CONSTRUCTION OF GRID-BASED MONITORING MECHANISM FOR SLOPELAND

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ABSTRACT:

Owing to the rapid developments in the filed of Geographic Information Systems and Remote Sensing techniques, it has been widely available from various images sources to identify ground changes information. Those commonly used multi-scale images provide the sources from macro to micro information and can be served as basic analysis platform in landslide monitoring and land use classification.Taiwan has a unique and vulnerable geological condition with potential disasters easily triggered by landslide occurrence due to typhoon and heavy precipitation each summer season. In order to identify and analyze those landslide information temporary and spatially, this research integrate satellite images, aerial survey data from aviation photography and LIDAR, and remotely controlled helicopter techniques to set up a diverse information network. Satellite images can fulfill the need for large area environmental inventory and land use classification. Digital Terrain Model generated by LIDAR and aerial photos can be used to mark the landslide area and estimate the size and volume. While remotely controlled helicopter can overcome the barriers of site accessibility and data transmitting simultaneously. This network then provides a less time and cost consuming platform by the idea of Grid methodology. The output from this research demonstrates the integration of heterogeneous data into a uniform communication interface to construct a thorough analysis mechanism. It is applicable and feasible to monitor the vegetation, terrain, and landscape changes through land use and land cover identification by multi-scale spatial data.

1. INTRODUCTION

As a result of the typhoon and torrential rains, the head of SHI MEN watershed in Taiwan experienced lots of collapse disaster and a great deal of sediment silted up course of river. Now, the Taiwan government has started restoration and rebuilding works along the destroyed areas and the final goal is to recover the environment.

In this research, we introduce how the related government organizations integrate multi-scale spatial information and technology (Including remote sensing, Photogrammetry, LIDAR and remotely controlled helicopter techniques) to attain the goal of the comprehensive environment is whole to cure to restore to original. And then, in order to build the monitoring mechanism, this research also used the Grid technique to build the sharing data and resource platform.

Grid computing is no longer limited to the traditionally perceived technology capable of carrying out large-scale and complex computation. Instead, it has been extended to a collaboration model which integrates distributed and heterogeneous resources under certain constraints on cooperation and security.

So, this research adopts the emerging grid technology to create a grid-based disaster management mechanism and further the government's abilities to manage disasters, and substantially strengthen the cooperation and communication between the government and academic units.

In brief, this research is the administration and execution of disaster monitoring in Taiwan are able to achieve the goal of overall monitoring with the assistance of various tools and technology distributed in different organizations.

2. STUDY AREAS INTRODUCTION

SHI MEN watershed stretches across three counties cities, respectively be Taoyuan County, Hsinchu County and Yilan County. The watershed spans over an area of 75929ha and it is the third reservoir in Taiwanese region. （as Figure 1）

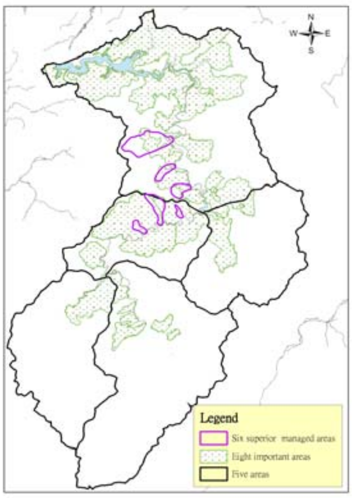

Figure 1. The research range of Shi Men Reservoir watershed

There has various functions such as irrigation, generate electricity, water supply, flood control etc.. Because of the steep slope, the rapid river, unstable geology and copious and concentrated rain, it always experiences collapse disaster（as table 1）.

