UNIVERSITI TEKNOLOGI MALAYSIA

JASTIP
Japan - ASEAN
Science, Technology and
Innovation Platform

UNESCO-JASTIP Joint Symposium

Intra-Regional Water Security and Disaster Management

The 3rd Symposium on JASTIP Disaster Prevention International Cooperation Research

16 November 2017 @ Metro Manila, the Philippines

GEOHAZARD RISK ASSESSMENT IN A TECTONICALLY ACTIVE REGION IN MALAYSIA

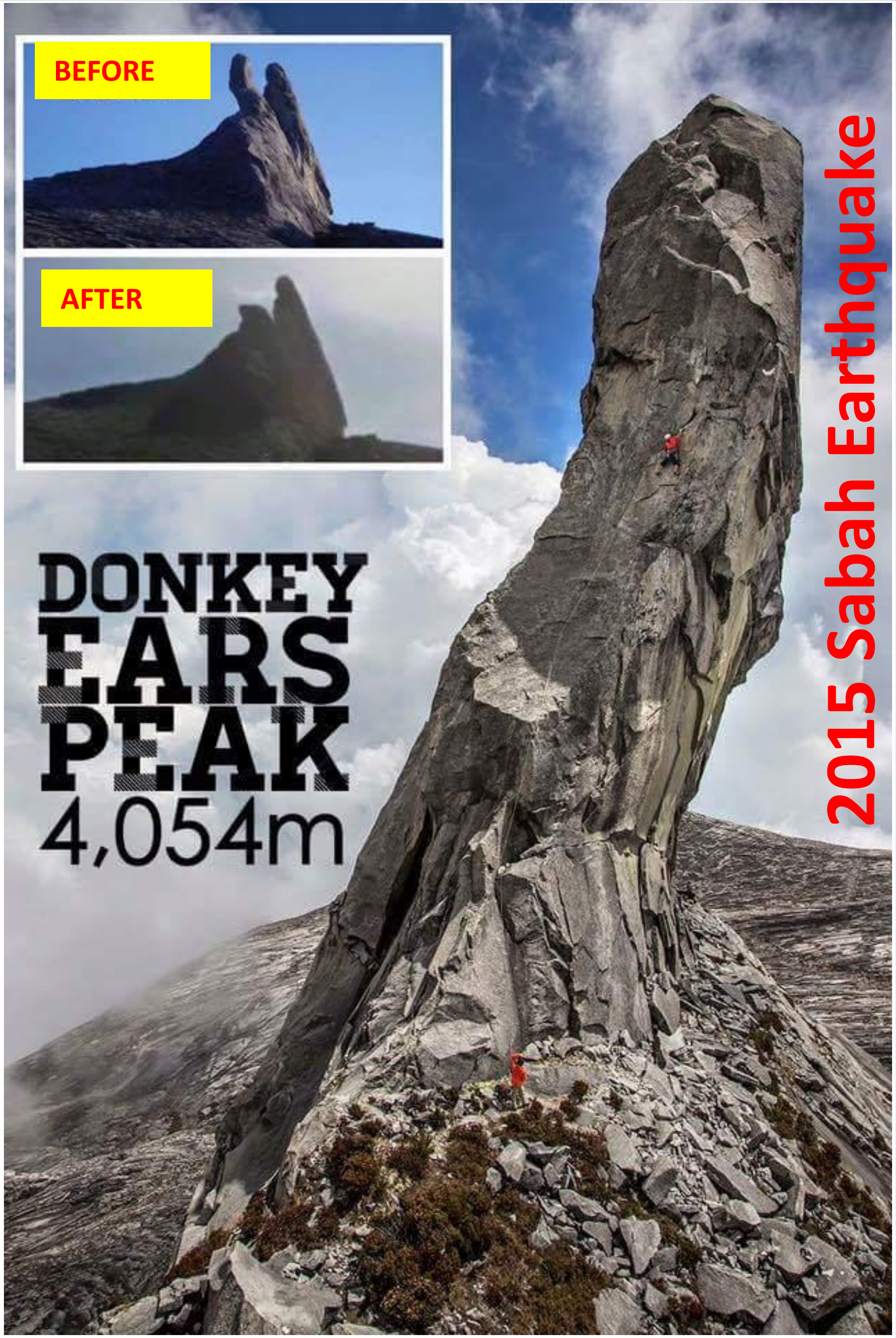
Khamarrul Azahari Razak [1,2]

[1]UTM RAZAK School of Engineering and Advanced Technology,
[2]Disaster Preparedness and Prevention Center,
Malaysia-Japan International Institute of Technology
Universiti Teknologi Malaysia (UTM) Kuala Lumpur

@ khamarrul.kl@utm.my

CONTENTS

1. Current Issues & Challenges
2. Sabah Earthquake in June 2015
3. Cascading hazards
4. Multi-Hazard Risk Assessment
5. Future works and collaboration

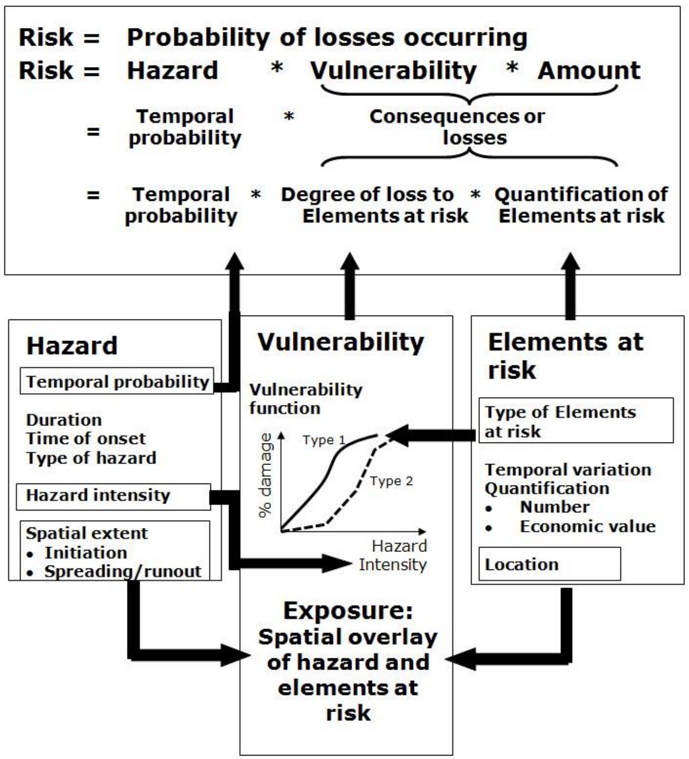


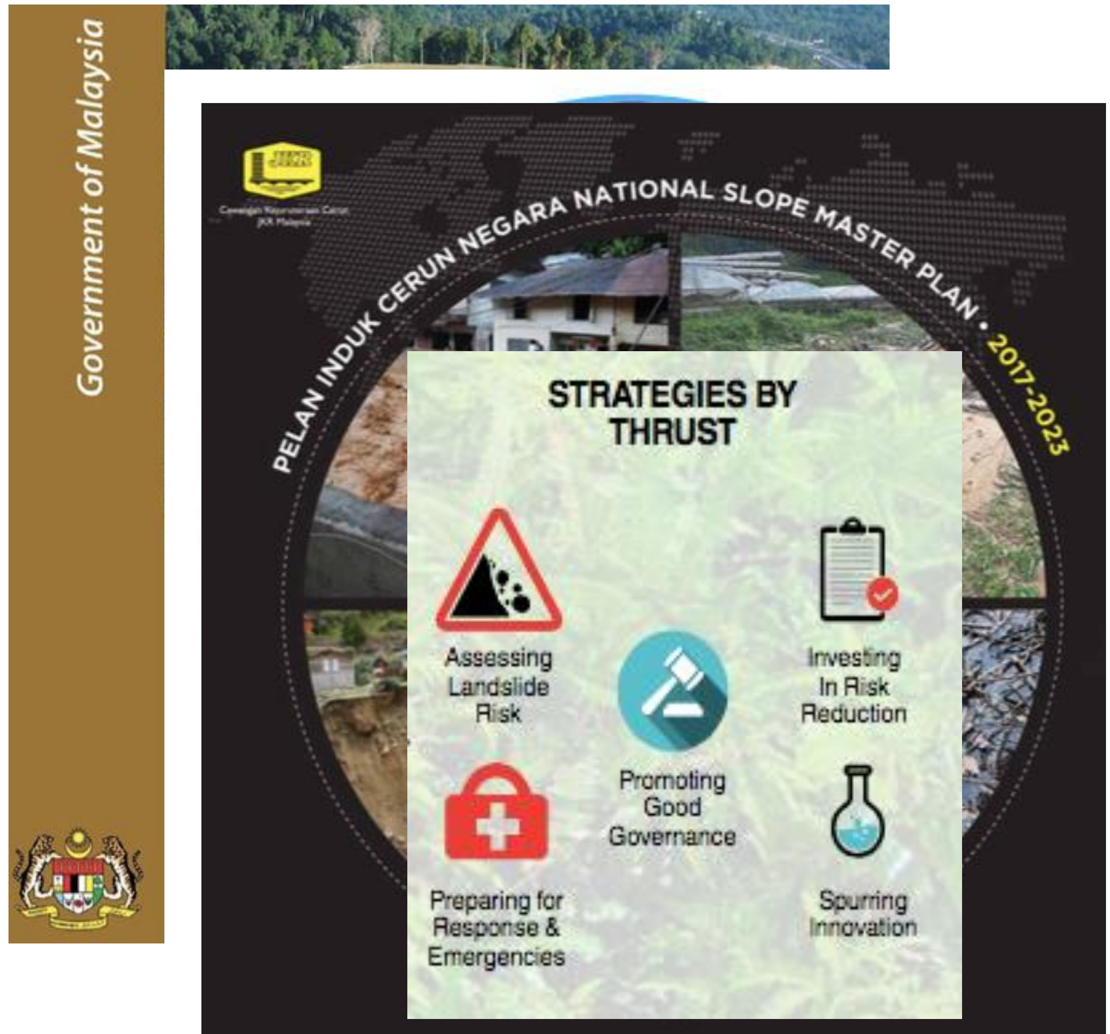
A complex geological hazard and risk assessment

> 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.

