Determining Landslide Susceptability in the Cordillera Talamanca, Costa Rica

Rutgers Aresty Research Center for Undergraduates

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Introduction

Due to its location and tectonic setting, Costa Rica is a hotbed for dangerous natural events such as earthquakes, volcanic eruptions, and landslides. These disatsers can have a direct impact on the infrastructure of the country and affect its development. To minimize the impact of landslides, risk management deals to clearly identify which areas could be the most damaged. To accomplish this task, the Mora-Vahrson-Mora-Ruiz model was applied to a region in southeastern Costa Rica to determine its landslide susceptability and to see if any new landslide had occured as a result of recent local earthquakes in May (6.0 Mw, 24.0 km) and June (6.4 Mw, 29.0 km) of 2019. This region is especially important because it contains the heavily trafficked Pan-American highway (R2) and Route 613, a relatively new road that is being analyzed by LanammeUCR to monitor deterioration. Aerial images of the region were examined to pinpoint known landslide locations and determine the accuracy of the model.

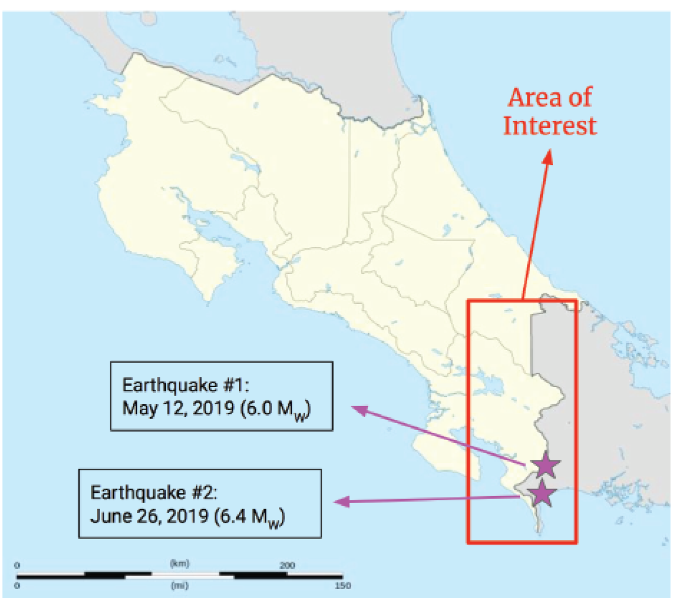

Figure 1: Map of Costa Rica with area of interest outlined and earthquake locations shown

Methods

Variable	Theory	Method
Slope Steepness	• The more steep an area is, the more susceptible it is to landslide • Steeper slopes occur most often in mountain ranges like the Cordillera Talamanca	• A digital elevation model (DEM) of the region was run through a function in GIS to analyze its surrounding pixels and determine slope angles
Rock Lithology	• Different types of rocks are more or less susceptible to landslides due to their ages and compositions	• Geologic maps of Costa Rica and Panama were traced in GIS and categorized by rock type
Soil Saturation	• Higher moisture content in soil leads to higher susceptibility • Moisture makes the soil more dense and less compact	• Saturation intensity was found using average rainfall according to Holdridge Life Zones and number of rain days per year • Intensities were correlated to saturation indexes
Earthquake Trigger	• The landslide threat due to an earthquake depends on its magnitude, location, and depth • Susceptibility is highest at the epicenter and decreases radially as you move away	• A equation was used to find the Peak Ground Acceleration at every point in the region • These PGA values were correlated to an index number for 3 different earthquakes

Figure 2: Table of variables analyzed to determine landslide susceptability

In order to determine total susceptabaility, the Mora-Vahrson-Mora-Ruiz model takes four different variables into account using the Geographic Infromation System softwares ArcGIS and QGIS. Within each variable map, each pixel (representative of a 30 meter x 30 meter area) is given a value from zero to five or six in order of increasing potential hazard due to that variable. These maps are combined via raster multiplication to calculate total susceptability. The final values are then classified into five categories: "very low", "low", "moderate", "high", and "very high" susceptability.

