LANDSLIDE OCCURRING PROBABILITY DECISION BASED ON REMOTE SENSING AND QUANTIFICATION THEORY Ⅱ

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ABSTRACT:

Monitoring and evaluating natural disasters is one of important applying fields of remote sensing. In this paper, the authors monitor dynamically the change and move laws of landslides by making use of high-revolution remote sensing imageries (taking Hiroshima, Japan for example); they construct the optimum regression relation between the remote sensing imageries and the affecting functions of landslides based on multi-variable regression analyses, and put forward to applying Quantification Theory Ⅱin landslide disaster monitoring. The concrete procedures include: 1. Identify the positions, scales, types, and boundaries of the landslides by using the Object-oriented classifications, after geometric corrections, spatial matching, mosaicing and enhancement； 2. Construct the multiple regression analysis equation about the natural and environmental functions affecting the landslide; 3. Decide the risk indexes based on remote sensing imagery pixel referring to the regions which landslides possibly occur by using Quantification Theory Ⅱ; the external standards are weathering, slope, geology, topography, soil, land-use, saturation, and NDVI for deciding risk indexes.

The prediction results are proven to satisfying the needs, and can provide referrence for similar situations.

1. INTRODUCTION

Landslides are one kind of common, large-scale, dangerous and complicated natural disasters, there are some laws in the occurences of landslides however. Remote sensening discribes the obejects locatedly, qualifiedly and quantitedly by detecting the objects remotely, processing and analysizing the detected information. Monitoring dynamically the landslides making use of remote sensing, and furthemore forecasting , foretelling the disasters and making precautions is one of the important tasks of geospatial information technology.

In this paper, the authors monitor landslides located in Hiroshima, Japan, using the IKONOS imageries, construct the optimum regression relation between the remote sensing imageries and the affecting functions of landslides, and decide the risk indexes referring to the regions where landslides possibly occur applying Quantification Theory Ⅱ

The softwares used in this research include: ENVI Version 4.0, SPSS 13.0, PHOTOSHOP and the Quantification Theory Ⅱ programme.

2. DATA ORIGINS IN RESEARCH REGION

Hiroshima, Japan is one of the areas landslides occur frequently by virtue of geological, environmental factors, heavy rains, earthquakes, and typhoons, etc. The data involved in this research are: Ikonos remote sensing imageries, 1:5000 vector electrical topographic map and other maps which offered by Japanese Geographic Institute. The aerial photograph of landslide disaster is shown at Fig. 1. The analyzing region is in section 9, Guishan, Miyake, Saeki-ku, Hiroshima.

Figure.1 The aerial photograph of landslide disaster

3. TECHNOGICAL PROCEDURE

In this research, the authors accomplish Multiple Regression Analysis (MRA) and construct the optimum regression expressions, taking weathering degree, geoligical rock layer, land use etc, as criterion variables and the DN values of remote sensing imageries after ratio operation as explanation variables[1].

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The concrete technogical precedure is shown at Fig. 2.

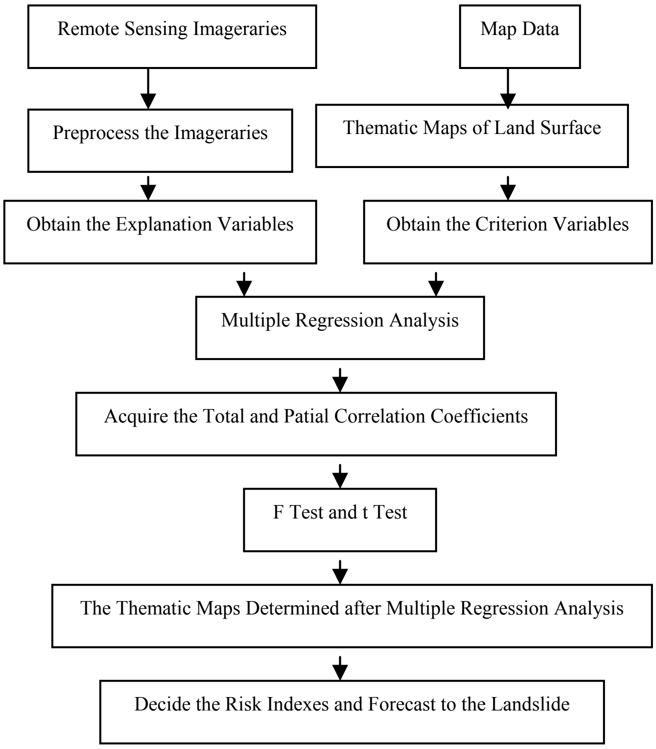


Figure.2 Technical flowchart of monitoring landslide disaster using remote sensing

