Utlizing Multi-scale Remote Sensing Technology for Evalutaing Sediment Disaster in the Catchment Area

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Abstract. This study combines multi-scale remote sensing imagery and intelligence gathering to investigate water catchment area environment. Temporal telemetry information combined with object-oriented technology is used to create a semi-automated algorithm for identifying landslide location and area. Through this process, landslide changes on a watershed scale are explored. This study also demonstrates the use of air-borne LiDAR technology for conservation treatment project effectiveness evaluation.

1. Introduction

With rapid advances in satellite remote sensing, image processing and data storage in recent years, remote sensing images have provided new methods for performing photogramtric surveys, landuse monitoring and natural disaster reconnaissance. Natural disaster reconnaissance objectives can include identifying changes in the natural environment, land topography, public facilities, or transportation structures. Remote sensing data, processed with image analysis techniques can serve as a tool for environmental assessments and contribute to environmental protection and conservation work. Using multi-scale remote sensing tools for fast, automated surveys and can break through access features not accessible by field reconnaissance survey such as the wide area of the landslide. Satellite remote sensing technology has been in use for a long time and has a wide range of shooting features. Given field observations, data with time and space continuity and preservation of the image information, multi-band analysis is different from the visible indicators. Distinguishing vegetation and bare land, can be successfully mastered with a wide range of the current situations. Unmanned Aerial Vehicles (UAVs) offer one avenue, hover UAVs are impacted by fog and low clouds. UAV's have a high mobility, compared to other telemetry vehicle, they spend a relatively low cost, and are suitable for special monitoring of the small area. This study applies object-oriented technology for landslide interpretation to multi-period satellite images to process changes in order to understand the spatial and temporal evolution of the landslides on a landscape scale.

2. Study area

Shih-men Reservoir catchment area is approximately 76350 ha and is located south of New Taipei City, Taipei Township, its geographical is location shown in Figure 1.

Shih-men Reservoir catchment topography is defined by gentle hills of the northwest end of the reservoir catchment area The catchment area to the southeast Fangzhi Tai Kong Creek, is defined by rapid uplift of the terrain mountainous areas, the rapid transformation from 135m above sea level to 3,500 is especially apparent in the southern tip of the catchment at the 3,529 m mountain Tian Shan, the highest location in the catchment, The overall catchment area is shown in Figure 2. Catchment altitudes between 500 ~ 1,500 m, slope fall into five slope categories and the six slope aspect categories

Shih-men Reservoir Watershed is located in the Han River Basin. River systems originate in the Snow Mountains with mainstream Han River being the largest tributary in the Tamsui River of about 94.01km. It is comprised of the Thailand Kong Brook, Whitehead Creek, Sanko Creek, card pull Creek, Po where bitter Creek, Olympia Creek, tributaries confluence made Shih-men reservoir of Amuping the western foothills. The current network was the status of irregular branches, the branch current total number of 64, with a total length of 352.63 km. From the Herb typhoon since, several more cases of severe typhoon event have occured, respectively, Herb, Avery, and Ke Luosuo. The return period for the typhoon rainfall of the three typhoon events are more than frequency analysis of the 10-year return period. Particularly among the worst Allie typhoon also caused by the upstream catchment area upstream landslide dramatic increase in accumulation in the river until the typhoon torrential rain and then the sediment taken downstream of the reservoir area, resulting in raw water turbidity is rising rapidly, thereby affecting water use. Therefore, the relevant units have been put into the catchment area remediation plan.

3. DATA ACQUISITION and Analysis

This study is to grasp the changes in the Shih-men Reservoir catchment area over the years 1993 to 2010 for a total of seven historical disaster event satellite images, as shown in Table 1, the image selection principles include cloud amount and high resolving power of satellite images as a priority. Commonly used in all kinds of satellite launch process and can shoot the image resolution, summarized as follows:

1) SPOT5 satellite (SP5) was launched on May 4, 2002, black and white images (PAN) with color multi-spectral images (green / red / near infrared) resolution of 2.5 m and 5 m.

2) FORMOSAT (FS2) was launched on May 21, 2004. Black and white images (PAN) with color multi-spectral images (Blu-ray, green, red section and the near-infrared light period) resolution for the 2m and 8m, respectively.

Continuation will use object-oriented technology to the judge to release of landslides and circle painted, spatial statistics and GIS to explore the changes in the course of the landslide.

