# Advanced Geospatial Data for Cascading Geo-Hazard and Disaster Risk Assessment: A case study of 2015 earthquakes in Sabah

**Khamarrul Azahari Razak, UTM Kuala Lumpur Malaysia**

FIG Working Week 2016
CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016
Recovery from disaster

Organised by FIG NZIS
Platinum Partners Trimble esri
Diamond Partner Land Information New Zealand Toitū te whenua

# ADVANCED GEOSPATIAL DATA FOR CASCADING GEO-HAZARD AND DISASTER RISK ASSESSMENT: A CASE STUDY OF 2015 EARTHQUAKES IN SABAH

Khamarrul Azahari Razak[1,2],
Zakaria Mohamad[3], Razain Abd Razab[4],
Mohd Othman Sosi@Said[4], Ahmad Zulfadli Ahmad Mazuvil[4]

UTM UNIVERSITI TEKNOLOGI MALAYSIA RESEARCH UNIVERSITY
BUMITOUCHplmc

Acknowledgement

seadpri southeast asia disaster prevention research initiative

UTM UNIVERSITI TEKNOLOGI MALAYSIA

UTM RAZAK School of Engineering and Advanced Technology

Universiti Teknologi Malaysia (UTM) Kuala Lumpur

# Contents



www.disaster-risk-malaysia.com

**Malaysia has reported of an average annual loss by multi-hazard of about 1.3 billion USD -** International disaster database OFDA/CRED 1990-2014.

Hulu Langat 2010

Bukit Antarabangsa 2008

**Quantitative hazard and risk assessment** for regulatory and development planning by local authorities is still **elusive** in Malaysia

Lebuhraya Mahameru 2014

## Problematic aspects of geological risk assessment

i) spatial probability of initiation; ii) volume and type geological hazards; iii) temporal vulnerability of elements at risk; iv) degree of damage to different types of elements at risk; v) runout distance of landslides; and vi) probability of triggering event given type and volume.

Bukit Antarabangsa 2

Highland Tower 1993

**Hyogo Framework 2005-2015**

**Sendai Framework for Disaster Risk Reduction 2015-2030**

# A complex geological hazard and risk assessment

> requires a multi-hazard approach, as different types of disaster may occur, each with different characteristics and causal factors, and with different spatial, temporal and size probabilities.