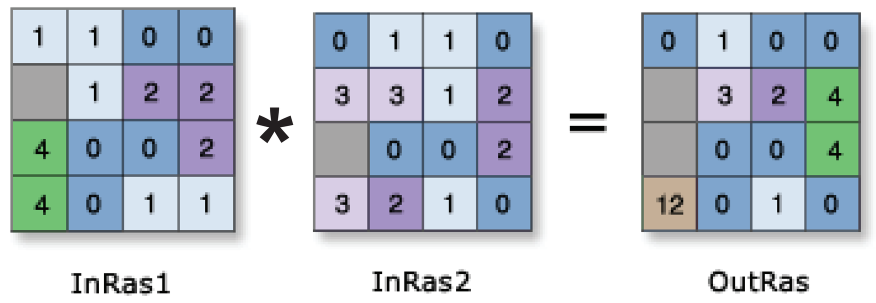

Figure 3: Diagram showing how raster multiplication works

Symbol	Range	Label
	0 - 0.1	Not Applicable
	0.1 - 93.24	Very Low
	93.24 - 186.48	Low
	186.48 - 279.72	Moderate
	279.72 - 372.96	High
	372.96 - 491.526947	Very High

Figure 4: Classification of final susceptabaility values into qualitative categories

Results

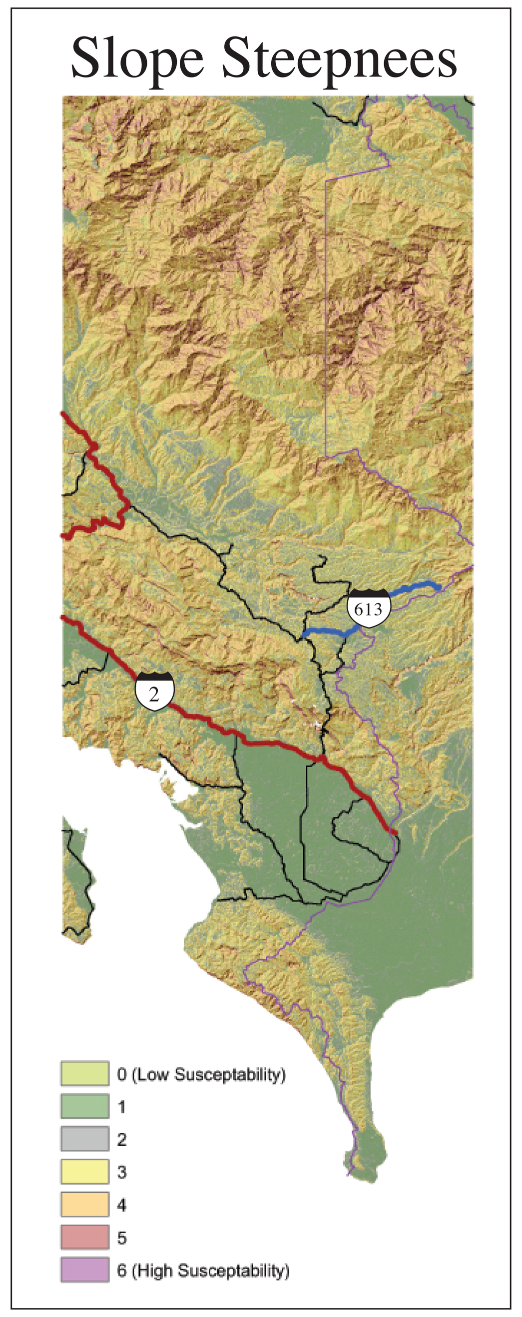

Figure 5: Susceptability of the region due to slope steepness

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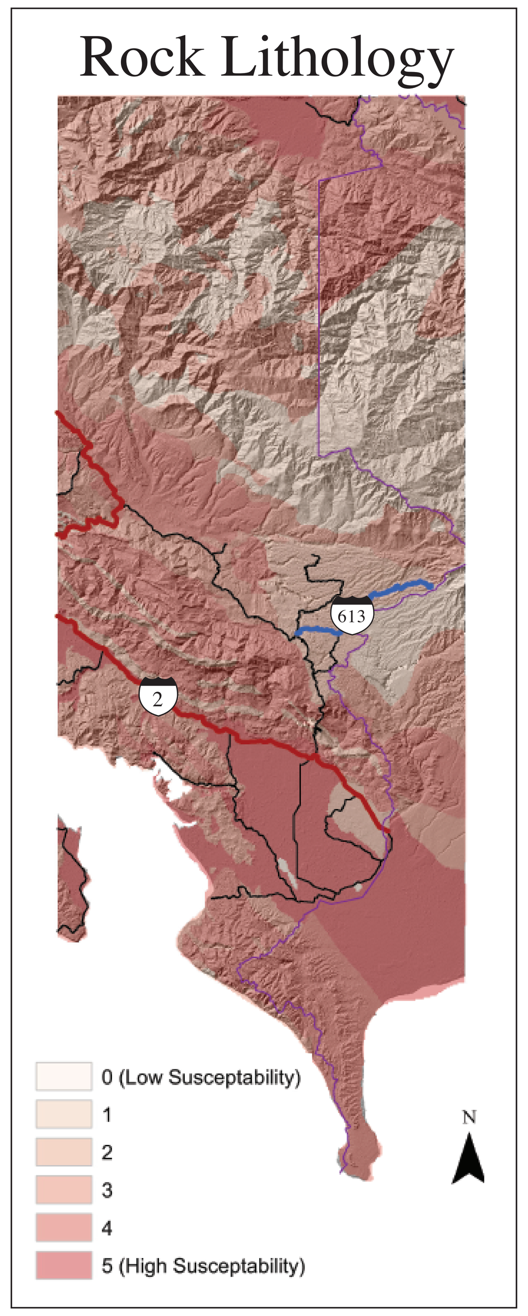

