COURSE: GEO-INFORMATICS IN EARTH SCIENCE, TECTONIC HAZARD AND INFRASTRUCTURE MANAGEMENT

LECTURE 3 – Introduction to Geological Hazard

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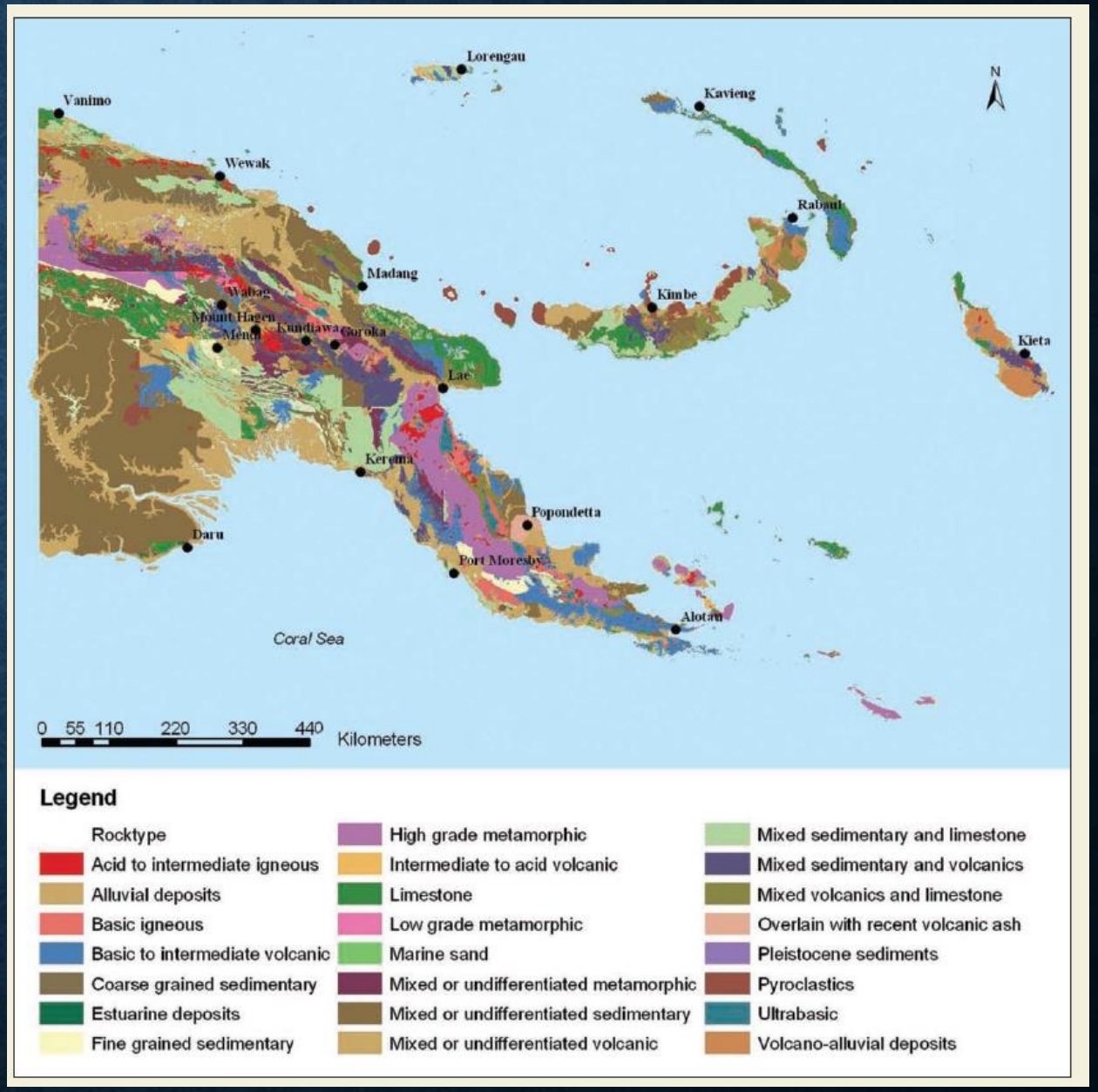
Geology

Geological:

- Related to Earth's structure, composition, and processes.
- Involves solid materials, such as rocks, minerals, and surface features.
- Pertains to the study of Earth's history, evolution, and dynamic forces.