**RISK is a multi-disciplinary SPATIAL problem**

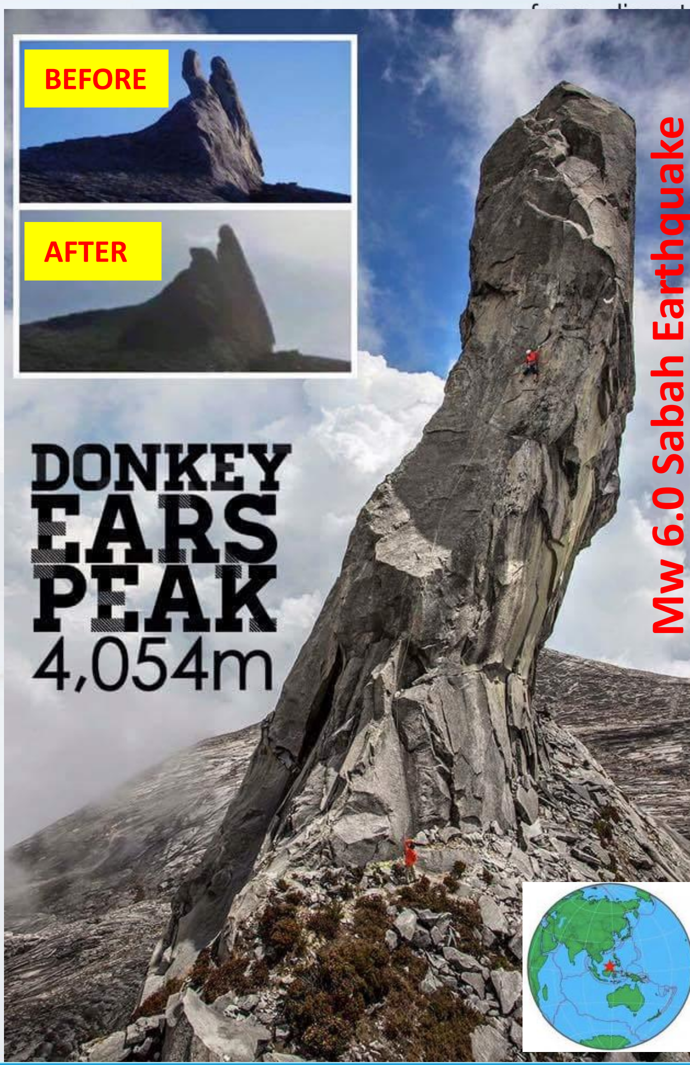
## Case Study

Earthquake occurred on 05 June 2015 in Sabah with about 200 aftershocks

https://en.wikipedia.org/wiki/2015_Sabah_earthquake

**2015 Sabah earthquake**

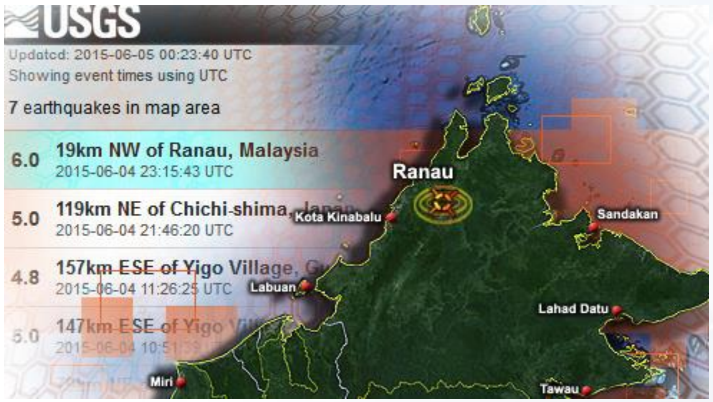
| | |
|---|---|
| **Date** | 5 June 2015 |
| **Origin time** | 07:15:43 MST (UTC+08:00)[1] |
| **Duration** | 30 seconds |
| **Magnitude** | 6.0 ($M_w$) (USGS)<br>5.9 ($M_w$) (MetMalaysia) |
| **Depth** | 10 km (6.2 mi)[1] |
| **Epicenter** | 5.980°N 116.525°E[1] |
| **Type** | Normal |
| **Areas affected** | West Coast & Interior Division (Mount Kinabalu area), Sabah, East Malaysia |
| **Total damage** | Building and infrastructure damage, landslides & geological changes |
| **Max. intensity** | VII (Very Strong) |
| **Landslides** | Yes |
| **Aftershocks** | 90 (As of 23 June 2015)[2] |
| **Casualties** | 18 deaths<br>11 wounded |

