrated in the southwest and southeast of the study area, land types in unstable areas are mainly construction land, the slope is mainly sunny, A slope is concentrated above 30°. The proportion of unstable regions is small through overall analysis, the number of pixels in the unstable region is 15841, the number of pixels in the more stable region is 29522, the number of pixels in a very stable region is 14198, the total number of pixels is 59561, the proportion is 0.266, 0.496 and 0.238 respectively. The proportion of unstable regions is 26.6 percent, therefore, it can be concluded that the soil stability of Daming Palace National site Park is generally good.

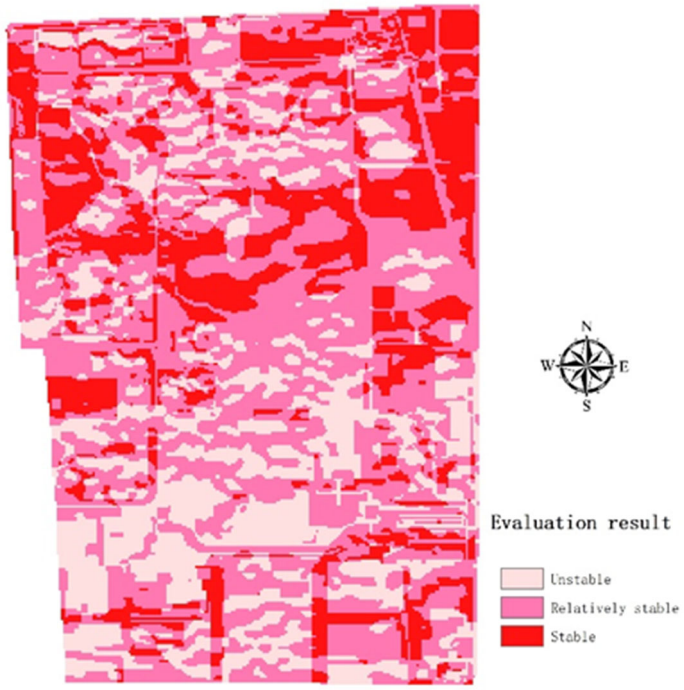

Figure 6. Thematic map of soil stability assessment in Daming Palace National Heritage Park

4. TERMINOLOGY

At present, there are not many studies on soil stability using ArcGIS, more analysis of soil stability according to actual soil conditions and land use database. The traditional method of soil stability analysis has a large workload. It takes resources and manpower to field check and data to analyze soil stability. Based on the analysis of soil stability by ArcGIS, the soil stability can be analyzed and evaluated according to the slope, aspect, land use type and some geographical theories. This method is more efficient and results are faster. If only a simple analysis of soil stability in a region is needed, this method can be used. there are still many

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shortcomings in using ArcGIS to evaluate soil stability. In order to improve the accuracy of soil stability assessment, further research is still needed.

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