2013 International Training Workshop of Earth Sciences

Detection and Actions to the Large landslide Harzard

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OUTLINE

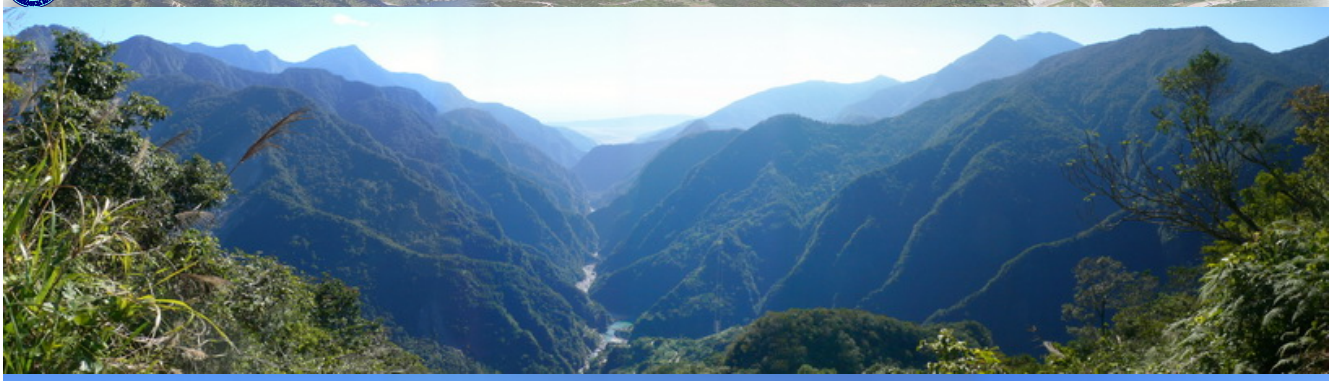
Geologic Characteristics of Taiwan

Taiwan Rock in Ping-Tung

Small Taiwan in Peng-hu

If
Taiwan is a flat land, we wouldn't have so many slopeland disasters.

Unfortunately…



Most landscapes in the mountain area are not look like here

The realities are

Damaged landscapes hit by Typhoon Morakot

Dainiao Village

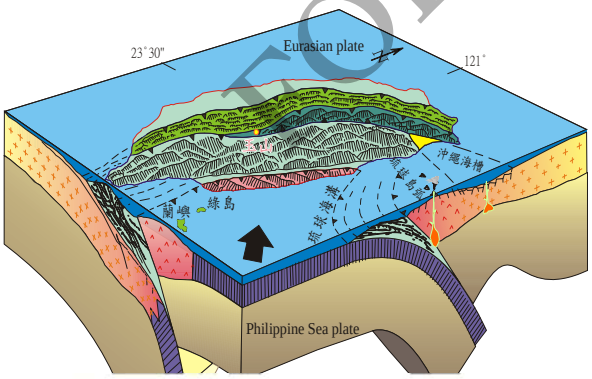
Shiaolin village

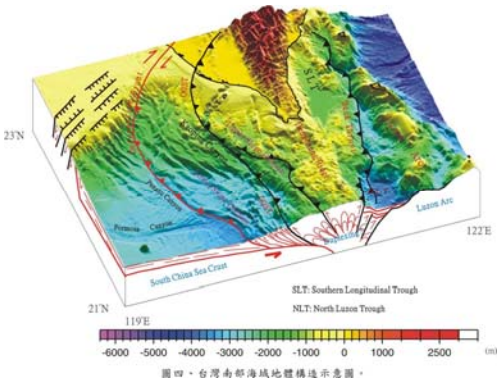
Chiamu Village

Landslide dam , Taimali

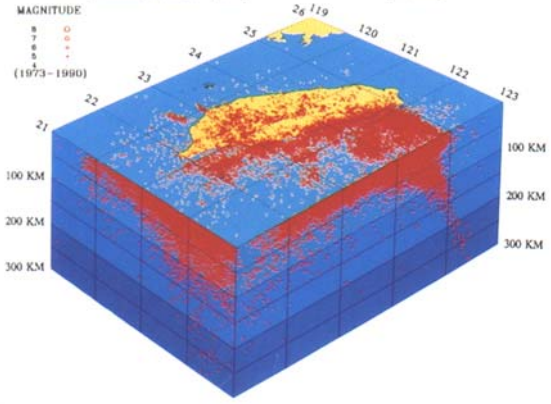
(from Yu-chung Hsieh)

The Results of Active Plate Tectonic Movements in Taiwan





圖四、台灣南部海域地體構造示意圖。

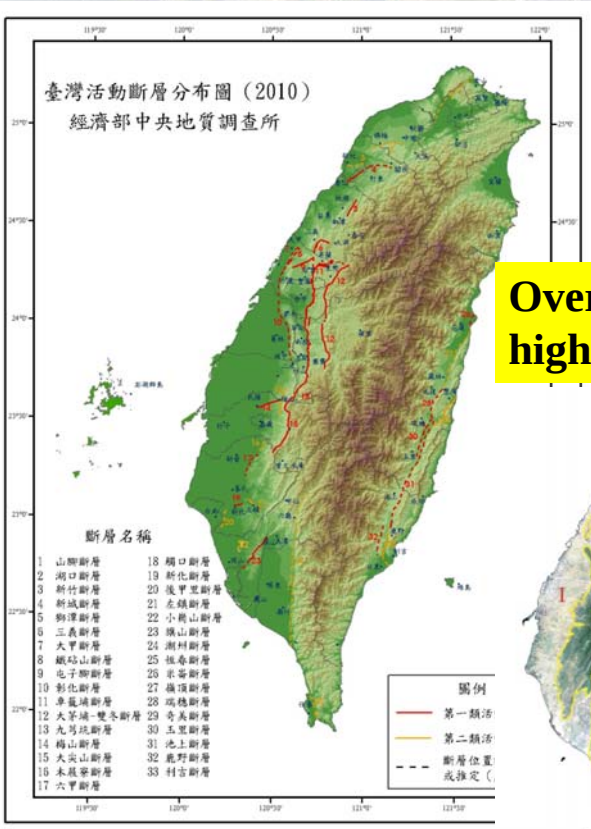


(concept from Wu, T.G. & Chen, M.M.)

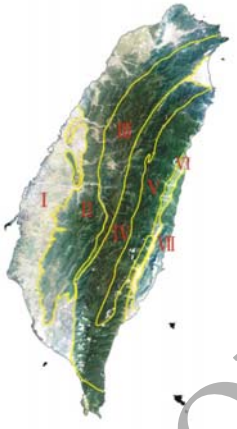
http://www.aifang.info/blog/archives/tag/%E8%BB%8A%E7%A6%8D

＞33 Active Faults locating in Taiwan

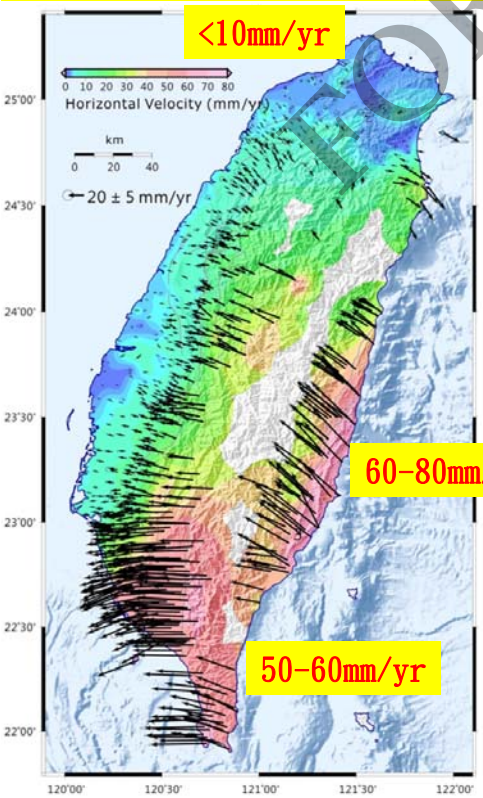
(1999 Chelungpu Fault)



Over 75% of highlands



Horizontal Displacements analyzed by GPS Data in Taiwan from 2002~2011

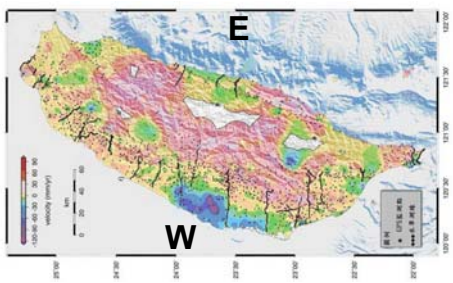


◆Continuous Observation：

- ➢67 Continuous record GPS stations
- ➢8 Geochemical sampling stations
- ➢13 Borehole strain-gauge stations

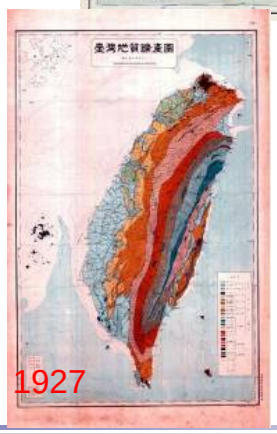
◆Measurement once per year：

- ➢850 points for GPS to measure
- ➢41 Lines, about 1,000km long for leveling measurement across the active faults



Vertical Displacement

(羅偉，2008)