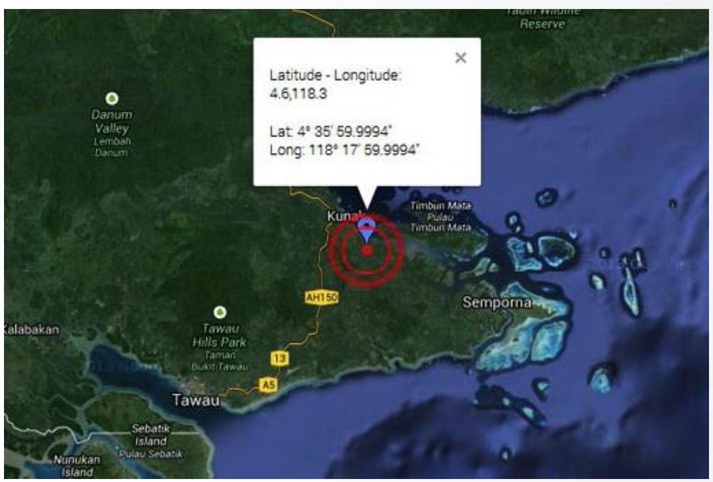


# Cascading Hazard




# Earthquakes & Cascading Hazard



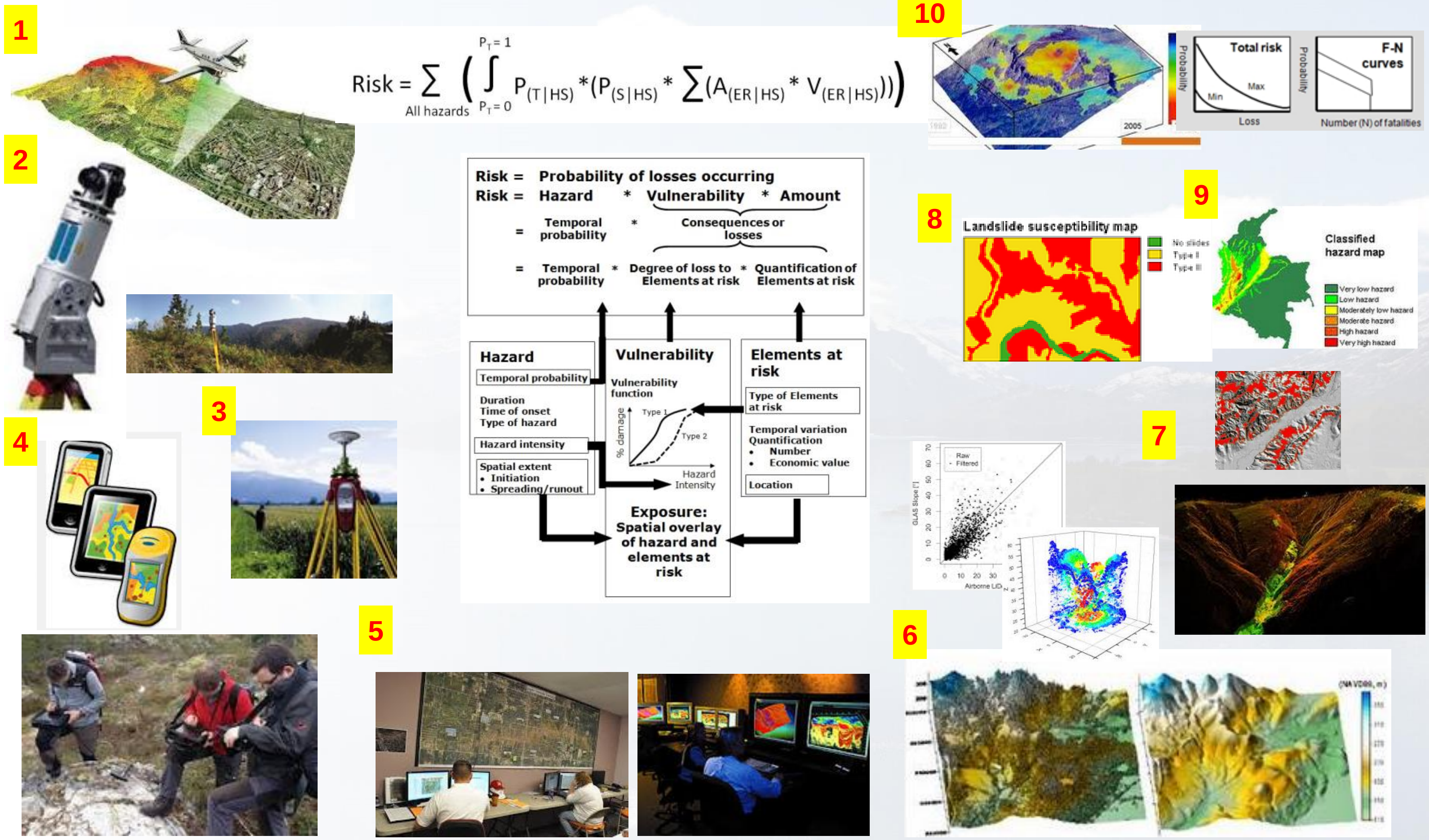




$$Risk = \sum_{\text{All hazards}} \left( \int_{P_T=0}^{P_T=1} P_{(T|HS)} * \left(P_{(S|HS)} * \sum \left(A_{(ER|HS)} * V_{(ER|HS)}\right)\right)\right)$$

In which

- $P_{(T|HS)}$ = the temporal probability of a certain hazard scenario (HS); $P_{(S|HS)}$ = the spatial probability that a particular pixel in the susceptible areas is affected given a certain hazard scenario;
- $A_{(ER|HS)}$ = the quantification of the amount of exposed elements at risk, given a certain hazard scenario (e.g. expressed as the number or economic values); and
- $V_{(ER|HS)}$ = the vulnerability of elements at risk given the hazard intensity under the specific hazard scenario

# National Initiative - Landslide Hazard and Risk Mapping Project - 2014-2016




Razak et al. (2015)

**Methodological Framework and Functional Flow**: 1. Airborne LIDAR; 2. Terrestrial LIDAR, 3. GPS Survey, 4. Mobile GIS Field Mapping, 5. Data Processing, 6. LIDAR-Landslide Processing, 7. Landslide Inventory Mapping, 8. Landslide susceptibility Analysis, 9. Landslide Hazard Assessment, 10. Landslide Risk Assessment

# Main Components of Hazard and Risk Analysis

Landslide Inventory Mapping & Analysis (LIMA) → Landslide Susceptibility Mapping & Analysis (LSM) → Landslide Hazards Mapping & Analysis (LHM)

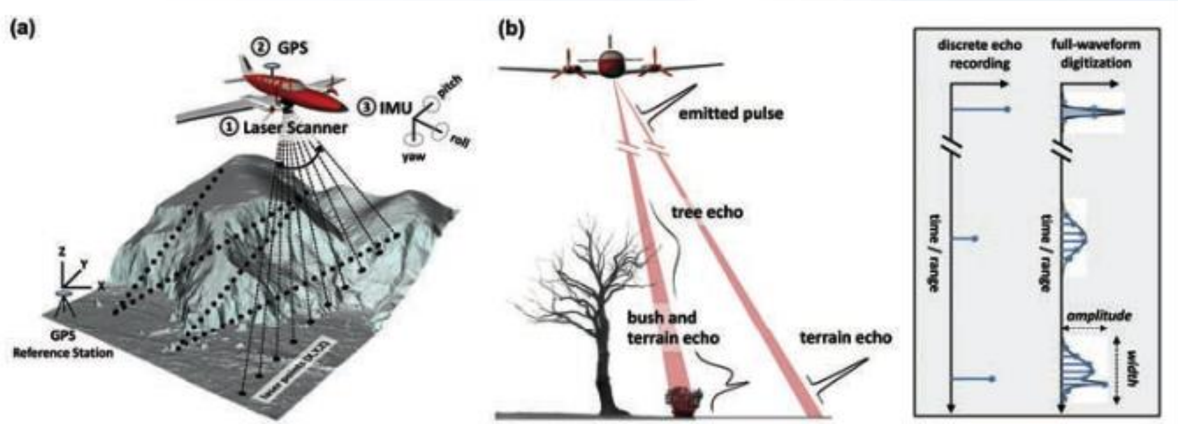
↓

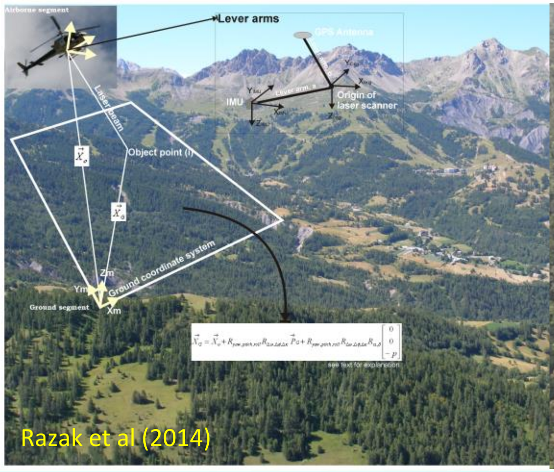
Landslide Element at Risk Mapping & Analysis (LERM) → Landslide Exposure Mapping & Analysis (LEM)

↓

Landslide Vulnerability Mapping & Analysis (LVM) → Landslide Risk Mapping & Analysis (LRM)