Figure 6: Susceptability of the region due to rock lithology

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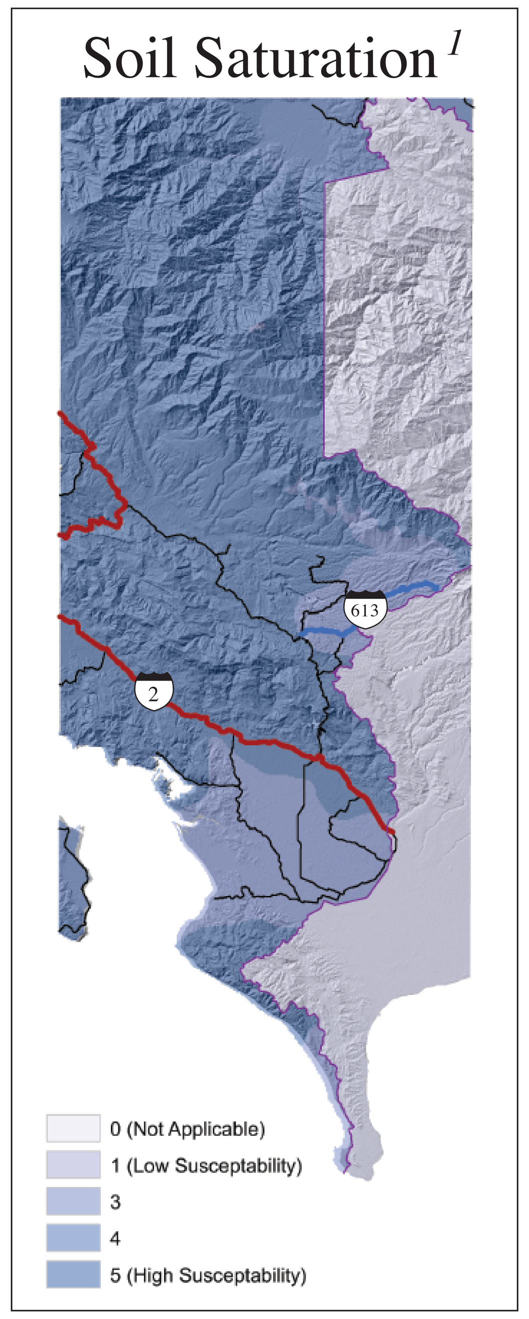

Figure 7: Susceptability of the region due to maximum rainfall patterns

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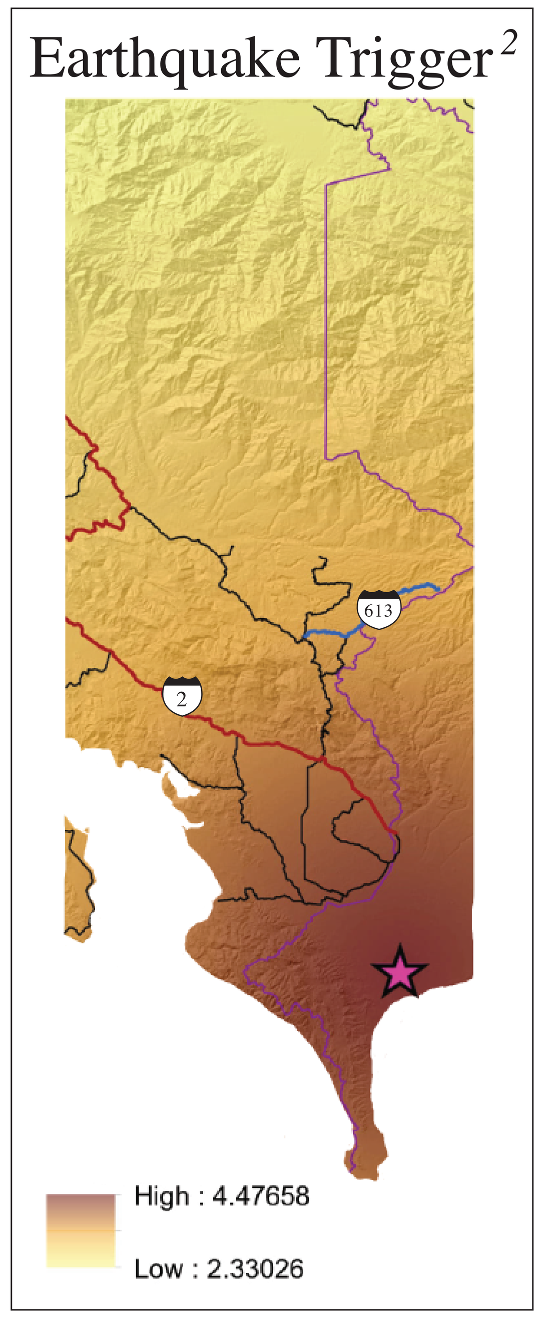

