Predicting Mechanisms of Flood Vulnerability for Southeast Asia Using Statistical Percolation Theory

Huang, Caroline (School: Abbey Park High School)

In 2020, more than 250,000 Vietnam households were inundated, and over 70% of the population is exposed to risks from flood-related hazards. While Southeast Asia has experienced an unprecedented increase in severity of flooding over the past decades, existing predictive models still rely on elevation-based geometrics and localized water-gaging facilities that overlook subsurface factors and rural communities. Percolation theory demonstrates a mathematical metaphor to flood mechanisms through its representation of interconnective water flow through the shortest pathway. Can a statistical reconstruction of coupled geological and overland flood factors, applied in percolation theory, predict the flood vulnerability of a region in Southeast Asia? Using NASA remote sensing data over a two decade period, the inundation vulnerability of Southeast Asian watersheds were determined by Digital Elevation Model slope calculations, and land cover, antecedent moisture content, and soil group classifications using the NRCS Runoff Curve Numbers methodology. Areas that are low-lying nested plains between mountain ranges, yield frequent horticulture development with consequent high dual soil groups, and demonstrate urban development resulting in high impervious land cover, were found to have the highest percolation probabilities. Additionally, both percolation theory and hydrographs exhibit similar mathematical function, suggesting a statistical similitude that allows percolation theory to describe flood mechanisms. The application of percolation theory to model natural disasters induced by climate change was also further investigated. A flood vulnerability indexing tool was proposed to build flood resilient remote settlements for sustainable flood protection in susceptible regions.

Awards Won:
Third Award of $1,000