## Topographic Laser Scanning System (LiDAR) is the most advanced geospatial technology in the last millennium





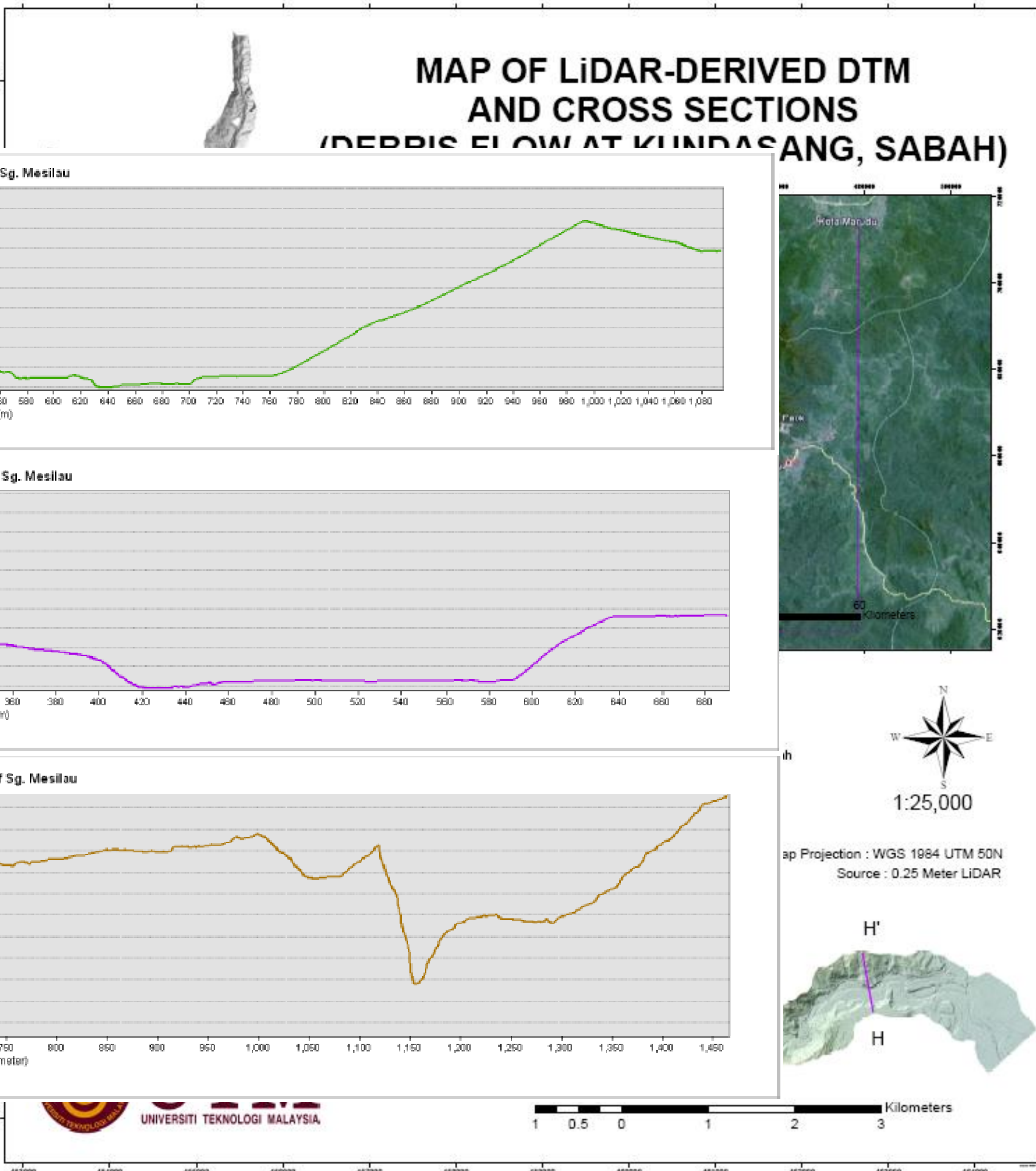
a high-density helicopter-based LiDAR data on August 24, 2015 using LiteMapper 6800-400kHz resulting in a total of 724 million point clouds over the channelized debris flow in Kundasang-Ranau, Sabah.

