25th Silver Anniversary Session of the Asia-Pacific Forestry Commission
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FORESTS and LANDSLIDES

The 2004 Landslides in Southern Sierra Madre, Philippines

Rex Victor O. Cruz

University of the Philippines Los Banos
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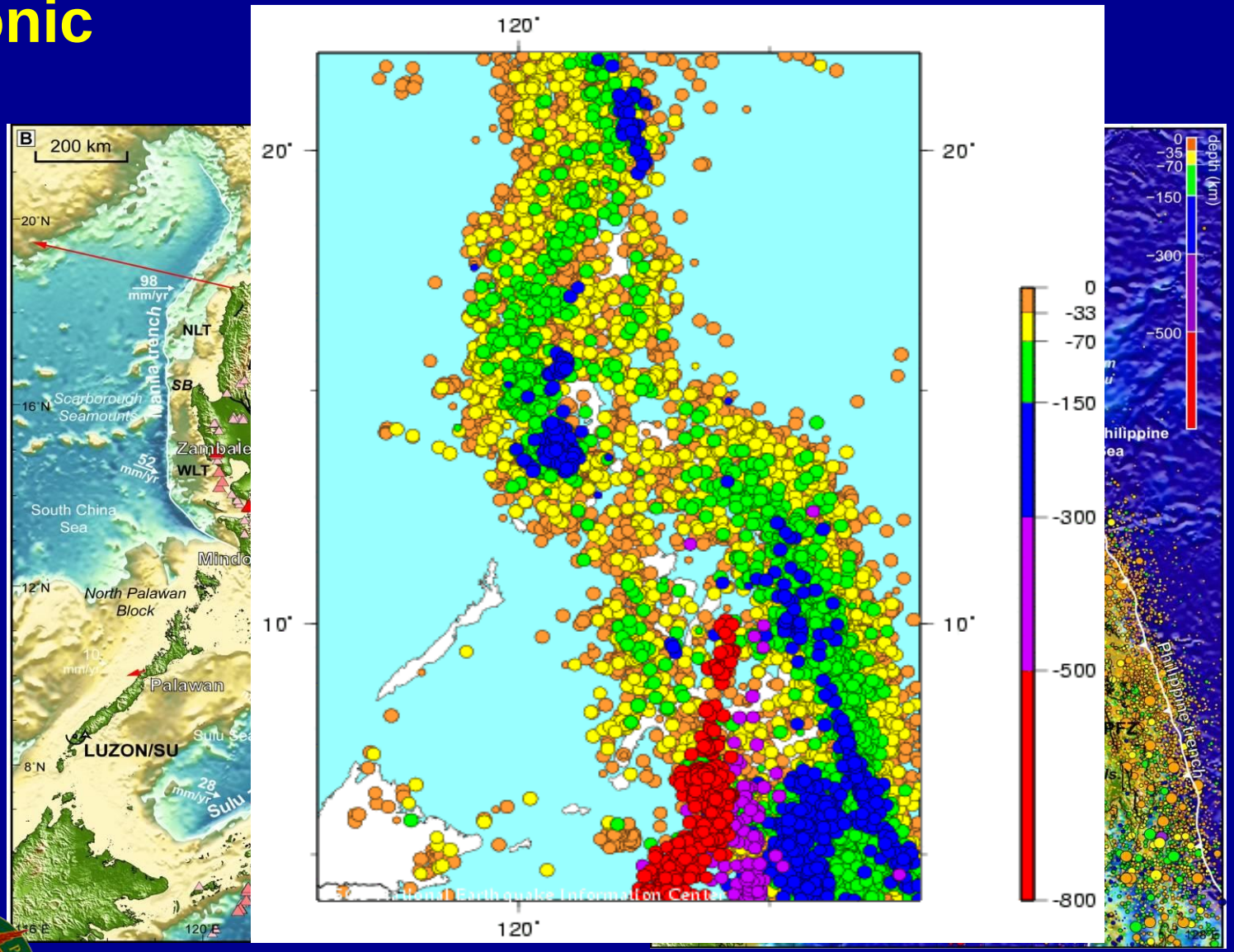
What is Landslide?

Rapid downslope movement of rock, regolith (unconsolidated material) and soil under force of gravity

Controlling Factors – tectonic, geologic, geomorphic (slope, slope overburden, forest cover)

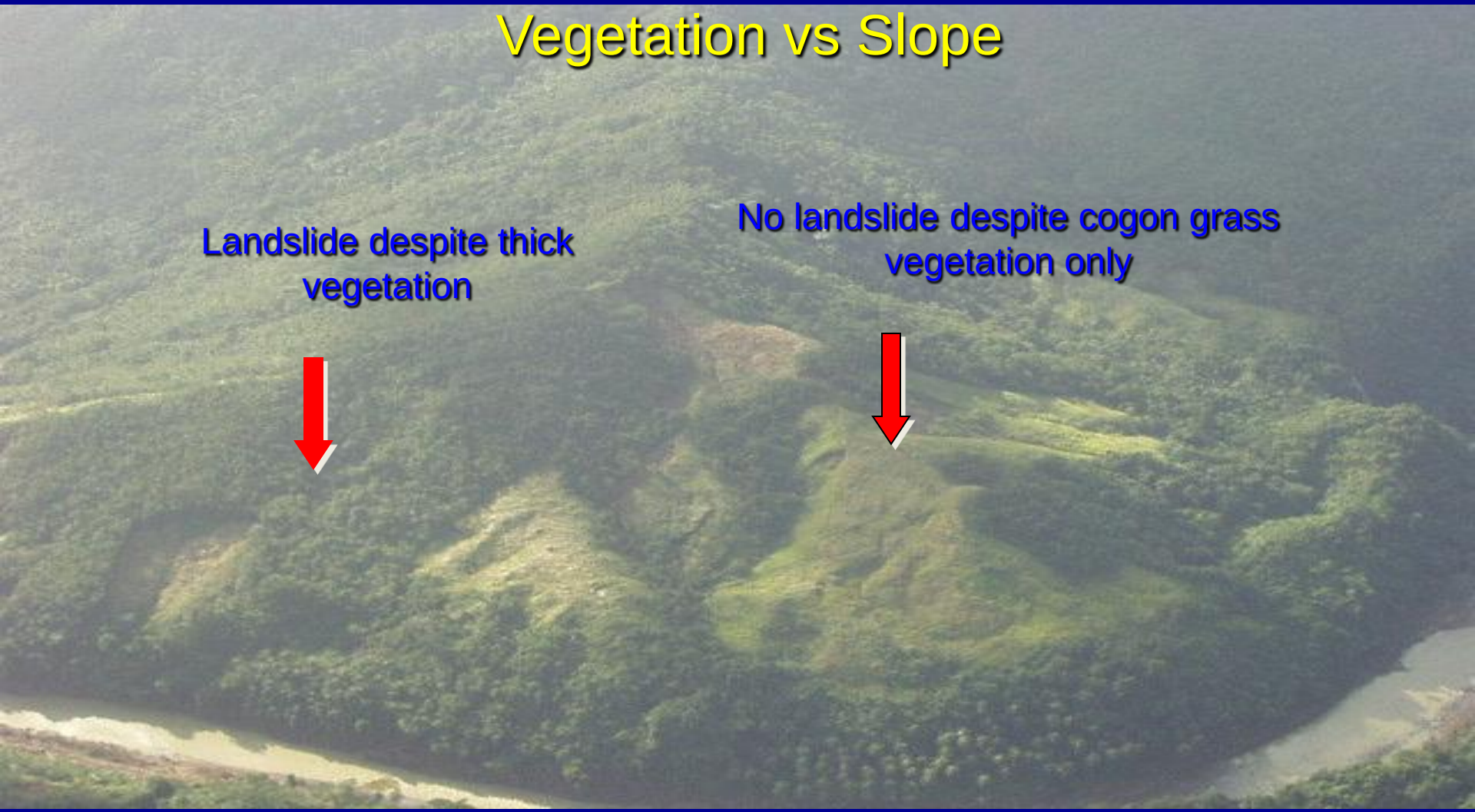
Triggering Factors - precursor weather events, seismic activity, land use