3.1 Object-oriented classification techniques for landslide interpretation

In this study, using the German By gray level value, area, shape, pattern management conditions, and have inherited judge to release results object-oriented automation judge to release software-the Definiens, explore its working principle and the current process (see Figure 3), and then on the image carried out over a reasonable range segmentation, and correction parameters boundary and the rate in addition to the noise, followed by sub-release of classified objects results.

1) Load the satellite image and the reference layer of the training area: landslide area must first set before the judge to release the whole lot of satellite images, satellite image features can be pre-landslide area as generated judge to release object reference.

2) Set the expected interpretation object boundary threshold: first threshold value to generate the object, the object at this time applied to the segmentation of different classification region, most of the area; should be filtered out and the designated area set a smaller threshold and hue difference small region is subdivided into more small polygon object, therefore the results interpretation a great impact for the range of follow-up landslide area.

3) Set the Step 2 polygon object classification conditions, and then sentenced to release of the landslide area, for example, found that by using the Feature View function experimental observation, the set of satellite images Levels Mean Mean red layer (layer R) greater than 50, that is, may include all of the landslide area in the satellite images, set this to the classification conditions.

4) Load a whole lot of satellite images and reference layers: the site satellite image features extraction from the training area to load the expected sentence of release the whole lot of satellite images and the pre-landslide area layer.

5) The object of the application of the training area boundary threshold whole lot of satellite imagery: application of Step 4 of the object boundary threshold polygonal objects produced in the whole lot of satellite images.

6) Quality control of the size of the object suitability: through the original satellite images to view the production of the polygon object size is appropriate (subject to separate the boundary of different shades).

7) Aapplication training area classification conditions set in the whole lot of satellite images: application Step 4 classification collapse automate the whole lot of satellite image interpretation.

8) The object after the QC Category: Step 7 sentenced to release results of the classification for landslide and non landslide, and then, and the classification results use artificial change of the original satellite images and aerial photos and other layers of miscarriage of justice area.

9) The polygon object output: interpretation for the collapse of regional GIS layers output in order to facilitate follow-up application.

3.2 Landslide change course

To explore the area of collapse after the Shih-men Reservoir calendar year, the major sediment disaster event, the new landslide area, and restoration to its corresponding catchment collapse ratio, defined as "current satellite images byinterpretation for the occurrence of the collapse of the range ", calculated as equation (1).

$$LSRation = \frac{LandslidesArea}{CatchmentArea} \times 100\% \tag{1}$$

3.3 Air-bron LiDAR technology project effectiveness evaluation

Hsiao *et al.*, (2009) worked in Shih-men Reservoir applications air-born LiDAR Shi measured for two during the topographic variation analysis, and accuracy better the ground LiDAR conduct does not move point data than the results show precision application range is sufficient to assess landslide hazards andthe effectiveness of the treatment project.

In this study, the air-born LiDAR test produced a wide range of digital elevation model (DEM, Digital Elevation Model), and by more than two during the different periods of DEM to analyze the terrain elevation change, estimate the amount of sediment transport to determine the main sources of supply of sediment material and the accumulation region, and then each sub-catchment sediment transport analysis and treatment effectiveness evaluation.

4. Results and Discussion

4.1 Before and after Typhoon Aere

Shih-men Reservoir Typhoon Aere before the typhoon caused by Typhoon Xangsane Shih-men water catchment area as a whole landslide area (Figure 4), about 586.1ha. From 1995 , Typhoon Aere Martha, Terry and the Dragon King of the most serious ground all the 800.0ha about the collapse. The collapse ratio between about 0.2 to 0.8% before Typhoon Aere; after Typhoon Aere from 0.7 to 1.0%.

4.2 Remediation Plan Investment

1999 typhoon MORAKOT resulted in a landslide area by typhoon Jangmi in 1998 (about 705.8ha) MORAKOT (about 781.1ha) an increase of approximately 75.3ha, and the collapse ratio of 1.0%; Typhoon Parma after the collapse area is slightly small increase in, so the collapse than to change. 2000 two typhoon events (Typhoon FANAPI and Maggie) its landing path is not toward the Shih-men Reservoir Watershed therefore, Shih-men Reservoir catchment as a whole less affected before the typhoon after Maggie typhoon, the total area of landslide maintain 580ha (collapse than about

0.8%), the overall collapse has slowed. 2011 years Nanmadol by Typhoon, the overall landslide and went, decline close to 284ha area better than before the collapse of Typhoon Aere.

