Landslide Risk Assessment of Saint Vincent

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Introduction:

The geology of Saint Vincent, located in the island chain of Saint Vincent and the Grenadines, has been shaped by coastal erosion and landslides which have caused the loss of thousands of lives and capital. It is known that persistent rainfall, earthquakes, volcanic activity, and steep slopes contribute to the intensity and frequency of landslides on the island, but an estimate of landslide risk does not yet exist for this community. Therefore, a current geostatistical risk assessment model of landslides is necessary for the safety of the citizens of the island.

Figure 1. Location of the island of St. Vincent (denoted with a star) in relation to the Carribean Sea.

Methods:

- ArcMap 10.1 -- UTM WGS84 Zone 20N
- Landslide inventory: Digitized PDF's of historic landslides in the 1980's -- georeference and digitizing landslides as point features (463 total)
- Global Moran's I: ensure autocorrelation
- Two assessments: binary logistic regression and co-kriging
- Create absence points: buffer 200 m radius from historic landslides, erase from SVG -- create 400 random points for validation (min 100 m distance)
- Slope (aggregated by factor of 5) and aspect -- created with DEM, values extracted to the 863 points
- Training (663) and a validation (200) data sets created
- Binary logistic regression: SPSS 20 -- resulting coefficients used to perform map algebra
- Transform slope: normal score and declustered
- Validation – assess accuracy

Acknowledgements:

We would like to thank Dr. Erik Nordman for providing technical support and advising throughout the project and Mr. Jerome DeGraff for providing landslide locations for the island of St. Vincent. Ikonos images courtesy of the DigitalGlobe Foundation.

DigitalGlobe

References:

DeGraff, J.V., 1988. Landslide hazard on St. Vincent, West Indies-Final Report. Washington, D.C., Organization of American States.

Figure 2. Landslide from a raod in Belmont, St. Vincent.
(Photo Credit: St. Vincent Central Water and Sewage Authority)

Data Sets:

- Saint Vincent boundaries-downloaded from GADM.org\country
- Digital Elevation Model-downloaded from U.S.G.S Earth Explorer
- IKONOS high resolution image-obtained through an image grant from Digital Globe Foundation
- PDF of 1980's recorded landslide points-provided by Jerome DeGraff (United States Forest Service)

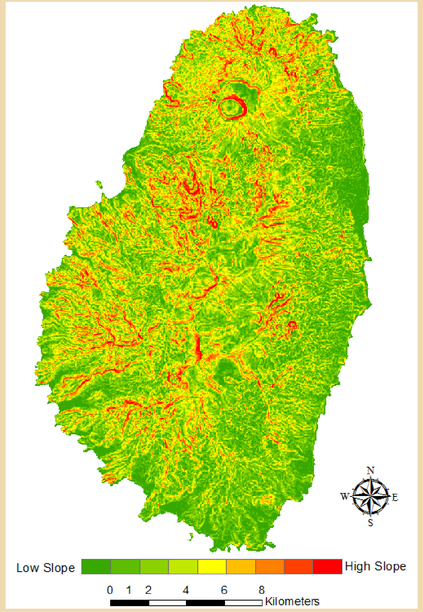

Figure 3. Slope of the island of St. Vincent derived from a 30 meter DEM.

Table 1. Results of binary logistic regression. * denotes statistical significance.

	Coefficient	P Value
Slope	0.130	0.000*
Aspect	-0.001	0.406
Constant	-2.575	0.000*

Results:

- Pseudo R^2 = 0.201 (Cox & Snell)
  Binary Logistic Regression (see Table 1)
- The Moran's I reported back a positive autocorrelation of 0.623 and has a significance of p= 0.00 indicating spatial autocorrelation.
- Co-kriging: Nugget 0.25
  Range 2,805 m
  Sill 0.77
- Accuracy Assessment (see Table 2)

Table 2. Accuracy assessment of the landslide points comparing predicted to actual.

		Actual		# of Predicted Points:	Users Accuracy:
		Risk	No Risk		
Predicted	Risk	96	11	107	90%
	No Risk	17	75	92	82%
# of Actual Points:		113	86	Total Points: 199	
Producers Accuracy:		85%	87%	Overall Accuracy:	86%

Figure 4. Sample of 1980's landslide locations (left) and the same points digitized over Ikonos image (right). Red dots represent verified landslide points. Blue points represent a control point.

Discussion:

Our data shows slope is a significant variable leading to landslides. Further, co-kriging proved to be more accurate at predicting landslide activity than binary logistic regression.

We explored co-kriging with geology layers, however it did not provide a significant enough difference to be worth displaying in our model. We also found aspect to be insignificant in assessing landslide probability. Other variables, such as roads, land cover, tectonic faults, and precipitation, may be significant in predicting landslide risk, however such variables were not included in our analysis.

To improve our results, it would be important to update and verify landslide locations.
We hope the results presented will provide useful information regarding landslide risk, improving mitigation and development strategies.

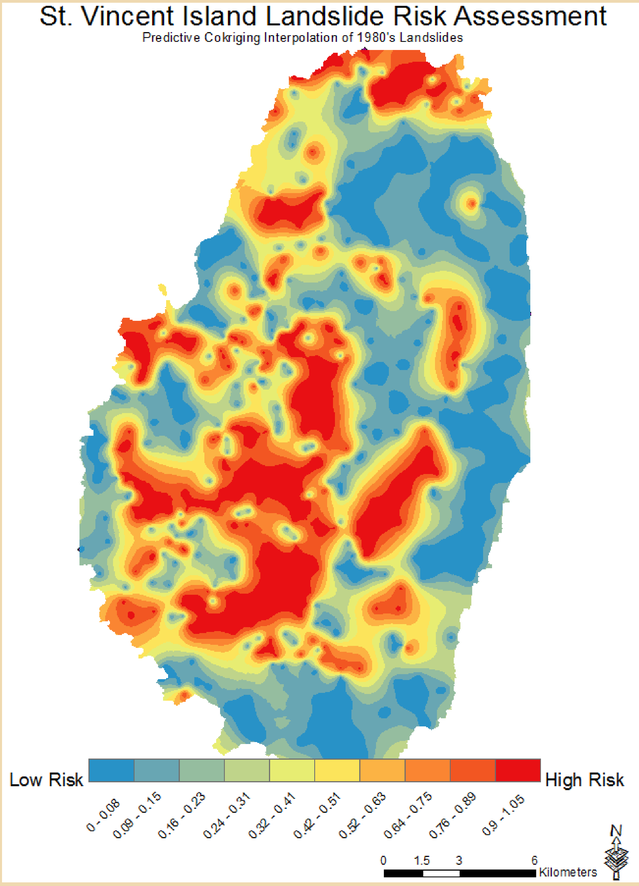

Figure 5. A co-kriging map illustrating areas of low to high risk of landslides on the island of St. Vincent.