Year/Month	Typhoon	Average rainfall (mm)	Discharge (cms)	Increase Sludge ($10^4 m^3$)
1957/09	GLORIA	1375	10141	1947
1961/09	ELSIE	493	5703	503
1971/09	BESS	515	5172	523
1973/08	BETTY	607	5665	
1976/08	BILLIE	454	5488	203
1985/08	NELSON	538	4906	370
1996/07	HERB	715	6363	867
2004/08	AERE	967	8594	2788
2005/08	MATSA	819	5322	1000

Data resource：Northern Region Water Resources Agency Ministry of Economic Affairs, National Science and Technology Center for Disaster Reduction.

Table 1. Shi Men Reservoir historic heavy disaster

3. MATERIALS AND METHODS

3.1 Building the Muti-scale Remote Sensing Data

Remote Sensing technology can divided into three kinds images that depend on the height and properties. The three kinds images are Satellite image, Aerial photo, remotely piloted vehicle image and those remote sensing images contain lots of information resources and the optimal choice is based on the goal of research and budget. Table 2 introduces the properties of difference remote sensing images in Taiwan.

	SPOT 5	QuickBIRD	Aerial photo	RPV image
cost	Low	The highest	Low	High
Contain range	Middle	Large	Small	The smaller
Spatial resolution	High	Higher	Higher	Higher
Temporal resolution	Fix	Fix	Depend	Depend
Mobility	Low	Low	High	Higher
Stable	Depend on weather	Depend t on weather	Depend on weather	The weather affect is not important
Process	Easy	Easy	Hard	Hard
Small area application	Adaptive	Adaptive	More adaptive	Best adaptive

Table 2. The comparison of Satellite image, Aerial photo, remotely piloted vehicle image

According to the reference of comparison of Satellite image, Aerial photo, RPV image, and evaluated the properties, goodness, weakness of different kinds of remote sensing images, this study would build the suitable images to carry on the research analyze. On the other hand, according to Shi Men Reservoir watershed had old environmental data, we would use LIDAR technology to get the newest high precision elevation data. So, this study integrates multi-scale images and high precision elevation data as the database of the Grid-based monitoring system. This system could become the decision support system to help the government organizations to analyze the multi-application and provide efficient reference information in managing the Shi Men Reservoir watershed.

3.2 Building the Grid-based Monitoring Platformfor Slopeland

3.2.1 What is Grid?

A Grid refers to an integrated environment which is composed of a variety of computing resources, including different types of computers, a communication network, storage space, and data. A grid computing environment is characterized by extensibility, adaptability, structural unpredictability, autonomy, and multiplicity of management systems. Such computing resources are then converted to ubiquitous, reliable, standardized, and economical computational capabilities (Li et al., 2005). Simply stated, the grid computing technology can be viewed as an extension of the Internet, yet there is essential difference between them. As shown in Figure 2, Internet applications traditionally are used to share independent information content, and users merely access the data stored in web servers. Figure 3 demonstrates that the grid computing technology integrates all the resources on the Internet. In other words, the Internet shares resources passively while a grid moves from passiveness to active integration by pushing organized information to users after specifying resources according to particular purposes.

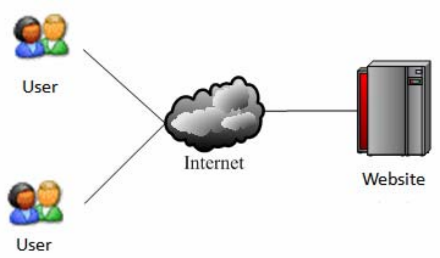

Figure 2. Traditional Internet information service

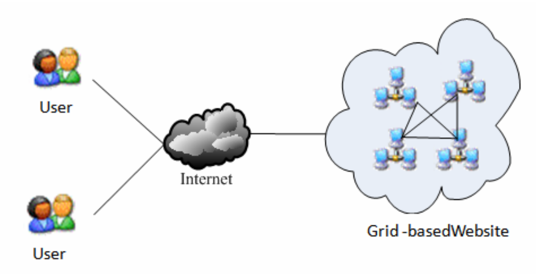

Figure 3. Grid service

Therefore, the superiority of grid technology provides a basic yet complete solution to the sharing and collaboration of resources in a dynamic grid environment. The core component of grid technology is to realize the exchange and share of resources through visualization, high-level abstraction, and combining heterogeneous data.

