REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM METHODS TO STUDY, EVALUATE AND ESTIMATE GRAVIITATIONAL LANDSLIDE IN SON LA AREA

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ABSTRACT

With 450 square kilomet area , Son la provincial capital is a small town in moutaineous area , the West-Northern part of Viet nam.As the developing condition in Viet nam , in last several years , Son la Town has been fastly enlarged with new constructions, roads and buildings… with very dynamic geotectonic regime, multiform of lithological component and complicated geotectonic-structure, difference land forms were formed after weathered process of geological periods, among these , karst land forms of limestone are domaintly such as : caves, sub surface caves , sub surface rivers, karst holes,karst tunels,karst lakes…Abover these geological basement , forest cover has been seriously destroyed. With such condition, in last several years, disaster phenomenas are usualy occurred in many place of the Sonla town and to jeopadize difference constructions. Purpose of the project is to study and to establish a map in which shown clearly about locations where phenomenas of land slide and land depression can be happened with difference probabilities and then to point out suitable solutions for disaster prevention . To carry the project, GIS and RS with Landsat- TM, SPOT images and aerial photography were visual interpretated, field-GPS locationing, alternative with some conventional digital image processing techniques wich done by Geomatic- a data base of the project were established. Weighted values are also calculated for each separately natural components for determination of their probability relationship to disasters in the study area. Out put result are raster maps, where shown locations in difference probability of disaster occurring. The study also to clear out causes of disasters and to suggest suitable solutions for preventing of disasters such as : growning of some special plants types ,engineering solutions , planning and management, monitoring..The result has been accepted by the local government and will be applied in the developed planning project

1. INTRODUCTION

Son La town accounts for square 32505 acres, includes 8 communes. Due to the favourable location, this area plays an important role in development of the province in separate and Northwest Part in general. Recently, Son La's economy has increasingly developed, especially in the infrastructural development. Whereas, according to the natural rule, when economy develops, more resources are extracted to increase the hazards more and more seriously.

The Geological structure of Son La town is partitioned complicatedly, due to this largely developmental process of differentially tectonic movements. The geological diversity creates the diversity of topographical forms, weathering, soil, vegetable cover, surface water, ground water, and some geology-engineering conditions etc. The natural characteristics of Son La town that has existed presently is the result of active, secular changing process to gain the balance temporarily. From 1979 up to now, Son La has planned, opened and modernize its infrastructure increasingly that include traffic system, public construction. Especially in the stages from 1984 to 1989, constructional process has been opened to break the natural balance, to appear. The landslide process usually appears in rainfall season, especially in

strongly flooding rain time. The gravitational landslide process has strongly effected constructional sites, caused the confused, worried, uncalm psychology for people, some time loss property, man. So from 1991, this problem has been concerned especially by several administrative levels, sectors from the centre to local. Many sections have been deployed to find out the cause and the hazard of the gravitational landslide.

Project "*Remote sensing and geographical informative system methods are use to study and evaluate and estimate the landslide in Son La town*" has been deployed on scientific base to establish the natural data of gravitational hazards in Son La town and calculate scientifically and map out landslide-estimated maps of the town in general and Khau Ca - Khi Tuong in separate. Some pertinent solutions are also offered to avoid and reduce the hazards in Son La area.

2. DATA USED:

+ SPOT image of scale 1:50.000 has been taken on the town on Jan 1, 1996. Band from 20 to 30m. The image is integrated in false colouration from 3 channels: light green, dark green, red spectra. Many pieces of information of weathering crust, soil, water, vegetable, geology, topography, hydrogeology etc. and another tectonic elements are shown clearly on the image.

+ The preference, field test of landslide location has been deployed in March 2000.

+ The past archived documents for reference includes: geology, geomorphology, geology-engineering, tectonics, seismology, hydrology, explovational drill, hydrogeology, etc.

3. THE STUDY METHOD

The remote sensing (RS) and geography informative system method (GIS) that has been applied officially to the project has been used widely in several universities and institutions in the world and has been deployed in Vietnam.

The software that is used includes: ARC/INFO, ILWIS, SUFFER, EXCEL, MADINFO etc.

4. THE DEFINITION OF HAZARD

In the massive movement without supporting of water flux or transportational agent, the landslide is the concept used to show the massive movement to occur apparently along slice surface (Crozier, 1988).

In this research, the concepts are used as same meaning: massive movement, ground landslide, escarpment landslide, broken escarpment. The concepts are shown separately: hazard, vulnerability, risk, based on the reference of Varne 1989 as following:

- Natural hazard - H: Occurred frequency of potentially hidden deformation in long time and in area.