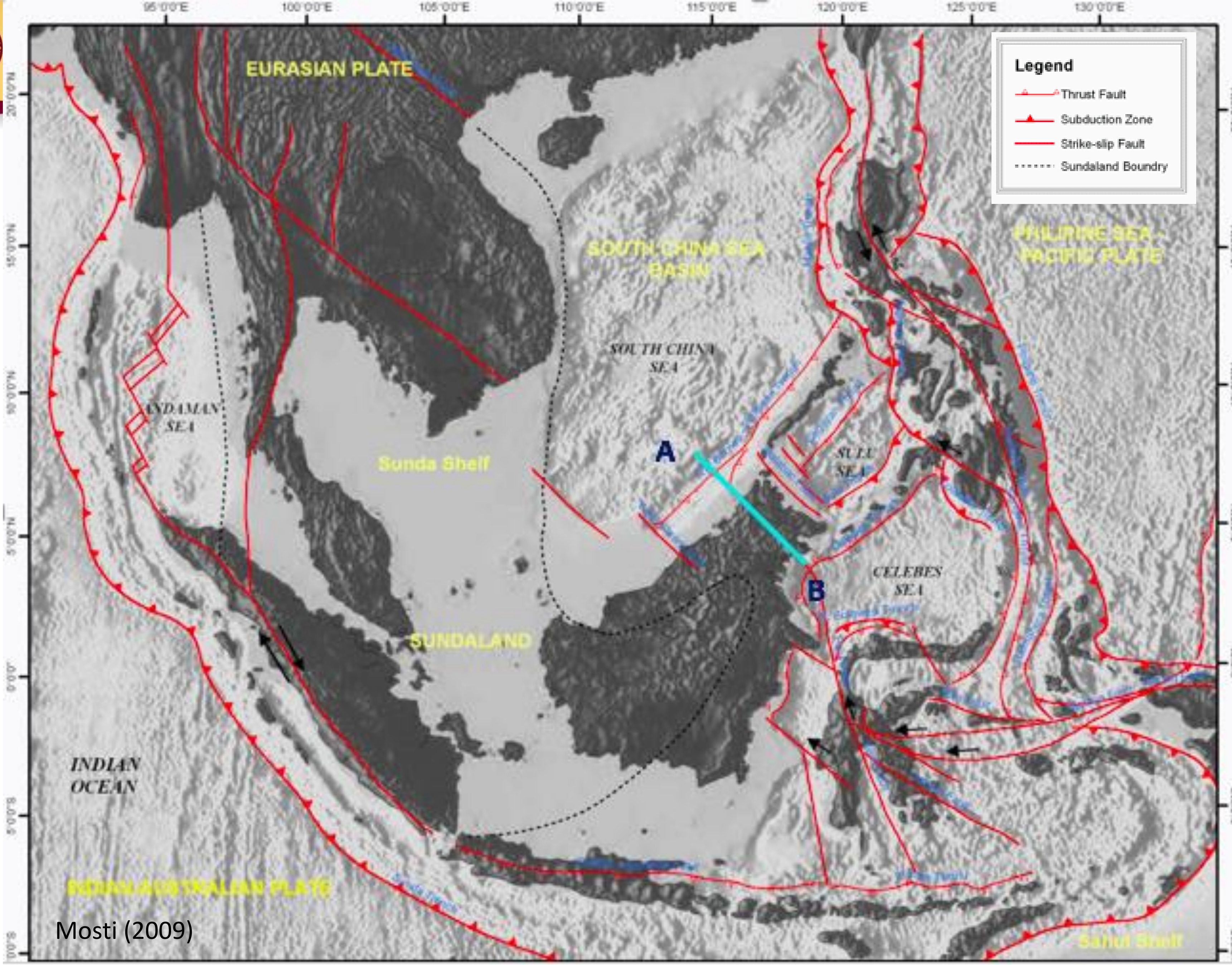
RISK is a multi-disciplinary SPATIAL problem

RISK ASSESSMENT: CHALLENGES



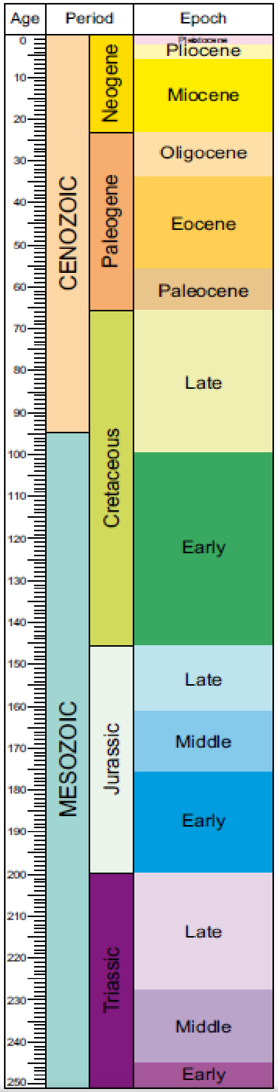


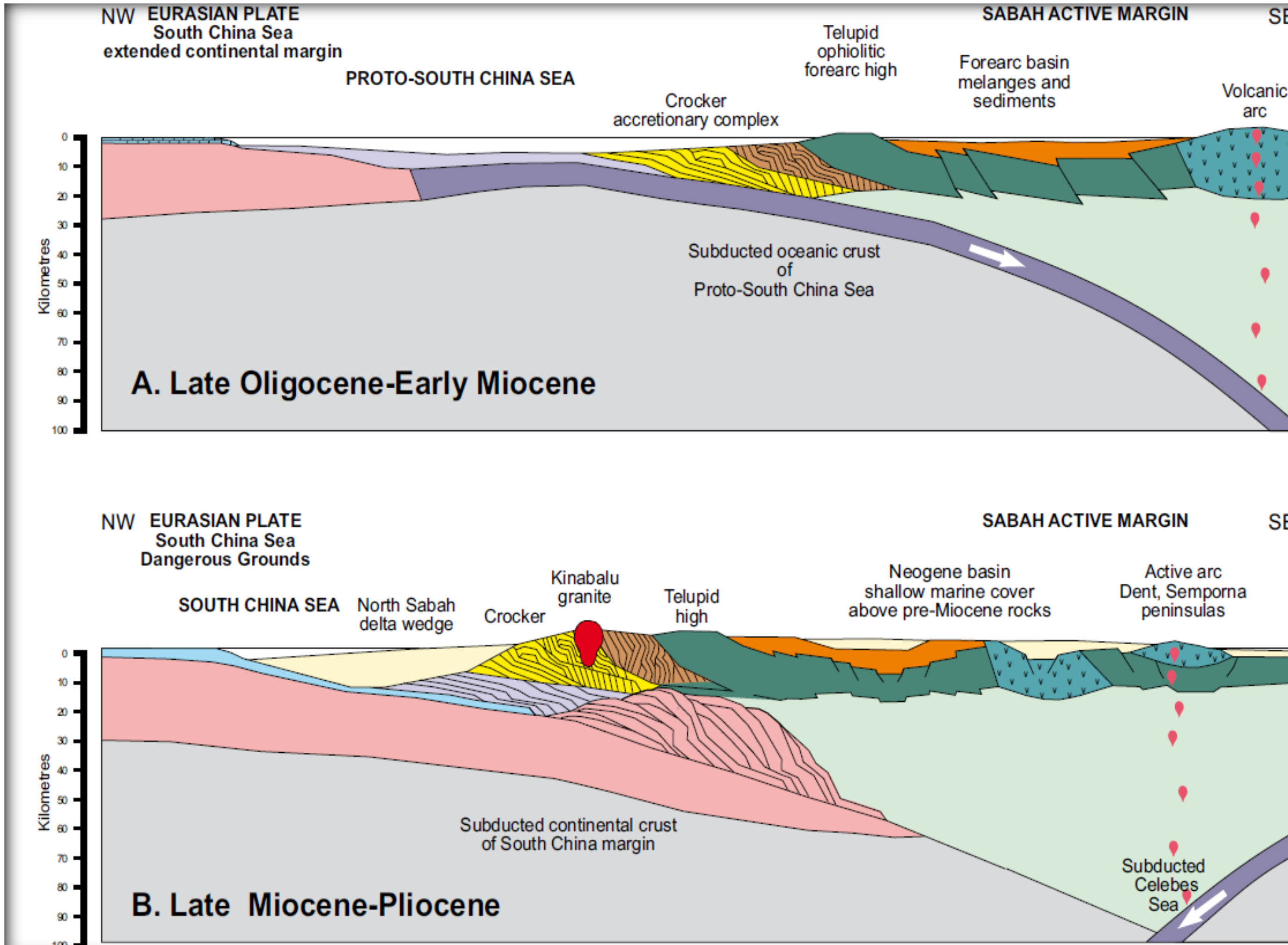
Sabah, Malaysia



Mosti (2009)