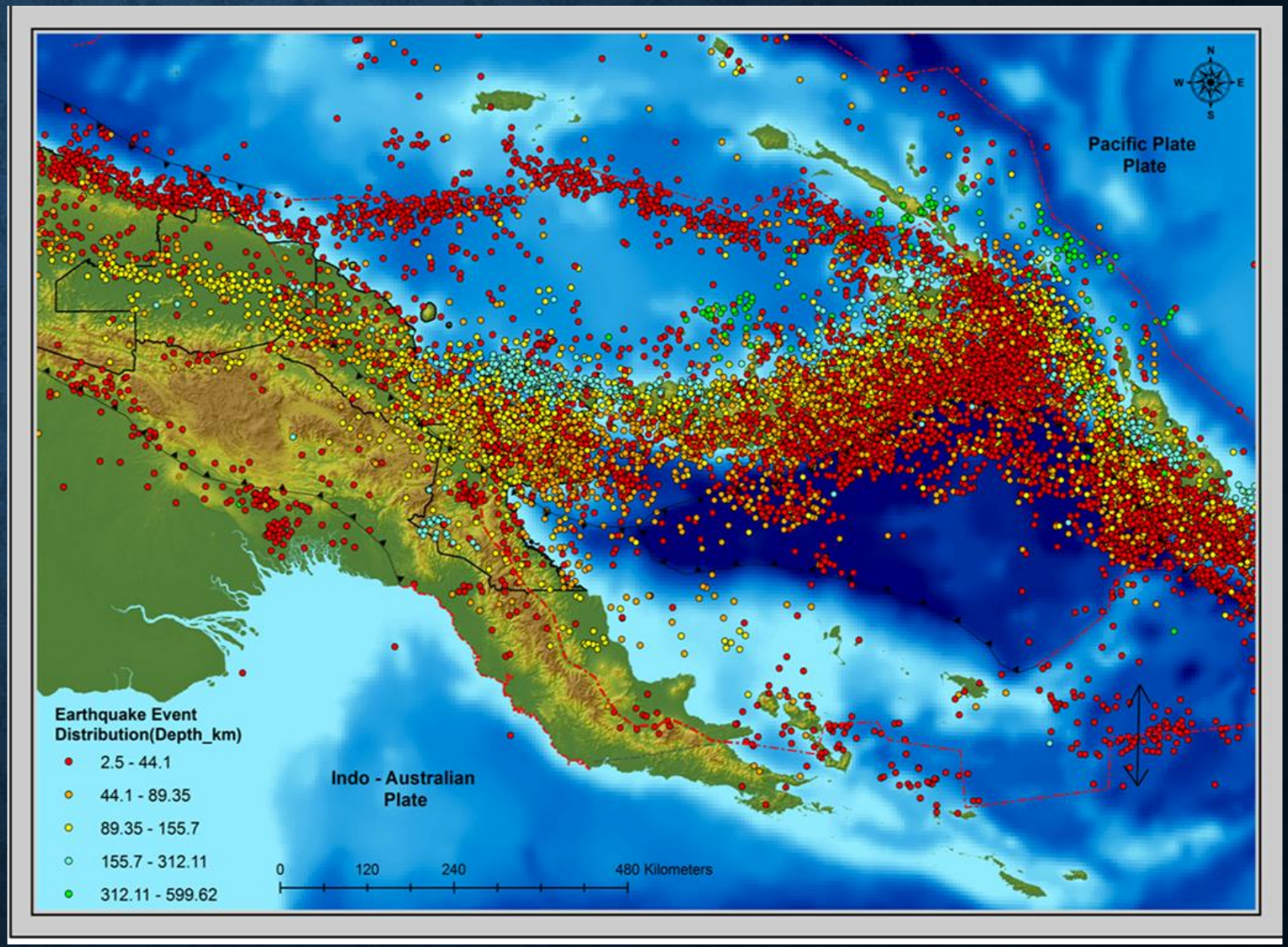


Map Source: PNG Resource Handbook 3rd edition

Hazard

Hazard:

- A situation, event, or condition with the potential to cause harm or damage.
- Can affect people, property, the environment, or society.
- Hazards can be natural, technological, or human-made.



Geological Hazard

Geological Hazard:

Specific type of hazard associated with natural events driven by geological forces.

Results from Earth's dynamic geological processes.

Includes hazards like:

- earthquakes,
- volcanic eruptions,
- landslides, and
- floods.

Natalie Whiting, 2020

Geological Hazard

A SIMPLIFIED CLASSIFICATION OF MAJOR GEOLOGIC HAZARDS

Earthquake - Hazard They Cause:

- Ground shaking
- Surface faulting
- Landslides and liquefaction
    1. Rock avalanches
    2. Rapid soil flows
    3. Rock falls
- Tsunamis

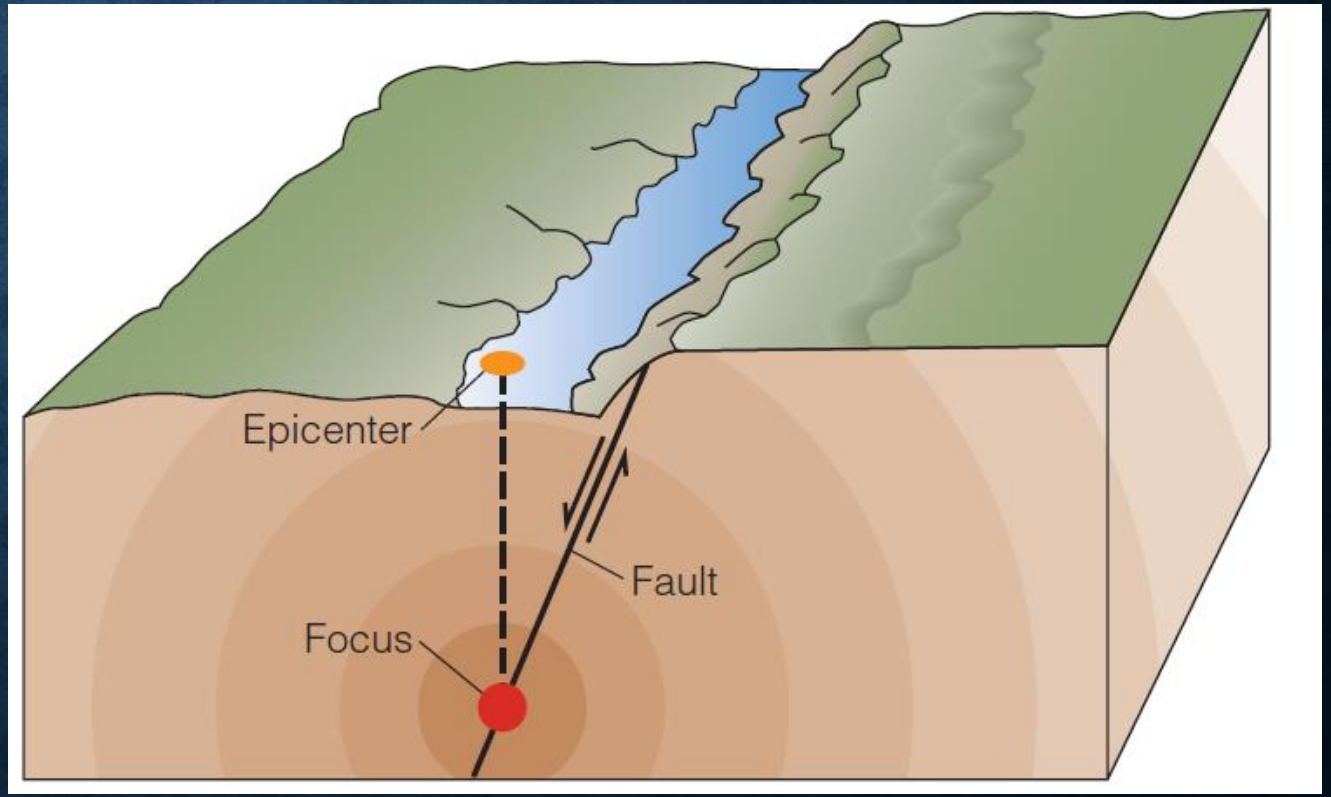


Image Source: Hyndman. D and Hyndman. D (2007)

Source: OAS/DRDE Natural Hazards Primer, 1990

Geological Hazard

A SIMPLIFIED CLASSIFICATION OF MAJOR GEOLOGIC HAZARDS

Volcanic Eruption - Hazard They Cause:

- Tephra falls and ballistic projectiles
- Pyroclastic phenomena
- Lahars (mud flows) and floods
- Lava flows and domes
- Poisonous gases

Image Source: Encyclopedia Britannica, 2023

Source: OAS/DRDE Natural Hazards Primer, 1991

Geological Hazard Mitigation

Mitigation:

- Requires understanding, monitoring, and mitigation for disaster preparedness and risk reduction.