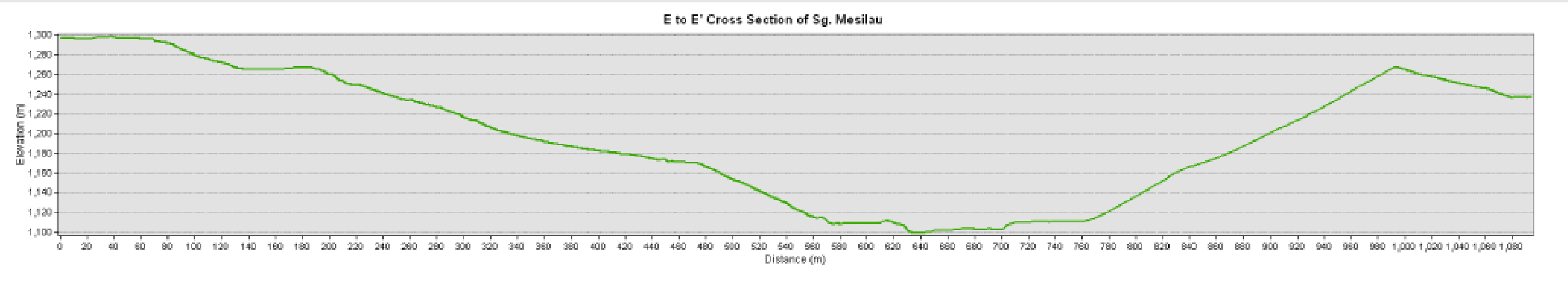
# FIG Working Week 2016

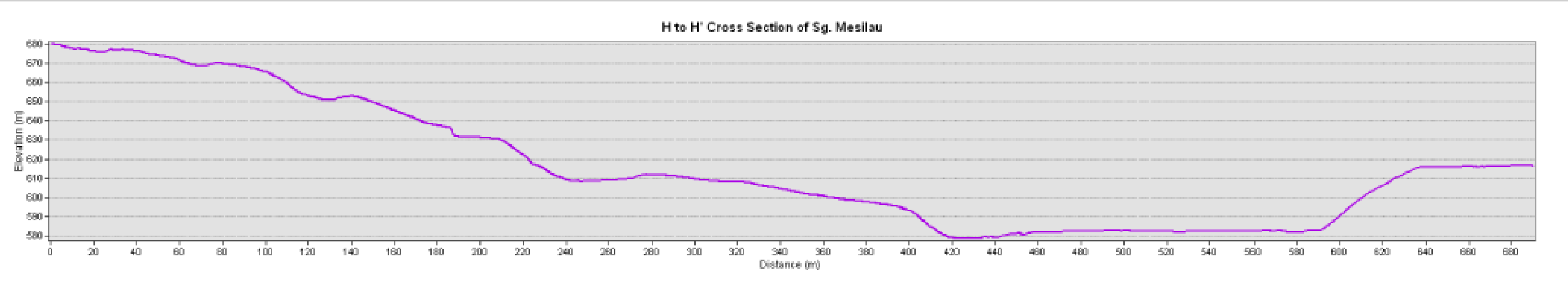
CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016

Recovery

## High density airborne LiDAR



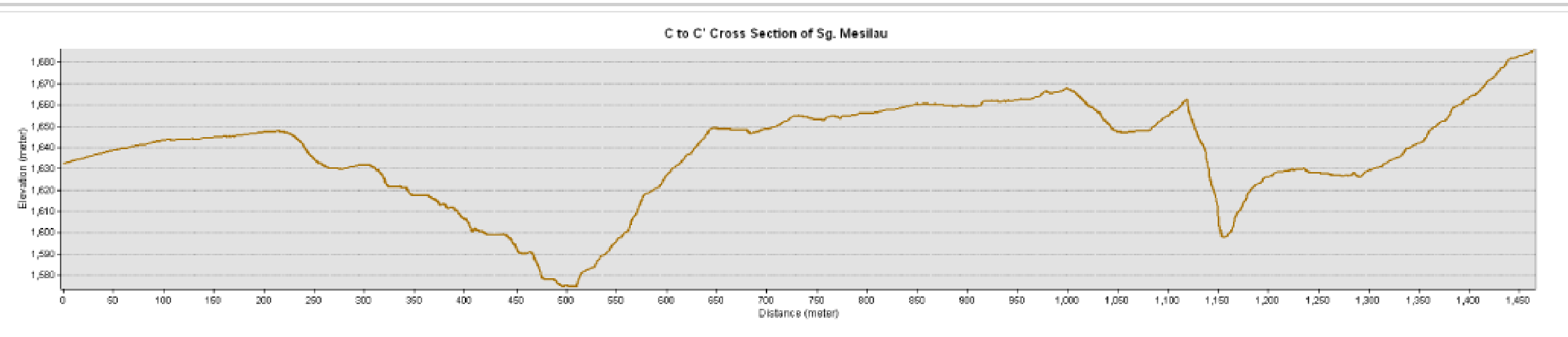
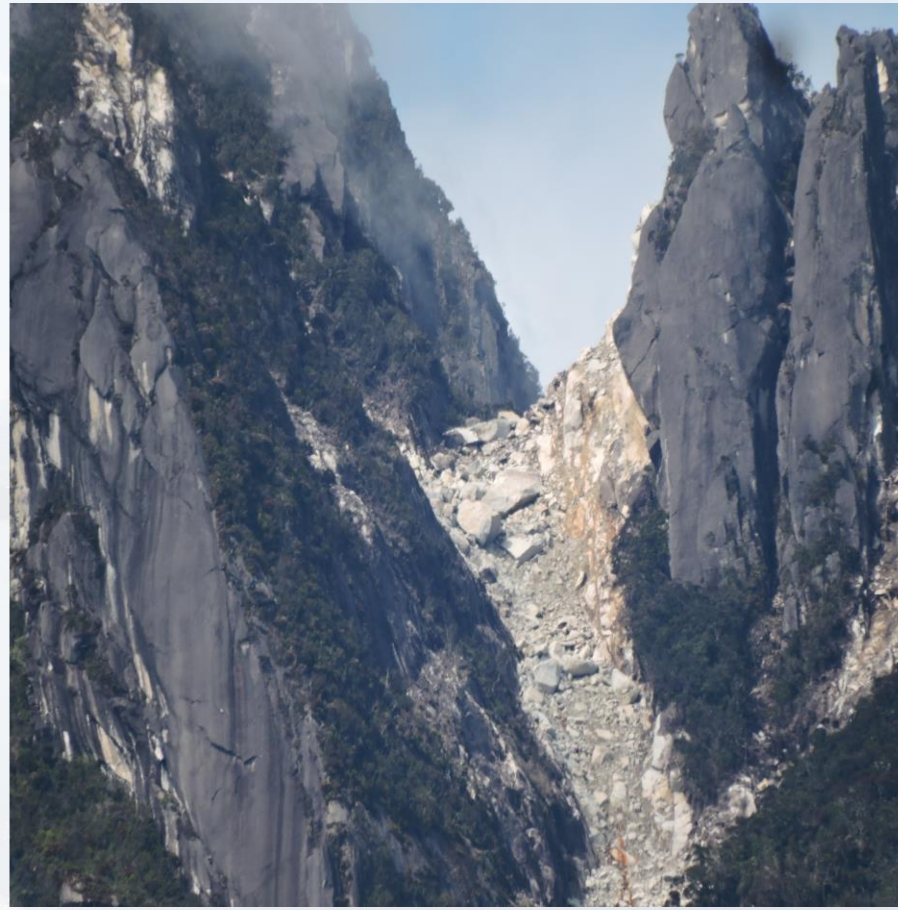
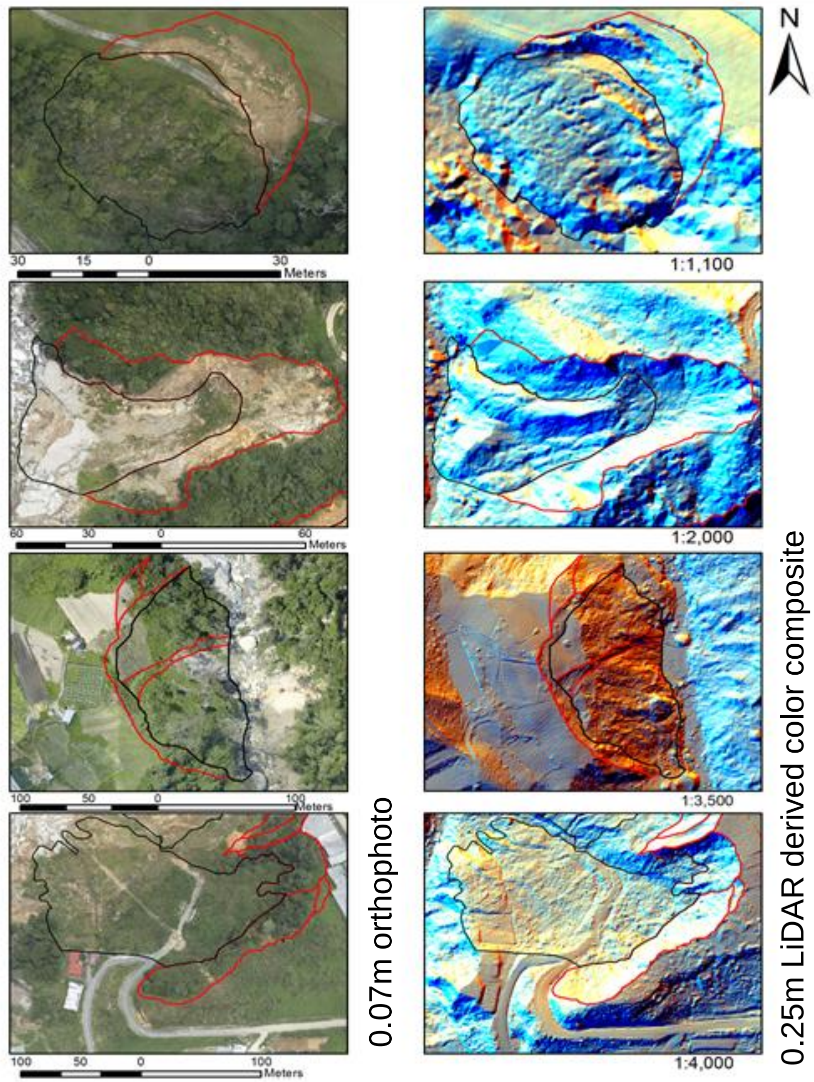




