

Determining Landslide Susceptibilities in the Cordillera Talamanca, Costa Rica

GREAT Project



Kyle Comito and Rosa Martinez M.
Mentor: Dr. Paulo Ruiz
University of Costa Rica:
Lanamme Lab



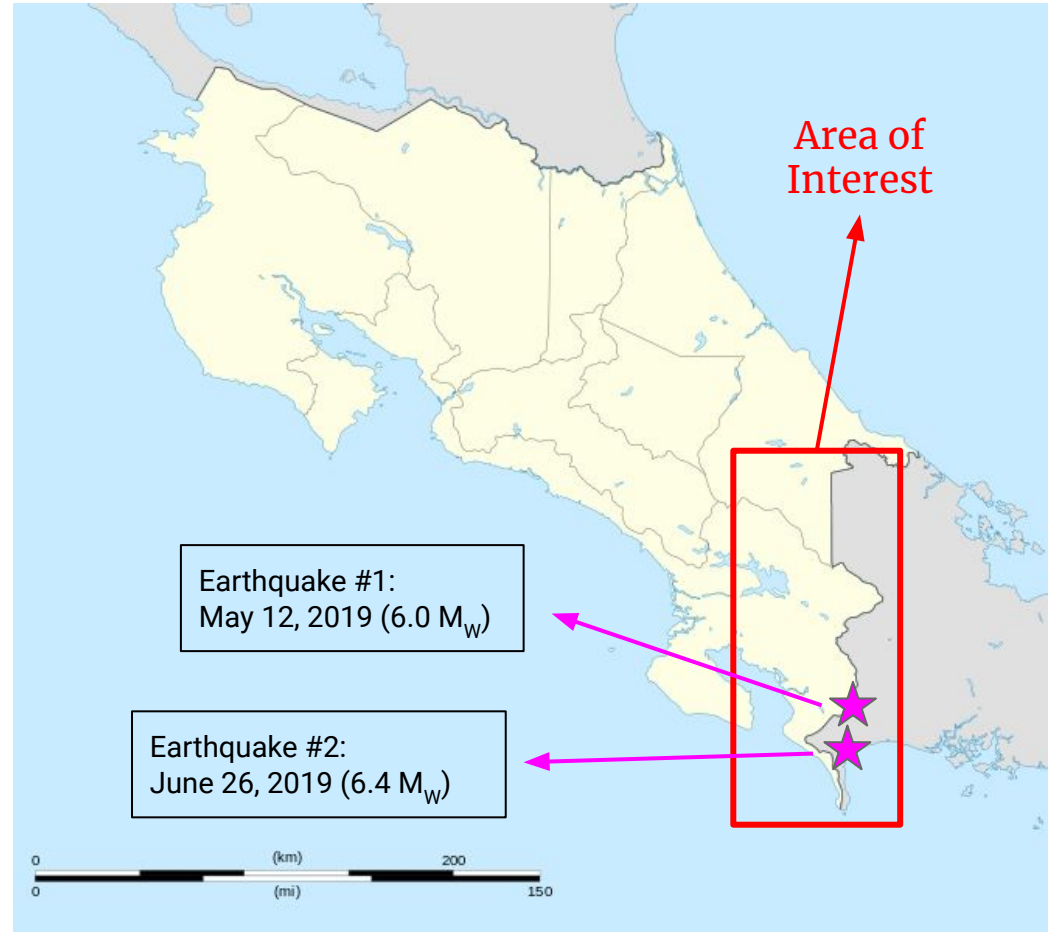
What is a landslide?

- Movement of soil, rock and/or organic matter under the force of gravity
- Can be triggered by a number of factors:
 - Earthquakes
 - Heavy rainfall
 - Human activities
- Can be dangerous to communities that are located near areas that are susceptible
- Can also be hazardous to roads and traffic



What are we doing?

- Applying the **Mora-Vahrson-Mora-Ruiz model** to determine landslide susceptibility in the southeastern region of the country (near Panama)
 - This method has been applied with ~97% accuracy in other parts of the country in the past
- Finding if any landslides had been caused by recent earthquakes in May and June of 2019
- Comparing our susceptibility results with existing landslide locations we found via aerial imagery



Why this Region?