Tectonic


B
200 km
20°N
16°N
12°N
8°N
98 mm/yr
NLT
Manila trench
SB
Scarborough Seamounts
Zambales
52 mm/yr
WLT
South China Sea
Mindo
North Palawan Block
10 mm/yr
Palawan
LUZON/SU
Sulu Sea
28 mm/yr
Sulu
116°E
120°E
120°
20°
10°
0
-33
-70
-150
-300
-500
-800
depth (km)
0
-35
-70
-150
-300
-500
Philippine Sea
Philippine trench
PFZ

Steep Slopes

Vegetation vs Slope



Infanta, Quezon, 2004

Vegetation vs Slope

Mt. Makiling 2006

Mt. Makiling 2006

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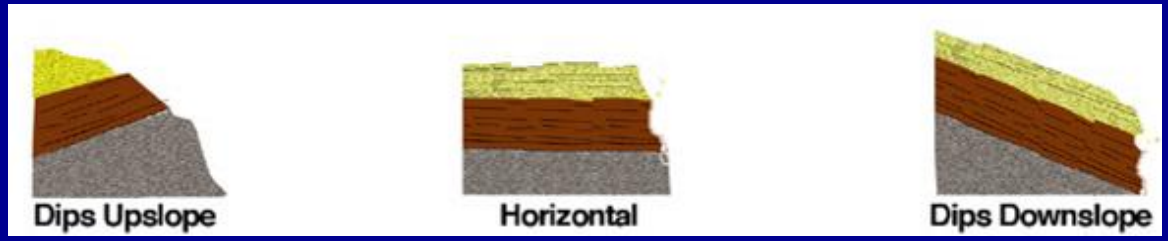
Geologic Features

- Type of rock
- Presence of joints or fractures
- Presence of bedding planes
- If the joints or bedding planes dip in the same direction as the slope

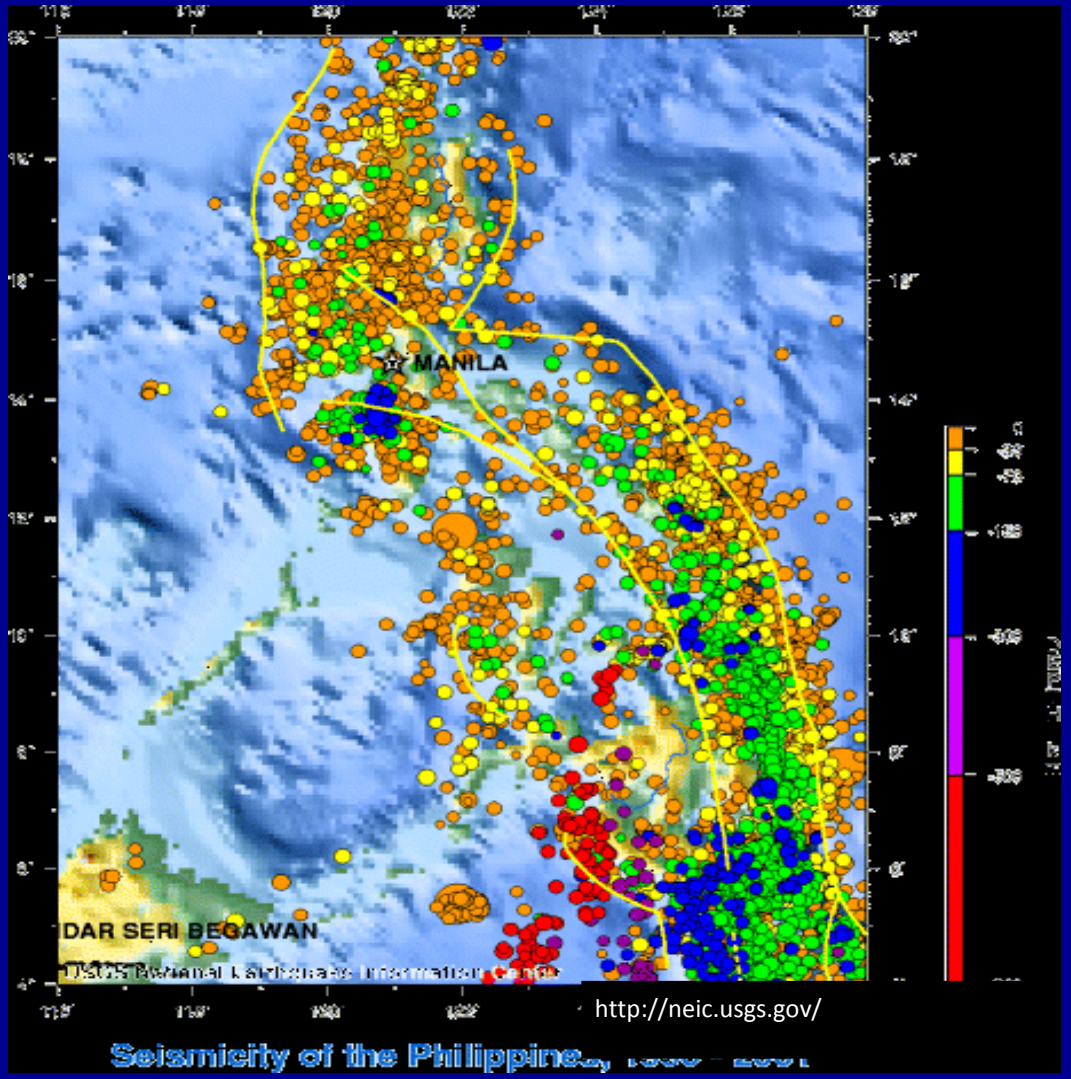


Soil Features

- Soil depth
- High proportion of clay minerals in soil
- Shrinking and swelling clay particles