4.3 Remediation Plan effectiveness evaluation

The analysis showed that from June 1996 to August 1998 Su Yue catchment area of riverbed midstream under unstable phenomenon, but in August 1998 after the new sand facilities were installed, a slow down of the good river slope and a solid stream bed were observed(see Figure 5 and Figure 6); November 1998 to October 1999, close to the riverbed of the large-scale landslides upstream to downstream riverbed clear the terrain changes; check relevant project information that (SWCB, 2010), because of the sand control facilities in the region have been overwhelmed affect the flow path, and the upper reaches of large-scale collapse continued sediment output; in order to minimize the danger of sediment disasters in January 1999 began the riverbed sediment removal, in addition to maintaining the riverbed water flow and maintain the function of the dam; October 1999 so far slope no obvious sediment outputs, stream beds there is no obvious under cut phenomenon and riverbed sand control facilities have significant sediment accumulation, indicating Su Yuecatchment area has been the effectiveness of good governance. By comparison governance before and after the catchment sediment production has been greatly decreased by about 31%, governance effectiveness is really good, but the upper reaches of large-scale collapse with the early collapse of accumulation of potentially unstable earthworks, it is recommended that the still ongoing monitoring. At the same time, the sediment blocking rate increased by 35% to 65%, showing the sand control facilities have been inhibition of the sediment outflow of the expected remediation the subject shown in Figure 7.

Combination of relevant monitoring and analysis of results, the application of remote sensing technology and the use of high-precision scanning, from a different scale and level of comprehensive analysis of sand production environment of the catchment waters and sediment disasters course, in addition to the historical situation of the water catchment area are clearly outside the course of its changes, the other can be established to assess the effectiveness of conservation management of catchment areas and to provide a reference for the future other water catchment area on business governance.

5. Acknowledgment

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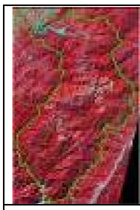
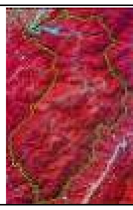
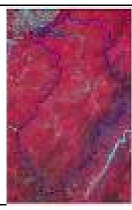
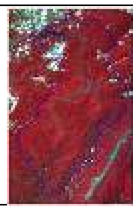
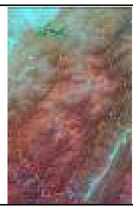
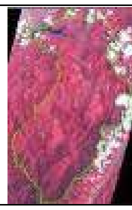
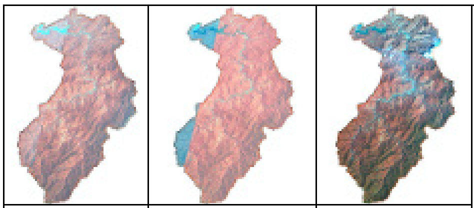
TABLE I. HISTORICAL DISASTER EVENTS AND USING IMAGERIES

Items	Typhone Event (Period)	Image Date	Image	GSD
1	Typhoon AERE (2004/08/23~08/26)	Before (2004/02/10)	SP5	2.5m
		After (2004/11/02)	SP5	2.5m
2	Typhoon MORAKOT (2009/08/05~08/10)	Before (2009/05/08)	SP5	2.5m
		After (2009/08/20)	SP5	2.5m
3	Typhoon PARMA (2009/10/03~10/06)	After (2009/10/21)	SP5	2.5m
4	Typhoon FANAPI (2010/09/17~2010/09/20)	Before (2010/04/01)	SP5	2.5m
		After (2010/09/22)	FS2	2m
5	Typhoon MEGI (2010/10/21~2010/10/23)	After (2010/11/01)	FS2	2m
6	Typhoon MEARI (2011/06/23-06/25)	Before (2010/04/19)	FS2	2m
		Before (2010/04/20)	FS2	2m
		After (2011/07/08)	FS2	2m
		After (2011/07/28)	FS2	2m
7	Typhoon NANMADOL (2011/08/27～08/31)	After (2011/09/04)	FS2	2m
		After (2011/09/17)	FS2	2m
		After (2011/09/26)	FS2	2m