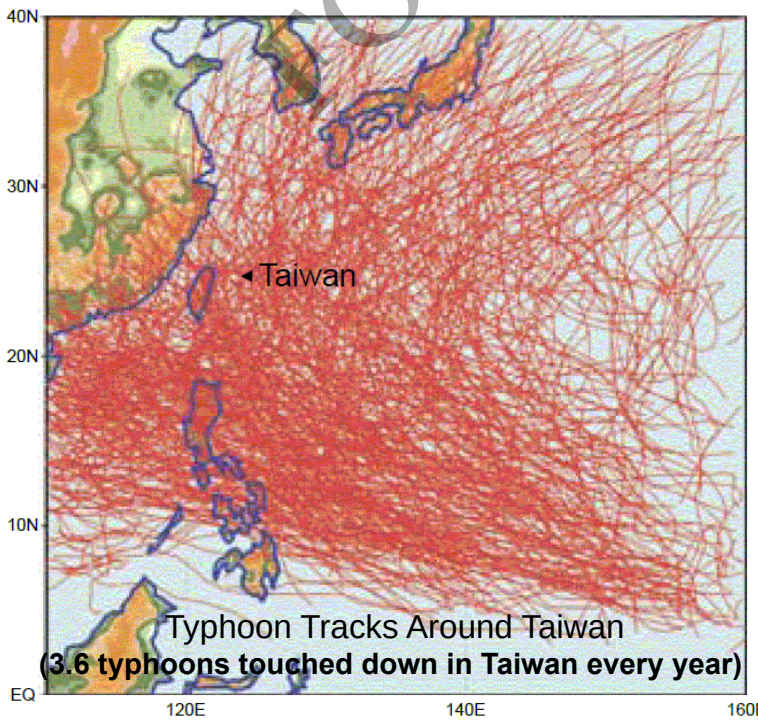
Igneous Rock

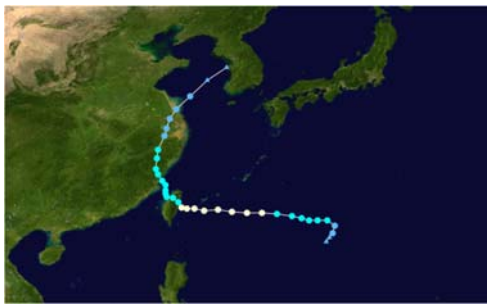
Sedimentary Rock

Low-grade Metamorphic Rock

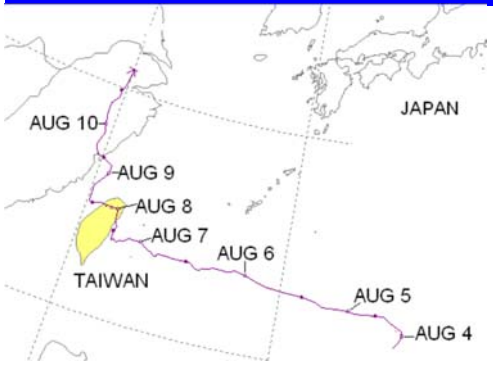
High-grade Metamorphic Rock

Taiwan is located on the tracks of typhoons in northwest Pacific area





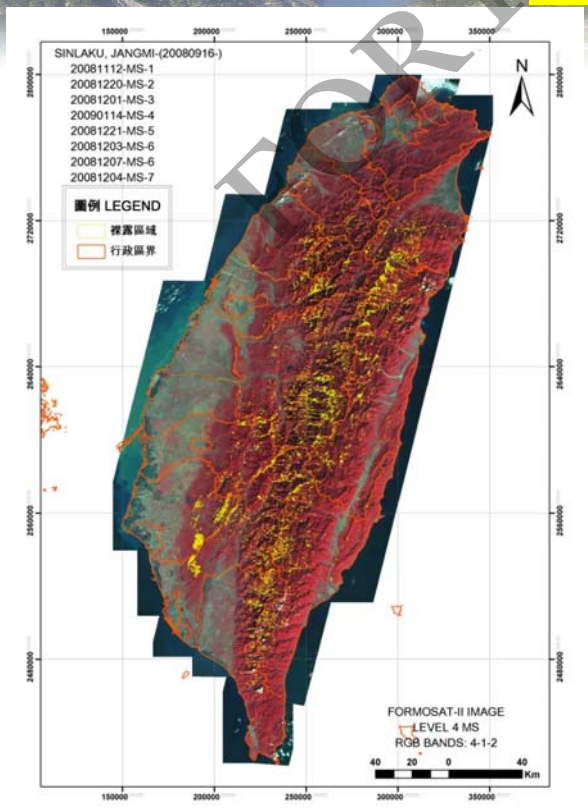
Track map of Typhoon Morakot



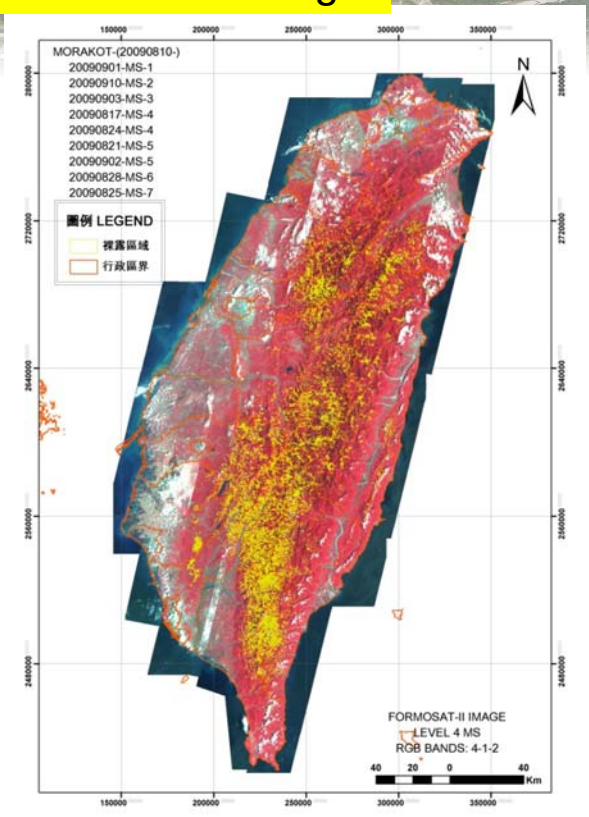
(From **Jin-King LIU**)