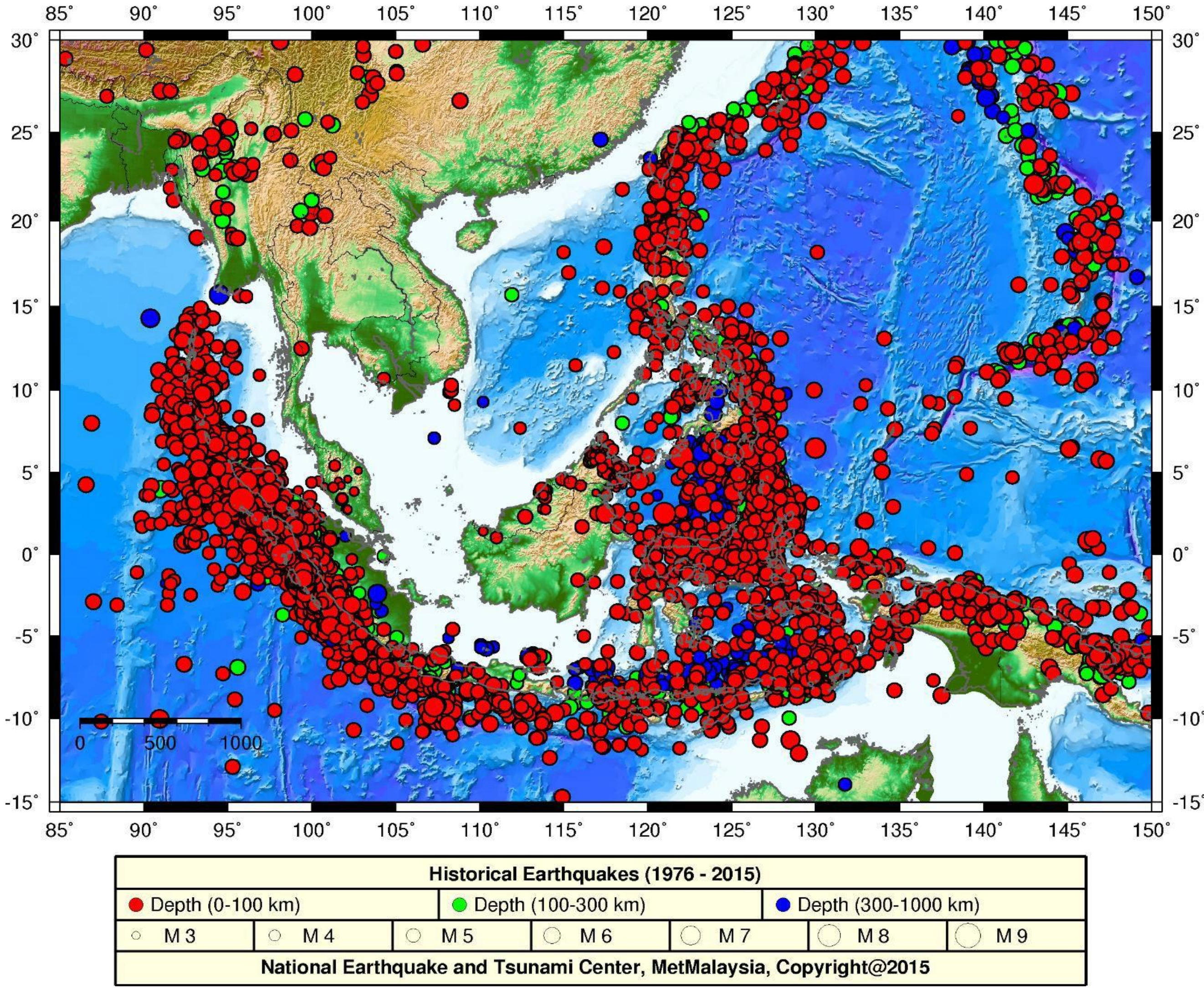
Geological characteristics – Sabah, Malaysia





(after Hall et al, 2008)

SEISMIC ACTIVITIES (1976 – 2015)

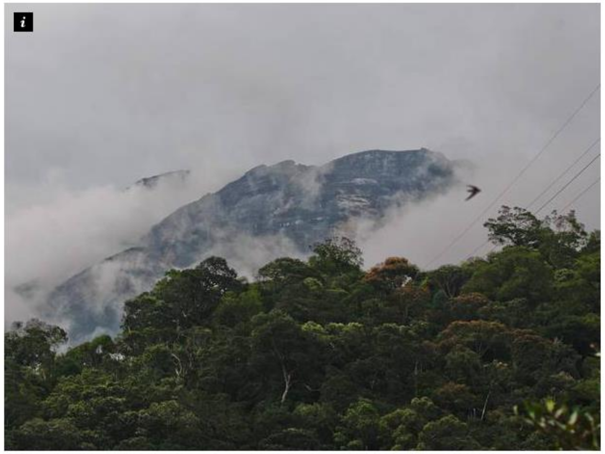


Earthquake I Sabah I 05 June 2015

The INDEPENDENT

News > World > Asia

Malaysia earthquake: 11 dead and eight missing after 5.9 magnitude quake hits Mount Kinabalu



The quake struck Malaysia's highest peak on Friday

More bodies found on Malaysia mountain as quake toll hits 13

By ASSOCIATED PRESS

PUBLISHED: 12:28 GMT, 6 June 2015 | **UPDATED:** 12:28 GMT, 6 June 2015

Share

KUALA LUMPUR, Malaysia (AP) — Rescuers recovered the bodies of 11 more climbers from Malaysia's highest peak on Saturday, a day after it was struck by a strong earthquake, bringing the total number of dead to 13.

Six people remained missing on 4,095-meter (13,435-foot) -high Mount Kinabalu in eastern Sabah state on Borneo, where a magnitude-5.9 earthquake on Friday sent rocks and boulders raining down the trekking routes, trapping dozens of climbers.

"This is a very sad day for Kinabalu," said Sabah's tourism minister, Masidi Manjun.

Sun.my ONLINE

Home News World Technology Sports Health Ente

A helicopter leaves Kundasang, Malaysia for Mount Kinabalu to recover the bodies of cli... ...urday recovered the bodies of several more climbers from ... struck by a strong earthquake. (Munehiro Yamaoka/Kyod

...d on Malaysia mountain as quake

5.9 magnitude earthquake hits Sabah (Updated)

theSundaily

Posted on 5 June 2015 - 09:36am

Last updated on 6 June 2015 - 09:38am

CHANNEL NEWSASIA

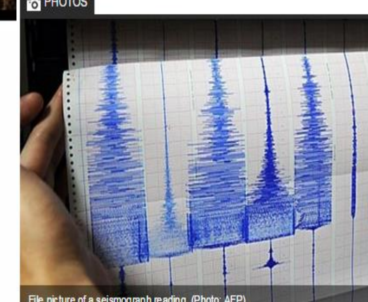
ASIA PACIFIC

Strong 6.0-magnitude quake strikes Malaysia's Sabah

A strong 6.0-magnitude earthquake rocked the state of Sab... Malaysia's Borneo island early Friday, say US geologists sa...

POSTED: 05 Jun 2015 08:08 **UPDATED:** 05 Jun 2015 10:57

PHOTOS



File picture of a seismograph reading. (Photo: AFP)

Australian climber stranded after Malaysia earthquake slams rescue effort

An Australian climber has savaged Malaysian authorities following Borneo earthquake that killed 13 people when it jolted south-east Asia's highest peak

Hikers trapped on Mount Kinabalu, Sabah state, Malaysia on Friday after a 5.9-magnitude earthquake. One climber says they waited nine hours for help before walking out by themselves as tremors continued. Photograph: Xinhua/Rex Shutterstock

THE HANS INDIA

HOME AP TELANGANA INDIA WORLD NRI BUSINESS SPORTS CRIME LIF

Malaysia's Sabah state jolted by earthquake of 5.9 intensity

June 05,2015, 05:33 PM IST | IANS

Kuala Lumpur: A 5.9-magnitude quake jolted Malaysia's Sabah state on Friday.

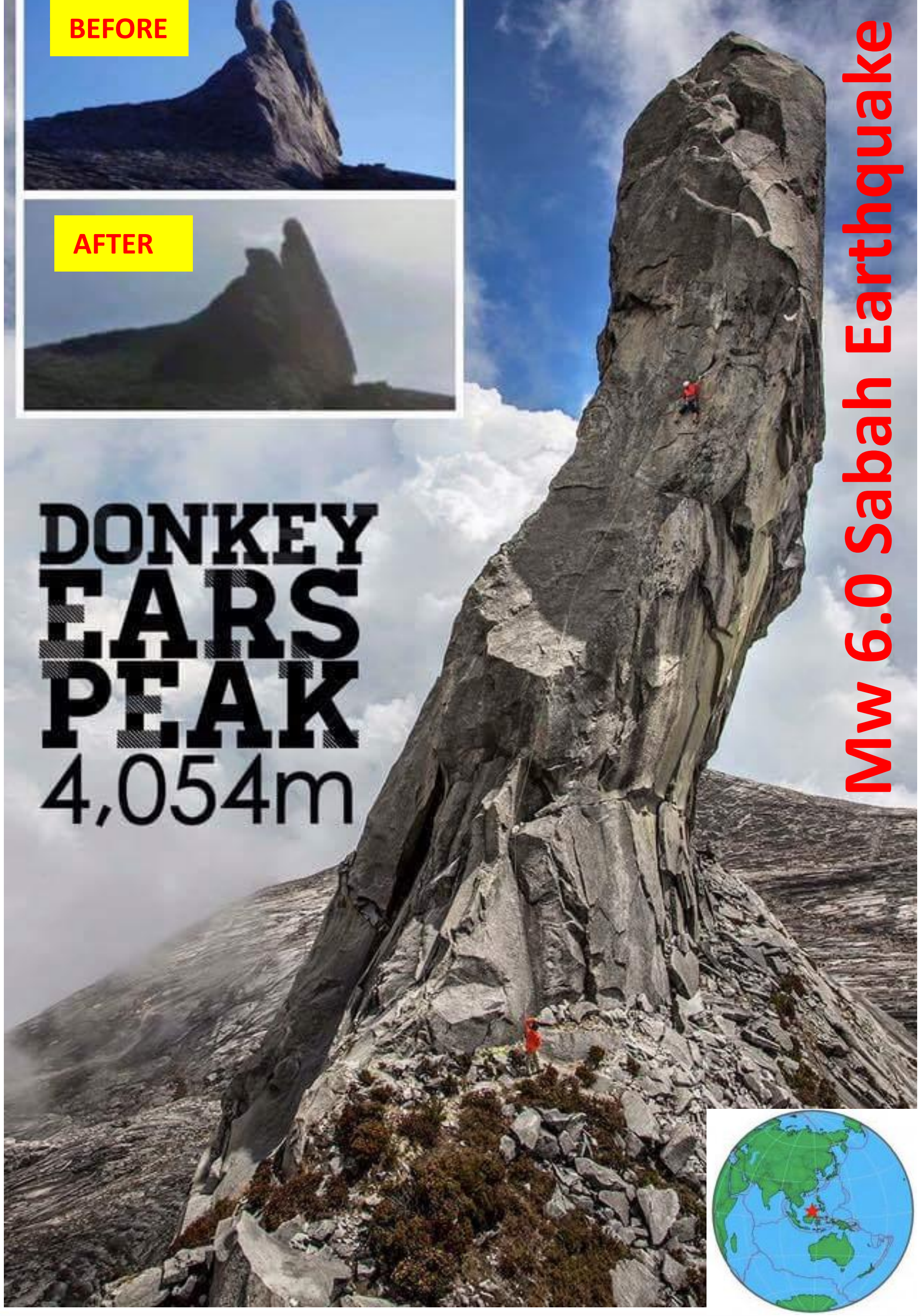
Initial reports from the Malaysian Meteorological Services Department said the quake struck 16 km northwest of Ranau district, The Malaysian Star reported.