- Mitigating geological hazards is an ongoing process that involves:

- scientific research,
- engineering solutions,
- policy development, and
- community involvement.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Risk Assessment:

- Evaluate the geological hazards in a region, including their frequency, magnitude, and potential consequences.
- Identify vulnerable areas and assets, such as communities, infrastructure, and critical facilities.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Early Warning Systems:

- Establish early warning systems for hazards like earthquakes, tsunamis, and volcanic eruptions.
- Utilize seismic and geospatial data to provide timely alerts to residents and authorities.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Land Use Planning:

Develop and enforce land-use regulations and zoning codes that restrict construction in high-risk areas, such as:

- floodplains,
- fault zones,
- landslide-prone slopes.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Building Codes and Retrofitting:

- Implement and enforce strict building codes that incorporate earthquake-resistant and hazard-specific construction techniques.
- Use geospatial data for vulnerability assessments.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Natural Hazard Maps:

- Create hazard maps that depict the likelihood and impact of geological events in specific areas.
- Use geospatial data to visualize and communicate risks to the public.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Public Awareness and Education:

- Conduct public outreach and education campaigns to raise awareness about geological hazards.
- Teach residents how to prepare for and respond to emergencies.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Infrastructure Resilience:

- Design and construct critical infrastructure (e.g., bridges, dams, and utilities) to withstand geological hazards.
- Incorporate geotechnical engineering solutions for stability.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Emergency Preparedness and Response Plans:

- Develop comprehensive emergency plans that outline procedures for evacuation, sheltering, and first response.
- Conduct drills and exercises to ensure readiness.

Geological Hazard Mitigation

Key processes and approaches for geological hazard mitigation:

Monitoring and Early Detection:

- Continuously monitor geological conditions, such as ground movement, volcanic activity, and river levels.
- Employ geospatial technologies for real-time data collection and analysis.

Geological Hazard Mitigation

Geospatial Mitigation measures:

Geospatial data and technology play a crucial role in hazard;

- assessment,
- monitoring, and
- response,

This helps authorities make informed decisions to protect communities from geological threats.

Geological Hazard Mitigation

<u>Geospatial Mitigation measures:</u>

Liquefaction.

- Liquefaction is a phenomenon in which saturated soil temporarily loses its strength and behaves like a liquid, often causing ground shaking-induced damage.

Photo courtesy of Stuff.co.nz

Geological Hazard Mitigation

Geospatial Mitigation measures:

Liquefaction Potential Zonation:

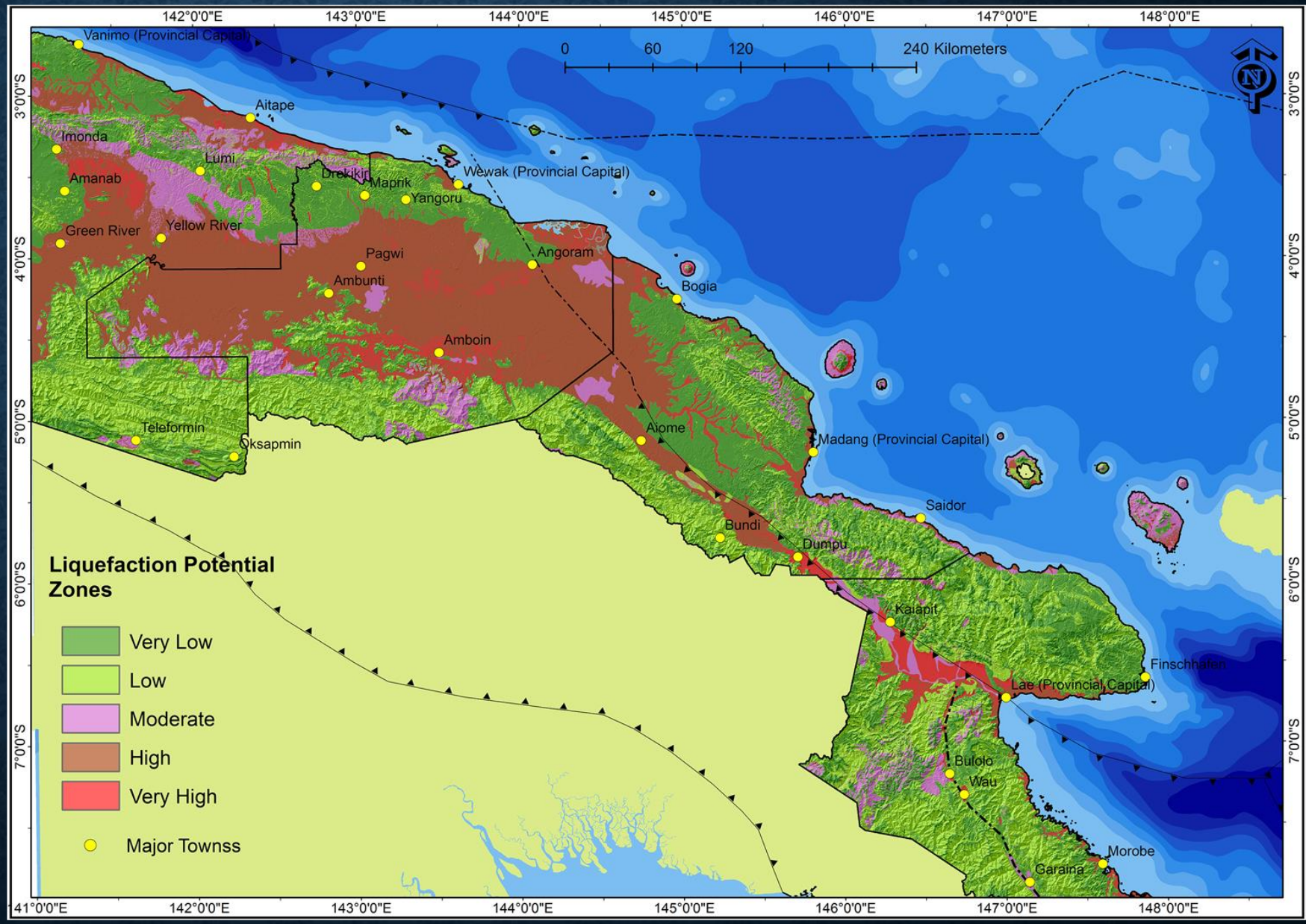
- Refers to the mapping and classification of areas based on their susceptibility to liquefaction during seismic events.