- Vulnerability - V: Loss level of an element or series of elements occur in damaged place that show in scale from 0 (0 without damage) to 1 (1 is total loss).

- Specific risk - RS: Loss level of special phenomenon that show is the product of H and V.

- Element at risk - RT: is calculated as residences, properties, economic activities, public sites etc., based on the damage site.

- Total risk - RT: The loss estimated numbers, injured people, the damaged economic activities are caused by unusually natural phenomena that are calculated normally by specially damaged results.

$$RT = (E)\ (RS - E)\ (H.V)$$

- The normal landslide is shown on many differential layers that are characterized by differential landslide. The same regions are listed, divided in the same property, in the same hazard, that are caused by massive movement. (Varner, 1989)

That focus on solving the difficulties of the damageable and hazard quantities whereas, the statistic data are impossible to control totally large region. Finally, the hazards are divided relatively as quantity or semi quantity as: low, average and high hazard etc., of from 1 to 5 level, from 1 to 10 level.

5. MAPPING OUT THE HAZARDS AND ANALYZING THE HAZARD

The ideal map of unstable escarpment area includes much information of special; time statistics, type, gradient, speed, slide distance, movemental limitation of mass in the region. (Hortten and Viberg, 1988). Some research steps for mapping of slope vulnerability as follow:

a) Analyzing location: mapping out the locational situation of massively movemental characteristics, in which show location that has occurred in the past.

b) Analyzing direct quantities or indirect quantities of the number of geological, geomorphological information etc., that relates closely to the landslide.

c) Analyzing statistics: indirect method.

The connecting maps of massive movement are analyzed statistically to estimate the hazard in general, in separate. The important data are shown to calculate finally.

d) Analyzing decision: The indirect methods are used to calculate the integrated parameter of connecting landslide. The most general data are decided in studying process.

e) The landslide occurred frequency analyzing: The indirect methods that contain the parameters of earthquake or rainfall or modeling.

The used resources: SPOT images were taken in September 1997.The imagery deciphering methods and techniques: The landslide situation maps that are mapped out, legended compose of the units: newly appeared slide traces, falling slide traces, slide arcs, ground sinking regions.

The situation of landslide process is seen in Son La town as following:

The landslide traces that are distributed in many places are the olds they run parallel the mountainous – hill feet to create the slide arcs.

The occurred process of the slide traces that have occurred in many years cover each other to create escarpment foot alluvial patches in rain season. Generally, the stable areas are weak, the slide phenomena can continuously occur, especially in rain season.

The slide arcs that are decided clearly by the evidence are cracking traces round the mountainous escarpment. The cracking traces that are clearly seen mostly create deep trenches that are filled by fine material due to washing process and transportation nearby.