Local residents take shelters at the open air in Ranau, Sabah state, Malaysia, June 5, 2015. A 5.9 magnitude earthquake has occurred in Malaysia's Sabah state on North Borneo early Friday morning, authorities said. (Xinhua Photo)

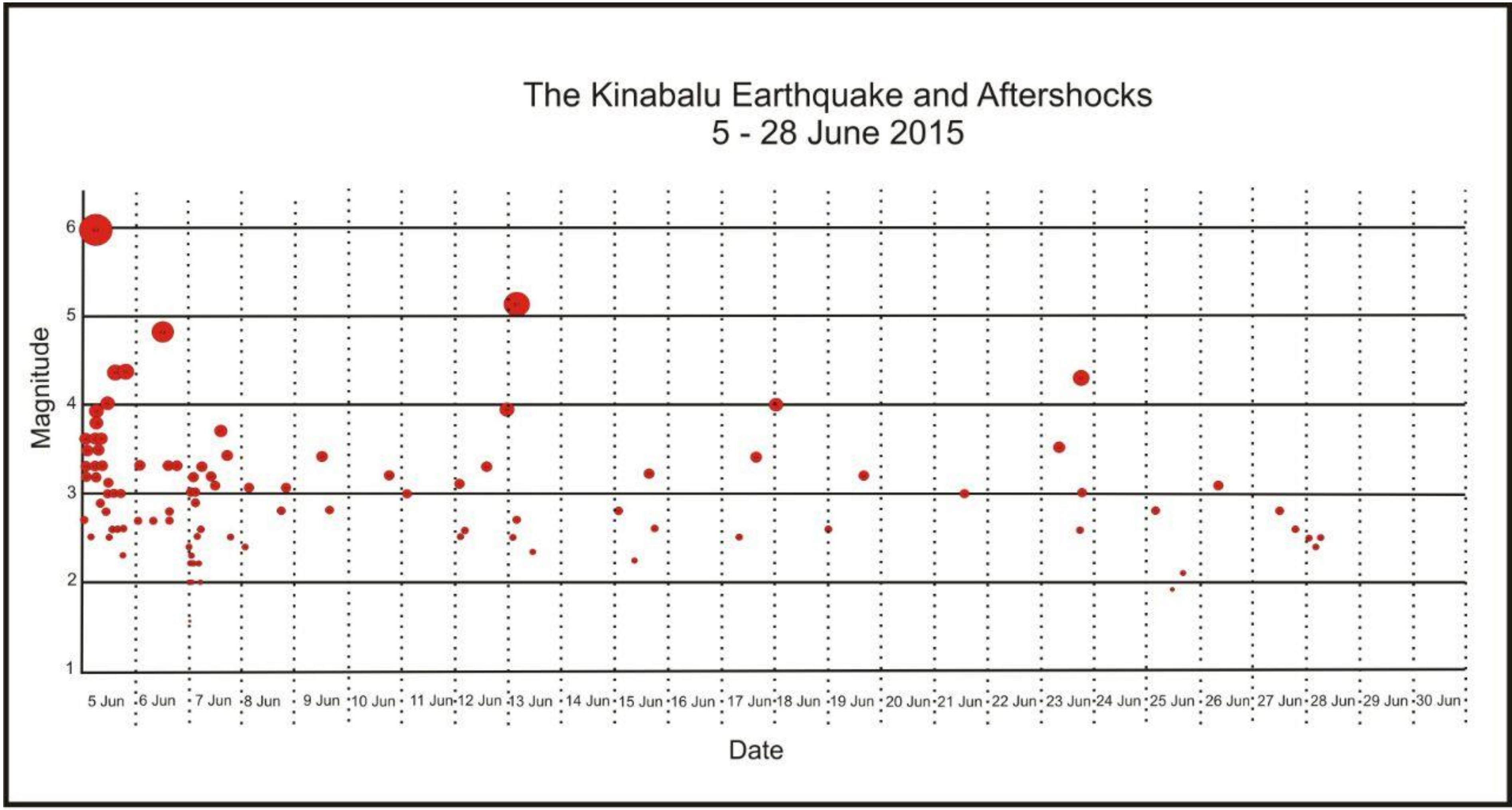
2015 Sabah earthquake

Date	5 June 2015
Origin time	07:15:43 MST (UTC+08:00)[1]
Duration	30 seconds
Magnitude	6.0 (M_w) (USGS) 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 11 wounded

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



EARTHQUAKE AND AFTERSHOCKS



Compiled by Alexander Yan

Data Source: MetMalaysia


Low's Peak
Crocker fault trend
Lobu Lobu
Burton-Johnson (2013)