This study creates the grid structure for disaster monitoring based on international standards and frameworks as discussed in the following paragraphs. We will introduce international standards and frameworks as follow:

A.DoD AF（Department of Defense Architecture Framework）

The Department of Defense Architecture Framework (DoD AF) released by the United States Department of Defense in 1998 defines the relationships among nodes, activities, tasks, assignments, and resources within a domain. The relationships are presented with a framework in the forms of graphs, texts, and charts. Our study applies the DoD AF to the description and planning of a grid-based monitoring mechanism for slopeland, and builds an information display platform for the Shihmen Reservoir Watershed.

B.OGSA（Open Grid Services Architecture）

Figure 4 illustrates the structure of the Open Grid Services Architecture (OGSA). Operation, interaction, and aggregation of distributed services are handled via the OGSA. With the idea of 'virtual domain', these services can brought into full play by functioning as virtual groups and by being shared and managed in the virtual organization. As shown in Figure 5, as OGSA has developed over time, it has merged with Service-Oriented Architecture (SOA) via the integration of framework, and reached common ground on technology. This research executes the grid technology on the basis of SOA, with the combination of Façade Pattern, and achieves the goal of utilizing grids.

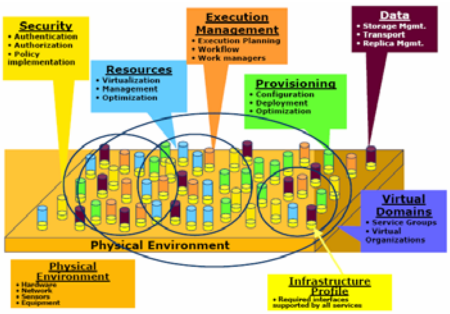

Figure 4. Structure of the Open Grid Services Architecture

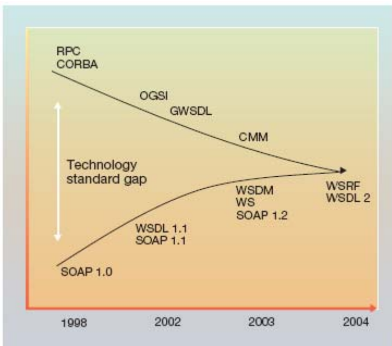

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Figure 5. Convergence of grid technology and Service-Oriented Architecture

C.SOA（Service-Oriented Architecture）

Figure 6 shows an emerging architectural style and important software development technology, SOA, which unifies software components according to the demands of companies. SOA facilitates integration of heterogeneous systems and increases the reuse possibilities of programs. Rather than building or possessing every program component, developers are able to assemble the best services available on the Internet according to their needs. In addition, real openness of systems will be achieved with SOA since the components are not limited to units of functionality or platforms developed by certain vendors.

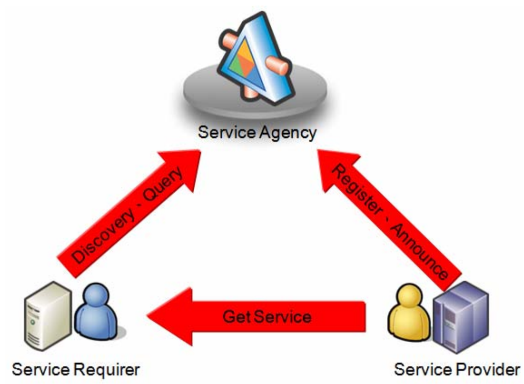

Figure 6. Service-Oriented Architecture

3.2.2 The Architecture of the Grid-based Monitoring System

According to the international standards and frameworks, we design the Grid-based monitoring system. The system's network nodes included four government units and these units had shared their information. So the government can via the Grid-based monitoring platformto get useful data to manage and monitor the slopeland. Figure 7 is the architecture of the grid-based monitoring system.