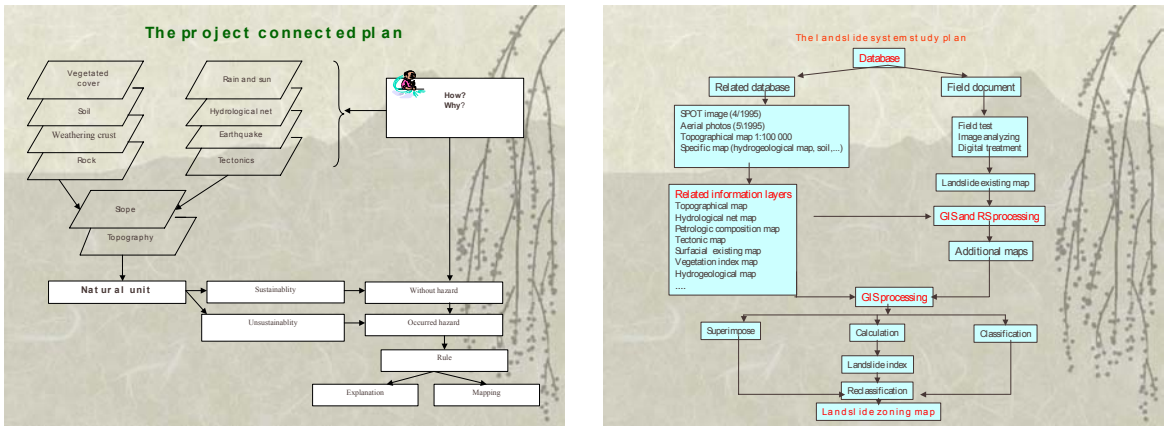

Figure 1: The remote sensing methods are used to map out the landslide situation

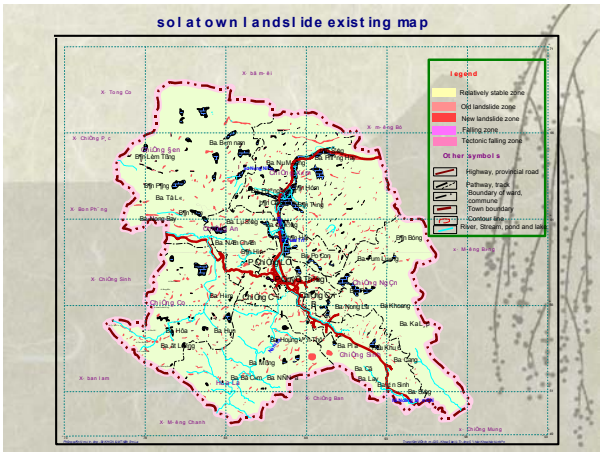

Figure 2:The slide traces are recognized on the images.

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The slide arcs appear in the layers of indigenously sedimentary weathering crust they are at age of Trias (T_2 dg) or basic mixed sediment, age of Pecmi. The area or size of the arcs belongs to the thickness, dip and material composition of weathering crust. The arcs appear

from stream-river surface to hill-mountainous foot where contain ground water in rain season to create slide table along kaolin layer of weathering crust.

A long main valley, branches of upper Nam La stream exist many slide traces and slide arcs in many elevations.

The arcs that have just occurred normally keep unchangeable form of slide mass, slide wall and slide distance. They are discovered clearly by light traces on the images that appear near hill-mountainous feet on river valleys.

The signs of the old arcs are normally erased by developing of vegetable covers, whereas, the arcs are easily recognized by evidences when tested in the field.

Road $N^0$6 wall of Eastern and Southeastern area of Khi Tuong hill, the landslide phenomena occur strongly in weathering layer due to flattening the road wall to build house.

6 CLASSIFICATION AND CAUSE OF THE LANDSLIDE

The landslide due to the slope load is caused by nature and made-man activity.

In Son La, there are three load types seen importantly:

- Due to the constructions are focused on the slope.
- Water is percolated in weathering crust increasingly.
- Material sediment is accumulated more and more on the slope.
- The ground is sunk in karstic valleys.

Out of shrink causes of clayey layers in the modern sedimentary formation orginates from the lacustrine, the ground sinking phenomena are appeared popularly in the subsurface karstic action area (Chieng Khoi, Chieng Xom commune etc.).

- Collapse phenomenas

Differing from the landslide, the collapse process is characterized by fast movement of rocky mass that does not connect with bed rocky mass. Belonging to the integrity of slope, the rocky masses move in falling form from the elevation to the low of topography, and roll along the slope. This process is activated by internal activities of the earth such as earthquake that cause the serious hazard. The karstic masses that compose of massive limestone in Son La usually create vertical walls. They favor for collapse process. The constructions are destroyed by rolling and falling of limestone masses from every tens cm^3 to over $5m^3$.

The bounder masses that are fallen in big bounder or mountainous foot. Falling masses related to earthquake (small) accompanying the heavy rain to erode the foundation foot. The collapse phenomena have been occurred for several years. The collapse causes to endanger the mountainous foot area strongly.

7. THE GRAVITATIONAL HAZARD IS ESTIMATED BY GIS PROCESSING

The informative layers are completed to treat GIS and map out the landslide estimated maps such as geology, geomorphology, slope, weathering crust, land use and vegetation cover etc. Some steps are deployed as following:

To study the landslide estimation, the steps are developed, generalized in system plan 1: This is the model that is used widely in the world, especially in becoming the educational books of International Training Program (ITC) in studying unstable slope area.

- Image processing

The images that are treated are while and bleach images panchromatic, contains the critical solution (band) 10m. The images that are updated apply techniques to lasting dark band, filter techniques of all direction etc, to show landslide elements and faults clearly. A part from image making techniques. The land use and vegetated covers are easily recognized by vegetation index.

- Spatial modeling

This is the most important step to map out the estimated maps of landslide. The work is deployed in order as following:

+Count statistically the units of modern landslide maps.

+Put together the modern landslide maps with naturally compositional maps such as: geomorphology, vegetation cover, hydrological net, fault etc. Apart from the fault maps are mapped out automatically to consider the zones that early occur landslides under fault affect.