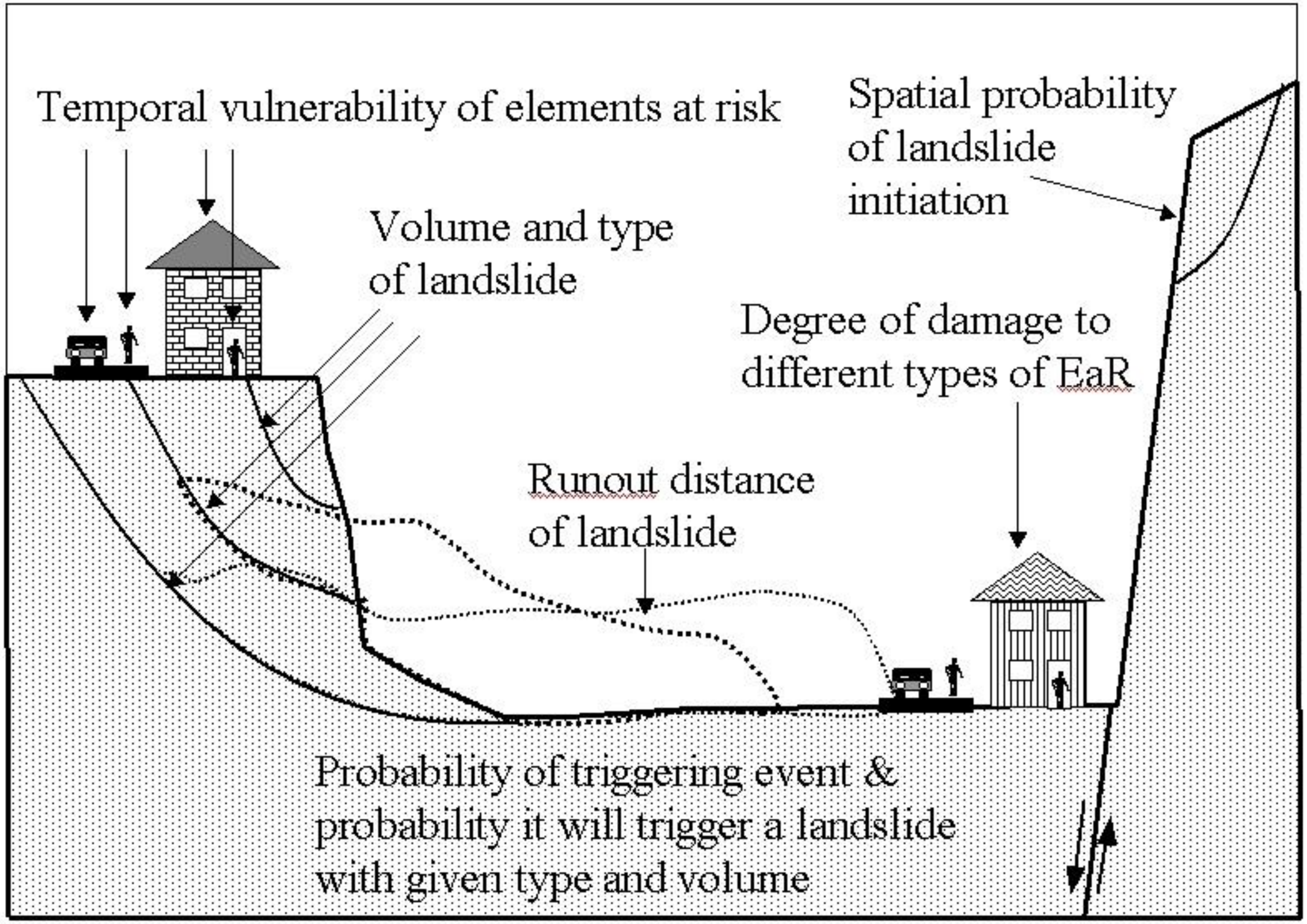
QUANTITATIVE RISK ASSESSMENT

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

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

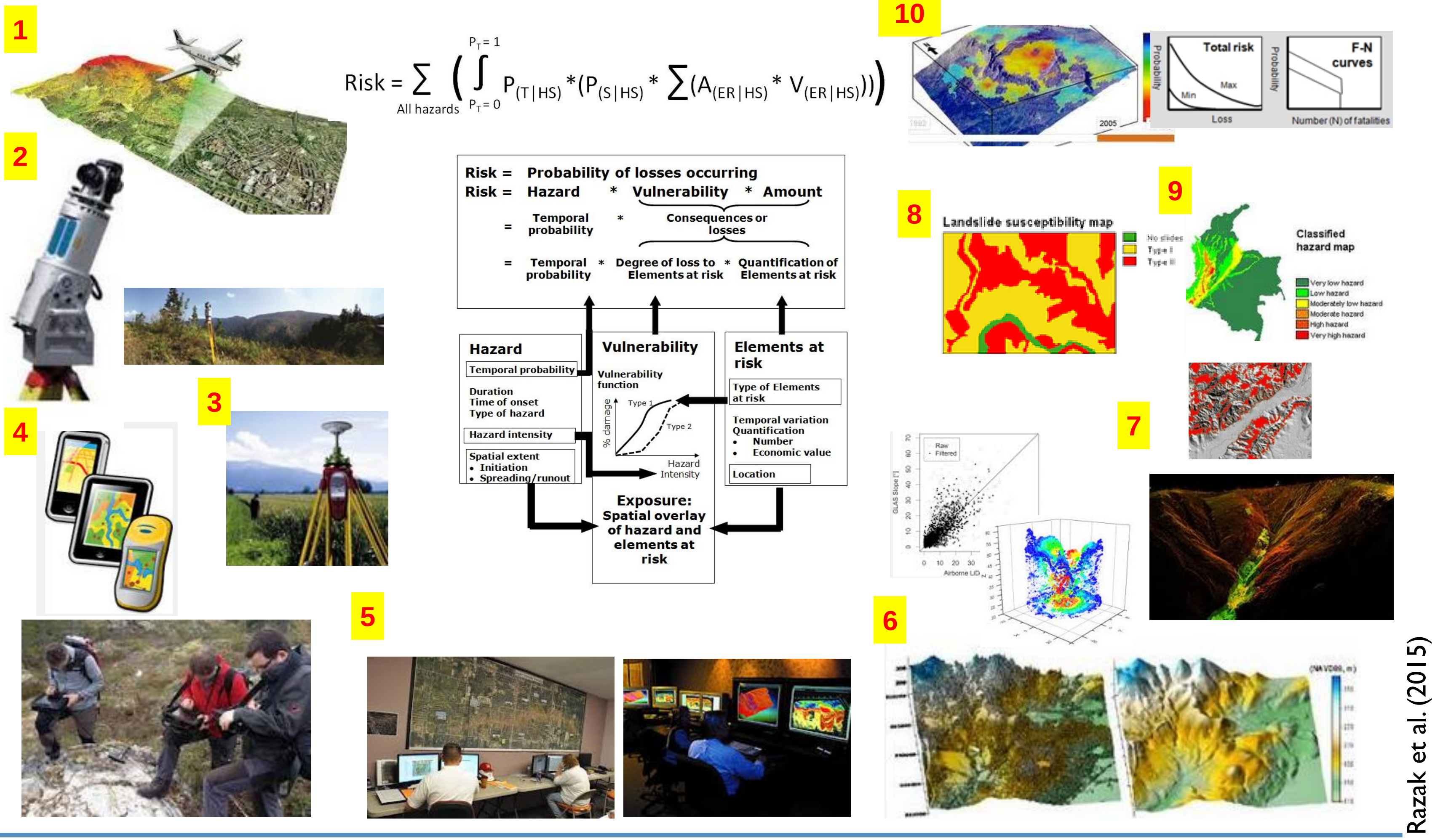
Landslides: Issues and Problems



Source: Prof Cees van Westen (UNU-DGM, ITC-UT Netherlands)

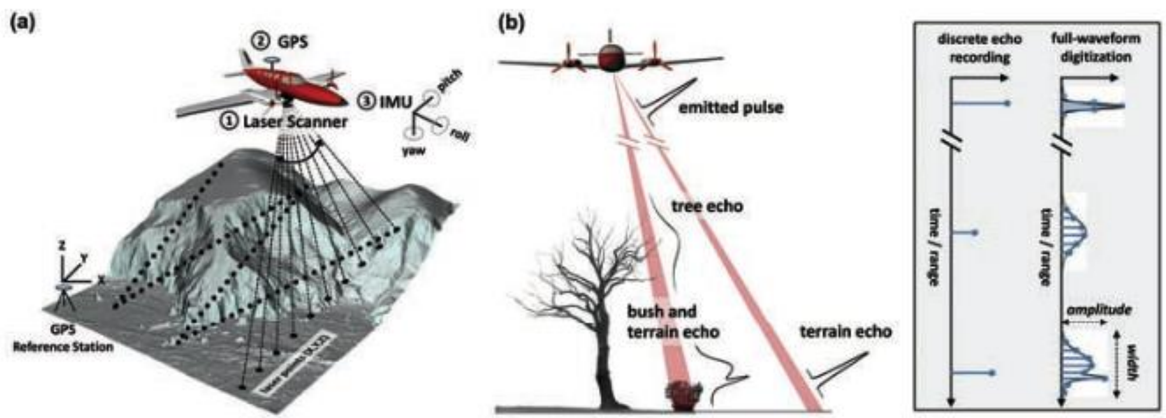
National Initiative - Landslide Hazard and Risk Mapping Project - 2014-2016

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



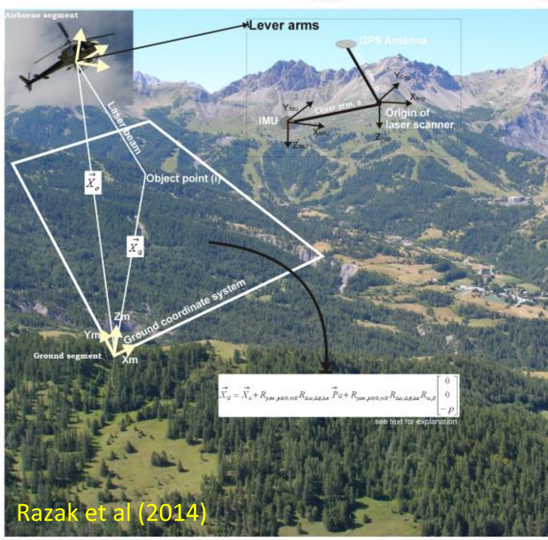
1. Airborne LIDAR; 2. Terrestrial LIDAR, 3. GPS Survey, 4. Mobile GIS Field Mapping, 5. Data Processing, 6. LIDAR-Landslide Processing, 7. Landslide Inventory Mapping, 8. Landslide susceptibility Analysis, 9. Landslide Hazard Assessment, 10. Landslide Risk Assessment

Topographic Laser Scanning System (LiDAR), most advanced geospatial tech to mapping, characterizing, and assessing landslide processes



Höfle & Rutzinger (2011)

High density airborne LIDAR is a powerful tool for mapping, monitoring & modelling of the disaster prone area



Razak et al (2014)

Courtesy of BUMITOUCHplmc

New capability of modern LiDAR system for recording full-waveform spatial data

A: Input data

B: Susceptibility assessment

C: Hazard assessment

D: Exposure analysis

E: Vulnerability assessment

F: Risk assessment

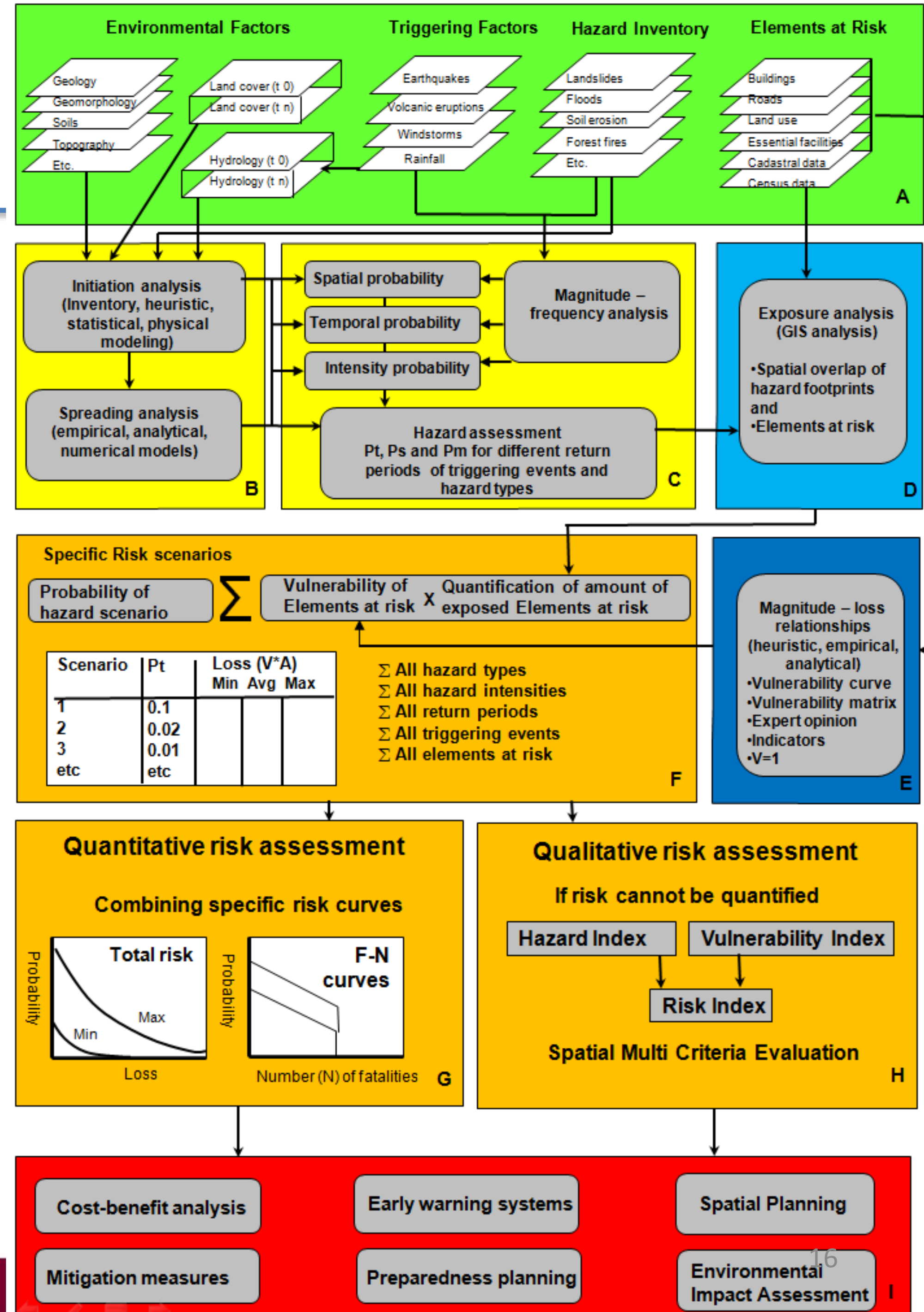
G: Quantitative risk

- Economic risk
  - Direct
  - Indirect
- Population risk
  - Societal risk
  - Individual risk