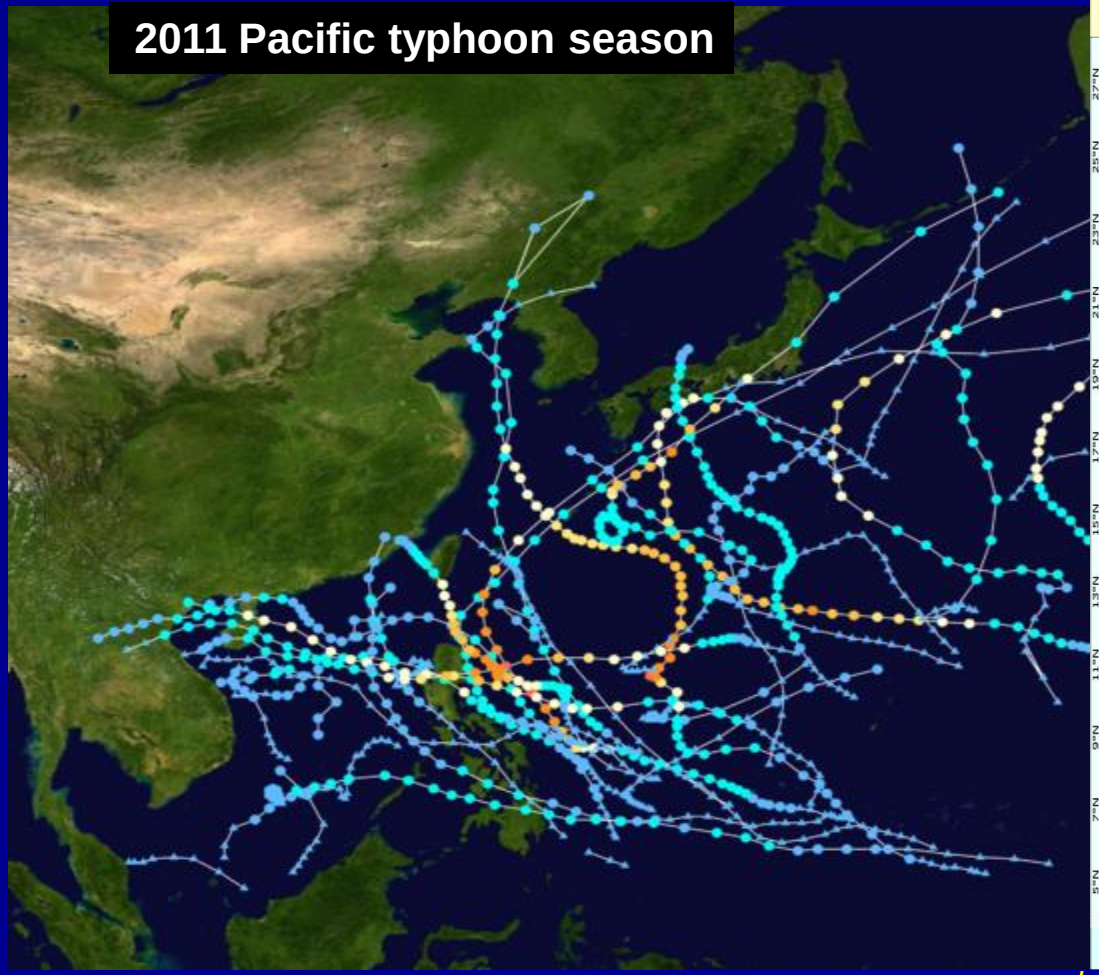
Triggering Factors

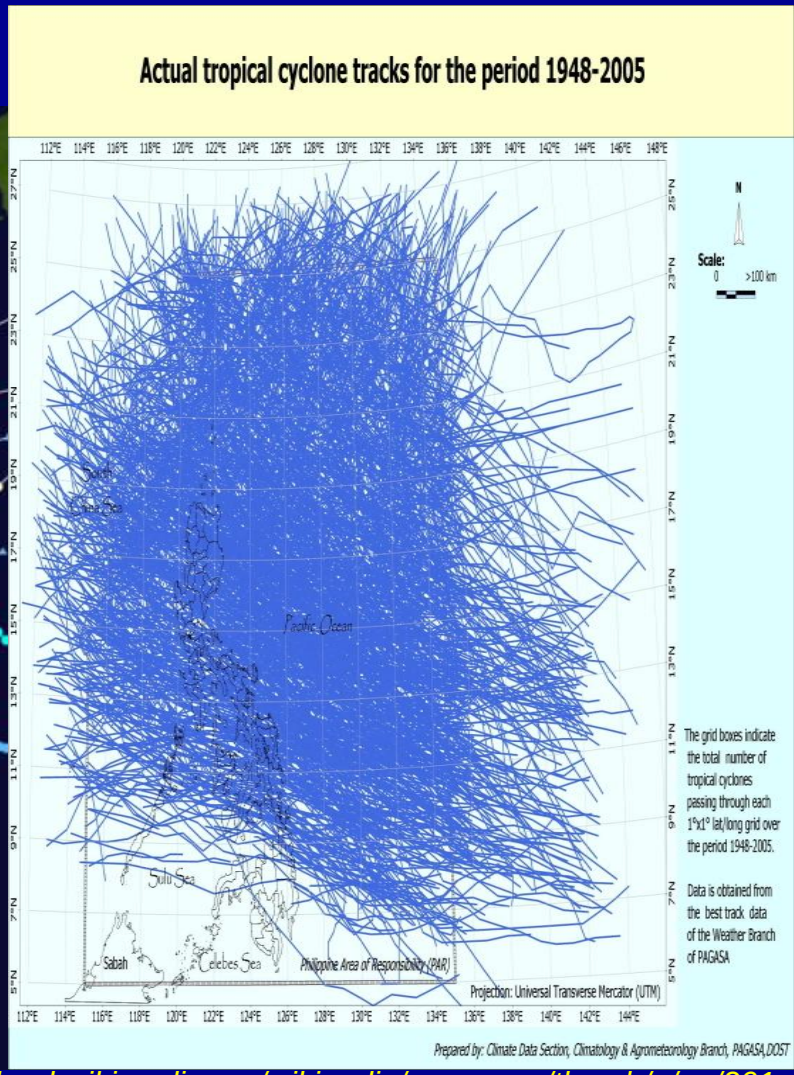
- Ground shaking
  - Earthquake
  - Volcanic eruptions
  - Shocks caused by heavy equipment or blasting



Meteorological

2011 Pacific typhoon season





upload.wikimedia.org/wikipedia/commons/thumb/e/ee/2011_Pacific_typhoon_season_summary.png/800px-2011_Pacific_typhoon_season_summary.png

Year	Location	Type	Trigger	Fatalities
1919	Indonesia	lahars	volcanic eruption	~5,000
1920	China	landslide	earthquake	> 100,000
1933	China	landslide	earthquake	~3100
1941	Peru	debris flow	flood	~4,000-6,000
1949	Tajikistan	flowslide	earthquake	~7,200
1953	Japan	landslide	typhoon	~1046
1962	Peru	landslide	glacier	~4,000 - 5,000
1963	Italy	landslide	heavy rains	~2,000
1970	Peru	debris avalanche	earthquake	~22,000
1985	Columbia	mudflow/slide	volcanic eruption	~23,000
1999	Venezuela	landslide	heavy storm	~30,000
1998	Nicaragua	debris avalanche and mudflow	heavy rains	~2,000
2006	Philippines	debris avalanche; mudslide/flow	heavy rains	~1100; ~1300
2010	China	mudslide	heavy rains	~1300

en.wikipedia.org/wiki/List_of_landslides

- Excessive rainfall
  - heavy rains can saturate regolith reducing grain to grain contact and reducing the angle of repose

Land Use and Land Cover

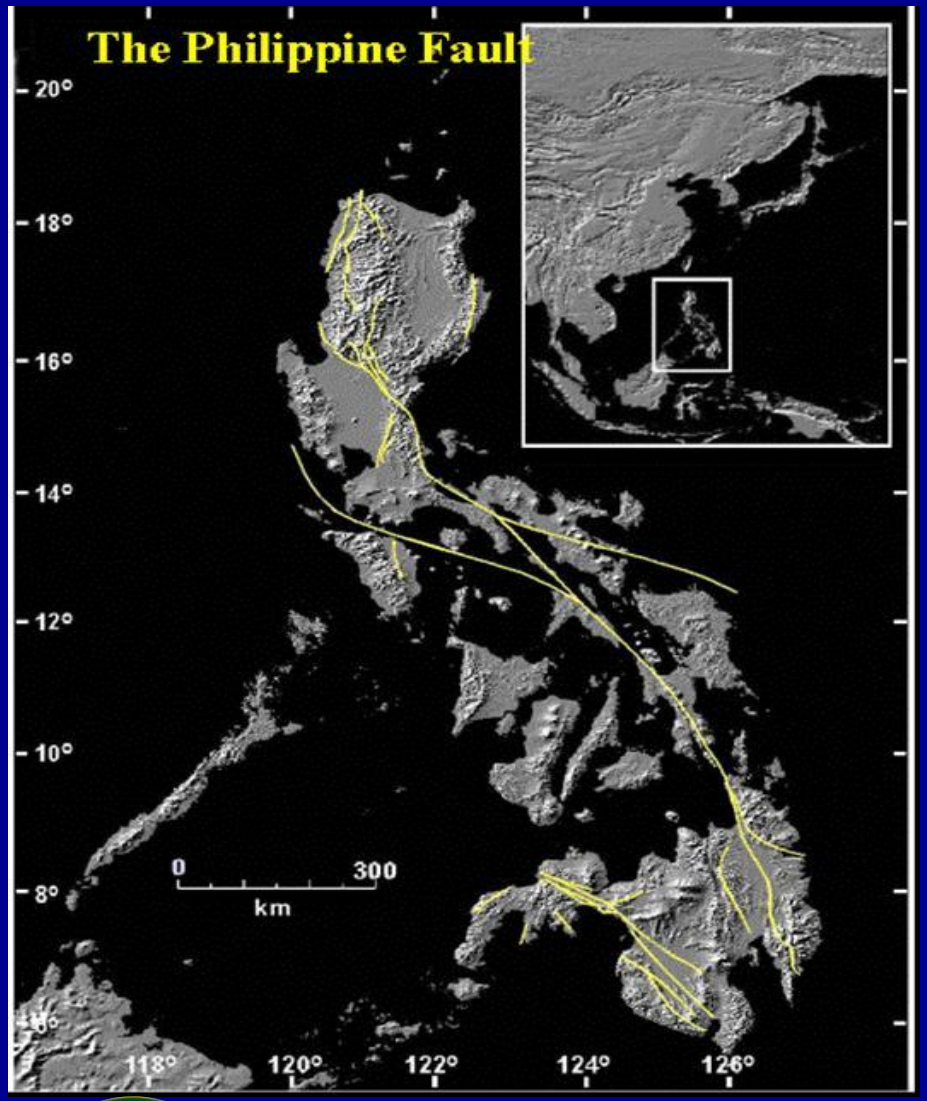
Poor site selection for built up areas (roads, buildings)