- We are studying this region because it contains the Cordillera de Talamanca
 - Geoscience REsearch At the Cordillera Talamanca: G.R.E.A.T
- This region contains some important roads and could benefit from landslide hazard studies

Route 613

- A new route finished on late 2011
- Not a major road
- Lanamme monitors the route to measure how fast/slow it deteriorates

Route 2: The Pan American Road

- Stretches from Alaska all the way to South America
- High vehicle density- (Widely used for transportation/shipping)

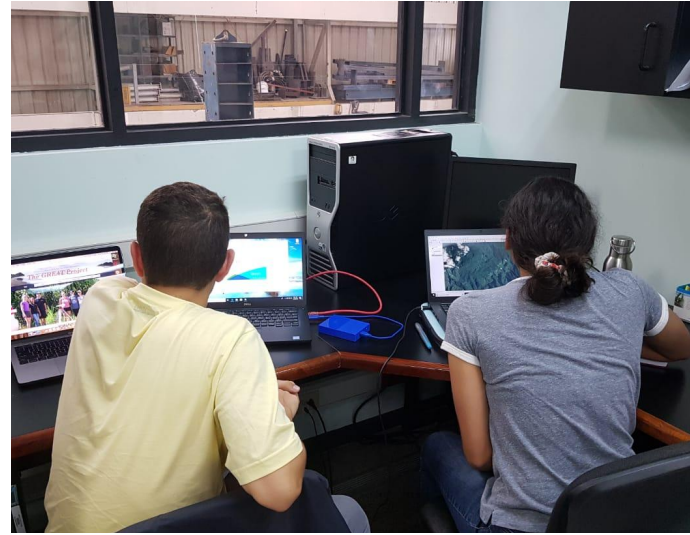


The Method

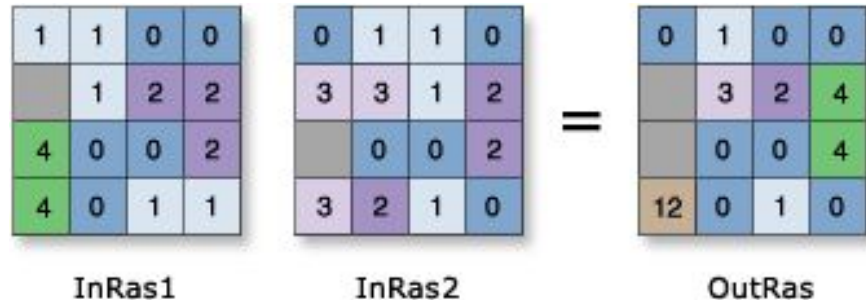
Mora-Vahrson-Mora-Ruiz Model

- Create an independent map for landslide susceptibility due to each variable
- Give each pixel a “score” of 0-6 in terms of increasing susceptibility for each variable
- Combine all the susceptibility maps via raster multiplication (not addition!)
- Classify final susceptibility values into categories from “Very Low” risk to “Very High” risk

*NOTE: Susceptibility \neq Probability!



How the variable maps are combined to find total susceptibility:



We created susceptibility maps due to...

1. Slope Angle



2. Rock Lithology



3. Soil Saturation



4. Earthquake Triggers



... and combined
the results!

(13 Maps Total)