H: Qualitative risk

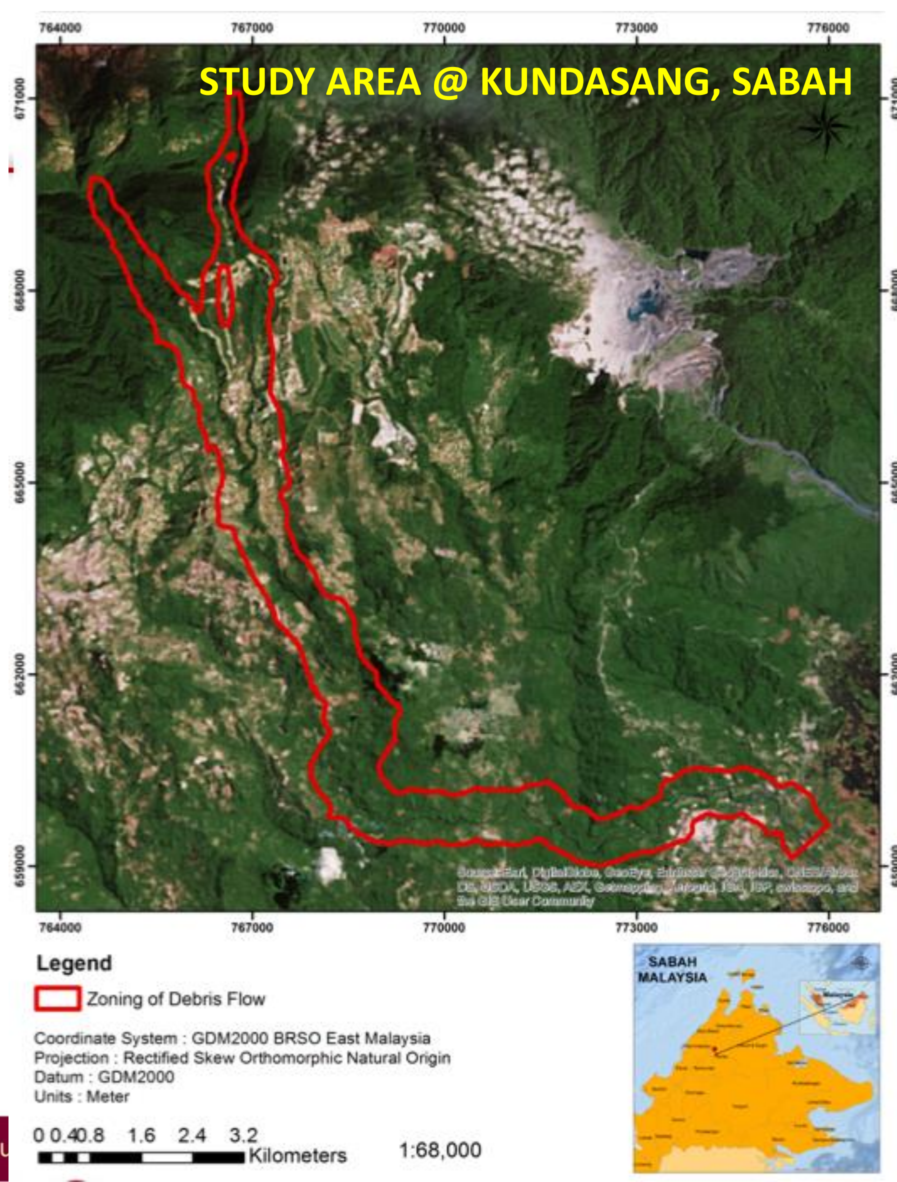
I: Risk reduction measures

Corominas et al. (2013)




7 April 2015


20 July 2015


STUDY AREA @ KUNDASANG, SABAH
764000
767000
770000
773000
776000
671000
668000
665000
662000
659000
Legend
Zoning of Debris Flow
Coordinate System : GDM2000 BRSO East Malaysia
Projection : Rectified Skew Orthomorphic Natural Origin
Datum : GDM2000
Units : Meter
0 0.4 0.8 1.6 2.4 3.2
Kilometers
1:68,000
SABAH
MALAYSIA

Sediment-based disaster

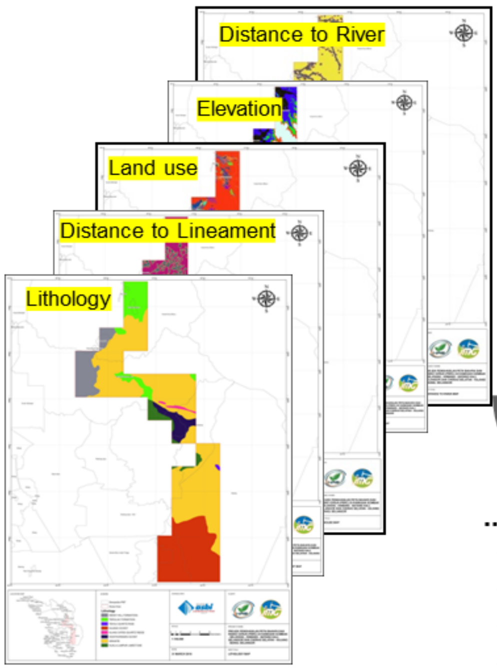
– damage to infrastructures (houses, bridges, schools, hotels, etc.), hot-springs, water drainage pipe (supply disruption) and ecological- (aquatic habitat) & socio-economic impact)

@ Kundasang, Sabah (June 2015)

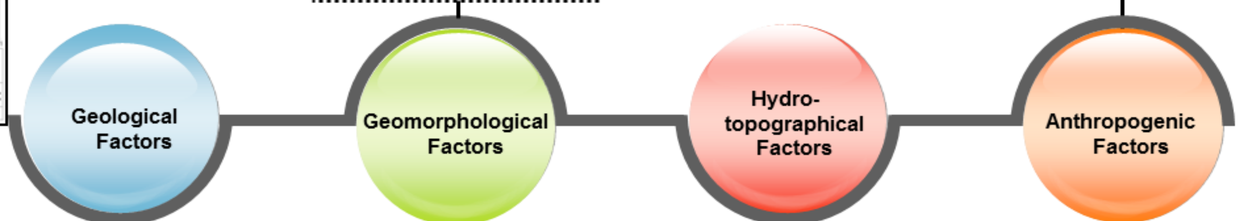
"…Notable here is the amount of timber in the river – to me this suggests that there must have been quite extensive landslides in the forested areas on the lower slopes of the mountain. ***I have not seen detailed reports or images of these landslides.****"*

LANDSLIDE SUSCEPTIBILITY AND HAZARD

Indicating Likeliness and Severity of Landslide



Sample Causal Factor Maps

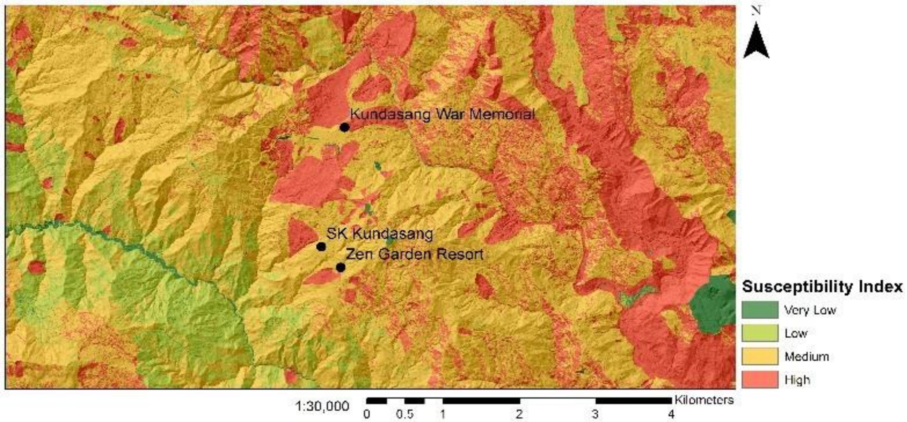


Geological Factors
- Lithology
- Soil
- Lineament
- Faults
- Distance to Lineament
- Distance to Fault
- Distance to Earthquake Epicenter

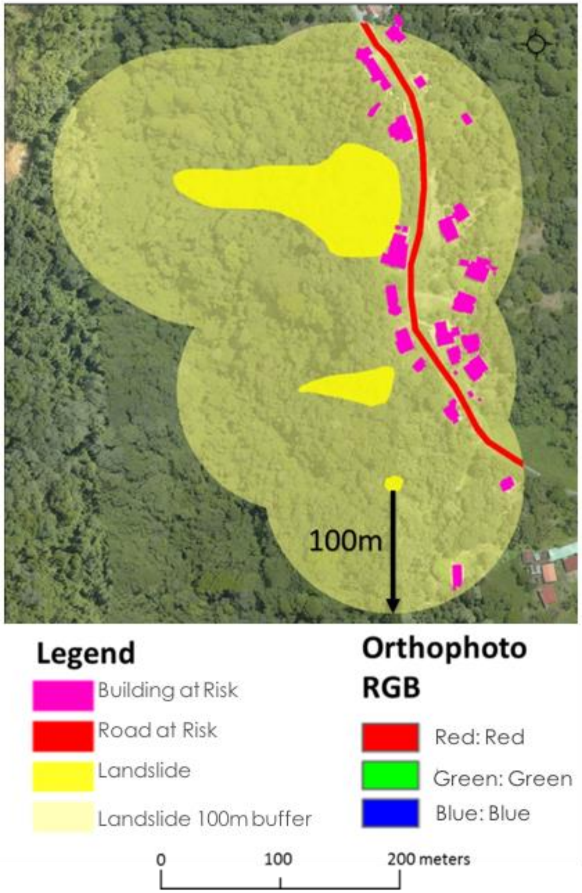
Geomorphological Factors
- Slope Map
- Curvature Map
- Geomorphological Map
- Aspect Map
- Terrain Roughness Index
- Terrain Surface Classification
- Terrain Surface Texture
- Terrain Surface Convexity
- Vector Ruggedness Measure

Hydro-topographical Factors
- Flow Direction
- Watershed
- Flow Accumulation
- Channel
- Stream Network
- Topographic Wetness Index