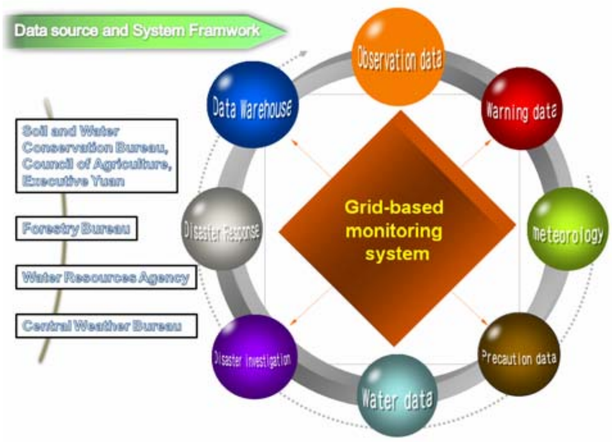

Figure 7. The Architecture of the Grid-based monitoring system

4. RESULTS AND DISCUSSION

4.1 A Service Oriented Architecture Based Grid-based Monitoring Platform Application

In this case study, we can take an example of a service oriented architecture based Grid-based monitoring platformfor explaining the GRID application benefit.

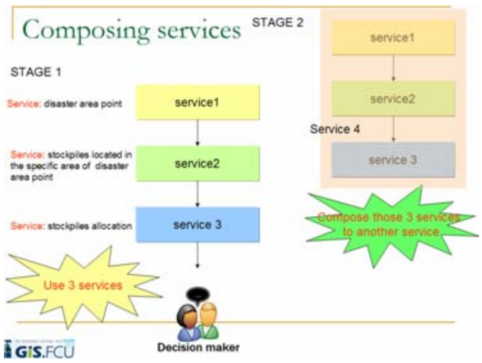

Figure 8. Composing services

The characteristic of SOA is services can be composed to another service. For an example（in fogure8）, suppose one has a requirement for analyzing how to allocate proper amount of stockpiles from warehouse to disaster area and also need to know the route, however, it spend much cost to develop a whole new application system from scratch, after one discover the service directory from Grid-based monitoring system, it show that there are 3 individual services may composed to meet one's requirement, service 1 is a service which provide the disaster area point; service 2 can analyze where are the stockpiles warehouse within a specific distance; service 3 can provide the optimized allocation and route if disaster area point and stockpiles warehouse as well as stockpiles requirement are known.

Hence, after one connect those 3 services to achieve objective, one can compose those 3 services to another service then publish and register on Grid-based monitoring platformto avoid the composing procedure by others who has the same analyzing requirement.

Figure 9 is a demonstration of heterogeneous information which can show that how a local government Grid-based monitoring platform to integrate and compose the services published by other department. And also the system can enhance the performance of government administration.

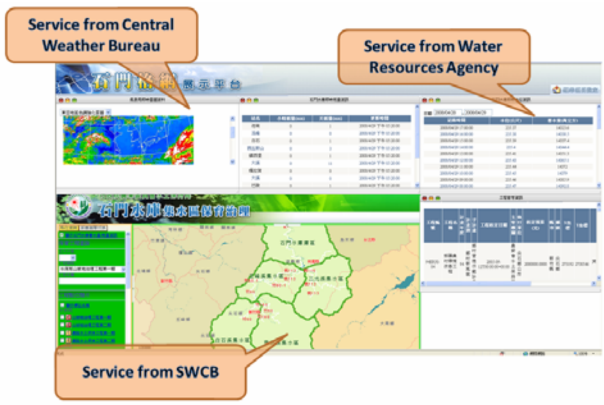

Figure 9. a demonstration of Heterogeneous information

4.2 The Grid-based Monitoring Platform Continuity Application

As we use the SOA mechanism to build the Grid-based monitoring platform, the platform can integrate heterogeneous information which from different government units but also develop different continuity application. So in this study, we would also use the multi-scale images which are in the Grid-based monitoring platform database to do some continuity application.