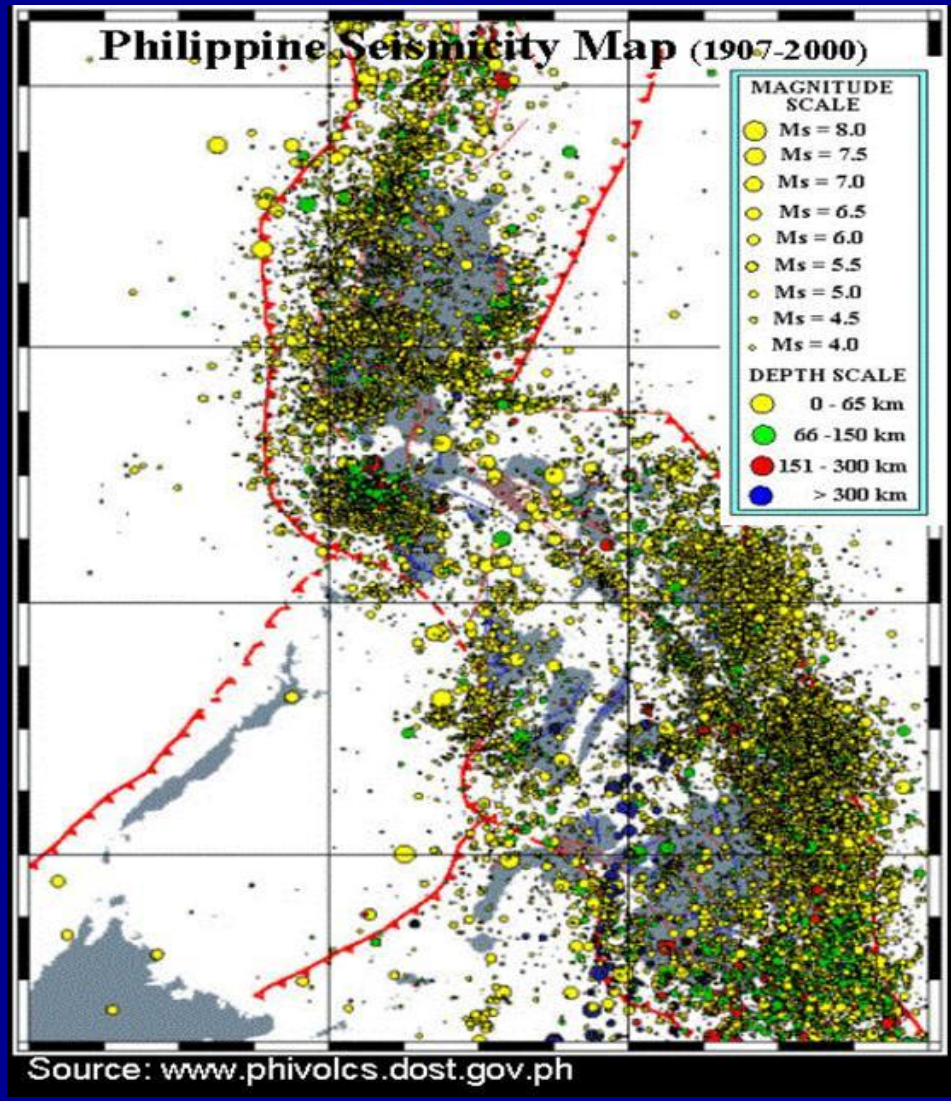
Slope undercutting

Vegetation removal

Blasting and earthwork

Landlsides in Southern Sierra Madre





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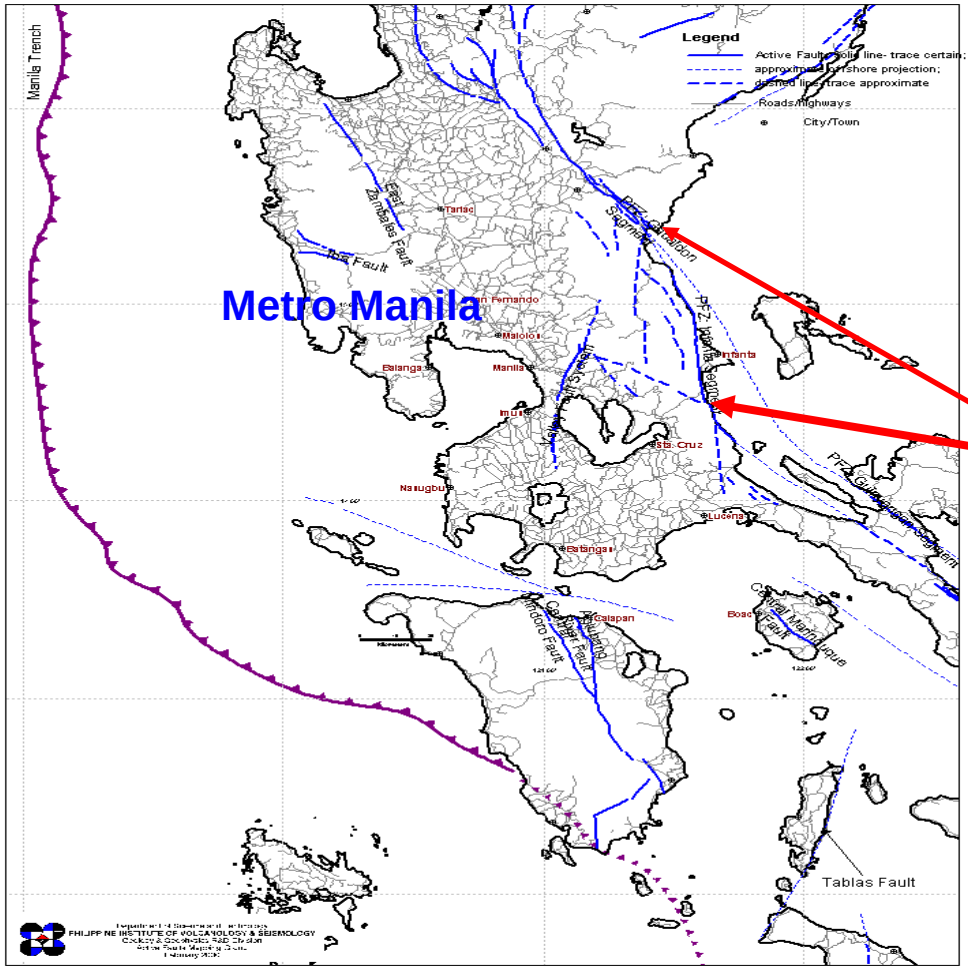
Active Faults Near the REINA, Dingalan Areas



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Landslides in 2004 Not Triggered by Fault Movements

- No recent significant movement of the faults
- No strong earthquakes affect the areas
- Many landslides not along the fault