FIG NZIS

More to come



Courtesy of Dr Tajul Anuar Jamaluddin, UKM




# Landslide diagnostic features

- Figure 1 is retrogressive and rotational landslide at Mesilou Golf Club: semi-circular scarp, step-like slope, and hummocky deposition part. Backtilted trees can be seen on the orthophoto. Present after the earthquake.
- Figure 2 is an active and complex rotational landslide at Kampung Mesilou: Concave-convex and flow morphology.
- Figure 3 is complex and deep-seated rotational at plantation area: Disrupted plantation terrace, the recent scarp is induced by the 5 June earthquake.
- Figure 4 is active and complex landslide in a forested terrain at Kampung Mesilou: The recent scarp has the semi-circular shape but the older scarp does not have the perfect semi-circular shape, showing multipe episodes. The deposition part has hummocky and flow feature.
- Orthophoto: Active and new landslide can easily be seen in the orthophoto as a brown patch. For high resolution orthophoto, tilted and backtilted trees can be to identify type of landslide.

# LiDAR-Derived Landslide Causal Factor Maps

**Geomorphological Factor Maps**

1. Geomorphological Map
2. Slope Map
3. Aspect Map
4. Curvature Map
5. Terrain Roughness Index
6. Terrain Surface Classification
7. Terrain Surface Texture
8. Terrain Surface Convexity
9. Vector Ruggedness Measure