4.2.1 Discussion of Collapse Disaster Interpretation

Using remote sensing images to recognize the landslide areas, the best practice was to use surface spectral reflection to recognize the cover area. For example, in the original vegetation area, when the landslide areas were produced, it would cover the original vegetation, and the surface of spectral reflection would become non-vegetated. After comparing the image obtained before and after the event, the change area can be recognized. So, this study used satellite image, matching up aerial photo information and local investigation to recognize the landslide area in the Shi Men Reservoir watershed.

Image classification process in this study can be divided into two parts; first, we employed the Maximum Likelihood Classifier based on supervised classification and SPOT5 satellite image was selected to classify the large scale of land use types. The classified categories include forest, agriculture, landslide, water, lake, developed area and cloud. Secondly, in order to construct the detailed land use data, we used the aerial photographs and RTF to interpret near urban and populous area. The research flow chart was shown as Figure 10.

There are 173 training sites which has been chosen in 2006 SPOT5 satellite image. The TD index of each classified categories is higher than 1900, and the average is 1995.7. That shows the differential process effect is reasonable and it could assist the further image classification. The result was shown as Table 4. After image interpretation process, as Table 5 the overall accuracy is 91.25％. The related result was such as Table 6 and Figure 11.

	Water	Forest	Farm	Build up	bare	collapse	Road	Others
Water	0	2000	2000	2000	2000	2000	2000	2000
Forest	2000	0	1996.58	2000	2000	2000	2000	1973.26
Farm	2000	1996.58	0	1999.32	2000	1997.35	2000	1994.63
Build up	2000	2000	1999.32	0	2000	1990.72	2000	1995.28
bare	2000	2000	2000	2000	0	1975.44	2000	2000
collapse	2000	2000	1997.35	1990.72	1975.44	0	2000	1978.53
Road	2000	2000	2000	2000	2000	2000	0	2000
Others	2000	1973.26	1994.63	1995.28	2000	1978.53	2000	0

Table 4. The TD index of training sits

	Water	Forest	Farm	Build up	bare	collapse	Road	Others	Row sum	Ref. sum	Class. Number	Correct Number	PA	UA
Water	30	0	0	0	0	0	0	0	30	30	30	30	100%	100%
Forest	0	46	4	0	0	0	0	0	50	49	50	46	93.88%	92.00%
Farm	0	3	26	0	0	1	0	0	30	30	30	26	83.87%	86.67%
Build up	0	0	0	17	1	0	0	2	20	23	20	17	70.83%	85.00%
bare	0	0	0	1	25	4	0	0	30	33	30	26	78.79%	86.67%
collapse	0	0	0	3	6	185	2	4	200	193	200	185	95.85%	92.50%
Road	0	0	0	0	0	3	17	0	20	19	20	18	94.74%	90.00%
Others	0	0	0	2	1	0	0	17	20	23	20	17	73.91%	85.00%
Colum sum.	30	49	30	23	33	193	19	23	400	400	400	365		
OA= 91.25%														