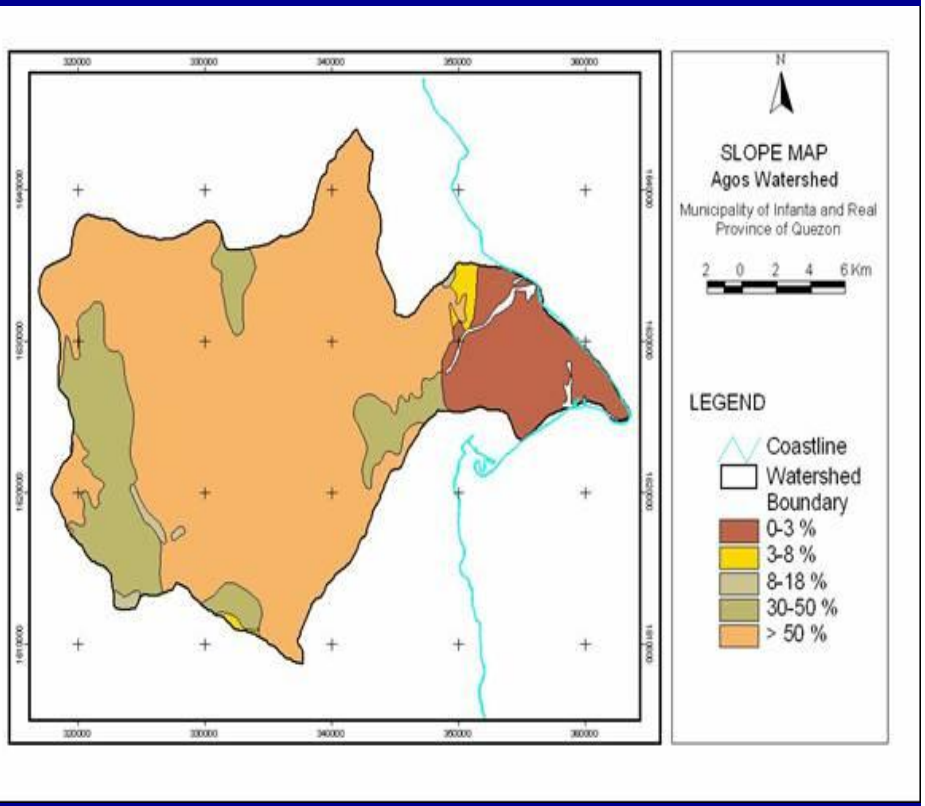
Steep Topography in Southern Sierra Madre