*Due to minimum
potential rainfall*

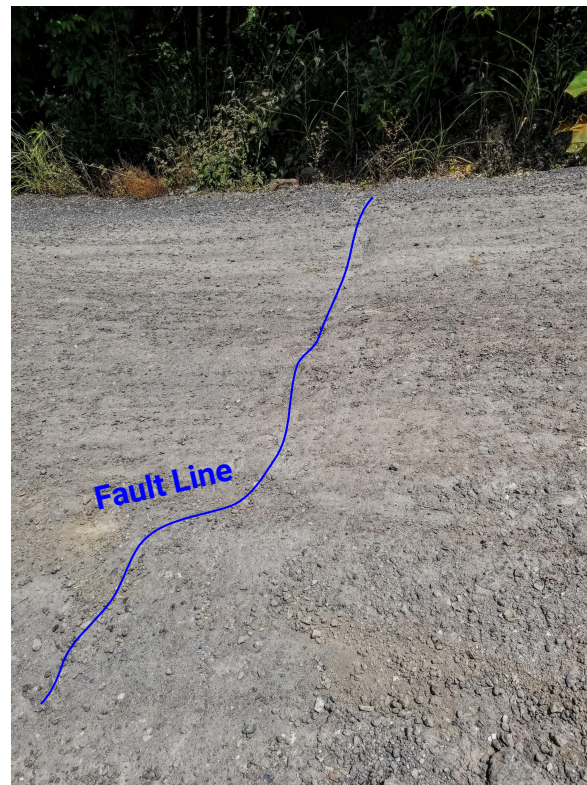
*Due to maximum
potential rainfall*

*Due to
quake #1*

*Due to
quake #2*

*Due to a strong
hypothetical third quake*

Field Work– Route 27



Field Work– Route 613



Field Work– Route 35

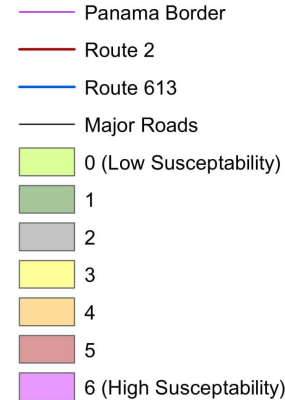


1) Slope Angle

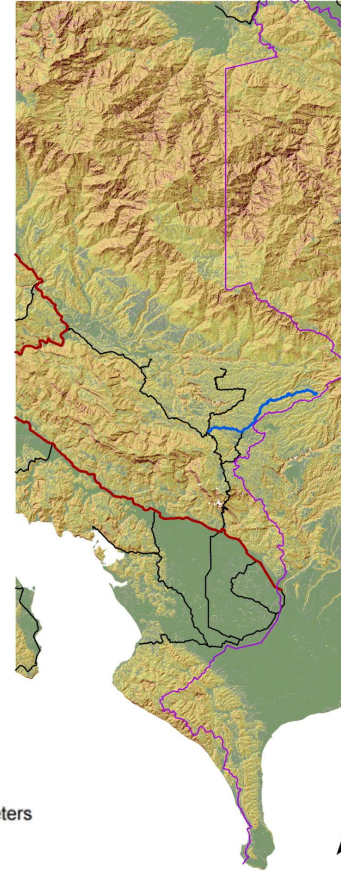
- The more steep an area is, the more susceptible the area is to landslides!
- Steeper slopes occur most often in mountain ranges
- To calculate, we took a digital elevation model (DEM) of the region and analyzed each point's surroundings to determine slope angles
- We then classified the data into 7 groups depending on steepness

Landslide Susceptibility of the Cordillera Talamanca due to Slope Angle

Legend



0 4.5 9 18 27 36 Kilometers



2) Rock Lithology

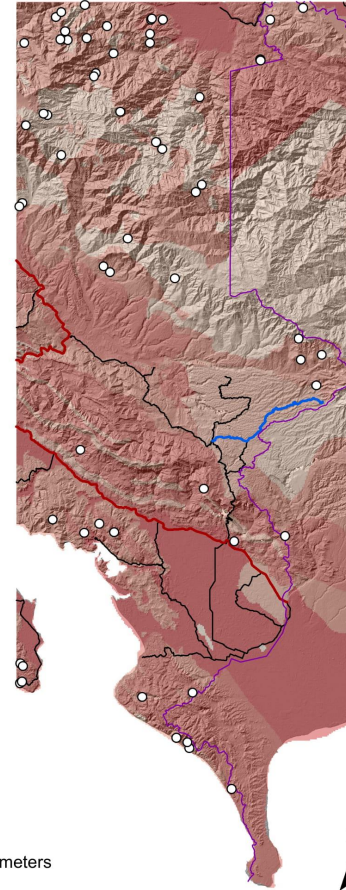
- “Lithology” describes the physical characteristics of rocks
- Different rock types are more or less susceptible to landslides due to their ages and compositions
- We traced a geologic map of Costa Rica and categorized the region by rock type

Landslide Susceptibility of the Cordillera Talamanca due to Lithology

Legend

- Known Landslide Locations
- Panama Border
- Route 2
- Route 613
- Major Roads
- 0 (Low Susceptibility)
- 1
- 2
- 3
- 4
- 5 (High Susceptibility)