Landslides occurred in Typhoon Morakot damaged area

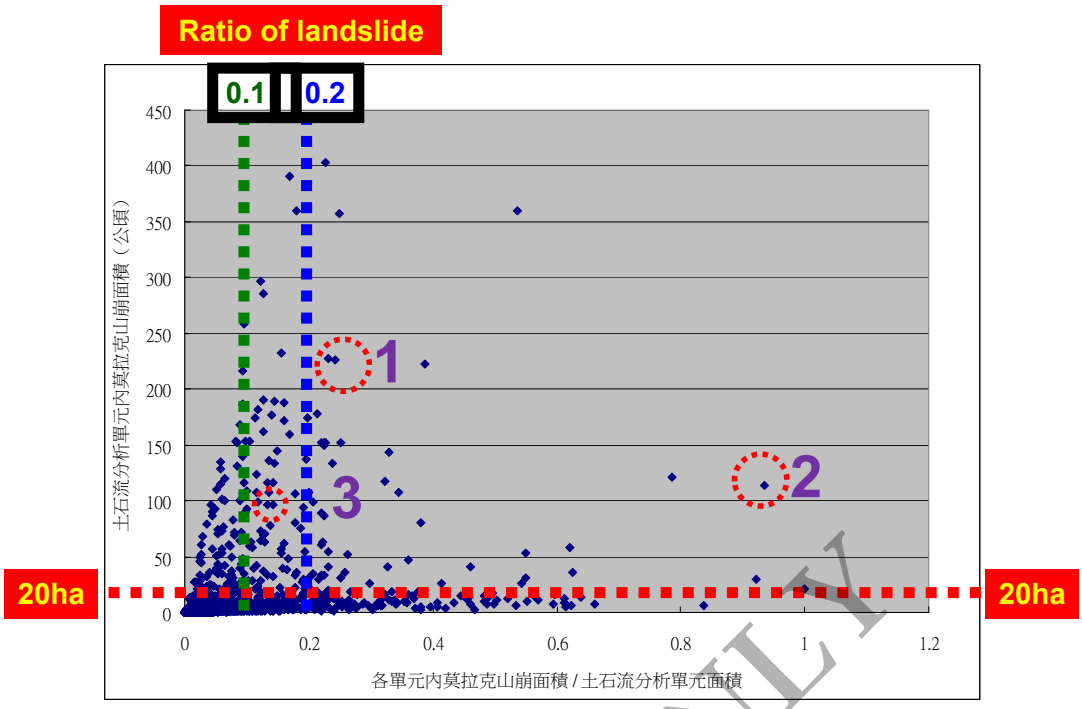
FORMOSAT II Image

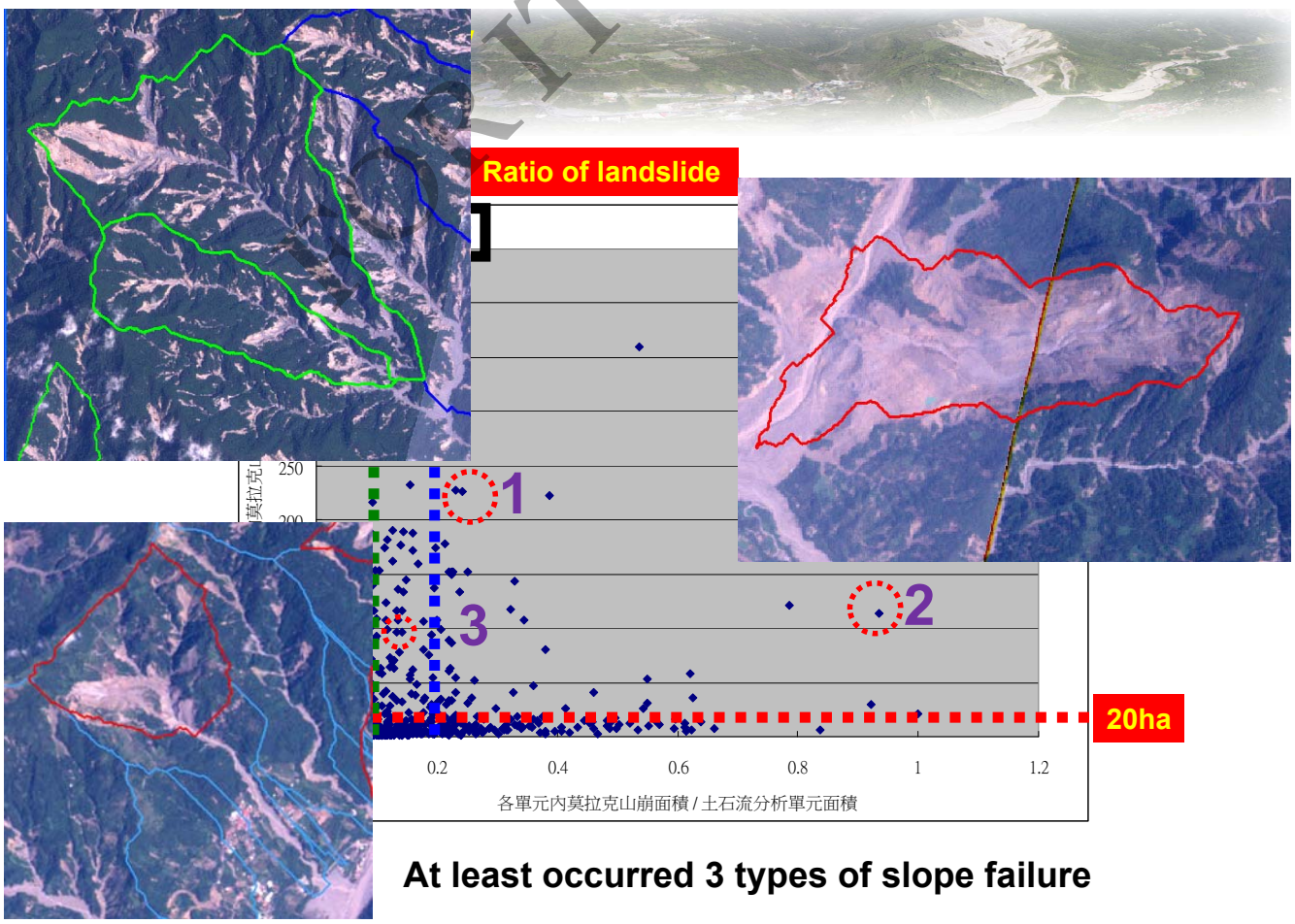


Bareland before typhoon Morakot



Bareland after typhoon Morakot



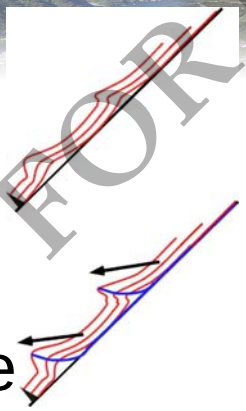


At least occurred 3 types of slope failure

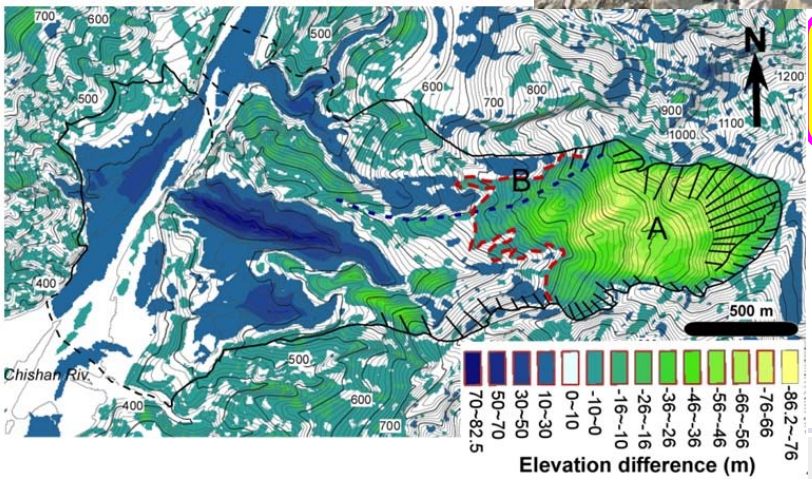
2009. 09 ⬆ 2010. 10 Chishan river valley(S→N)

Memory from the Shiaolin Landslide

Buckling In Shiaolin Landslide



(From Prof. Masahiro CHIGIRA)



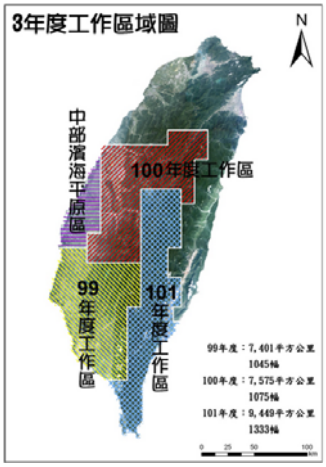
Elevation changes before and after the large landslide, from 5mx5m DTM data

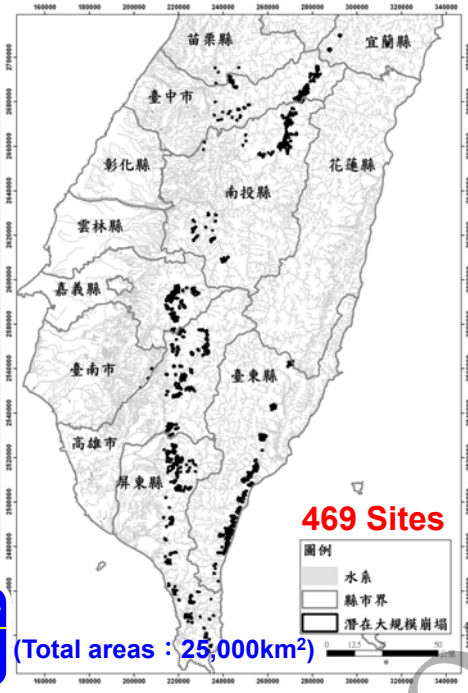
Catastrophic landslide induced by Typhoon Morakot, Shiaolin, Taiwan(**Tsou, Feng, and Chigira, 2011, Geomorphology, 127, 166-178**)

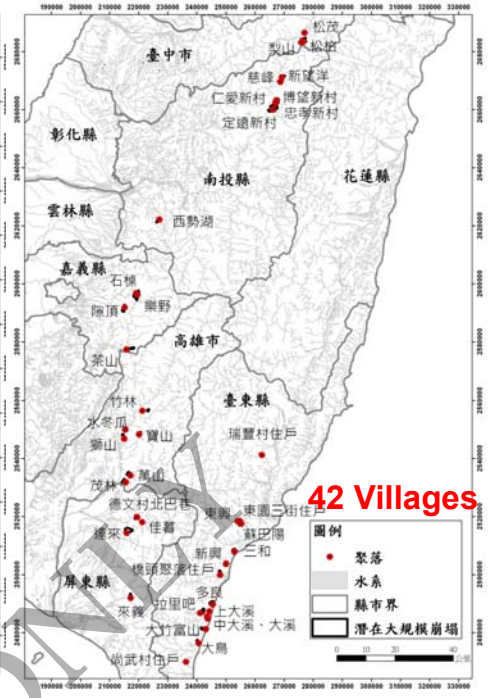
Large Landslide

(Studied areas： 2,100km^2)

469 Sites were identified
56 Sites located nearby
42 Villages







" National Land Conservation of Geologically Sensitive Zones" in Morakot damaged area

(Total areas：25,000km^2)

(about 10% of the studied areas with potential)

Large Landslide

Large Landslide

Large volume
Very deep
Sliding very fast
Including bedrock
Severe damaged

Volume ＞ ($10^5 m^3$)
＝ 100m×100m×10m

Large landslide(USGS):The criteria used for inclusion in the list are (1) at least 100 deaths and/or (2) major monetary losses, and/or (3) notable effects on the natural environment.(http://landslides.usgs.gov/learning/majorls.php)

Large-scale Landslide

Deep-seated Landslide

- mountain slope deformation
- rock slope deformation
- catastrophic rockslide-avalanche
- catastrophic landslide
- large-scale rock avalanche
- sturzstrom
- sackung
- sagging
- mass rock creep

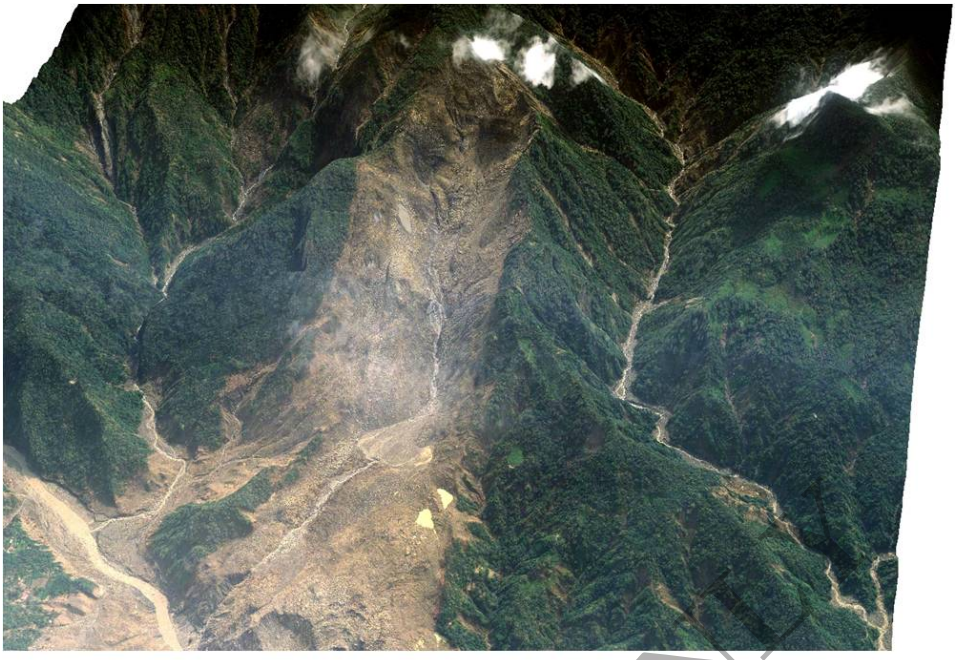
Deep-seated Gravitational Slope Deformation (DSGSD)

Types of Large Landslides

Types	Criteria	Activity
Type A: Occurred in recent years	■With many sliding features can be identified ■The sliding area is still bared	Low
Type B: Occurred in the past years	■With many sliding features can be identified ■The sliding area mainly has coverd with vegetation	Low
Type C: With many landslide features and has potential to occur in the near future	■Failure of Circular type：with features of main or minor scarp、cracks at the crown or along the flank、erosion gully、displaced material accumulated in the toe ■Failure of Planar type or Wedge type：with features of main scarp、minor scarp、cracks along the flank、displaced material accumulated in the toe	High
Type D: Without any sliding features, but with adverse geological conditions	■With adverse geological conditions, such as faults, folds, dip-slopes and conjugate discontinuity ■Significant erosion conditions are at the toe of slope ■Evaluated as a high susceptible landslide area	Medium