Figure 8: Susceptability of the region due to 6.4 Mw earthqauke (June 2019)

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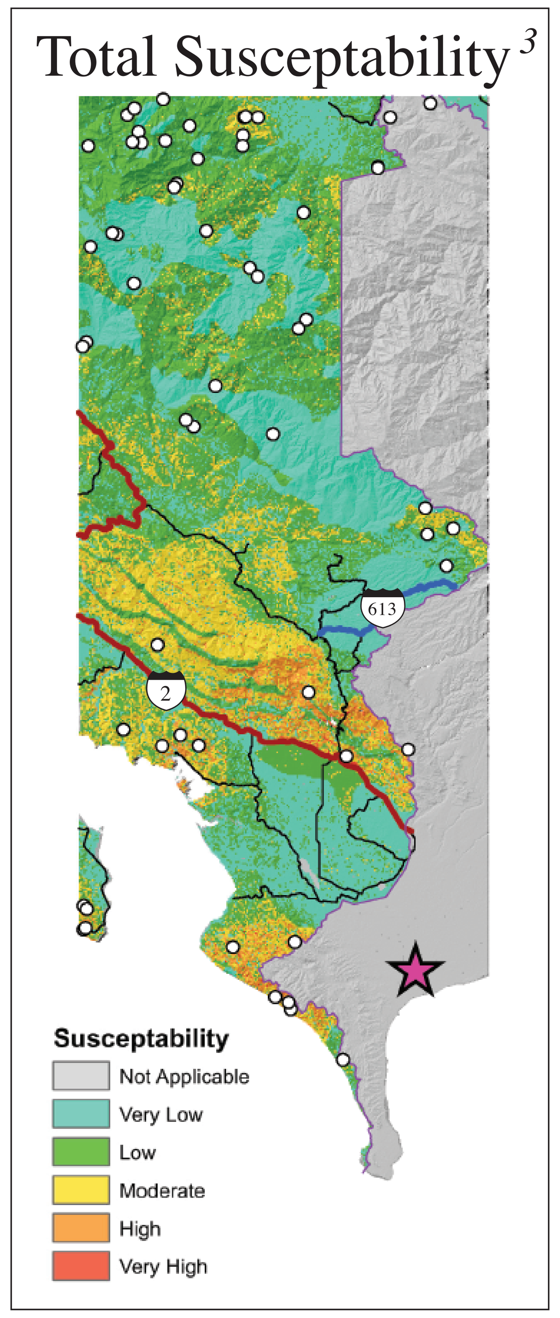

Figure 9: Total Susceptability of region, combining the 4 prior variable maps

Figure 10: Field work was conducted to monitor deterioration on a road where landslides were frequent

Figure 11: Landslides were observed, studied, and photographed in the field by our team. We searched the region to see if new landslides had occured since the earthquakes

[1] *Two soil saturation maps were created, using minimum and maximum rainfall patterns. The map displayed uses maximum rainfall patterns.*
[2] *Three earthquake trigger maps were created, using data from the two known earthquakes and a strong hypothetical third earthquake (a "worst case scenario") in the same location as the second with a magnitude of 6.7 and a depth of 10.0 km. This map displays earthquake #2 (6.4 Mw, 29.0 km)*
[3] *Six total susceptability maps were created, using every combination of soil saturation and earthquake trigger maps. This map uses maximum rainfall and the second earthquake.*

Key (all maps):
- Earthquake Location
- Known Landslide Locations
- Panama Border
- Route 2
- Route 613
- Major Roads

Conclusion

This research accurately found that landslide susceptability is higher in areas around the Pan-American Highway and lower around Route 613. These findings are consistent with the locations of known landslides found via aeriel imagery. This was suspected since Route 2 is in the Cordillera Talamanca, which has high slopes and soil saturation.

Future Work

To further understand the results of this project, more research should be conducted in the areas where our model predicts high susceptability. These potentially hazardous areas would benefit from the opportunity to be able to adjust for potential landslides by putting preventative measures into place such as retaining walls and proper evacuation procedures.

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