TABLE II. QUICKLOOKS OF COLLECTION IMAGES

			
Before Typhoon AERE	After Typhoon AERE	Before Typhoon MORAKOT	After Typhoon MORAKOT
			
After Typhoon PARMA	Before Typhoon FANAPI	After Typhoon FANAPI	After Typhoon MEGI



Before Typhoon MEARI	After Typhoon MEARI	After Typhoon NANMADOL

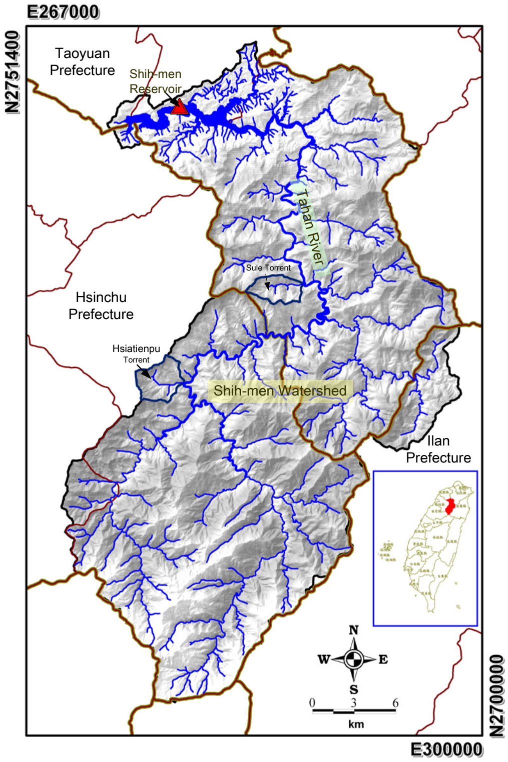


Figure 1. Location of Shih-men Reservoir catchment

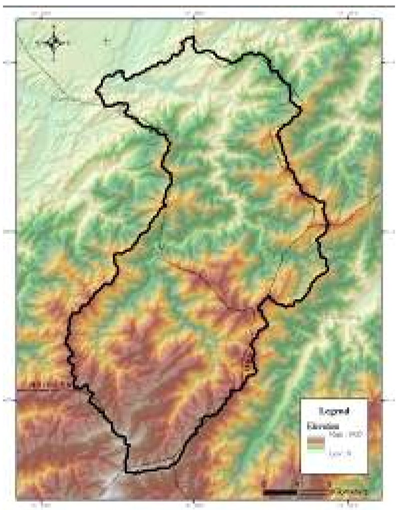


Figure 2. Topographic map of Shih-men Reservoir catchment

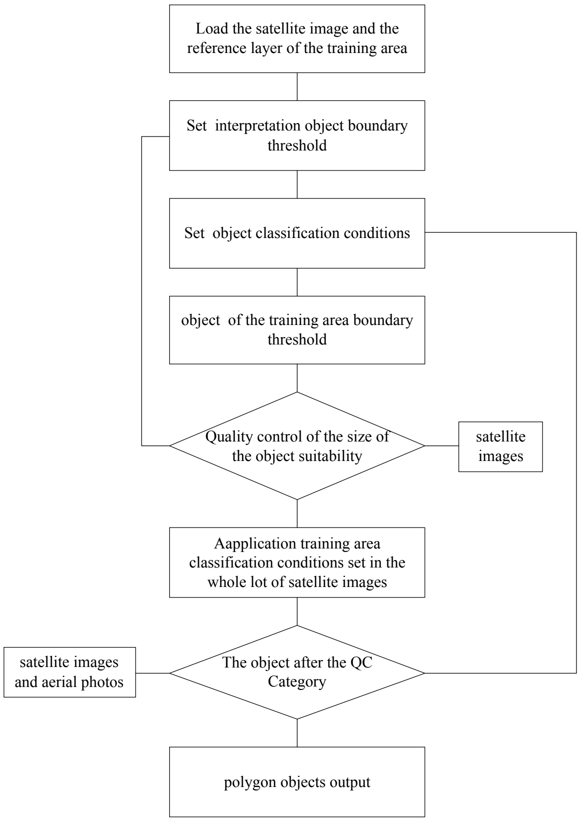


Figure 3. Process of landslide interpretation (Hsaio *et al.*,2009)