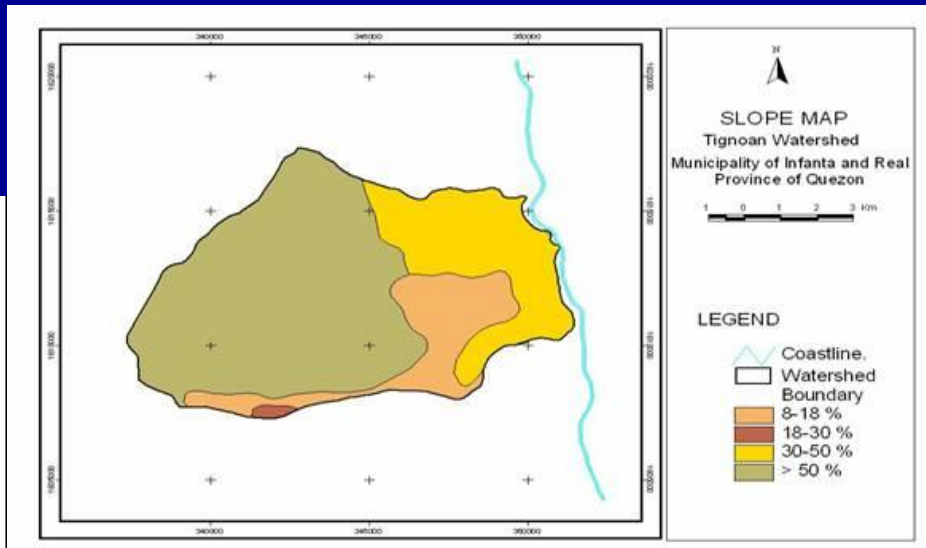
Source: HIGP, Univ. Hawaii

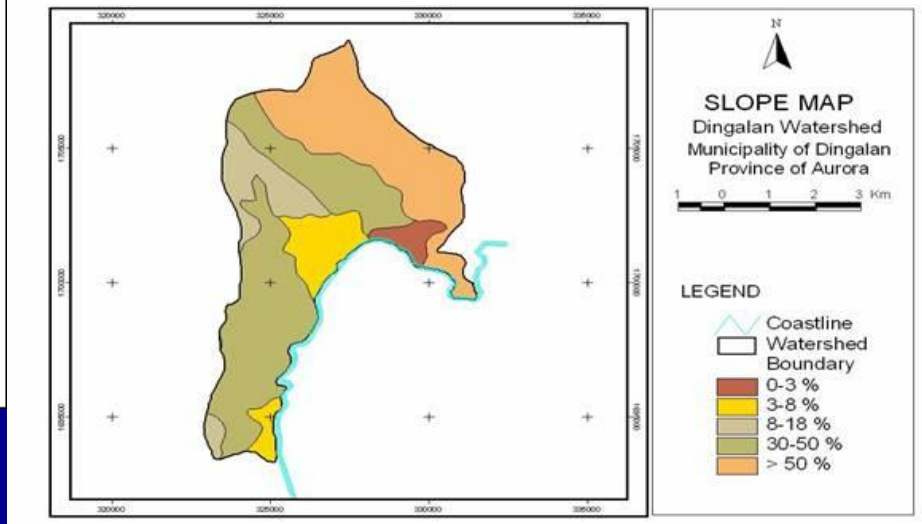
DOST
PHIVOLCS

2004 Landslides in Southern Sierra Madre

Topography







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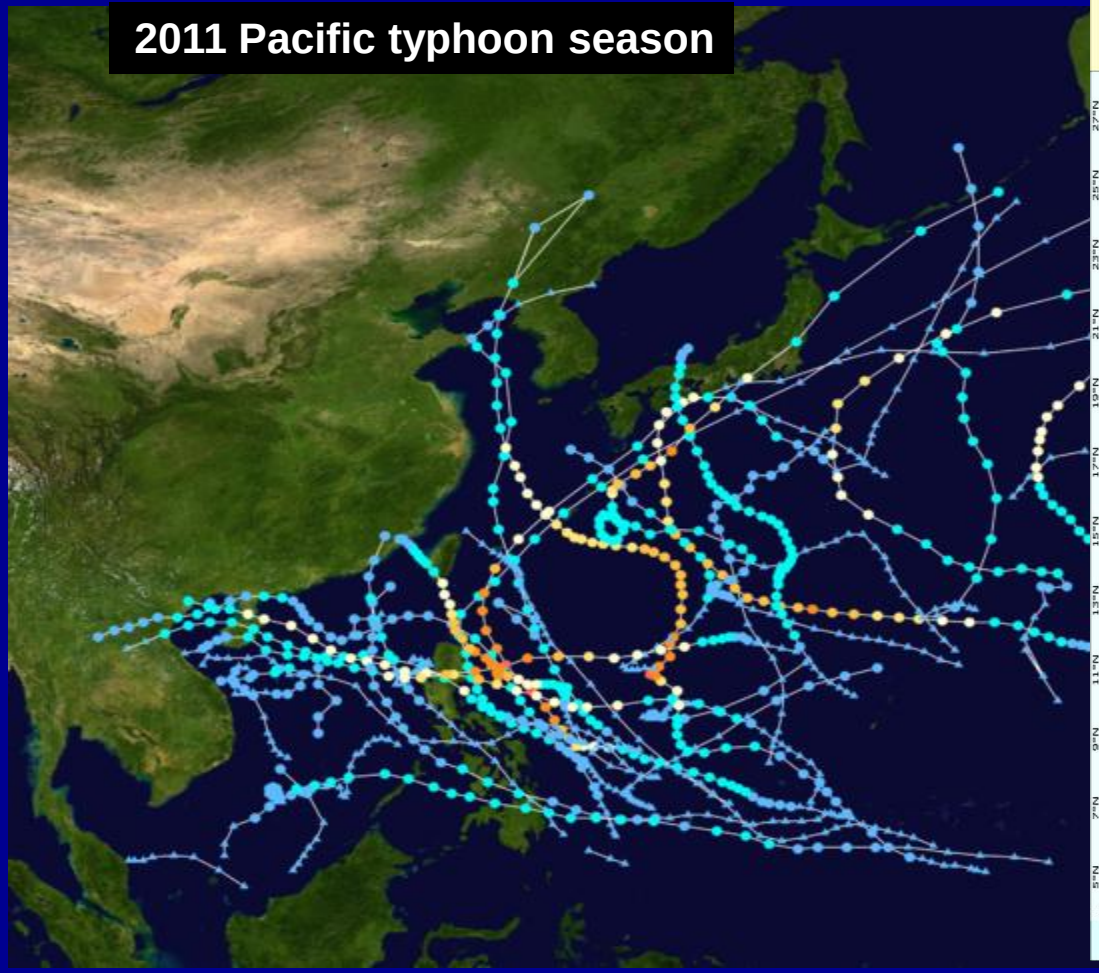
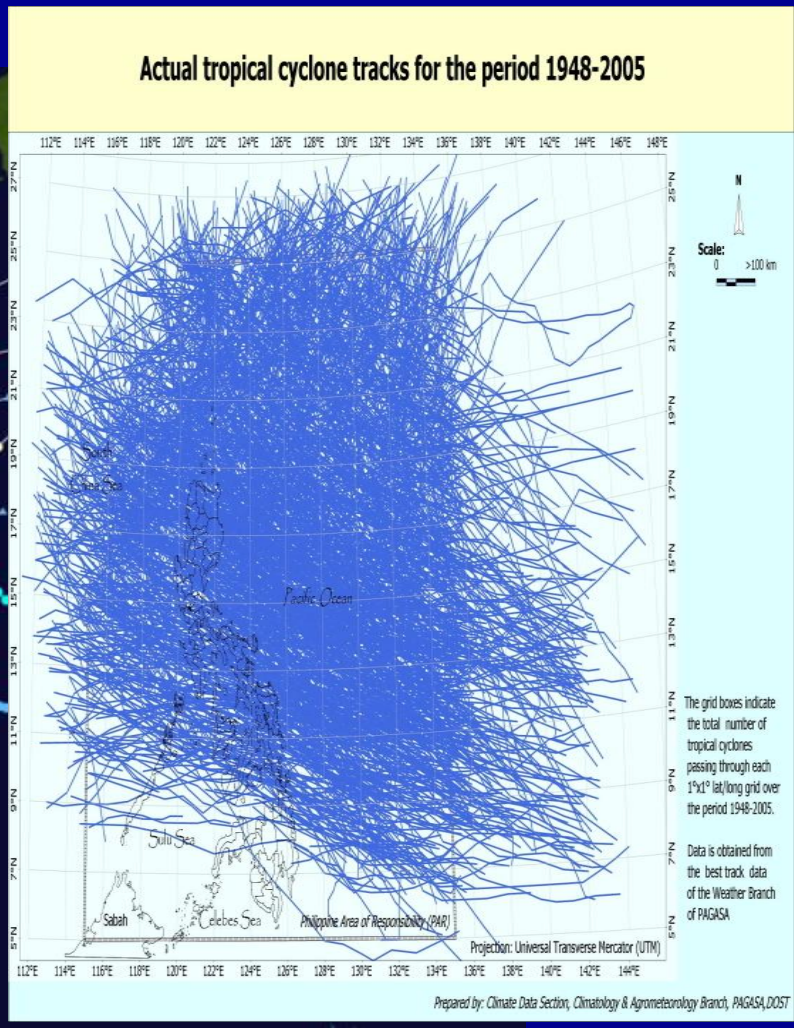
Meteorological





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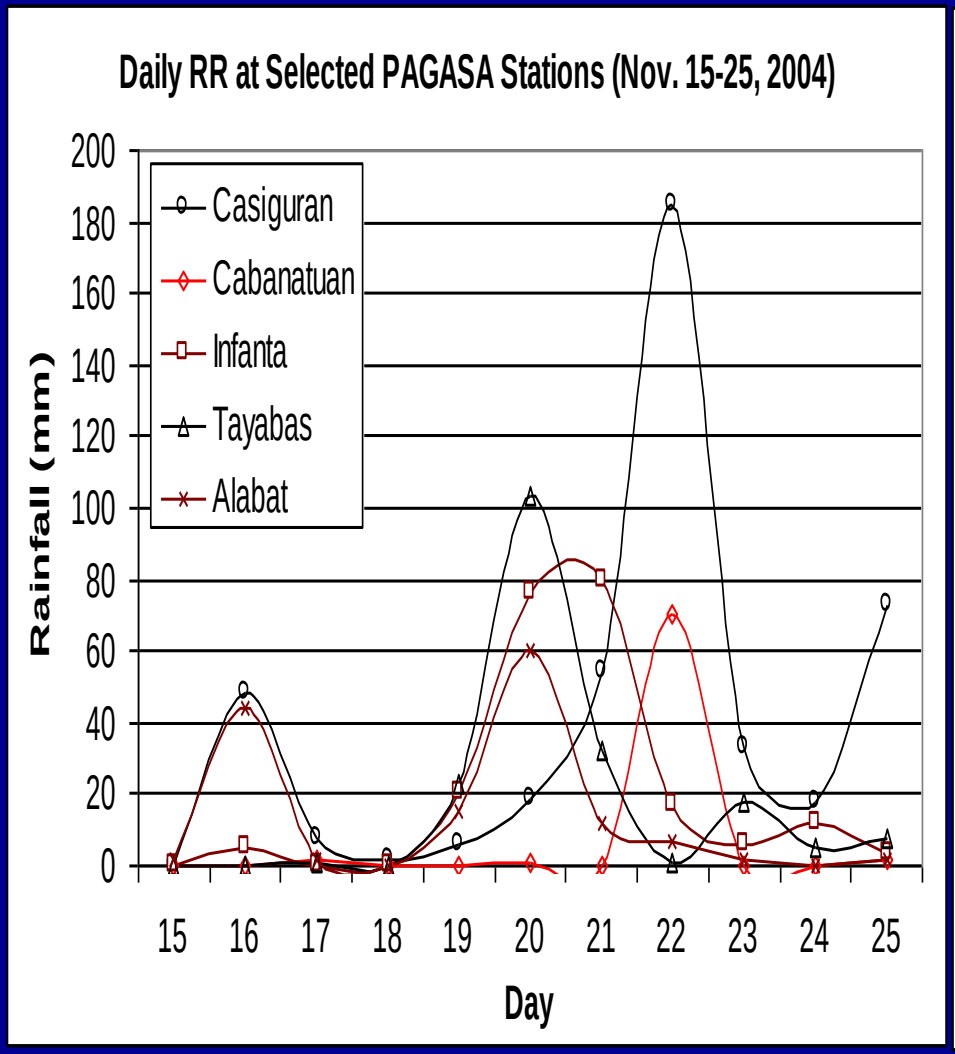

