Creating the Mechanism for Slope Land Monitoring and Computerized Management

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Abstract

In Taiwan, many improper acts of land development damage the environment and cause disasters. To maintain environmental resources, the SWCB uses GIS, Remote Sensing, and MIS technologies to assist slope land monitoring and management. Satellite images are analyzed and used to differentiate the changed point area by spatial information to make the data. The local governments retrieve the data, inspect on-site information, register case information, and manage the follow-up case tracking through the system. The whole structure of this system is planned and developed to provide an integrated and web operation system. Meanwhile, the database is built with normalized database structure and integrated spatial and attribute data using ArcSDE remote data exchange technologies. This system promotes a solution for data unity, data sharing and instantaneous response. These are essential to manage the slope land monitoring business effectively.

1. Preface

Taiwan, with its unique climate, steep mountains, fast running rivers, and concentrated rain falls, constant monitoring and management to the slope lands is absolutely necessary for the protection of geographical resources and prevent possible damages to the slope lands done by the economic activities.

For efficient monitoring and deter illegal developments of the slope land, The Soil and Water Conservation Bureau (herein refer to as SWCB) of Agricultural Council had introduced modern remote monitoring technology, RS,GPS and GIS to assist on monitoring the developments on the slope land. Applying the NDVI module and the before and after satellite images, the suspected illegal development site can be obtained and refer to as the changed-point. The information of the changed-point is then fed to the local administration authorities for on site inspection and confirms the information of potential illegal activities.

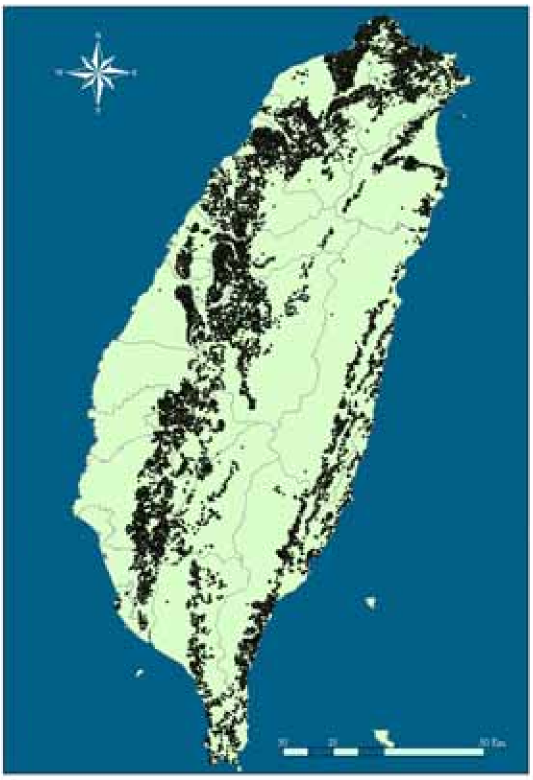

Figure 1: Distribution of variation points

Table 1 statistics of numbers of changed-points by year

Year	Natural changed	Non natural changed	Total

2000	1,041	2,843	3,884
2001	373	1,722	2,095
2002	496	1,455	1,951
2003	375	766	1,141
2004	615	1,169	1,784

This research aimed at constructing slope land management information system and decision support mechanism. Years of changed-points' satellite data were gathered and spatial analysis were conducted with SDE Geodatabase. We tried to identify the behavioral trends of slope land developments and information of spatial distribution density; results of these analyses can be used as decision making references at local authorities on slope land developments.

2. Gathering data

Data of Taiwan slope land changed-points were gathered from 2000 to 2004 and six periods of changed-points data were generated every year, totaling 30 different periods of data available for analysis purposes. Base on the inspection results, changed-points can be divided into two different categories, natural and non natural changed. The natural changed-points include collapses, plantation changes due to climate shifts, and so forth; the non natural ones are manmade changes. Our research focuses on subjects of non natural changed-points, analyzing the spatial distributions and trends of slope land development projects.

3. Research method

This research aimed at constructing slope land management information system and decision support mechanism including data acquisitions, organizing, analysis, and output of results. First, the before and after satellite images are analyzed to identified the location of changed; next the data array is obtained through overlapping diagrams of sub-basin, map-extend, and roadway buffer analysis. The array is then feed into the statistical analysis for final result inspections; procedures are as shown in Figure2.