Geological Hazard Mitigation

Geospatial Mitigation measures:

Liquefaction.

- **Identification of Vulnerable liquefaction zone of Momase Region in PNG**



Geological Hazard Mitigation

<u>Geospatial Mitigation measures:</u>

Volcanic Risk Zone Mapping

- It involves the assessment and classification of areas based on their susceptibility to volcanic hazards, such as;

- lava flows,
- pyroclastic flows,
- ashfall, and
- volcanic gases.

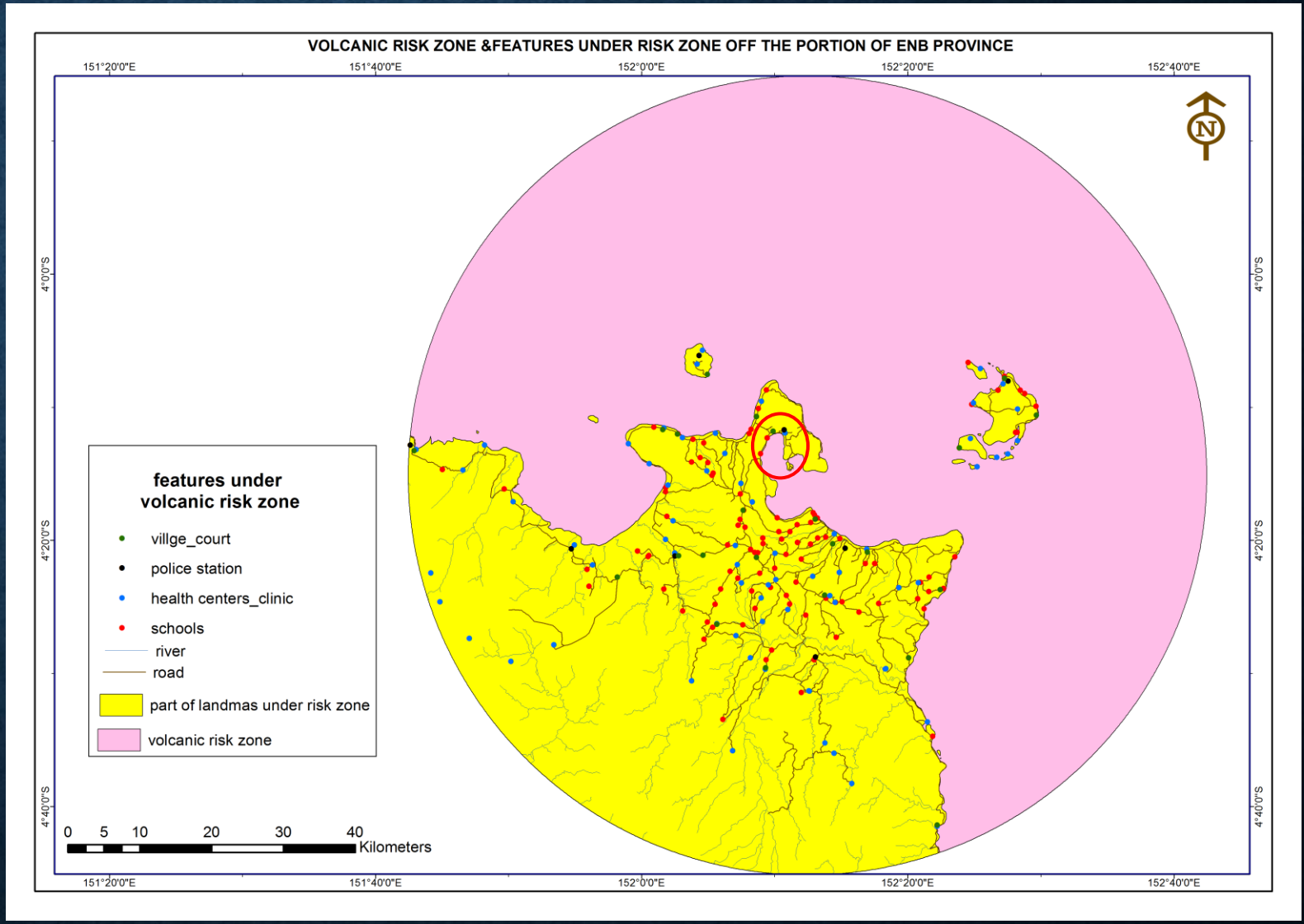
Eruption of Tavurvur volcano (Rabaul, PNG) (photo by Ulla Lohmann).

https://www.volcanoadventures.com/expeditions/papua.html

Geological Hazard Mitigation

Geospatial Mitigation measures:

Volcanic Risk Zone Mapping of Rabaul-ENP, PNG



Geological Hazard Mitigation

Geospatial Mitigation measures:

Manam Volcanic Risk Zone

- The island of Manam, in the Bismarck Sea off the northeastern coast of Papua New Guinea, is one of the most active volcanoes in the South Pacific.