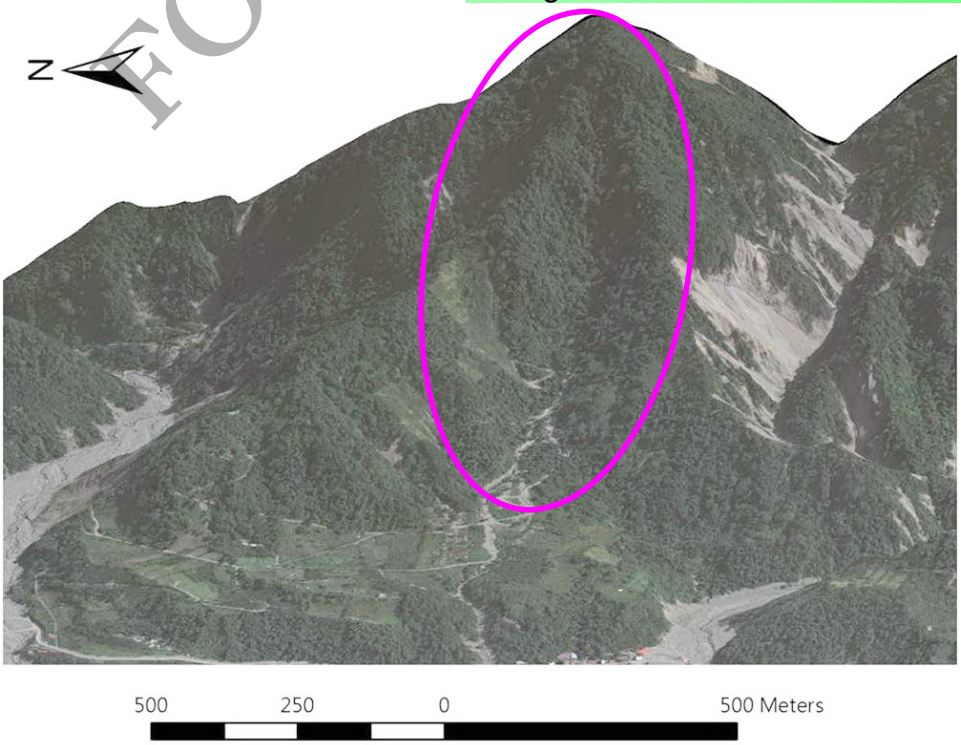
Type A

- With many sliding features can be identified
- The sliding area is still bared



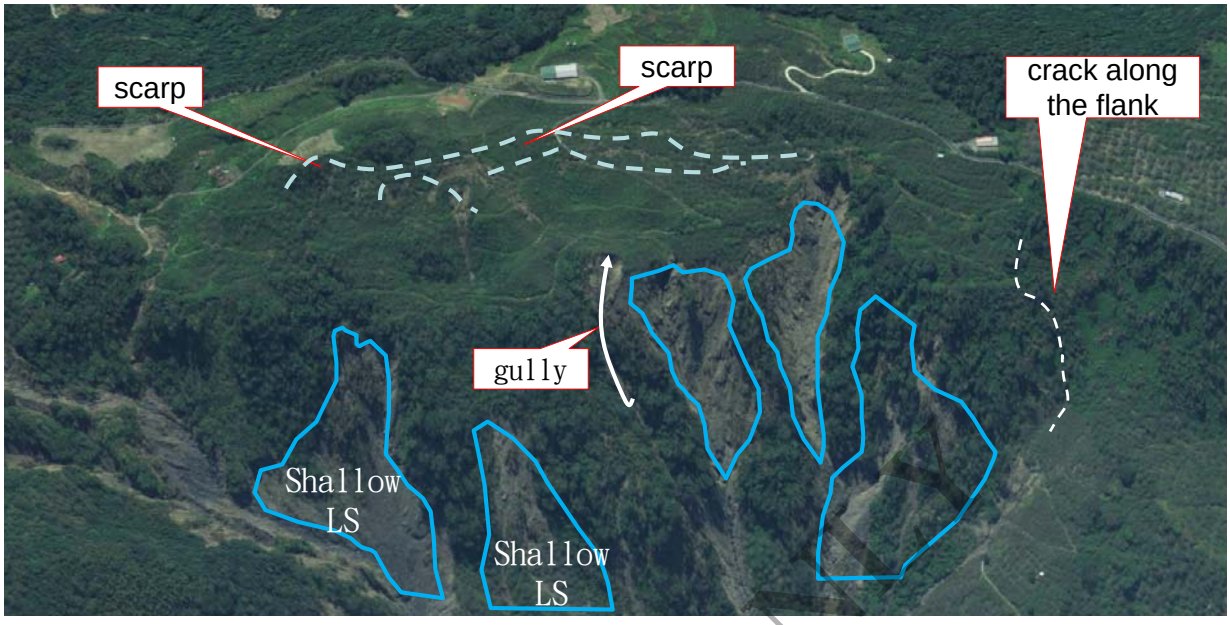
Type B

- With many sliding features can be identified
- The sliding area mainly has coverd with vegetation

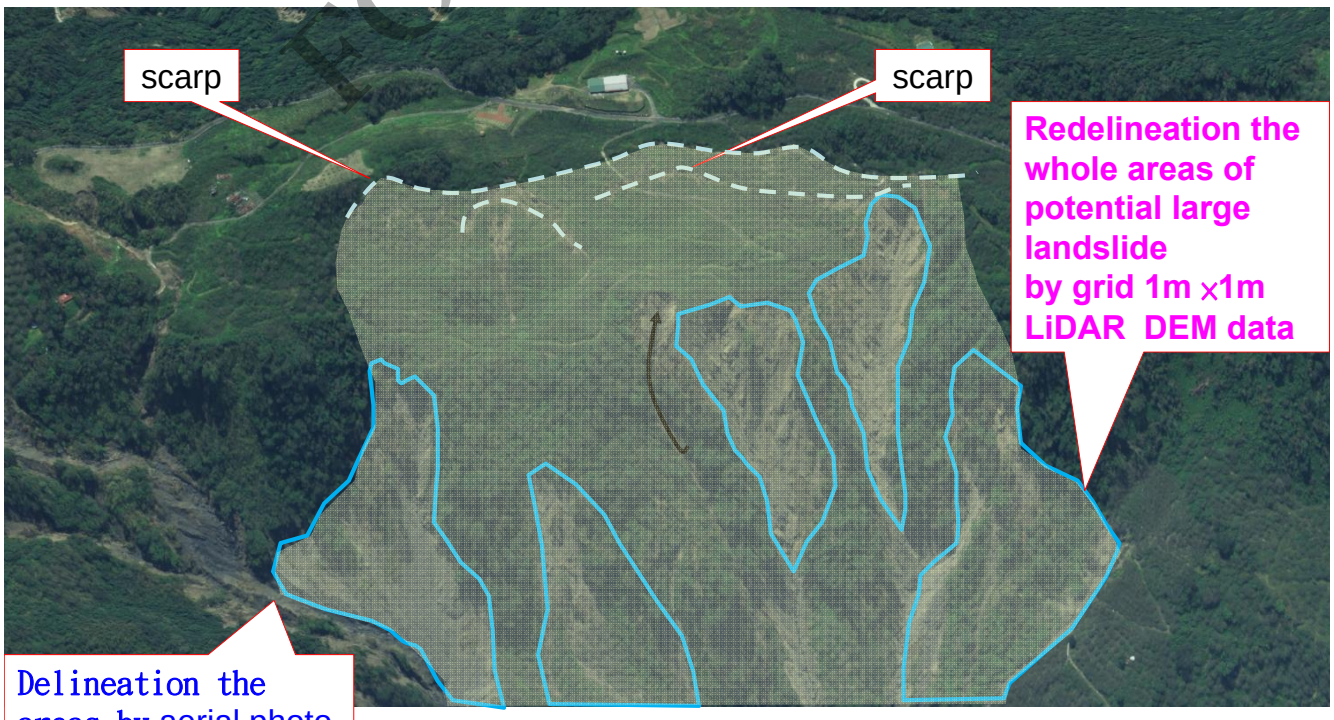


Type C

■Failure of Circular type：with features of main or minor scarp、cracks at the crown or along the flank、erosion gully、displaced material accumulated in the toe
■Failure of Planar type or Wedge type ：with features of main scarp、minor scarp、cracks along the flank、Displaced material accumulated in the toe



Type C -ex1

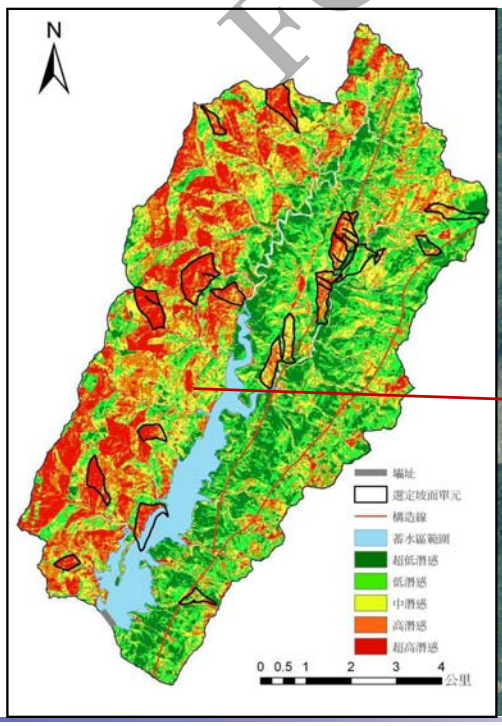


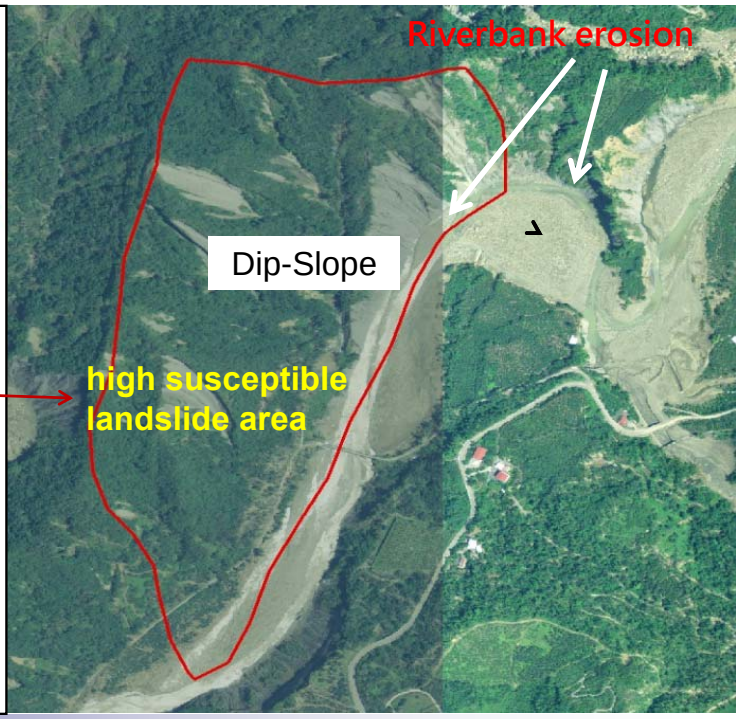
Type C -ex2

(cracks along the crown or the flank of slope in red)