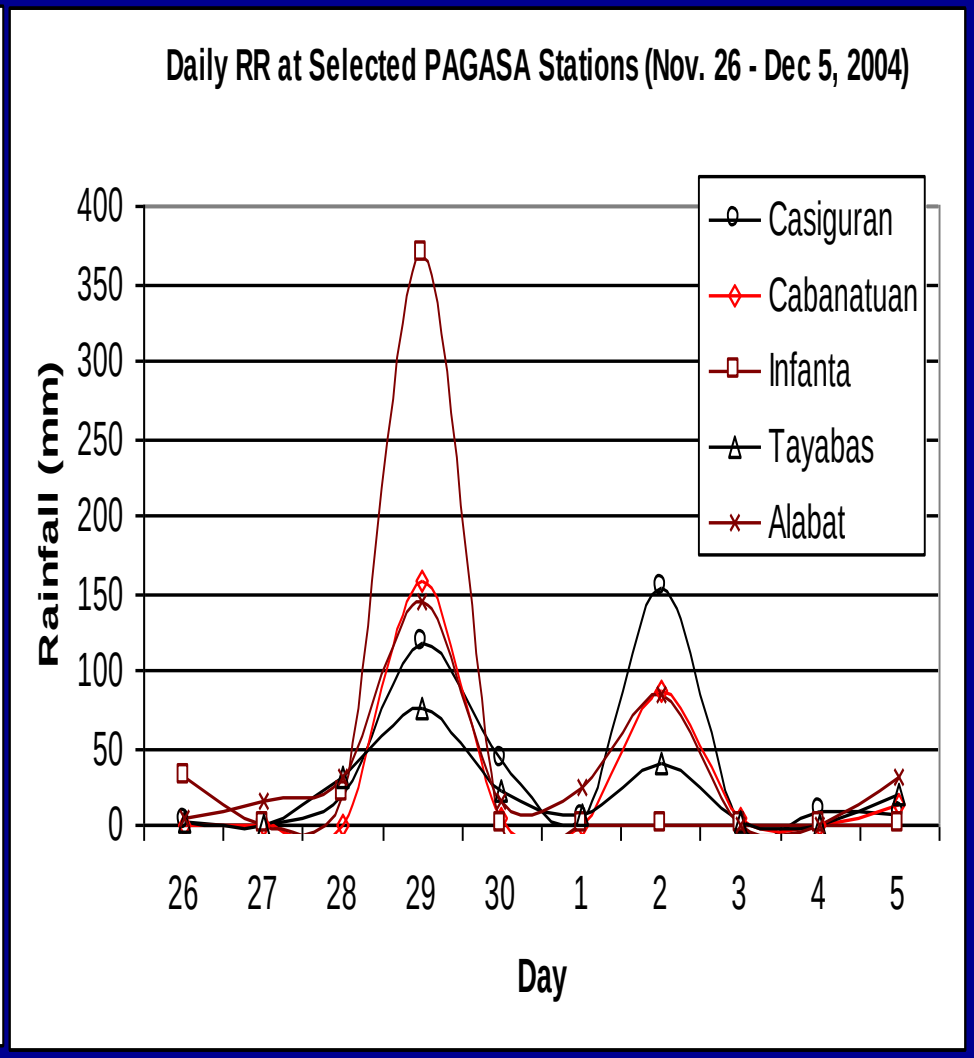

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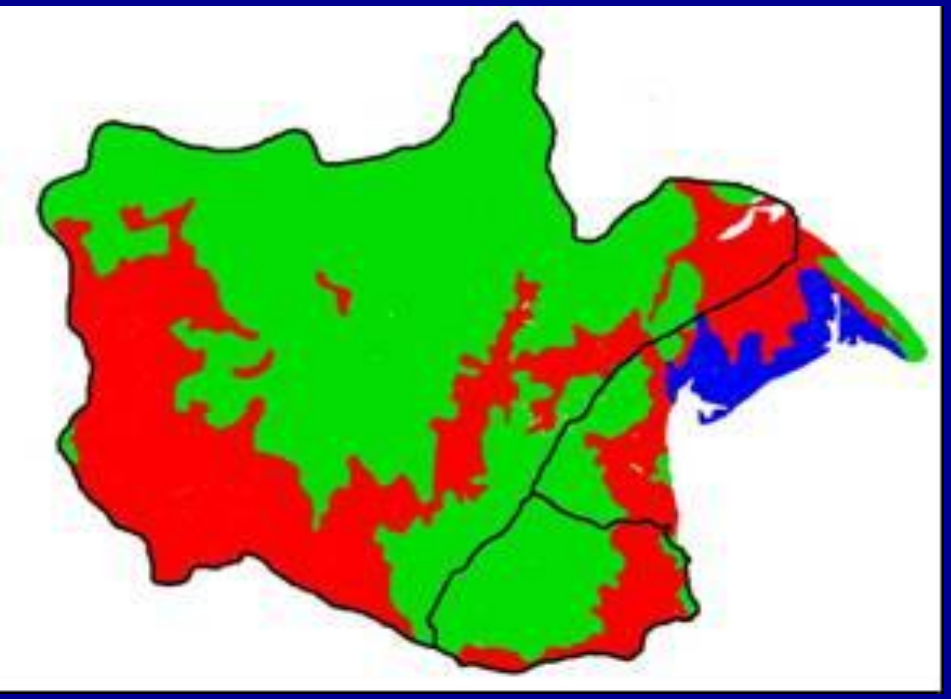
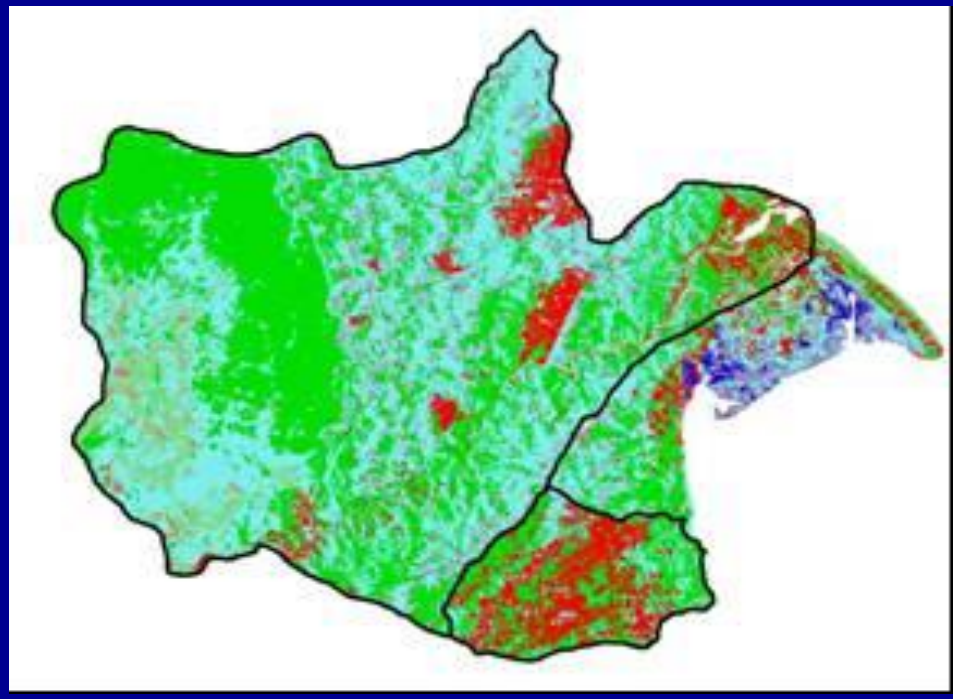


1988 Land use and land cover of Tignoan and Agos Watershed



2003 Land use/land cover of Tignoan and Agos Watershed

LEGEND
- agriculture
- coconut plantation
- fishpond
- forest
- grassland
- mangrove
- scars