Image Source: Lauren Dauphin, 2022

https://earthobservatory.nasa.gov/images/149883/manam-volcano-papua-new-guinea

Geological Hazard Mitigation

Geospatial Mitigation measures:

Manam Volcanic Risk Zone

- A type known for explosive eruptions that create steep-sided cones.
- Frequent mild-to-moderate explosive eruptions have been recorded here since 1616.
- They most often produces ash plumes, but occasional larger eruptions have produced lava and pyroclastic flows that reached the coast.

https://earthobservatory.nasa.gov/images/149883/manam-volcano-papua-new-guinea

Image Source: Lauren Dauphin, 2022

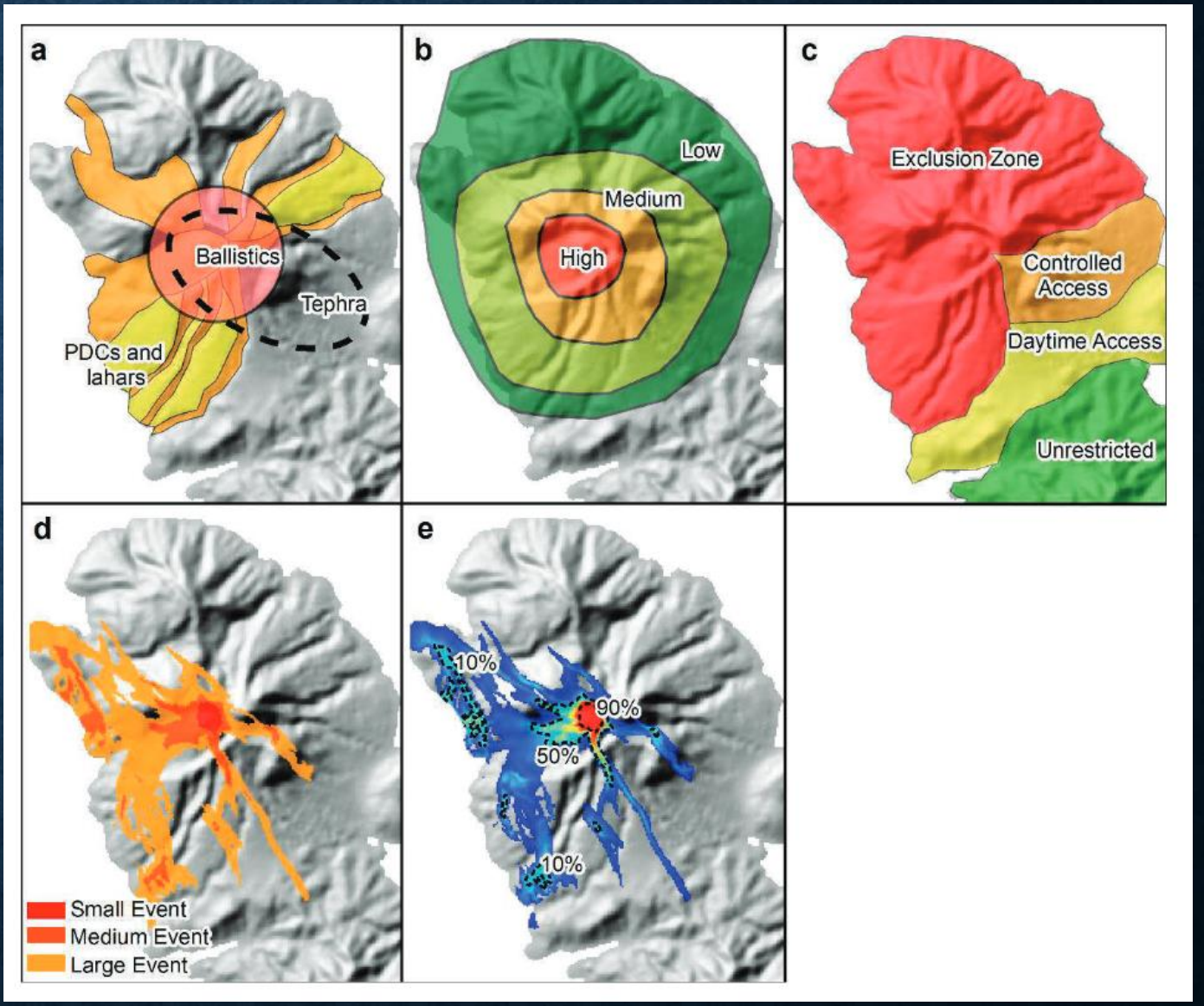
Geological Hazard Mitigation

Geospatial Mitigation measures:

Volcanic Hazard Identification

Five (5) predominant Volcanic hazard map types

- geology-based map,
- integrated qualitative map,
- administrative map,
- modelling-based map
- probabilistic map.



Source: Calder et al. 2015

Geological Hazard Mitigation

Geospatial Mitigation measures:

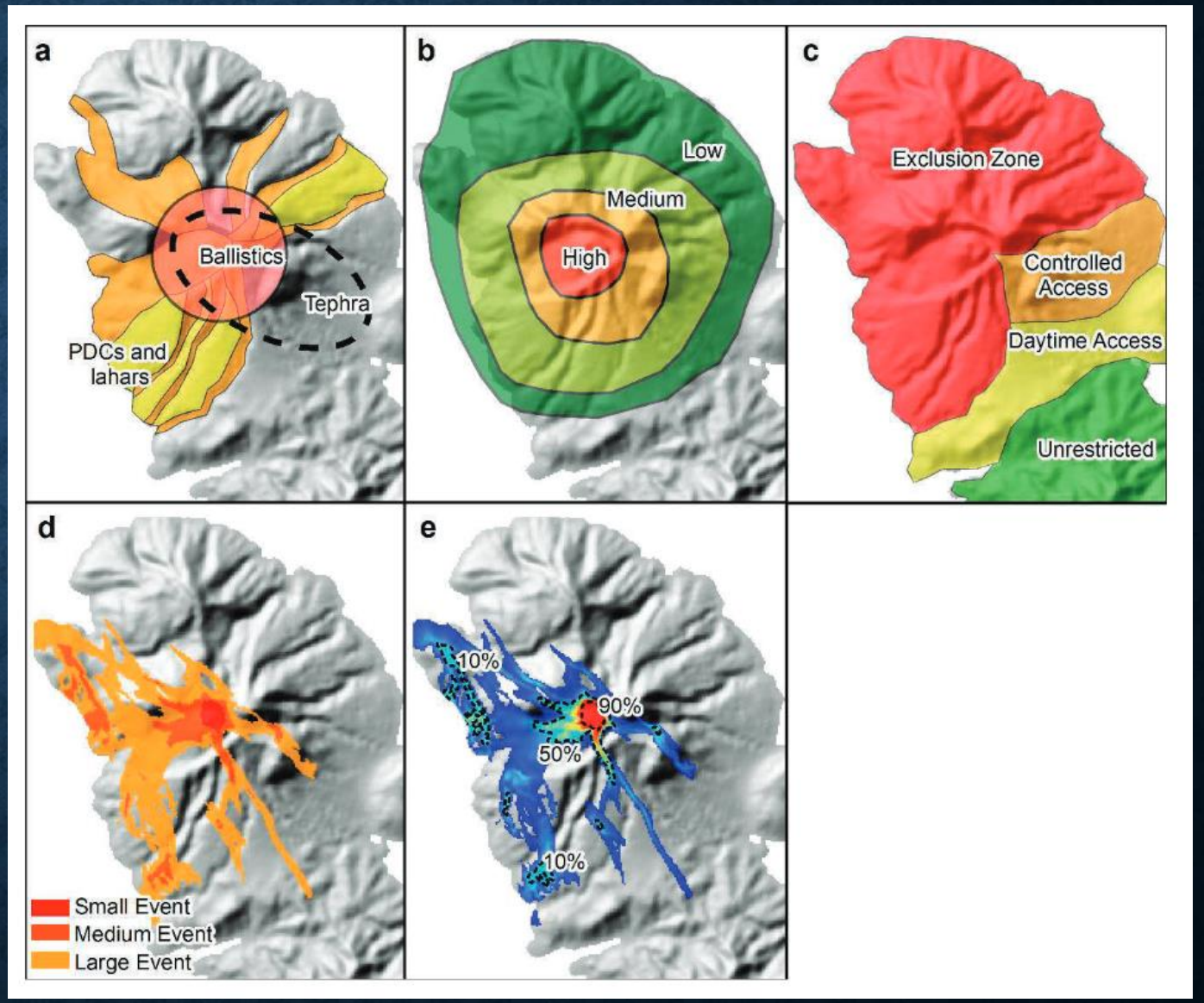
Volcanic Hazard Identification

- Hazard Mitigation:

Helps identify areas most at risk, enabling authorities to implement effective hazard mitigation measures.

- Public Safety:

Provides valuable information for evacuations and emergency response planning, ensuring the safety of communities near volcanoes.