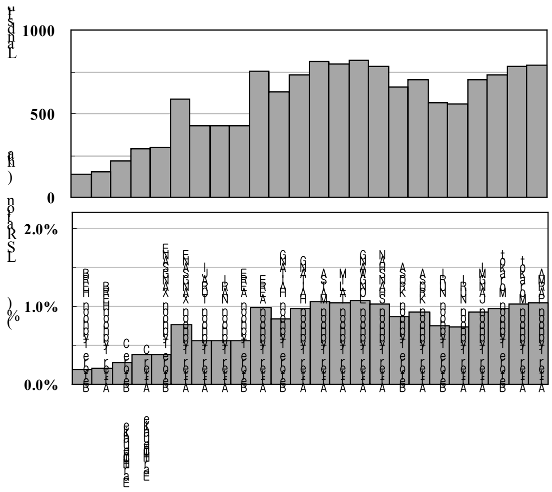


Figure 4. The change of Landslides area and LS Ration

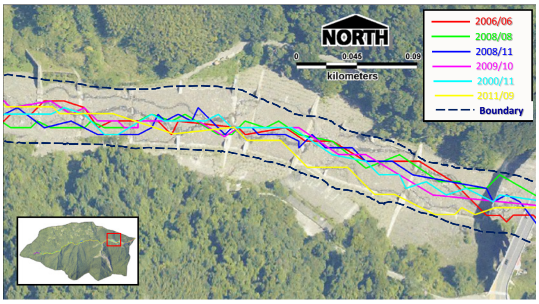


Figure 5. The change of stream center line of Su Yue River catchment

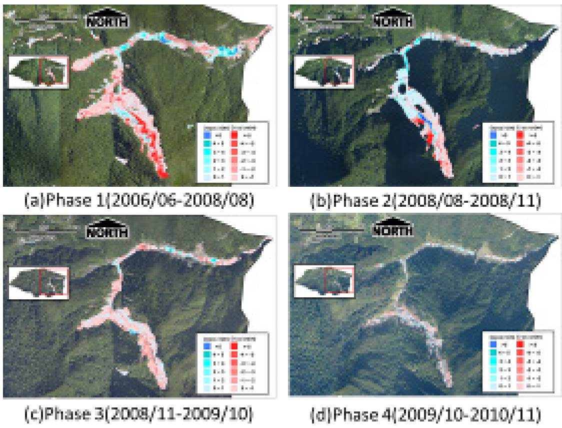


Figure 6. The sediment transport analysis results of Su Yue River catchment

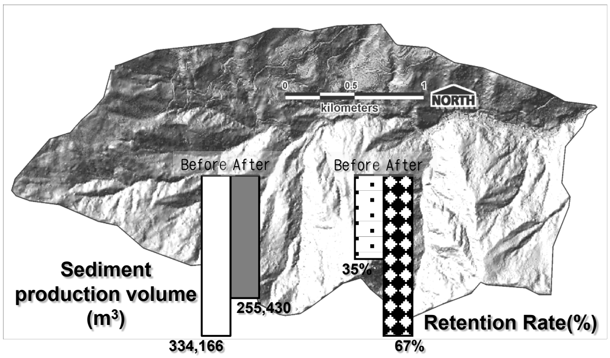


Figure 7. Sediment production volume and the change of blocking rateof Su Yue River catchment

References

[1] Soil Water Conservation Bureau (SWCB) “Study on high quality measurement and terrain historical migration in Shih-Men watershed”, 2009 (in Chinese).

[2] Soil Water Conservation Bureau (SWCB) “Study on historical migration and its mechanism of heavy rainfall-induced sediment disaster in Shih-Men watershed”, 2010 (in Chinese).

[3] Lin, B. S., Chen-Kun Hsu, Shu-Yeong Chi “Application and analyisi of soil depth emperical equation in a watershed scale”, Jounal of Sinotech Engineering, No. 111, pp. 35-45, 2011 (in Chinese).

[4] Hsiao, Cheng-Yang, Hsieh Pao-Shan, Shu-Yeong Chi, “Preliminary Study of Using Unconventional Photogrammetry to Evaluate the Earthwork Volume – a Case Study of the Landslide Occurred on the Cidu Section of Formosan Freeway”, Journal of Chinese Soil and Watershed Conservation, Vol. 29, No. 3, pp. 233-247. (in Chinese)