**Geological Factor Maps**

1. Lithology
2. Lineament
3. Faults
4. Distance to Lineament
5. Distance to Fault
6. Distance to Seismic

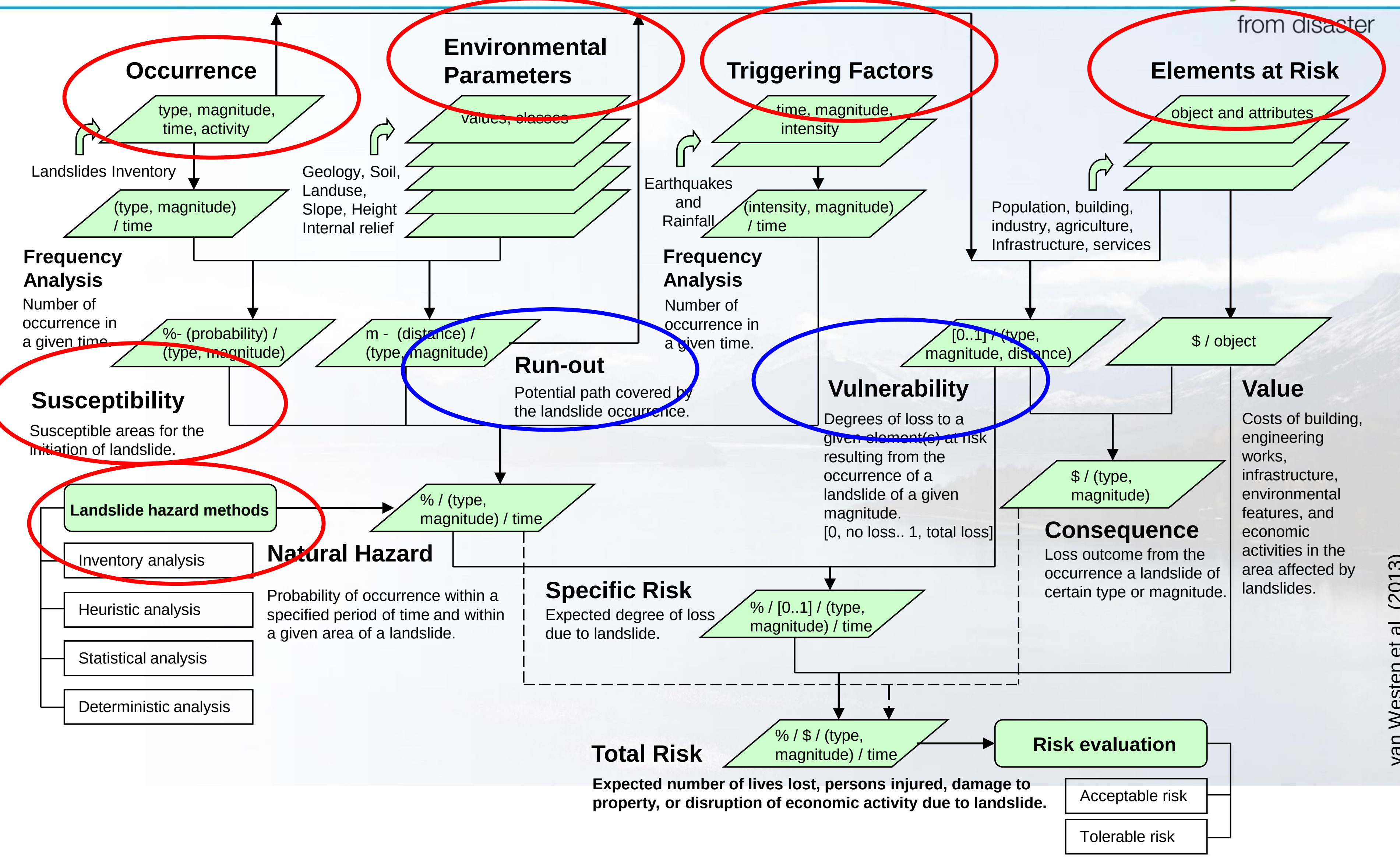
**Hydro-topographical Factor Maps**

1. Flow Direction
2. Flow Accumulation
3. Channel
4. Distance to Channel
5. Watershed
6. Stream Network
7. Topographic Wetness Index