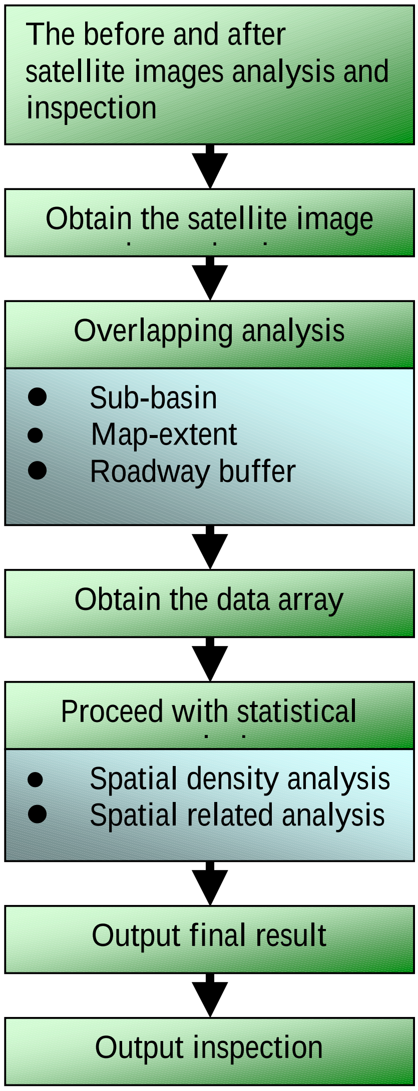

Figure 2: Mechanism of Analysis

The research was mainly based on ArcMap platform connecting the slope land spatial database (ArcSDE+Oracle) and the slope land management database. The relationship between spatial data and the obtained data were mostly from the joint data from another layer based on spatial location. In addition, the distances of roadways use functions of buffer analysis; the structure of information analysis platform is as shown in Figure3.

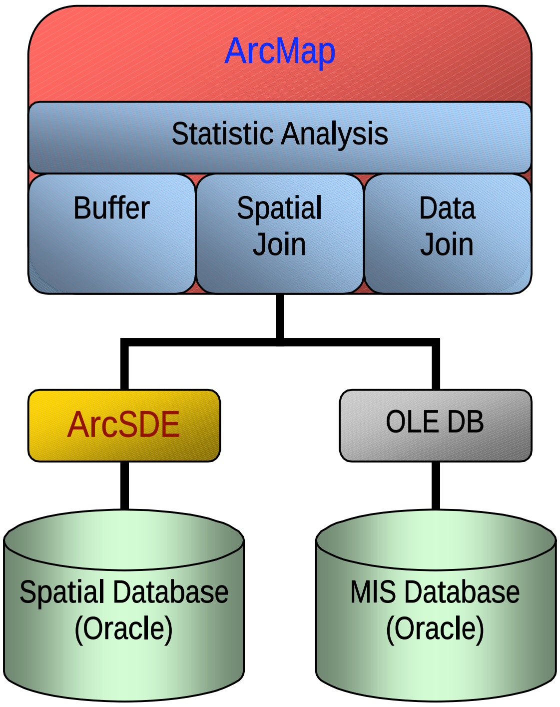

Figure 3: structure of information analysis platform

3.1 The spatial density analysis for Non natural changed-points

The spatial density analysis refers to the distribution density of target elements in the unit space. The analysis obtain information of changed-points' spatial density using non natural changed-points as prime subjects, excluding factors of administration areas and based on numbers of points in unit area and different sub-basin.

3.1.1. Basic information

This research first obtained the 1/5000 map-extent the slope land spatial database (1/10000 for the mountain area) and the sub-basin as unit area, then the annual changed-points' inspection results in the slope land management database were acquired. changed-point itself contains information of map-extents; hence the spatial data and attribute of changed-points were connected using "joint attributes in the table". Sub-basin, on the other hand, was connected using "joint data from another layer based on spatial location".

3.1.2. Spatial density fluctuation trend analyses for non natural changed-points

Unit area information was obtained through the above information connections, then through the SQL language queries to solve for numbers of points in a unit area. Information of spatial density can be thus obtained by dividing the quantity with unit area.

Base on the yearly established spatial density information, we can further conduct the trend analysis by comparing two adjacent years or between different numbers of years. The analysis use year as the unit of time and established unit area spatial density array relative to the unit of time; in the mean time, data analysis were conducted based on trend analysis. The slope of the trend line is negative if the density decreases as time progresses and vice versa. In the end, the results were feed back into the unit area diagram, connecting diagrams and results through related fields, then the fluctuation trend figure of unit area changed-points were drawn using values of different trend line slopes.

3.2. Analysis of non natural changed-points and the roadway spatial

areas

The analysis focused on the spatial distribution relationship between non natural changed-points and roadway areas. Were there higher probabilities for occurrences of non natural changed-points when it gets closer to roadways?

As the roadway itself is not quantifiable, therefore various distances' buffer analysis centered on the roadway must be conducted before the actual analysis. Together, the joint data from another layer based on spatial location were conducted between the results of the buffer analysis and the non natural changed-points. This was to establish quantity information of changed-points base on different distances. Nevertheless, quantity of changed-points did not present itself as meaningful information when the buffer area got bigger. Therefore, spatial density is much more suited for the analysis; it is to divide numbers of points within the distance by the changed-points' spatial density in the buffer area.

4. Analysis results

4.1. Spatial density analysis for non natural changed-points

The results from the non natural changed-point analysis had shown that there's not much density fluctuation throughout most of Taiwan. Ali Mountain, Miaoli, and mountain area of Hsinchu had shown trends of moderate increases but greater increases for sight seeing areas like Chlan mountain area in Yilan County, east coast of Yilan, and Chipen of Taidon.