0 4.5 9 18 27 36 Kilometers



3) Soil Saturation

- Higher moisture in soil leads to higher susceptibility because it makes the soil more dense and less compact
- Saturation intensity was found by using our region's average rainfall according to the Holdridge Life Zones and number of rain days per year
- We used maximum and minimum average rainfall to model the best and worst case scenarios

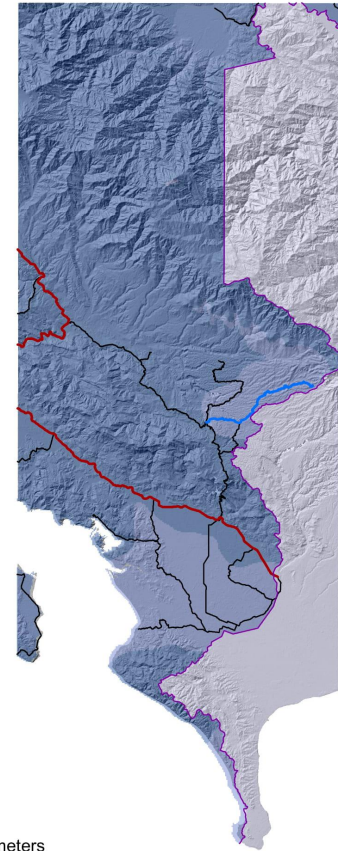
Landslide Susceptibility of the Cordillera Talamanca due to Soil Saturation

Using Maximum
Rainfall Data

Legend

- Panama Border
- Route 2
- Route 613
- Major Roads
- 0 (Not Applicable)
- 1 (Low Susceptibility)
- 3
- 4
- 5 (High Susceptibility)

0 4.75 9.5 19 28.5 38
Kilometers



4) Earthquake Triggers

- Earthquakes are very often triggers that cause landslides
- The threat of a landslide due to an earthquake depends on the **magnitude**, **depth**, and **location** of the earthquake
 - The threat is highest closest to the epicenter of the earthquake and decreases radially as you move away

$$\text{Log}_{10}(\text{PGA}) = Cb_1 + Cb_2 * M_w + Cb_3 \text{Log}_{10} \sqrt{d^2 + Cb_4^2} + Cb_5 * S + Cb_6 * H$$

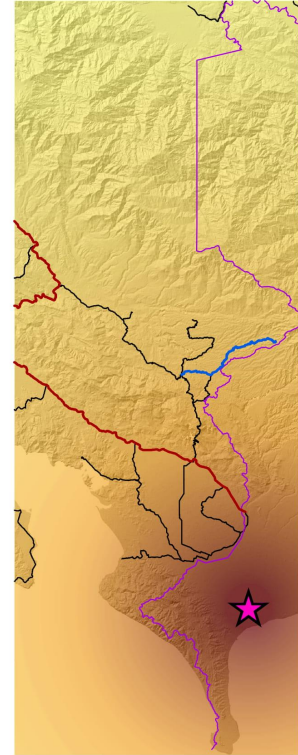
- We used the above equation to find the Peak Ground Acceleration (PGA) of every point and classified into index

Landslide Susceptibility of the Cordillera Talamanca Due To Hypothetical Earthquake #3

Hypothetical Earthquake #3
Magnitude: 6.7
Depth: 10.0 km

Legend

- ★ Earthquake Location
 - Route 2
 - Route 613
 - Panama Border
 - Major Roads
- Trigger Index**
High : 6.20767
Low : 2.77792



Final Results...

(Combining all of the variables)



Total Susceptibility

(for earthquake #1)

Factors Included:

- 1- Slope Angle
- 2- Rock Lithology
- 3- Soil Saturation*
- 4- Earthquake #1 Trigger






*Soil saturation data for map shown is using maximum rainfall patterns. Total susceptibility map using minimum rainfall data was also created but not shown.