Type D

- With adverse geological conditions, such as faults, folds, dip-slopes and conjugate discontinuity
- Significant erosion conditions are at the toe of slope
- Evaluated as a high susceptible landslide area

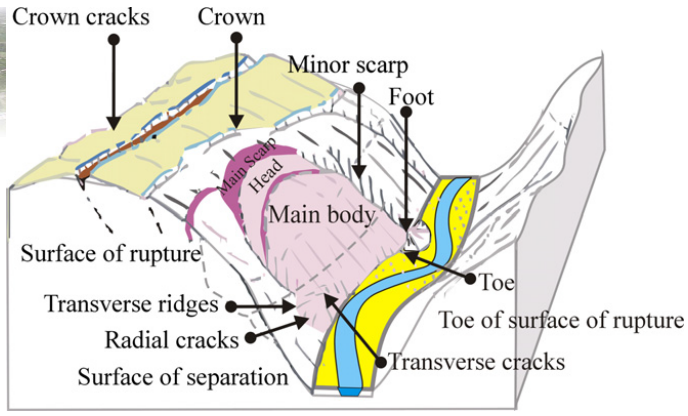




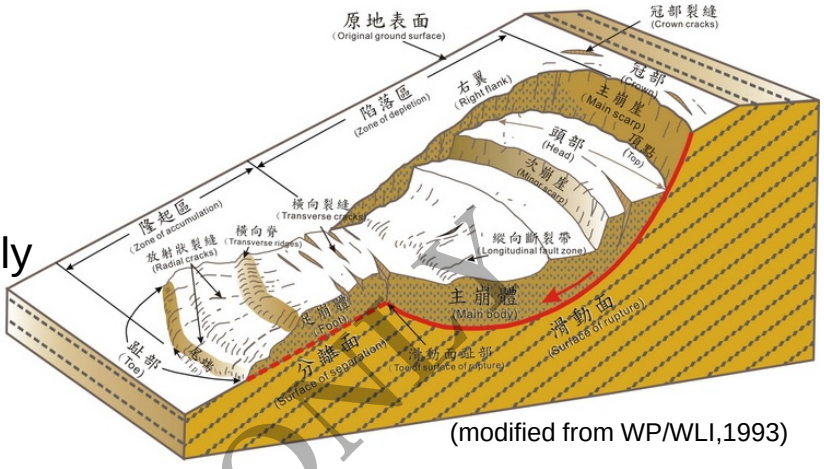
Landslide Susceptibility Map

Topographic features of the Large Landslide

- ✓ Ridge with a gentle slope
- ✓ Scarp、reverse slope、fissures and tension cracks
- ✓ Double ridge
- ✓ Linear depression
- ✓ Slide-body
- ✓ The bulge at the toe
- ✓ Gully sidewall and gully headwall failures
- ✓ Bedrock creep
- ✓ Older landslides



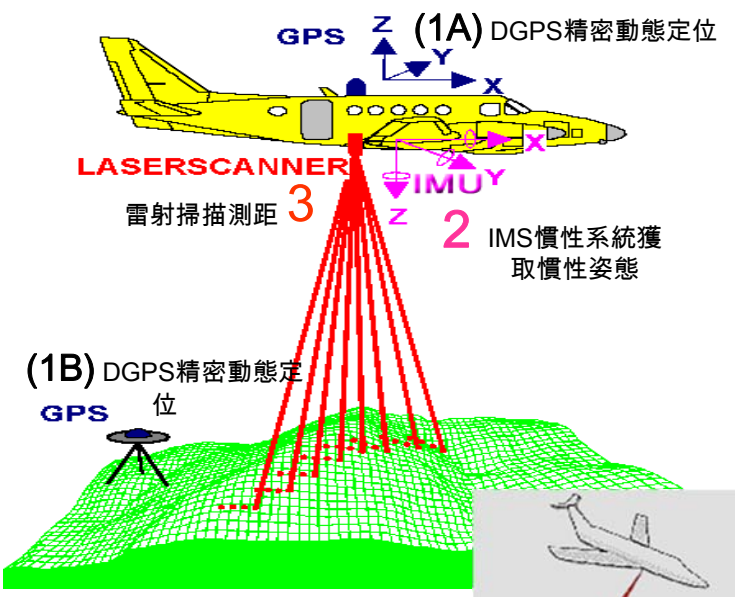
(Modified from Suzuki,2000）

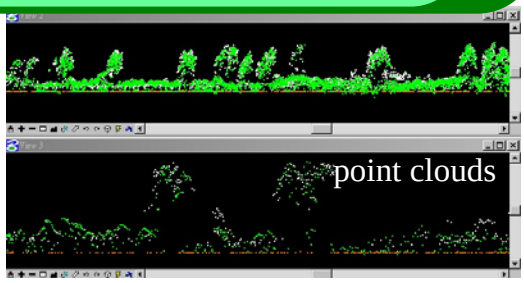


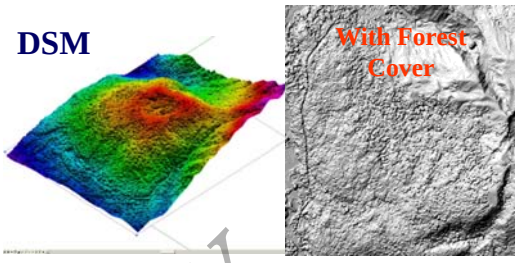
(modified from WP/WLI,1993)

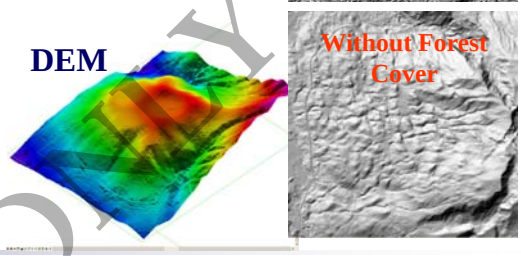
Detection of Large Landslide

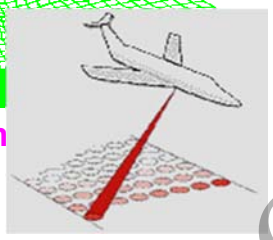
LiDAR(Airborne Light Detection And Ranging)





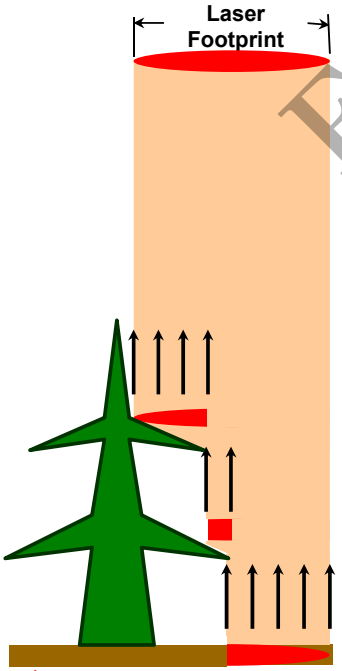






1. Inertial Navigation System
2. laser rangefinder
3. GPS

LiDAR Specifications – Deliverable



- multiple echoes
- Virtual deforestation
- Ground surface texture
- Landforms

(A) LiDAR point clouds:

(a) Raw point clouds: all strips before/after adjustment

(b) Classified point clouds: blocks of map unit--four classes outlier, water, ground, and others

(B) Digital Terrain Models(DTM):

- ✓ One meter grid of DEM (Digital elevation model) and DSM (Digital Surface Model)
- ✓ For subsequent geohazard interpretations.

●Point density:

✓For areas elevation<800m, 2 point/m^2
elevation>800m, 1.5 points/m^2

● Synchronous colour aerial photographs:

- ✓ **Medium format colour aerial photographs**
- ✓ **Exterior orientation parameters by direct geo-referencing**
- ✓ **Orthophotos with a GSD of 0.5m.**


(BN-2B-26)

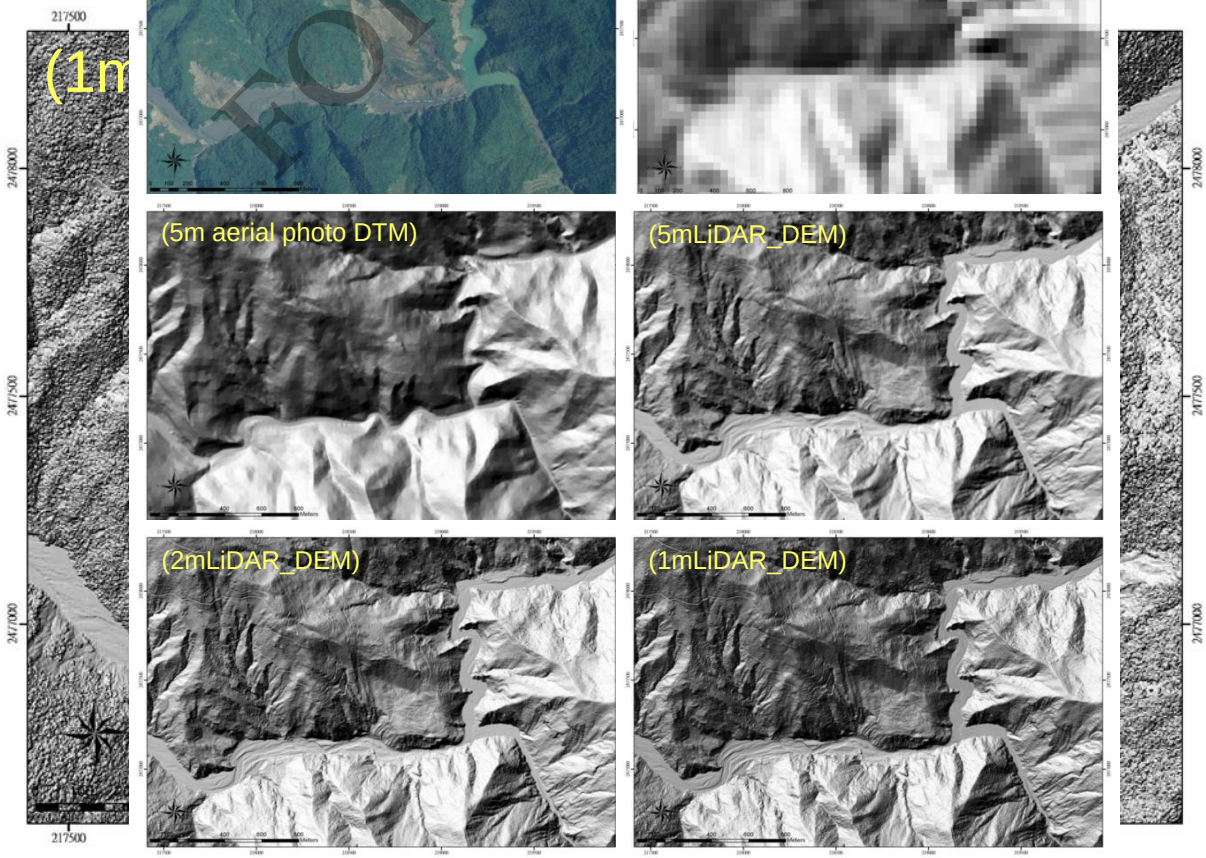

(BK-117)