Integrated inspection on developments in reservoirs can be conducted base on unit areas, results had shown that little changed-points in density in most of reservoirs in Taiwan; there's even density decreases in some of the reservoirs. On average, density increase areas of non natural changed-points matches the analysis results conducted from areas in map-extent.

4.2. Analysis of non natural changed-points and the roadway spatial areas

This research divided the roadway into three different levels of nation, providence, and county/village. Due to the difficulties associated with the massive amounts of roadway data, we selected Taipei County as our research area with buffer distance of 100 meters. In analyzing relationships between non natural points and roadways of different levels, the results came back showing significant correlation between non natural

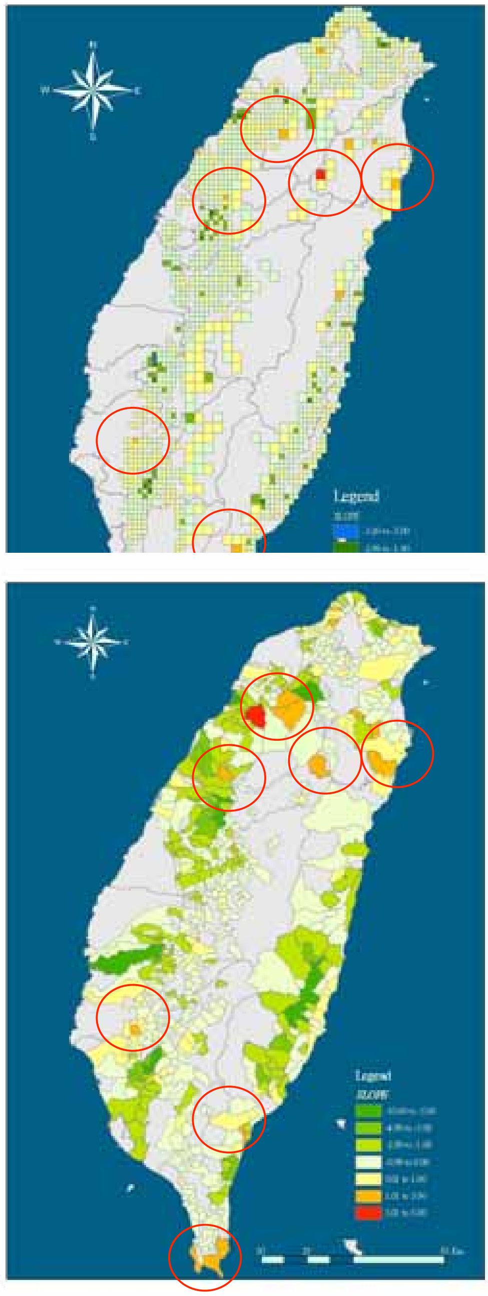

Figure 5: Results of spatial density analysis for sub-basin changed-points

changed-points and roadways base on t- inspection analysis; the correlation was the highest for country/village roadways. In addition, the Chi-square Test result shown significant differences, which meant that significant differences between distances of different level roadways and spatial density of non natural change-point. In the mean time, negative slopes stand for higher density when there's less distance between non natural points and roadways and among them; county/village had the highest value. Therefore, most of the non natural changed-points are located along the county/village roadways. From the above, we can conclude that there's significant correlation between the degrees of traffic accessibility and the slope land development projects.

Figure 6: Roadway buffer of Taipei County

Table 2: t inspection analysis for non natural changed-points and roadway areas

Items	National roadways	Providence roadways	County/village roadways
Related parameters	0.84	0.78	0.95
Groups	249	97	20
Degree of freedom	247	95	18
Significant t value	24.68	12.17	12.30
T critical value	±2.069	±2.069	±2.069

Table 3: Chi-square Test result for non natural changed-points and roadway areas

Items	Quantity	Slope
National roadways	55	-0.0014
Providence roadways	205	-0.0506
County/village roadways	586	-0.2307
Chi-square statistical value	531.4680851	
Critical value	5.991	

5. Conclusion

The following conclusions were derived from various statistical analyses of slope lands:

(1) The establishment of information decision support system can effectively and swiftly provide decision making authorities various statistical information, which can used as references for slope land development management.

(2) The connection of ArcMap and ArcSDE spatial database enables fast retrieval of maps for various analyses; this research was based on this very platform for analysis on slope land developments.
(3) The results of spatial density analysis pointed out that some of the areas in Taiwan had shown increases in their slope land developments, areas such as Hsinchu, slope lands in Miaoli area, Chilan mountain area in Yilan, Chipen of Taidon, and Ali mountain area in Chayi. These areas are for sight seeing/recreational businesses and also areas of highly developed agricultural industries, slope land development projects quickly invaded local slope lands. Our research results can provide important information for administrative authorities in strengthening their management efforts in the above areas.
(4) This research connected the buffer analysis results and data of the non natural changed-points before conducting different statistical analyses. The result pointed out that the closer the distance to roadways, the higher the non natural changed-point spatial density. Hence the traffic accessibility is positively correlated to the cost of slope land development projects. Therefore, besides traffic convenience, traffic construction institutions should also consider factors related to land conservation in order to avoid unrecoverable damages to our homeland resources.

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