Anthropogenic Factors
- LULC
- Road Cut
- Disrupted Drainage
- Distance to Road
- Distance to River



Landslide Susceptibility Map



Element at Risk analysis with 100 meters of buffering distance

UTM UNIVERSITI TEKNOLOGI MALAYSIA

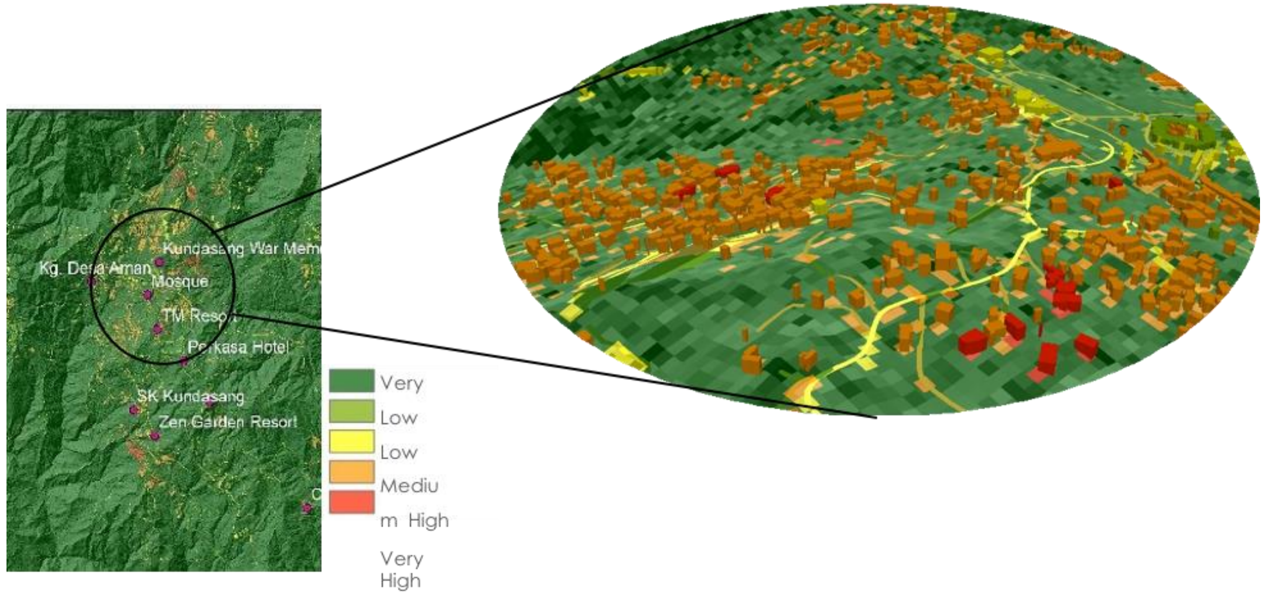
ELEMENTS AT RISK FOR MULTI-HAZARD AND DISASTER RISK

Type of elements at risk	Scale of analysis			
	Small	**Medium**	**Large**	**Detailed**
Buildings	By Municipality • Nr. buildings	Mapping units • Predominant land use • Nr. buildings	Building footprints • Generalized use • Height • Building types	Building footprints • Detailed use • Height • Building types • Construction type • Quality / Age • Foundation
Transportation networks	General location of transportation networks	Road & railway networks, with general traffic density information	All transportation networks with detailed classification, including viaducts etc. & traffic data	All transportation networks with detailed engineering works & detailed dynamic traffic data
Lifelines	Main powerlines	Only main networks • Water supply • Electricity	Detailed networks: • Water supply • Waste water • Electricity • Communication • Gas	Detailed networks and related facilities: • Water supply • Waste water • Electricity • Communication • Gas
Essential facilities	By Municipality • Number of essential facilities	As points • General characterization • Buildings as groups	Individual building footprints • Normal characterization • Buildings as groups	Individual building footprints • Detailed characterization • Each building separately
Population data	By Municipality • Population density • Gender • Age	By ward • Population density • Gender • Age	By Mapping unit • Population density • Daytime/Nighttime • Gender • Age	People per building • Daytime/Nighttime • Gender • Age • Education
Agriculture data	By Municipality • Crop types • Yield information	By homogeneous unit, • Crop types • Yield information	By cadastral parcel • Crop types • Crop rotation • Yield information • Agricultural buildings	By cadastral parcel, for a given period of the year • Crop types • Crop rotation & time • Yield information
Economic data	By region • Economic production • Import / export • Type of economic activities	By Municipality • Economic production • Import / export • Type of economic activities	By Mapping unit • Employment rate • Socio-economic level • Main income types Plus larger scale data	By building • Employment • Income • Type of business Plus larger scale data
Ecological data	Natural protected areas with international approval	Natural protected area with national relevance	General flora and fauna data per cadastral parcel.	Detailed flora and fauna data per cadastral parcel

Van Westen et al. (2015)

Risk is technically computed based on three contributing factors known as:
1) the probability of a landslide occuring at a given magnitude (Hazard); 2) the exposure level; and
3) the expected degree of loss resulting from the specified landslide magnitude (Vulnerability).

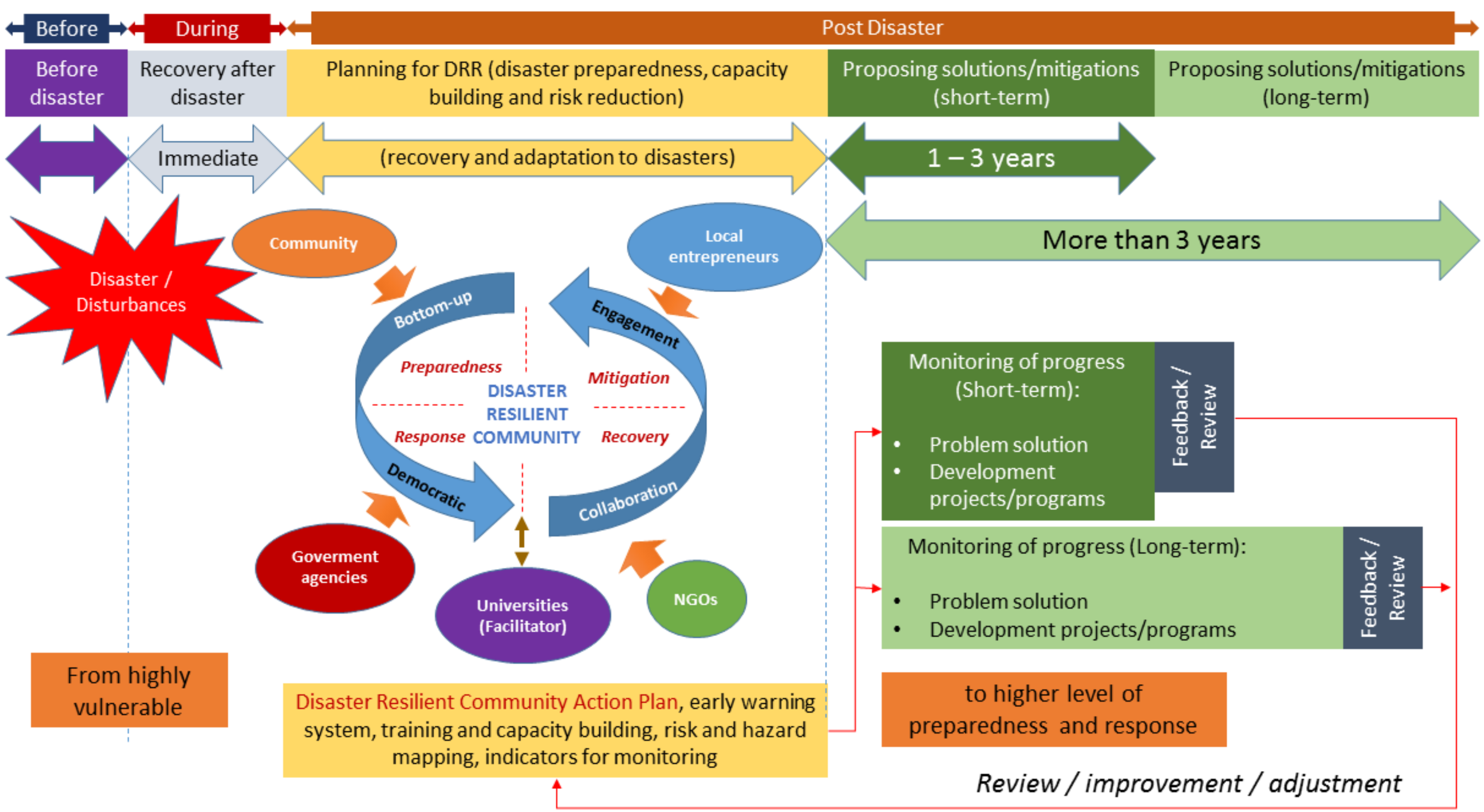
Landslide Risk Map



Challenges: Historical inventory and archived data to analyze triggering factors (rainfall & seismic), understand vulnerability variation and scientifically analyze a possible risk

TOWARDS A RESILIENT COMMUNITY

STAKEHOLDERS, COMMUNITY AND CAPACITY BUILDING



Scheme of the run-out methods type and their computation dimensions

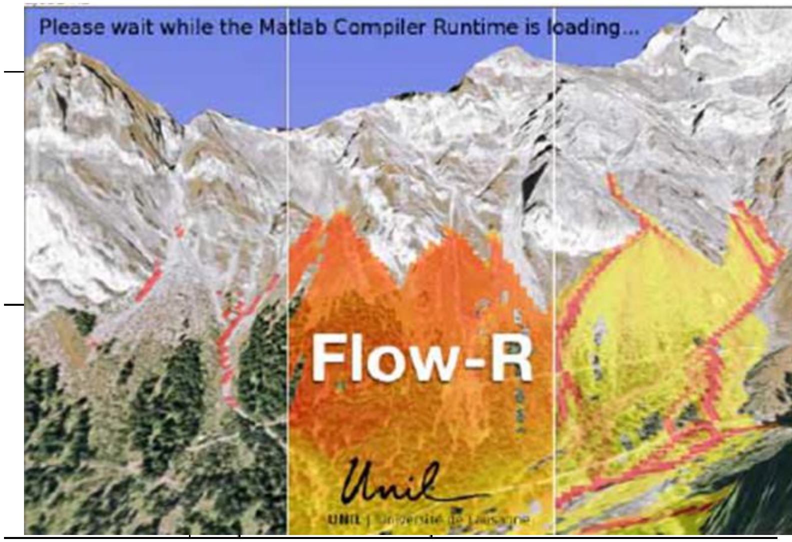
.. utilizing modern geospatial data and others in characterizing and generating data input for run-out assessment?