Landslide Susceptibility of the Cordillera Talamanca

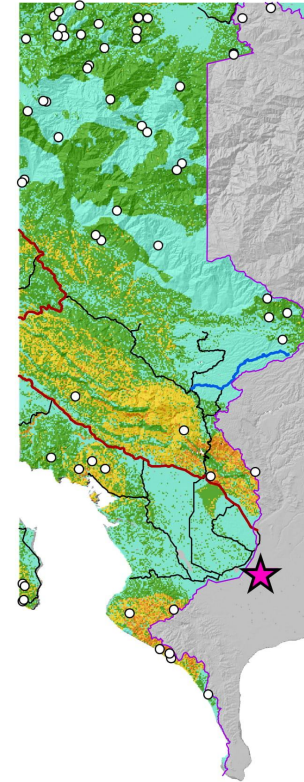
Earthquake #1
Magnitude: 6.0
Depth: 24.0 km

Using Maximum
Rainfall Data

Legend

-  Earthquake Location
-  Known Landslide Locations
-  Panama Border
-  Route 2
-  Route 613
-  Major Roads

- Susceptibility**
-  Not Applicable
 -  Very Low
 -  Low
 -  Moderate
 -  High
 -  Very High



0 5 10 20 30 40
Kilometers



Total Susceptibility

(for earthquake #2)

Factors Included:

- 1- Slope Angle
- 2- Rock Lithology
- 3- Soil Saturation*
- 4- Earthquake #2 Trigger

*Soil saturation data for map shown is using maximum rainfall patterns. Total susceptibility map using minimum rainfall data was also created but not shown.

Landslide Susceptibility of the Cordillera Talamanca

Earthquake #2
Magnitude: 6.4
Depth: 29.0 km

Using Maximum
Rainfall Data

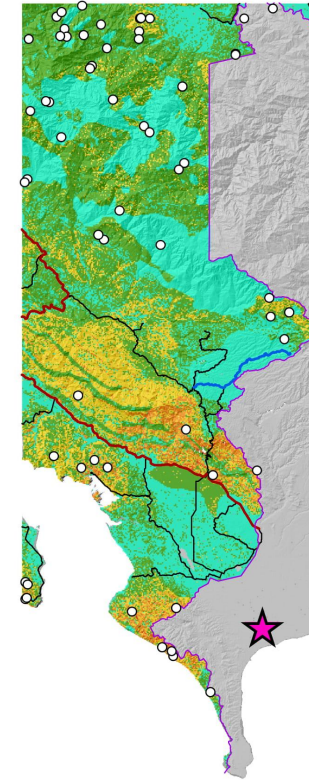
Legend

- ★ Earthquake Location
- Known Landslide Locations
- Panama Border
- Route 2
- Route 613
- Major Roads

Susceptibility

- Not Applicable
- Very Low
- Low
- Moderate
- High
- Very High

0 5 10 20 30 40
Kilometers



Total Susceptibility

(for hypothetical
earthquake #3)

Factors Included:

- 1- Slope Angle
- 2- Rock Lithology
- 3- Soil Saturation*
- 4- Earthquake #3 Trigger

*Soil saturation data for map shown is using maximum rainfall patterns. Total susceptibility map using minimum rainfall data was also created but not shown.

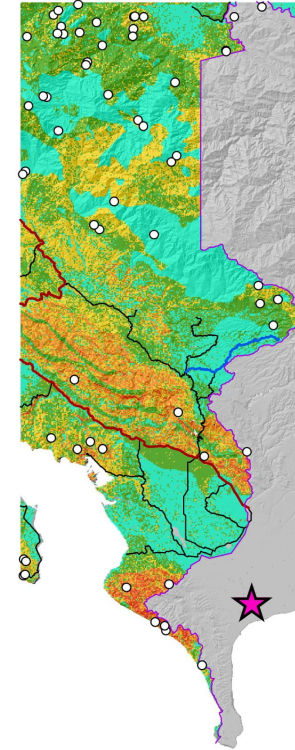
Landslide Susceptibility of the Cordillera Talamanca

Hypothetical Earthquake #3
Magnitude: 6.7
Depth: 10.0 km

Using Maximum
Rainfall Data

Legend

- ★ Earthquake Location
 - Known Landslide Locations
 - Panama Border
 - Route 2
 - Route 613
 - Major Roads
- Susceptibility**
- Not Applicable
 - Very Low
 - Low
 - Moderate
 - High
 - Very High



0 5 10 20 30 40
Kilometers



References

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Any questions?
Let's have a
conversation...