Quantification Theory Ⅱ Analysis can be used to accomplish the discriminant analysis for the landslide's risk index[2]. The technical flow-chart of landslide risk index estimation is shown in Fig. 2. The external standards which be applied are weathering degree, land slope, geoligical rock layer, topography, soil, landuse, vegetation index. The discriminant formula is:

$$X_{i(\alpha)}^{r(v)} = \begin{cases} 1: & yes = 1 \\ 0: & no = 0 \end{cases} \tag{1}$$

Where $i = 1,2,\cdots k$ (factors);

$\alpha = 1,2,\cdots I_i$ （the risk index scope）;

$r = 1,2,\cdots M$ (stes);

$v = 1,2,\cdots N_r$ (samples);

The value of $X_{i(\alpha)}^{r(v)}$ is decided by if the sample is in the risk index scope, as shown in formula (1).

The values of the samples are calculated with the formula (2):

$$y^{r(v)} = \sum_{i=1}^{i} \sum_{\alpha=1}^{\mu} X_{i(\alpha)}^{r(v)} \alpha_{i(\alpha)} \tag{2}$$

The samples are classified with regard to the external standards; and the dispersal degree among the samples from each set can be termed as correlation η^2, which are obtained with formula (3):

$$\eta^2 = \sigma_B{}^2 / \sigma^2 \tag{3}$$

where $\sigma_B{}^2$ is the dispersity among the samples, and σ^2 is the total dispersity of $y^{r(v)}$.

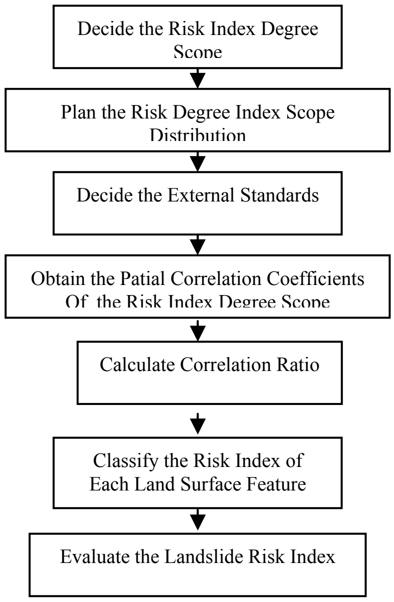


Figure.3 The technical flow-chart of landslide risk index estimation based on Quantification Theory Ⅱ Analysis

4. LANDSLIDE AFFECTING FACTORS' OPTIMUM REGRESSION ANALYSIS

The thematic maps can be updated by optimum regression analysis, taking weathering degree, geoligical rock layer, land use etc, as criterion variables and the DN values of remote sensing imageries after ratio operation as explanation variables[2][3]. For exsample, taking the geological feature in the exiting map as criterion variables, the result of regression analysis is shown in Tab.1. And the updated geological thematic map is shown in Fig. 4; Tab.2 can be referred to understand the map.

Thematical map	Total correlation coefficient	Contribution rate	Adjusted contribution rate
Geological feature	0.999	0.997	0.992
F test (Significance leval α)	t test (Significance lLeval α)	Explanation variable （XN）	Patial correlation coefficient
0.1%	Constant： 0.1% R-12:0.9% R-13:0.8% R-14:0.3% R-23:0.9% R-43:0.3%	X1:R-12 X2:R-13 X3:R-14 X4:R-23 X5:R-43 Constant	-0.510 1.047 -0.195 -0.682 -0.309 98.332
Optimum regression equation	-0.510X1+1.047X2-0.195X3-0.682X4-0.309X5+98.332		

Table.1 The result of regression analysis

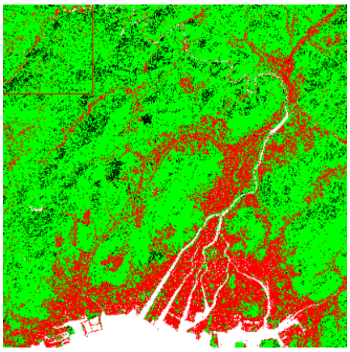


Figure.4 The updated geological thematic map

Geological features	DN values	Image Color	Occupying percent （%）
Consolidated sedits	0-50	Black	8.8
Platonic rock	50-80	Green	64.55
Unconsolidated sedits	80-130	Red	20.22