Dimension of calculations	Type of methods	Inputs	Outputs
1-D	Empirical methods: - Heuristic - Angle of reach - Mass-change	- Volume estimation - Topographic profiles - Image interpretation - Geomorphologic studies	- Maximum run-out - Area of deposit - Flow depth
	Analytical methods (point mass models)	- Rheological parameters - Topographic profile	- Maximum run-out - Velocity
	Numerical methods	- Rheological parameters - Topographic profile - Volume	- Maximum run-out - Velocity - Impact pressures - Flow depth
2-D	Flow routing methods	- DEM (Digital elevation model)	- Pxy= probability of each cell to be affected by a flow - Flow trajectories and extension of deposits
	Numerical methods	- DEM - Rheological parameters - Volume	- Extension of deposits - Velocity - Flow depth - Impact pressures

Quan Luna et al (2012)

Model	Reasons for selecting this particular model
MassMov2D	- Open source model implemented in a dynamic GIS (PCRaster). - Possibility to use different rheologies. - Models entrainment. - Outputs of the results can be obtained in forms of maps, graphs or text files. - User friendly. - Code can be modified to the user needs. - Can run batch files

– Regional scale empirical runout model
Based on travel angles



Model	Reasons for selecting this particular model
FLOW-R (*)	- Simple regional model for run-out assessment. - Use the energy-line approach.
1-D entrainment model (*)	- Models entrainment with a concept based on limit equilibrium and the generation of excess pore water pressure through undrained loading of the bed material.
AschFlow (*)	-Simplified regional run-out model. - Based on rheological parameters. - Different rheologies can be selected. - Models debris flow velocity and thickness.

Framework for Sediment Disaster Management

Where (spatial)?

- Mapping potential debris flow torrents
- Analyzing regional susceptibility zones for debris flow

What & How (vulnerability)?

- Inventory of possible affected zones/community & Elements-at-risk

Where (temporal) & What (risk level)?

Assessing debris flow hazard & risk

- Engineering
- Landuse restriction
- Residential Relocation
- Evacuation**

When? (Monitoring & Prediction)

Disaster analysis → Early warning system → Rainfall based model → Rainfall > Threshold → Warning → Evacuation

Disaster Info. (database development Updating & dissemination)

An Integrated Research Framework
"Disaster Resilience Model"

$$R = f\,(D,A,T)$$

Where
R: Resilience; D: Damage = f (H,E,V); A: Human Activities; T: Time

where D = f (H,E,V)

$$R = f\,(\underbrace{H,E,V}_{\text{Prevention}},\underbrace{A,T}_{\text{Recovery}})$$

Future work and collaboration

Quantifying geomorphological & fluvial processes and activities

Mountain geohazards, sediment-related disaster & flood risk

Regional seismotectonic activity and climate risk assessment

Multihazard and disaster risk assessment (space technology based; community-based); Monitoring & Early warning system

Mainstreaming DRR into the future development planning

Transdisciplinary approach for building resilient city and society

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
Web: http://www.razakschool.utm.my/khamarrul

Visiting address:-
Room no. 32, Level 6,
Malaysia-Japan International Institute of Technology (MJIIT)
Universiti Teknologi Malaysia
Jalan Sultan Yahya Petra, Kuala Lumpur

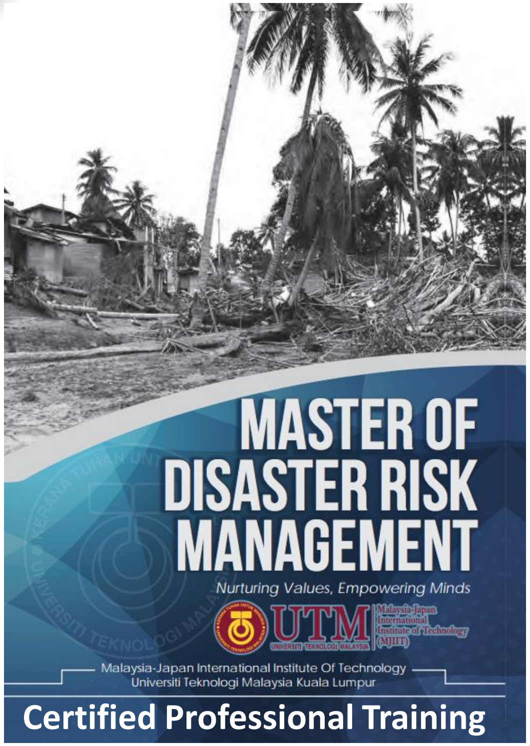
Disaster Preparedness and Prevention Center
Malaysia-Japan International Institute of Technology
Universiti Teknologi Malaysia (UTM) Kuala Lumpur

Geospatial Intelligence Research Initiative
Cascading GeoHazards Research Initiative
UTM RAZAK School of Engineering and Advanced Technology
Universiti Teknologi Malaysia (UTM) Kuala Lumpur
54100 Jalan Sultan Yahya Petra, Kuala Lumpur

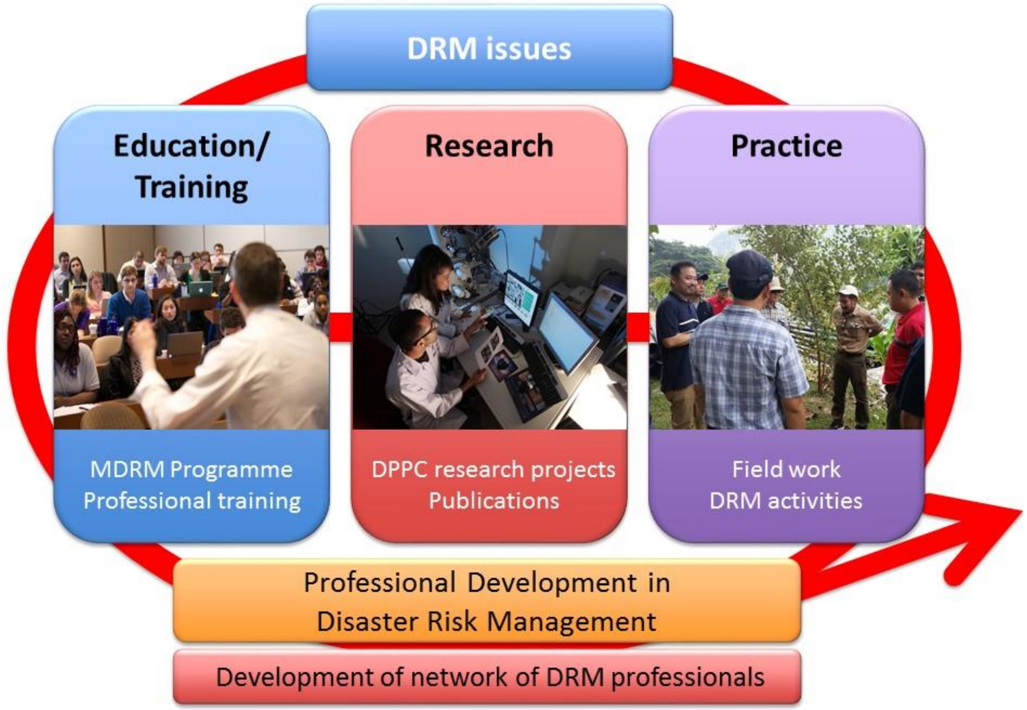
UTM UNIVERSITI TEKNOLOGI MALAYSIA

MASTER OF DISASTER RISK MANAGEMENT (MDRM)

MDRM @ MJIIT UTM KL is the first Master's degree in disaster risk management in Malaysia that is taught by both Japanese and Malaysian DRM experts.



Facilitating Disaster Risk Reduction in Asia through Training – Research – Field Practice



- Two Weeks Attachment In Japan
- Modular Programme
- Japanese Professional Support
- Short-Term Professional Training Programme
- Credit Transfer from Professional Training
- Full-Time, One Year Program

Supported by:

DISASTER RISK MANAGEMENT SUBCOMMITTEE

@ http://mjiit.utm.my/mdrm/

UTM UNIVERSITI TEKNOLOGI MALAYSIA | Malaysia-Japan International Institute of Technology (MJIIT)

CERTIFIED PROFESSIONAL TRAINING IN DISASTER RISK MANAGEMENT

Nurturing Values, Empowering Minds

http://mjiit.utm.my/dppc/

DISASTER RISK MANAGEMENT SUBCOMMITTEE

COURSE NAME	DATES	LECTURER'S NAME
Integrated Disaster Management	25 September - 6 October 2017	Prof. Kuniyoshi Takeuchi (ICHARM)
Disaster Data Management and Forecasting	16 - 27 October 2017	Dr. Koji Dairaku (NIED)
Emergency Response Planning and Communication	20 November - 1 December 2017	Prof. Michinori Hatayama (Kyoto University)
Recovery and Reconstruction Management	11 - 22 December 2017	Prof. Norio Maki (Kyoto University)
Control Measures and Mitigation Planning	3 - 17 January 2018	Prof. Kenichi Tsukahara (Kyushu University)
Healthcare in Emergencies and Rehabilitation	12 - 23 March 2018	Prof. Yukiko Wagatsuma (Tsukuba University)
Flood Forecasting and Hazard Mapping	16 - 27 April 2018	Prof. Shinji Egashira (ICHARM) & Prof. Koji Asai (Yamaguchi University)
Disaster Education and Preparedness for Social Resilience	7 - 18 May 2018	Prof. Fusanori Miura (Yamaguchi University) & Prof. Hitoshi Nakamura, (Shibaura Institute of Technology)
Geohazard Information for Disaster Risk Assessment	2 - 13 July 2018	Prof. Naoki Sakai (NIED) & Prof. Masahiro Chigira (Kyoto University)