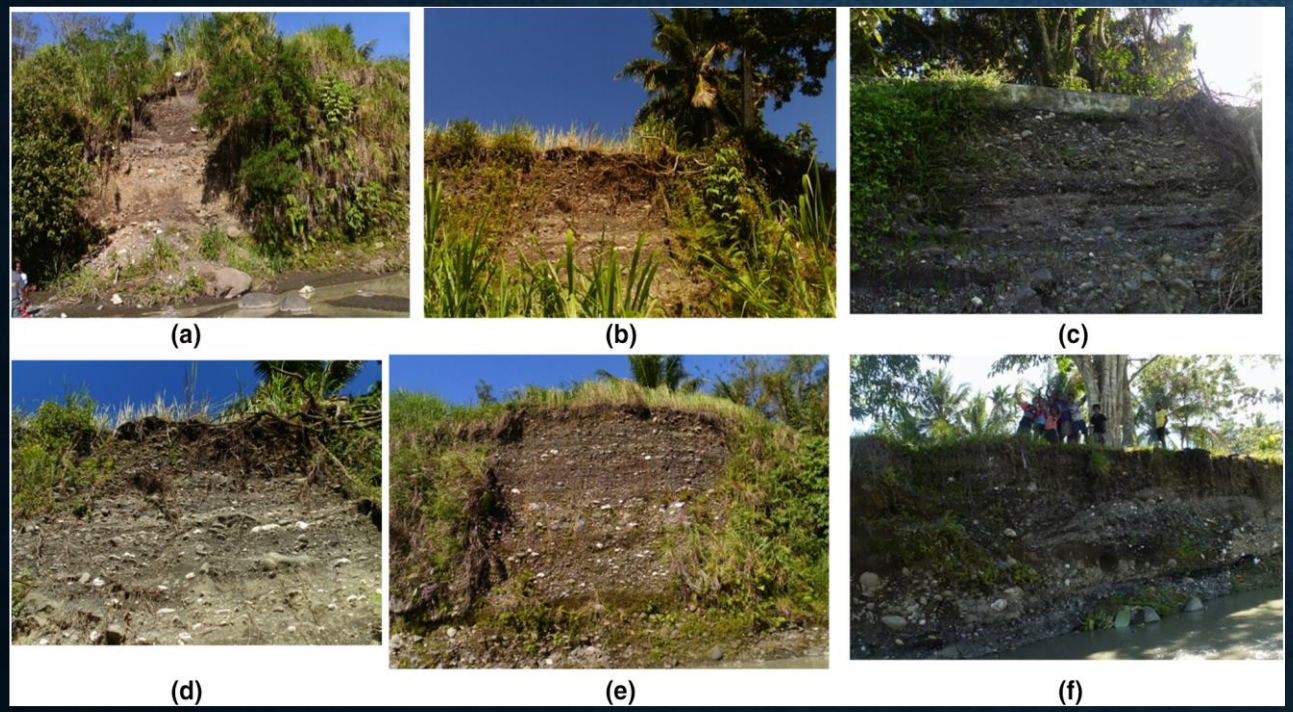
Source: Calder et al. 2015

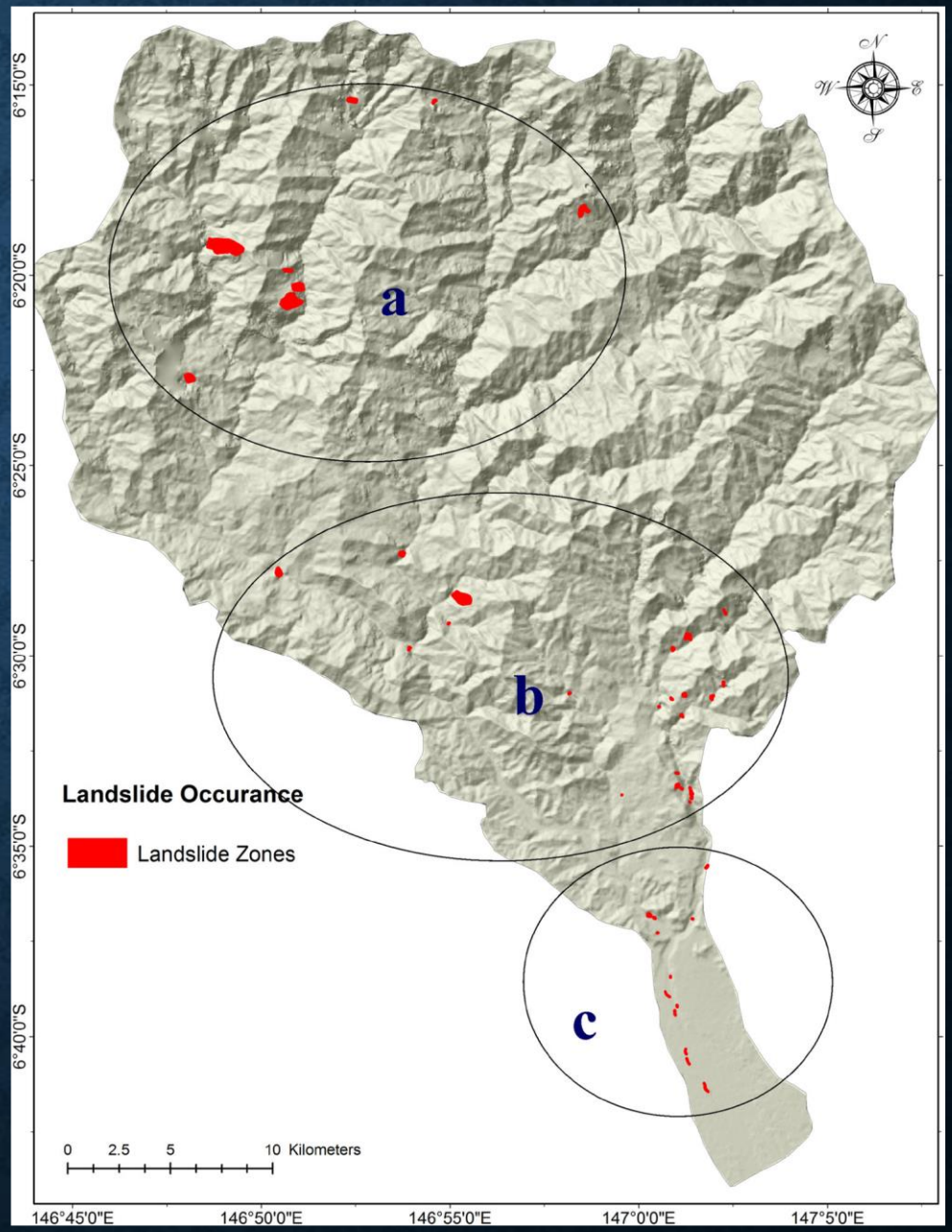
Geological Hazard Mitigation

Geospatial Mitigation measures:

Landslide Hazard Identification

Frequency Ration Method

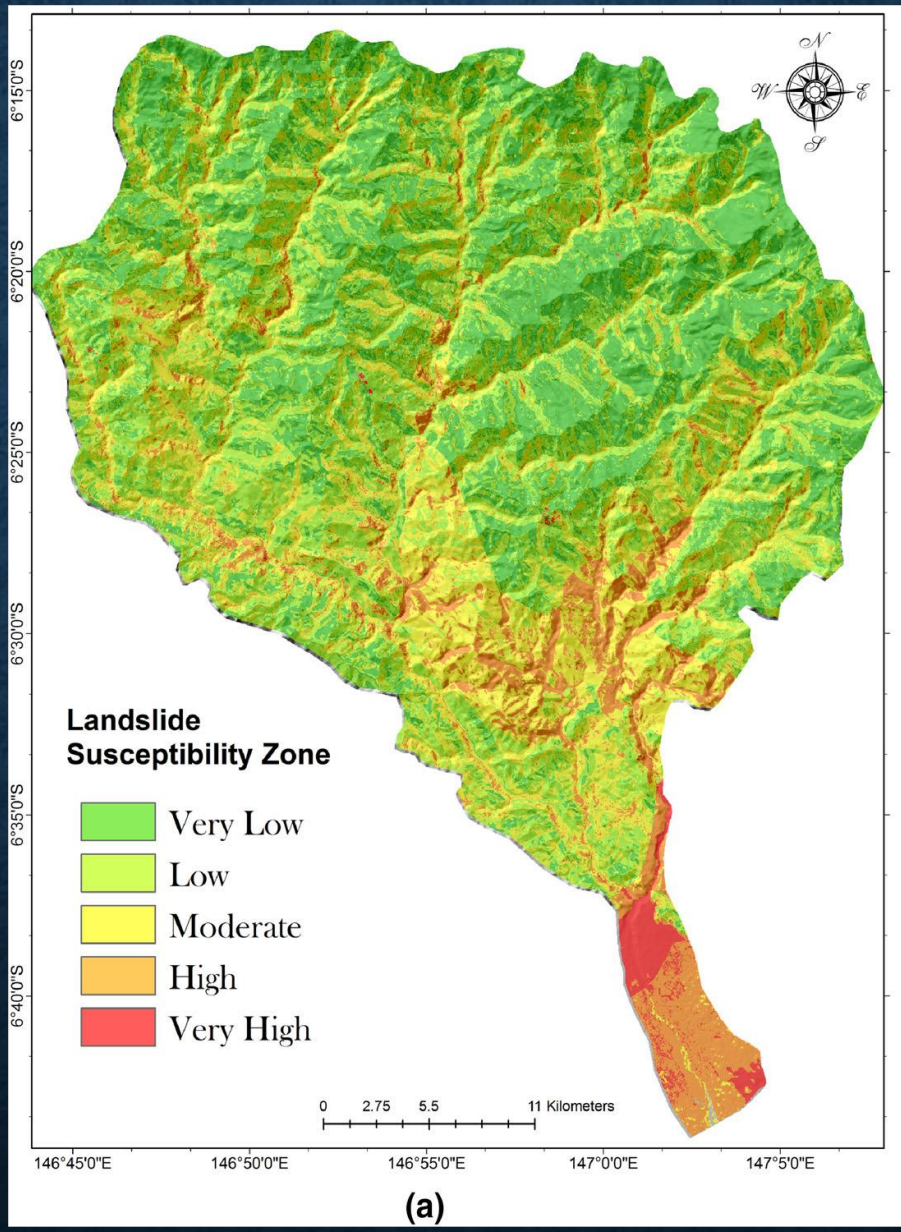




Geological Hazard Mitigation

Geospatial Mitigation measures:

- Landslide Hazard Identification and Vulnerability mapping



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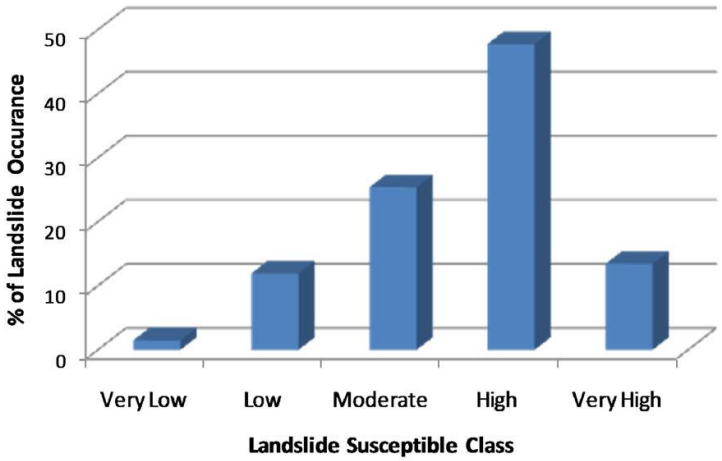
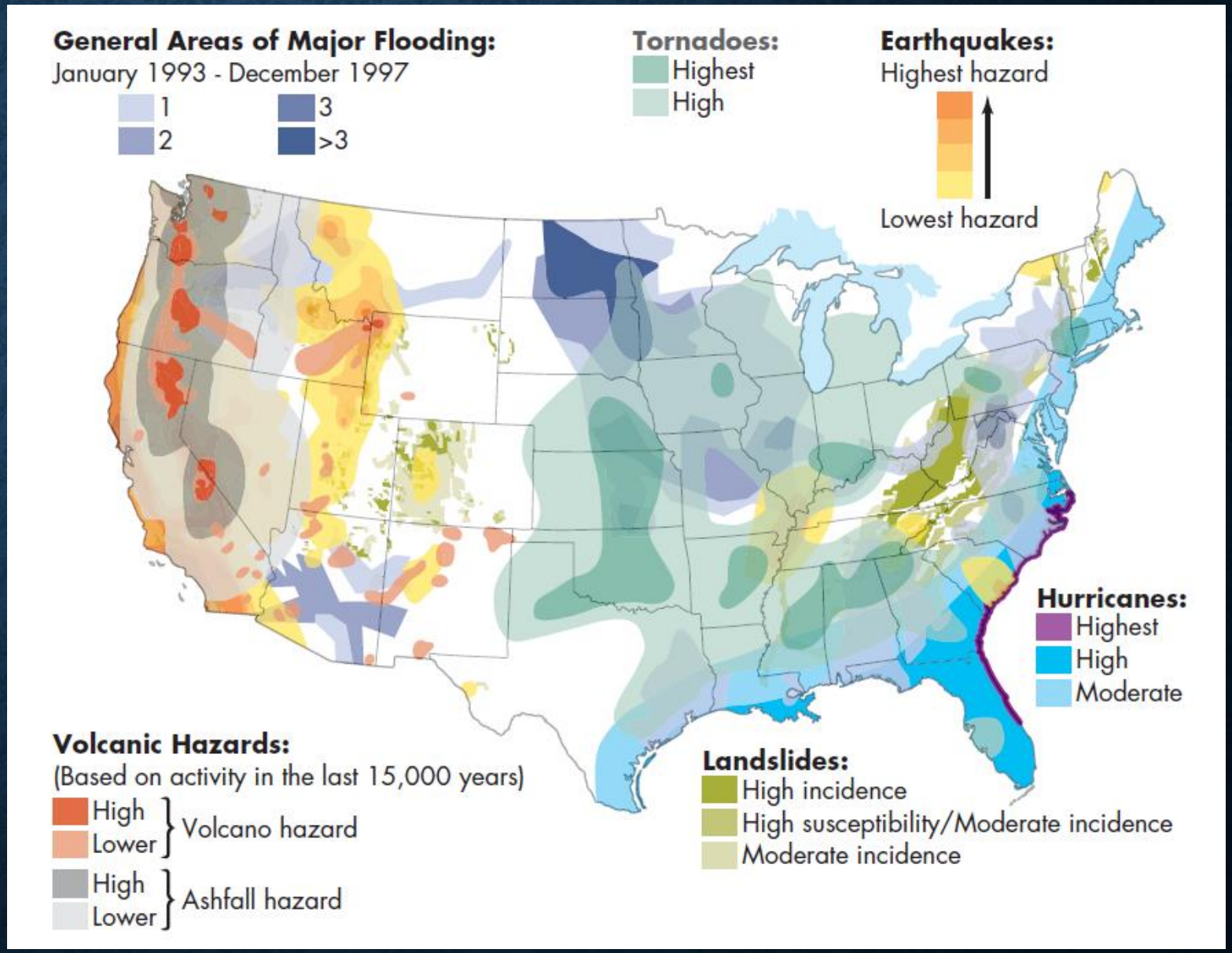


(b)

Geological Hazard Mitigation

<u>Geospatial Mitigation measures:</u>

Areas of the United States at risk for earthquakes, volcanoes, landslides, flooding, hurricanes, and tornadoes.



Source: U.S. Geological Survey

Main Source: Edward A. Keller, Duane E. Devecchio, Robert H. (CON)., (2012). Blodgett

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