Table 5. the error matrix of satellite image classification

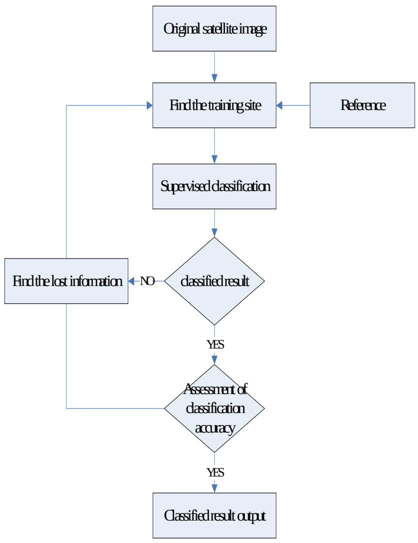

Figure 10. Image interpretation Process

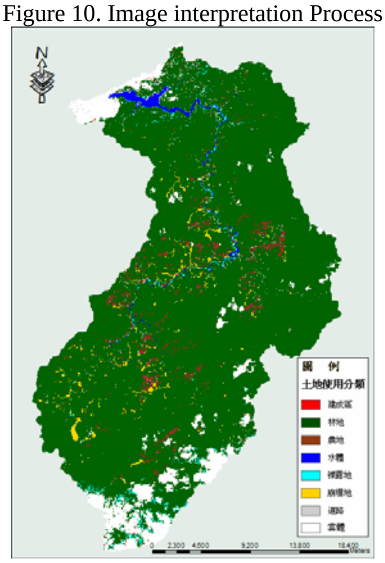

Figure 11. Interpretative result

Class	Water	Woodlands	Farm	Building	Exposed	Collapse	road	others
Area(ha)	706.72	65690.1	1580.18	182.98	705.36	937.16	385.29	5816.62

Table 6 All kinds of interpretation results

4.2.2 The Detection of Environment Discussion

In order to provide efficient reference, this study collected or built multi-scale images, including the high resolution satellite image, high spatial resolution aerial photo and RPV image. As shown in Figure 5, there was the multi-scale images built results and by these data it can accord with related engineer rebuild.

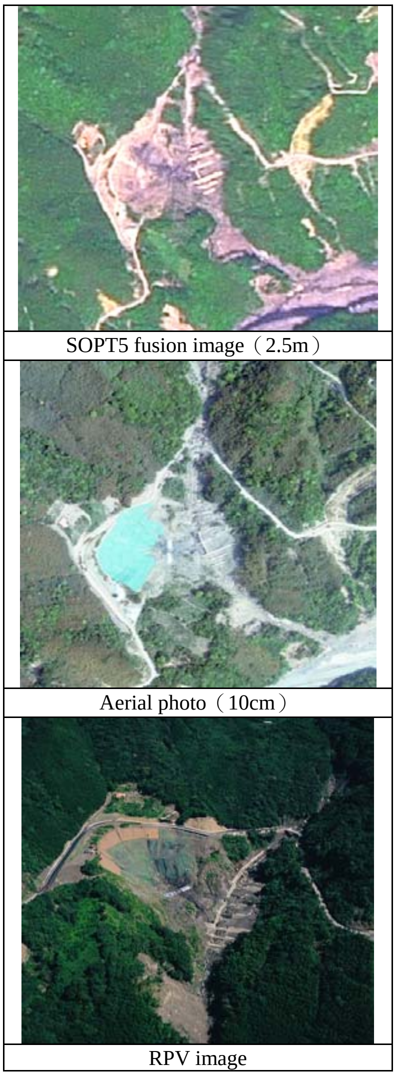

Figure 12. The multi-scale images built results

4.2.3 3D SIMULATIONS

The raw data needs to be integrated in post-process, such as ground GPS basic-station, Aircraft-track GPS data, IMU Inertial navigation system, and search GPS refined-ephemeris data. BY POSPac software, and three dimensions coordinate and position of parameters, It finds the optimum answer from all of the air-routes gradually. Figure 13 and 14 are shown about calculation with track parameter by POSPac., and GPS to resolve the orbital position in three-dimensional space precision analysis, and integrate the IMU to calculate the accuracy orbital.

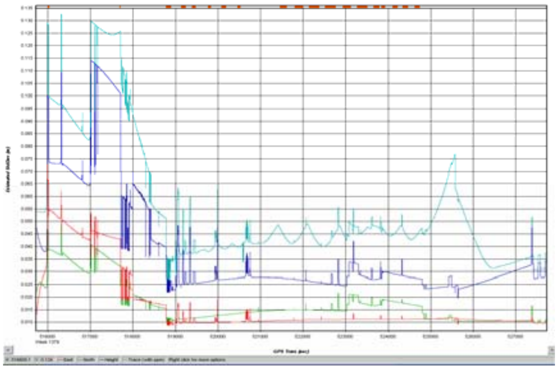

Figure 13. Using GPS to resolve the orbital position in three-dimensional space precision analysis (xy<2cm, z<4cm)