Table.2 The geological features and their occupying percent

5. LANDSLIDE RISK INDEX ESTIMATION

The landslide risk index estimation maps can be obtained making use of Quantification Theory II Analysis based on the updated thematic maps after the Multiple Regression Analyses[4] [5] [6]. The correlation ratios of affecting factors about the research region, are illustrated in Tab.3; and the analysis results in Tab.4, Fig 5 and 6, the external standard being the slope. In Fig.6, the areas in white blocks are the actual locations landslides occurring, 68.3% of which risk indexes are A.

Weathering classification	0.681
Slope	0.377
Geological classification	0.611
Vegetation index (NDVI)	0.542
Topographical Feature	0.606
Saturation	0.550
Soil classification	0.351
Land-use	0.609

Table.3 The correlation ratios：η^2 of affecting factors

Item	Category	Category quantity	Patial correlation coefficient
Weathering classifucation	Shallow Meddium Deep	-0.20227 -0.03985 0.27301	0.25423
Slope	＜3° 3°-20° 20°-40° ＞40°	External standard	---
Geological classifucation	Water Consolidated sedits Platonic rock Unconsolidated sedits	-0.39979 0.22273 -0.01300 0.04484	0.09944
Vegetation index (NDVI)	Small activation Middle activation Large activation	0.92403 -0.47201 -0.49040	0.62176
Topographical Feature	Dissected hill Piedmont Lowland	0.22142 -0.05739 0.55426	0.42006
Saturation	Low Middle High	0.13126 0.02977 -0.04176	0.10575
Soil classifucation	Residues of adobe Grey lowland soil Street and building	-0.07950 0.15037 0.31636	0.20676
Land-use	Broadleaf tree Conifer Street and building	-0.10224 -0.00486 0.04258	0.05967

Table.4 The Category quantities and patial correlation coefficients for analysis

6. CONCLUSIONS

This paper at first analyzes the remote sensing imageries' features of the research region and minimizes the noises by ratio operation; then obtains the thematic maps using Multiple Regression Analysis; at last estimates the landslide occurring probability. And the test shows that for the areas landslides occurring, 68.3% of which risk indexes are A.

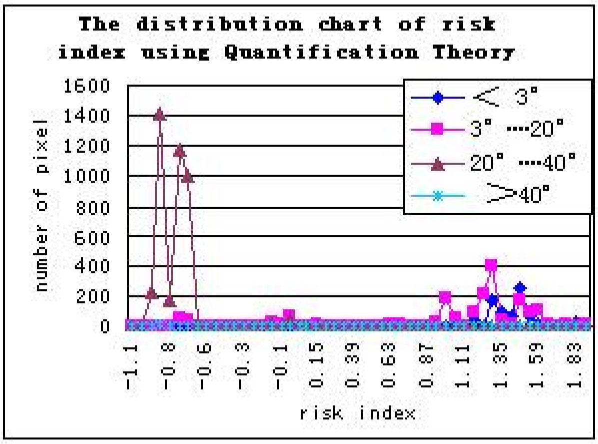
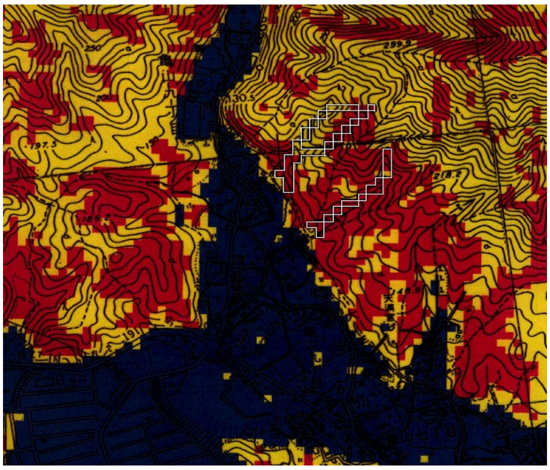


Figure.5 The distribution chart of risk index



Landslide occurring probability	Pixel number	Occupying percent	Color
High	1798	27.4%	Red
Middle	2499	38.1%	Yellow
Low	2264	34.5%	Brown

Figure.6 The estimation map of landslide occurring probability

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