中興測量 Optech ALTM

詮華國土 ALTM ORION M200


群立科技 Leica ALS60

自強工程 Riegl LMS-Q680i

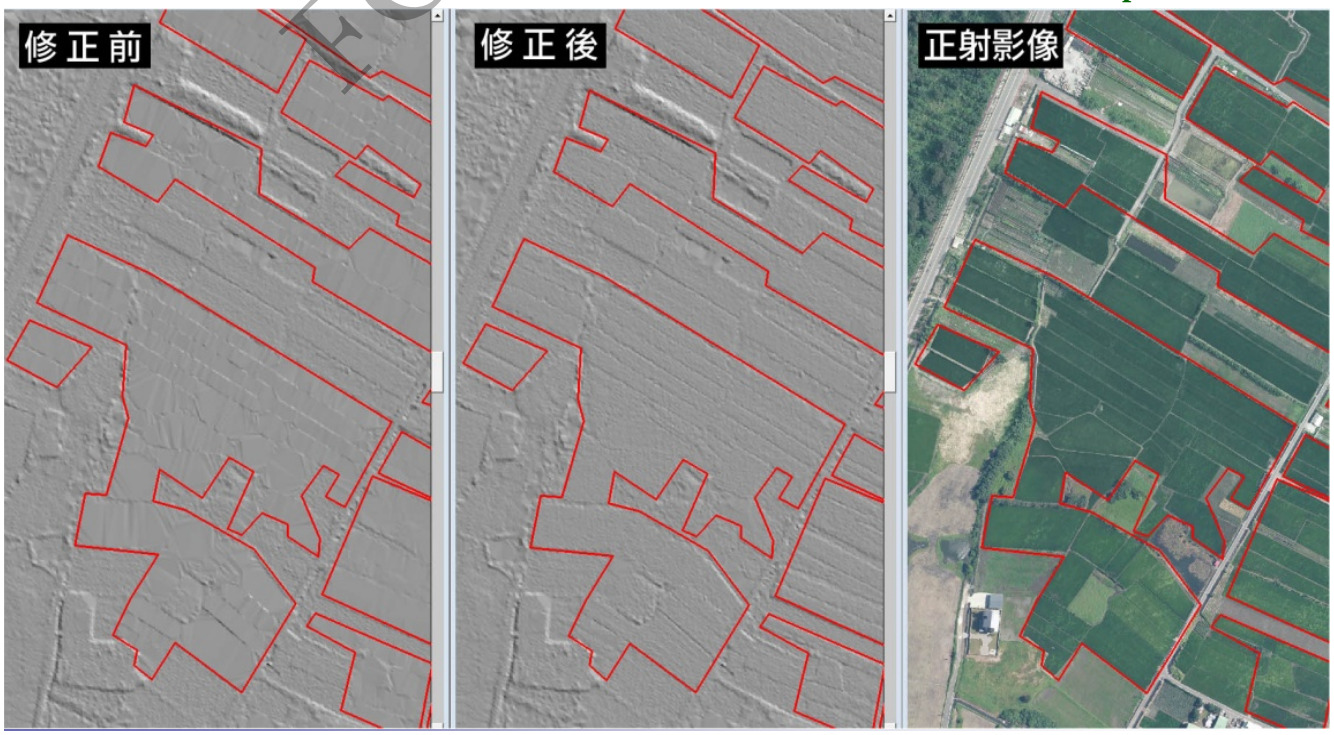


The advantages of LiDAR techniques

1. High-resolution, high-accuracy, digital elevation data
2. Weather/Light independence
3. Independently geo-referenced intensity and elevation data
4. Ranges to trees and to the ground beneath in a single pass: Simultaneous first- and last-pulse capability
5. Rapid coverage and data output: 1,000 square kilometers in less than 12 hours, with DEM data available within 24 hours
6. Range measurements independent of target composition
7. GCP(Ground Control Point)independence

Point Clouds Correction(DEM or DSM)

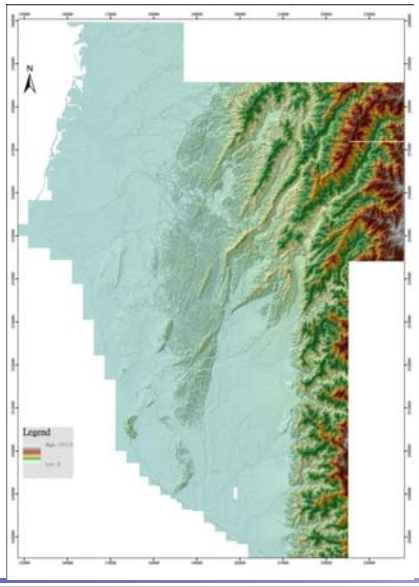
Before correction | After correction | Orthophoto

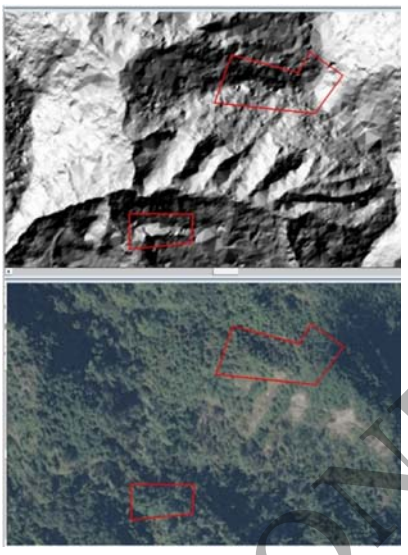


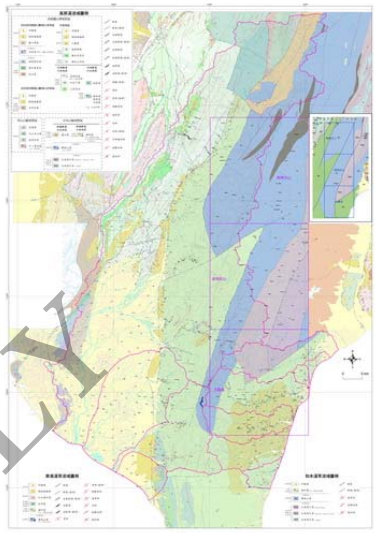
Identifying the potential Large Landslide Area

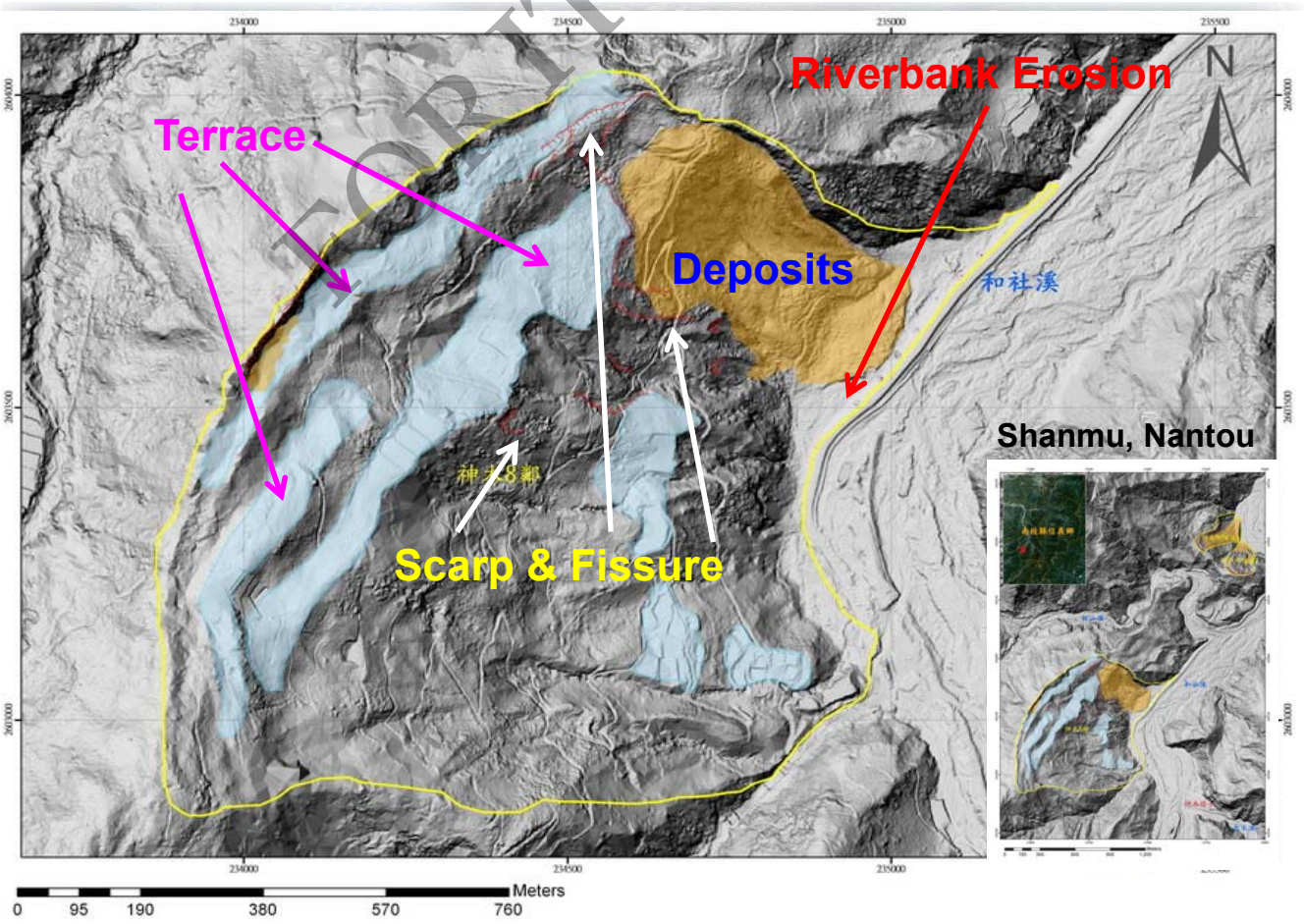
Tools:

- Sunlight shading map(from DEM) • Aerial photo
- Geological map, and Field surveying

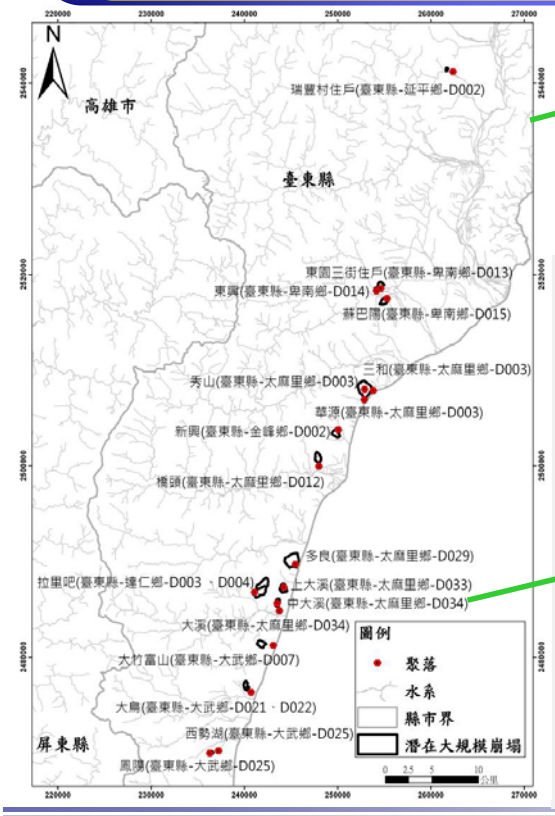




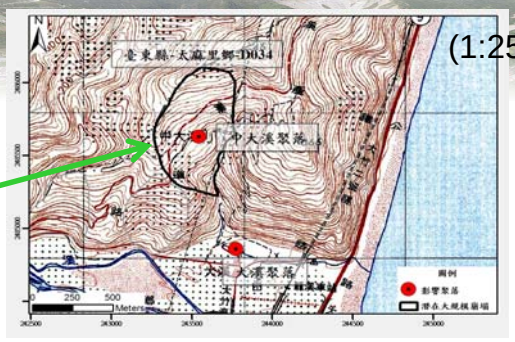




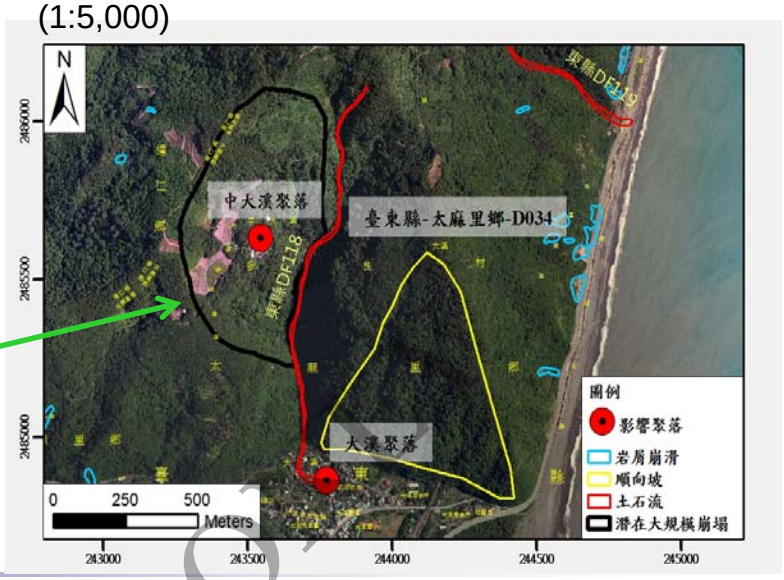
Taitung County-Taimali Township-D034



(1:25,000)

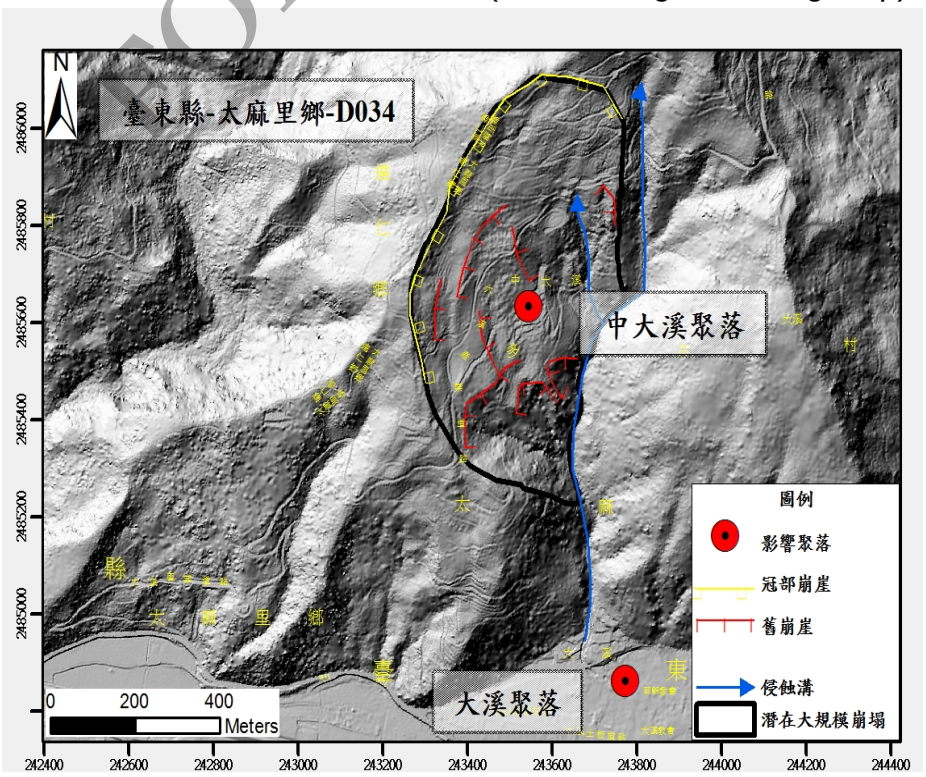


(1:5,000)



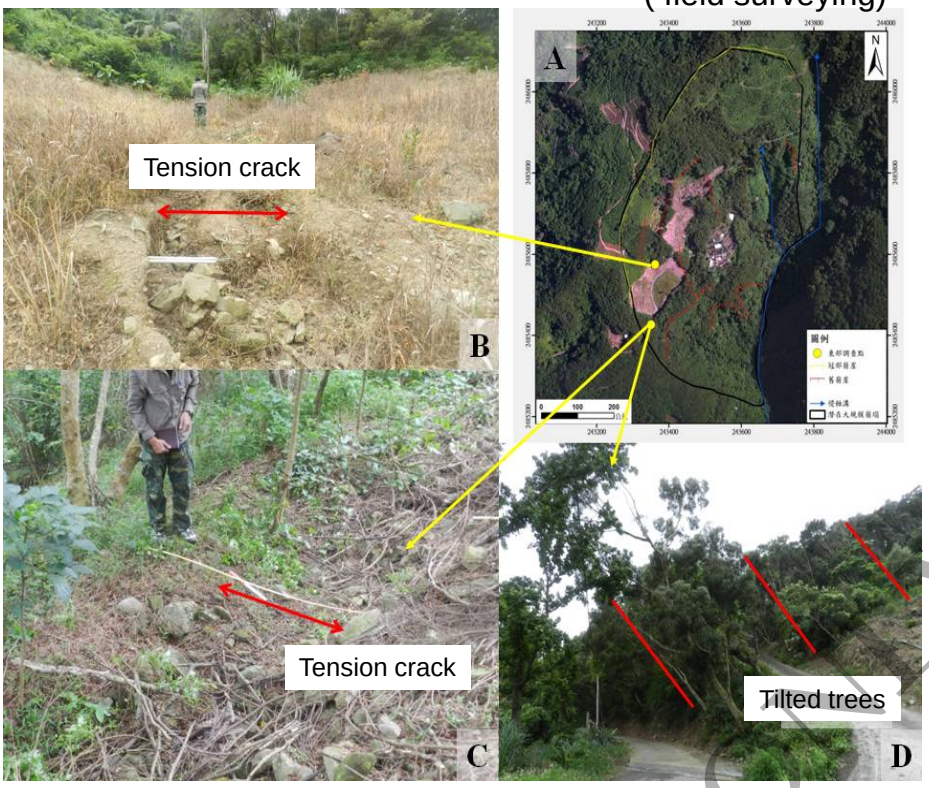
Taitung County-Taimali Township-D034

(From sunlight shading map)



Taitung County-Taimali Township-D034

(field surveying)



Typhoon Morakot damaged area

56 Sites

Actions to the Large Landslide Hazard

People question the government :

- Where has the large landslide hazard?
- Who can protect my families and properties?
- What can I do ?
- When should I evacuate or withdraw?
- What kinds of disaster will occur?
- Where is the safety shelter ?