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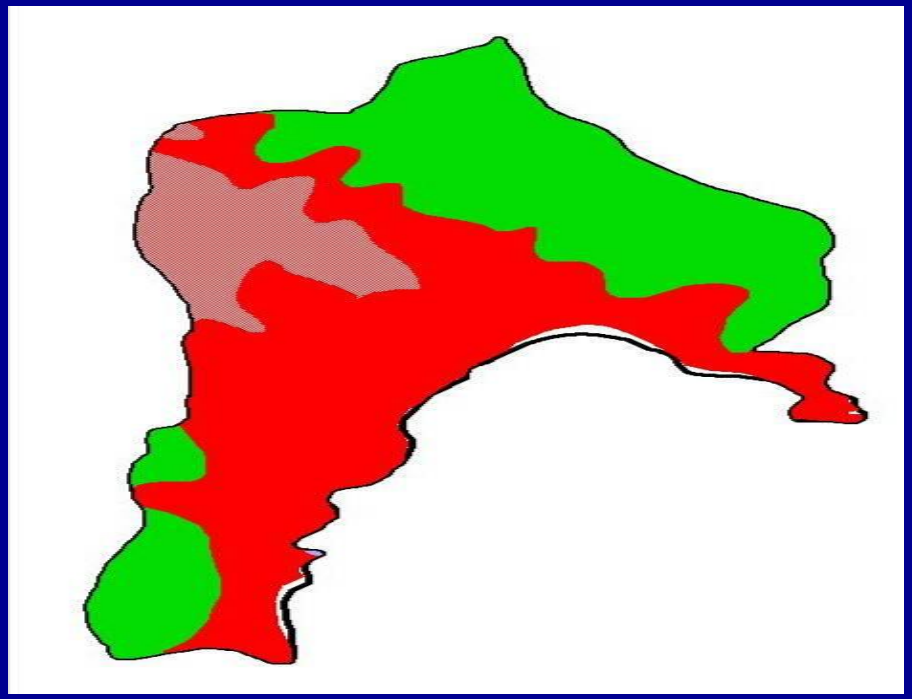
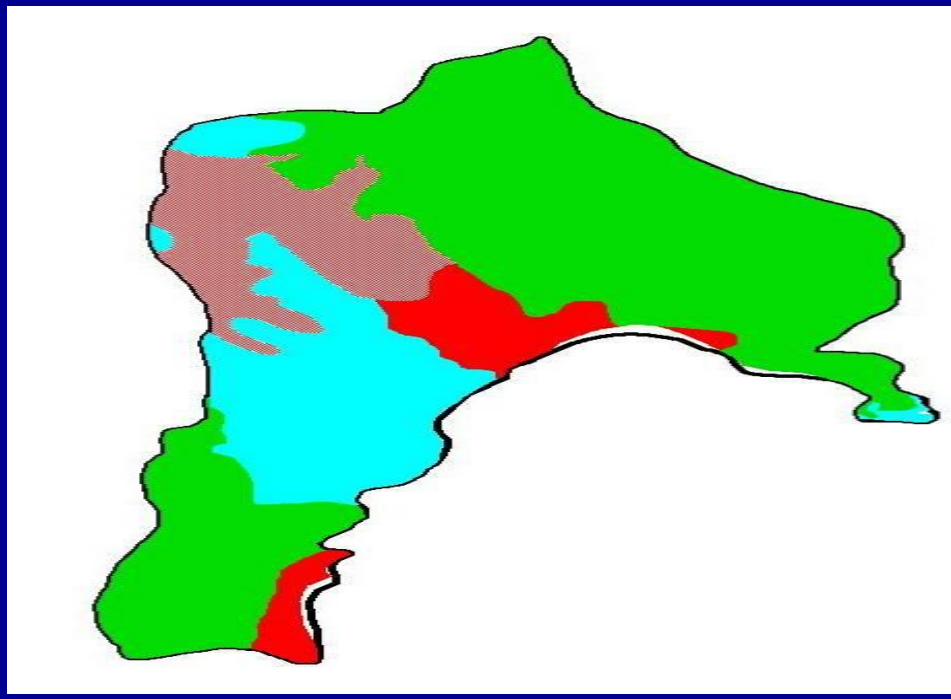
2004 Landslides in Southern Sierra Madre



1988 Land use and land cover of Dingalan Watershed



2003 Land use/land cover of Dingalan Watershed

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2004 Landslides in Southern Sierra Madre

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Landslide in Real, Quezon

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Excessive rainfall triggered landslide in steep slopes

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2004 Landslides in Southern Sierra Madre

Triggered by abnormally high rainfall

High rainfall happened toward the end of rainy season when the soil is highly saturated

Most landslides occurred in areas with forests

Where Forests Matter

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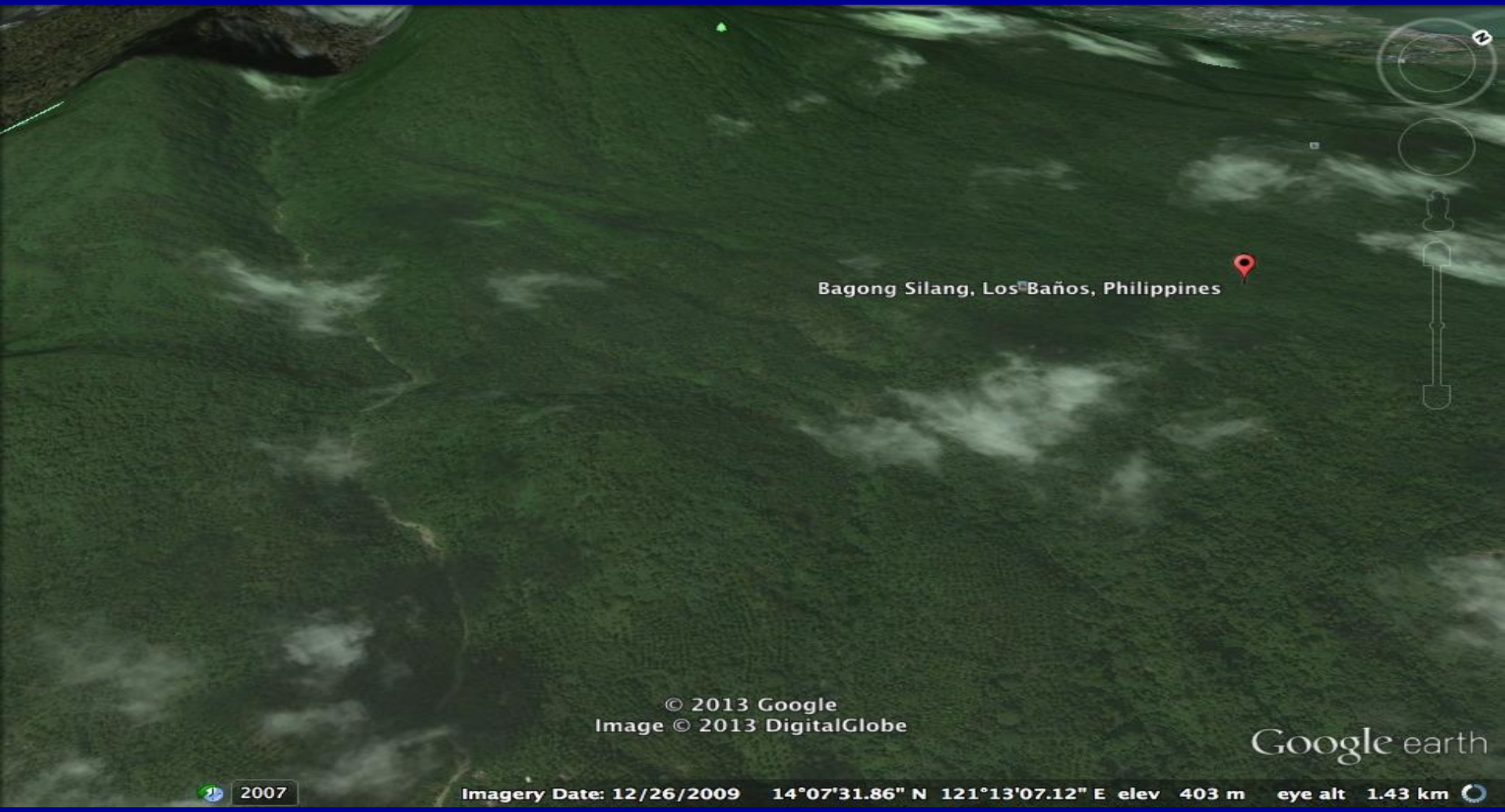

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Summary Statements

Forests cannot prevent landslide due to excessive rain

In rain-induced landslides, trees may even contribute by adding weight to the sliding mass

Forests help minimize shallow landslides but not deep seated landslides

Summary Statements

- In minimizing surface erosion and shallow landslides
- In reducing sediment yield
- In restoration of eroded lands including landslide areas
- In minimizing wind-induced erosion e.g., sand dune expansion
- Indirectly sustainable forestry minimizes erosive and destabilizing practices