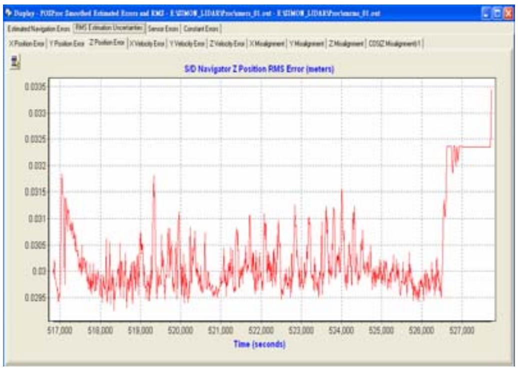

Figure 14 the accuracy of elevation after the accuracy orbital by using GPS+IMU (z<4cm)

To integrate material LIDAR scanning data (recorded distance of the each, scanning angle, signal intensity, and the each scanning echo and time), and the parameter of the track of the carrier flies, and rate of the instrument, and used the software of the post-processing by ALS50, to work out the three dimensional coordinate value of each echo and the intensity value under the coordinated system of WGS84, so-called the point cloud data. When we operate the point of cloud data, we should set the major parameters by software of ALS50 Post Processor. And then, involve the filtering processing of the ground point of cloud data, select the ground to classify of the TerraScan function, and also use TerraModel cloud editional function to cut a cross section by each 50m to discover the best ground trend line, and composes the 5M DEM file. Undergoing the ground points by artificial filtration processing may obtain Figure 15, the data of 5m DEM in whole area.

The 3D simulation result can display the surface details and reserving time, thus reducing the overall cost. So, this study integrated updated high resolution of aerial photos and high precision DEM data to simulate the 3D environment. The simulation result shows as Figure 16.

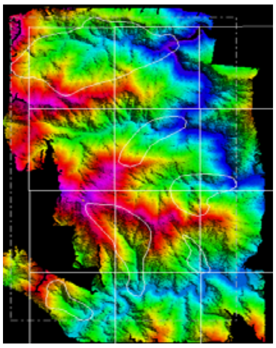

Figure 15. the data of 5m DEM in whole area

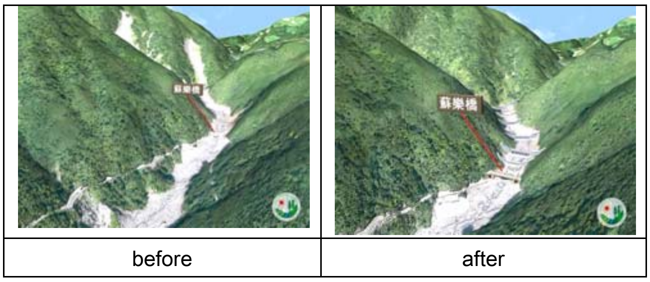

Figure 16. 3D visualized change in Shi Men Reservoir watershed

5. CONCLUSIONS

The use of grids was proposed to solve the problems in heterogeneity, distribution, and efficiency triggered by networking. Information worth sharing is uploaded to a platform which can publish and register data and control the flow of information; users then access the platform to search and fetch valuable information and value-added applications. On the platform, all of the heterogeneous and distributed data is encrypted, decrypted, monitored, and hence interchangeable according to international standards. Because the employment of grid computing does not require large-scale modifications of existing systems, grids designed for different purposes are being developed.

And also, GIS system and remote sensing technology can be integrated in widespread applications. In addition to the above application, there are several applications such as those in atmospheric sciences, oceanography, geophysics, biology and military affairs and so on. In Taiwan, the multi-scale images get the advantages of high resolution, low price and easy reception, in addition to the aerial photo and UPV image technology. It is believed that the judicious integration of all these technologies will develop more applications that are viable commercially.

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