**Anthropogenic Factor Maps**

1. LULC
2. Road Cut
3. Disrupted Drainage

* Pilot Area Submitted to GSSB on 19 April 2016




# Geospatializing landslide risk assessment in a quantitative manner

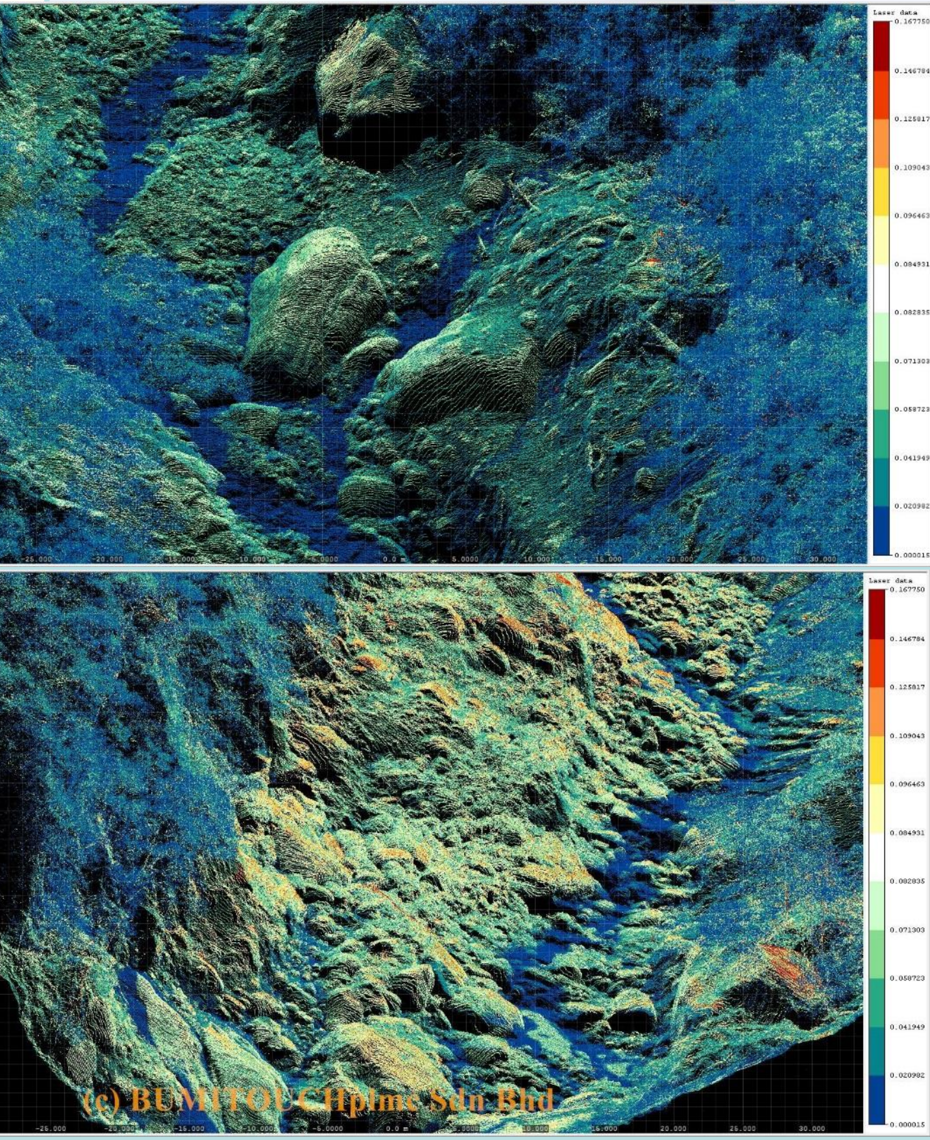
# Difficulty & Challenging

UTM UNIVERSITI TEKNOLOGI MALAYSIA
RESEARCH UNIVERSITY

Before the Earthquake


After the Earthquake


1. Establishing & updating historical inventory
2. Analyzing multi-scale and multi-sources geospatial data
3. Selecting appropriate models and parameterization for hazard and risk prediction
4. Convincing stakeholders – maps & output



## Conclusion

1. Extreme climate, rapid urbanization, excessive anthropogenic activity and environmental degradation increase our exposure to hazards.

2. A comprehensive and effective data management is critically needed for supporting decision-making system.

We need **fast, accurate, efficient, cost effective, low-labor-, reliable** mapping and analyzing tool new

# MASTER OF DISASTER RISK MANAGEMENT

- Master Programme
- Full-Time, Taught Course
- 2 Semesters + 1 Short Semester
- Collaboration between Malaysia and Japan
- First intake September, 2016
- More details at mjiit.utm.my/dppc
- Contact e-mail: dppc@utm.my

**Two weeks attachment in Japan!**

SCAN THIS QR CODE WITH YOUR SMARTPHONE TO SEE WHERE IT TAKES YOU!

UTM UNIVERSITI TEKNOLOGI MALAYSIA

Malaysia-Japan International Institute of Technology (MJIIT)

MJIIT · JAPANESE UNIVERSITY CONSORTIUM

JICA Japan International Cooperation Agency

# REGIONAL CONFERENCE ON NATURAL DISASTER (RCND) 2016

06 – 07 September 2016 @ UTM Kuala Lumpur

***"Towards efficient disaster preparedness and sustainable recovery"***

**http://www.mjiit.utm.my/**

The **RCND 2016: Regional Conference on Natural Disaster 2016** has the overall aim of bringing together stakeholders, decision makers, policy makers, prominent figure, leading academic scientists, researchers, and the public to explicitly discuss and advance our understanding of reducing and managing disaster risk. The conference will address issues of disaster risk management cycles across a deliberately wide range of relevant spheres and interesting topics. This professional event also deals with the multi-hazard risk analysis, assessment and evaluation from natural disasters.

It also provides the premier trans-, inter-, and multi-disciplinary forum for federal- and state government officers at different hierarchies, non-governmental organizations, academicians, and researchers to present and discuss the most recent innovations, trends, and concerns, practical challenges encountered and the problem based solutions related to the managing natural disaster and reducing its associated risks.

## CONFERENCE THEMES

**Investigation Methods:** Hazard & risk mapping; monitoring, prediction and early warning; Risk analysis and assessment; physical modelling; Remedial measures & prevention works; Inventory & database; Natural hazards and vulnerability; Disaster-based on statistical & deterministic modelling; & Mitigation & protection.

**Policy, Legistration & Guidelines:** Integrated risk governance; Emergency planning and strategies; Disaster preparedness standard; Post-disaster management response; Socioeconomic impacts of natural disasters; Build-Back-Better; DRR Sendai Framework 2015-2030.

**Resilient & Community-based Risk Reduction**: Building resilient community: Risk Management & Response, relief operations; Capacity development for disaster mitigation; Natural disaster risk reduction;

**Open Session:** Thematic and regional network on disaster; Climate change and disaster risk; Landuse change impacts; Advanced ICT-, Big Data-, LoT-, & Mobile computing for natural disasters; Security & privacy issues

**For any enquiry, please contact:**
khamarrul.kl@utm.my I **+603-2203 1372; +60193649495**

**http://mjiit.utm.my/rcnd2016/**

# THANK YOU FOR YOUR ATTENTION

**Khamarrul Azahari Razak, PhD**
UTM Razak School of Engineering and Advanced Technology
Universiti Teknologi Malaysia
54100 Jalan Sultan Yahya Petra
Kuala Lumpur
**Tel: +6019 3649495**
**Email:** khamarrul.kl@utm.my; khamarrul@gmail.com
@ *http://www.razakschool.utm.my/khamarrul*

***Affiliation to:***

*Multi Geo-Hazard and Risk (MGHDR) Lab*
*Disaster Preparedness and Prevention Center @*
*Malaysia-Japan International Institute of Technology (MJIIT)*
*Universiti Teknologi Malaysia (UTM) Kuala Lumpur*

**http://mjiit.utm.my/rcnd2016/**