+Numerable importance of every element is calculated as:

$$T = \frac{\Sigma s \text{ (landslide)}}{\Sigma s(\text{area}) - \Sigma s(\text{landslide})} \times 100$$

T is calculated in detail of every map unit in pecentages (%). The natural element is calculated generally to take the average values.

$$Ttb = \frac{\Sigma tn}{n}$$

Where:

Tn: The numerable system of every map out.

Ttb: The average number system of generalized map

n: Map unit (with weihted values)

The map results are calculated by formula:

$$\text{Map out} = \frac{\Sigma Ttb}{m}$$

Where:

Ttb: The numerable system of every map unit

m: Analysis of element unit (m=5 in the project)

Finally, the results are classified according to the levels 5 or 10. The landslides are shown under affect of the natural elements that considered.

In treatment process, the informative layers that are unable to count are geomorphology and weathering crust.

8. NUMERABLE IMPORTANCE THAT IS CALCULATED TO THE HAZARD

When the information of landslide map that is put together, the Numerable importance is calculated as following formula:

$$K = (\Sigma Si / \Sigma Sn) \times 100$$

Here: K : numerict values (%) and then reclasifie in to scale from 1-5

Si: Area of hazard type (i)

Sn: Area of hazard type (n)

n: Volume of hazard type.

The numerable important level is calculated to figure out:

When every element with separated map layer is calculated by CROSSING method (cross mapping) with the landslide map for each unit of separeted layear to gain the results of K value.

9. CALCULATE AND MAP OUT LANDSLIDE ESTIMATED MAP

The informative layers are treated by GIS to use the projects and select effective projects that are not deployed by map method normally.

With software ILWIS (Integrated land and water information system), the estimated maps are mapped out in several steps.

The most effective calculation: Areas that have high probability of hazard are the highly numerable important areas of natural elements.

The hazard map =(Max Σ weighted map)/n

Where:

The hazard map is the estimated map.

The compositional map is the one that contain the compositional layers is evaluated by numerable importance.

n : Informative layers

10. MAPPING OF VULNERABILITY AREA OF LANDSLIDE

The gravitational hazard estimated map is mapped out as levels and types of prospeted landslide map.There are 3 types of mass movement such as: Collapse, underground subsidence and landslide. Every type has 2 levels of high and average probability (level 5 and 4 in the considered levels). Particularly, the zones that cause the collapse highly and normally are the carbonate areas and differ from this particular point to the other. Fault density, slope and a vegetated cover is the same, the landslide relates closely to the fault system. In another word, the landslide is a function of slope, thick weathering layer fault density, vegetated cover.

Distributional area, collapse and landslide hazards that are centrally distributed in half area of NE part of the town focused on 'Chieng Xom, Chieng Den, Chieng Co commune. The strong hazards occur and concentrate in SW part of Hua La and Chieng Co commune.

According to the estimated maps, three differentially gravitational falling slide types are shown in the town.

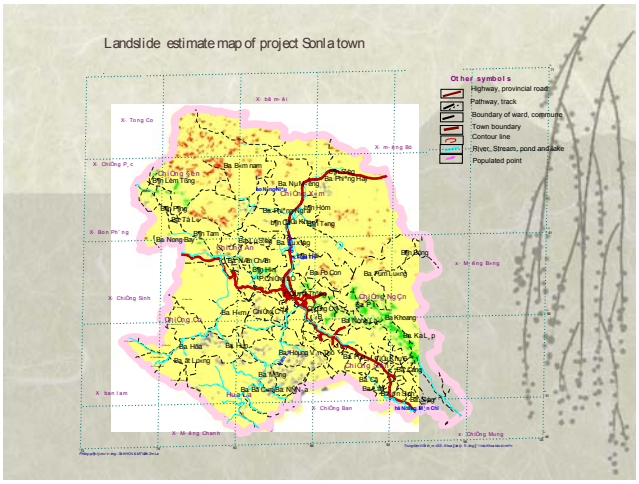

Figure 3: Result map with the maximum probability of vulnerability to landslide.

11. GENERAL CONCLUSION

Project: "The remote and GIS methods are used to study and estimate the gravitational landslide in Son La town" is deployed in a shorttime and in small scale study size.

The results of project are:

-To establish the database of environment and mineral resources, not only for the gravitational landslide hazard study but also for many goals of territory management and environment.

-The gravitational falling slide hazard causes are analysed and figured out clearly in the project.

-The objective information of quantitative and qualitative is shown in the estimated map. It will be the most effective information to extract and manage environment.

-Whereas, due to the average scale of study level the results that gained are shown up in the orientation. If project wants to gain the results effectively, will study deeply.

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