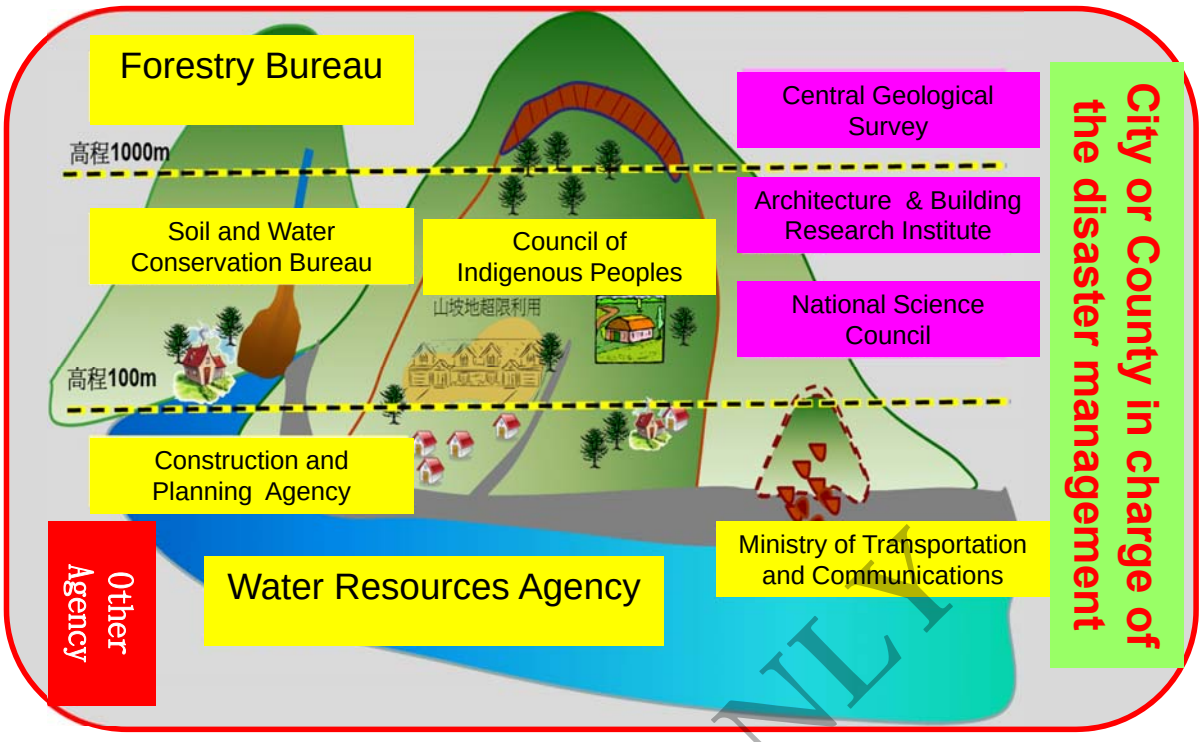
At the present stage, it is difficult to answer.

Good eyesight God

If we have "Good eyesight" and "Good hearing", It will be easy for us to react the large Landslide disasters.

Unfortunately…

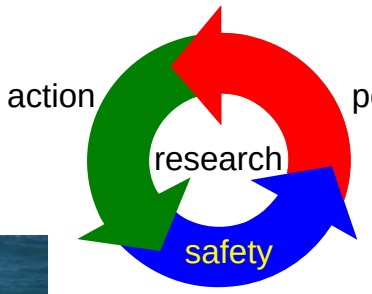
Good hearing God



Policy for preparations of the large landslide hazard(NCDR, Dr.Chen)

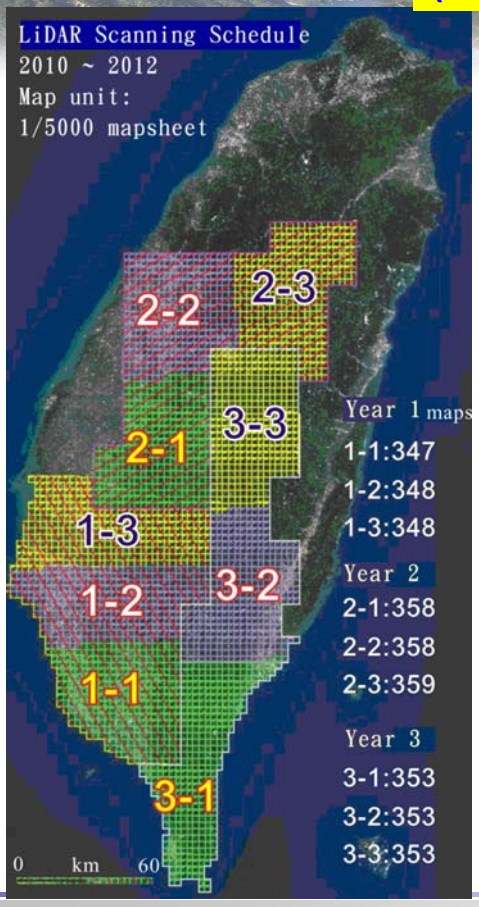
Issues to be done

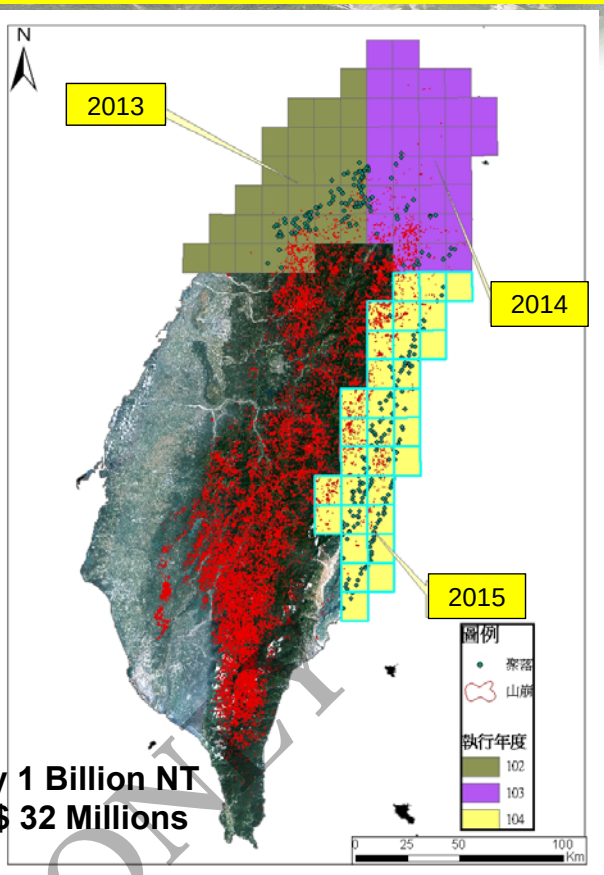
- Delineation the potential large landslide area and preliminary surveying in Taiwan(either > or < 10ha)
- Assessment the Impact Areas(Landslide, Debris Flow, Landslide Lake, etc.)
- Assessment the Activity of the large landslide
- Field & In-situ Surveying(Geomorphology、Geology、Hydrology、Geophysics、Boring、Soil & Rock Testing)
- The mechanism of movement from slow creeping to fast sliding
- Evaluation the dangerous class for each
- Define the rainfall threshold value for large landslide of different sites
- Database Construction
- Establishing the four stages of disaster preparations(or management)：mitigation, preparedness, response and recovery



Conclusion

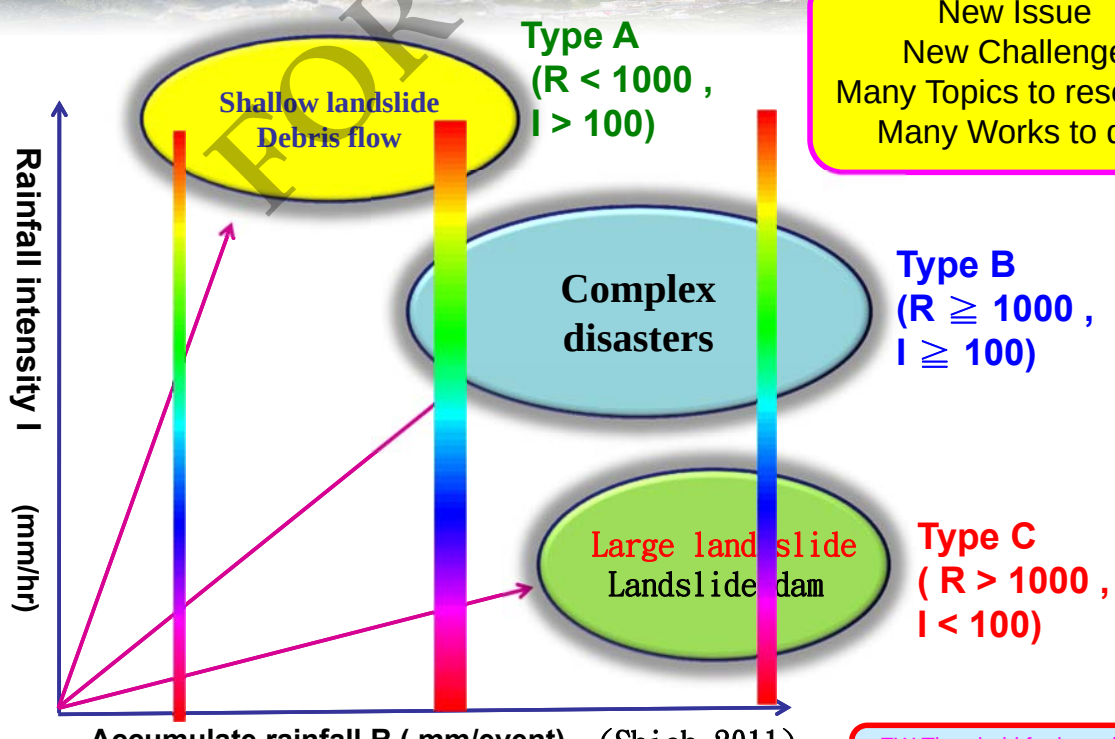
(Two Phases of LiDAR Project in Taiwan)





Totally 1 Billion NT
＝ US$ 32 Millions

New Issue
New Challenge
Many Topics to research
Many Works to do

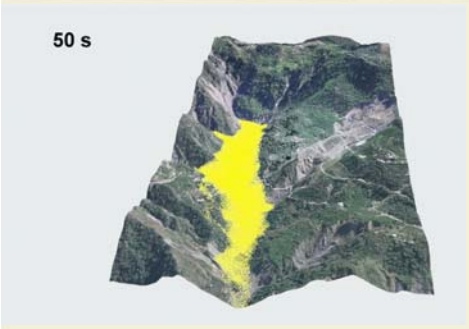


Rainfall Threshold Value for Debris Flow Warning

>600mm(in 48hr), more than 250 large landslides events occurred in Japan

EW Threshold for large landslide Should be at least **600~1,000mm** (without earthquake involved)

Simulation the coverage of landslide route of Chulin large landslide(in Kaohsiung City) Using PFC (Particle Flow Code) 3D model



The whole processes

Particle moving speed

Thank you for your attention

The fence of Shihfen Elementary School