

50 years of volcanic risk mitigation: Remarkable progress, but challenges remain

Chris Newhall, Mirisbiris Garden and Nature Center

Risk = Hazard x Vulnerability x Exposure x Value (modified from Fournier d'Albe)

Hazard: Since 1970, fantastic new monitoring instruments have been developed, from broadbands, GPS, and continuous gas analyzers on the ground to space-based methods (including InSAR) that are now of sufficiently high spatial, temporal, and spectral resolution to be combinable with ground-based monitoring. Many data sets are now open access, and we're starting to see testable AI algorithms for grouping volcanoes by behavior, and for forecasting eruptions. Quantitative physical volcanology reconstructs eruptions; new petrologic tools reconstruct intrusive runup to prehistoric eruptions. Increasingly, experimental, field, and petrologic results constrain each other.

Physical vulnerability: Russell Blong's pioneering "Volcanic Hazards: Sourcebook on the Effects of Eruptions" stimulated new studies on vulnerability of buildings to pyroclastic flows and ash loading, health effects of ash, and a myriad of other effects of ash, from crops to computers. Critical insights are also emerging on the vulnerability of aircraft to various concentrations and characteristics of ash.

Occupancy and duration of exposure: People and some property can be moved, or their time of exposure limited. If evacuations are indicated, hazard and vulnerability must be communicated effectively to decisionmakers and those at risk. Forecasts must be scientifically sound AND resonate with recipients. Evacuation and other mitigation decisions require not only WHAT CAN HAPPEN but also HOW LIKELY is it to happen? Quantification, via probabilistic event trees, is helping.

Value: The value of fixed property can now be estimated in GIS. The value of human lives at risk is in most cases even higher. Few officials are willing to discuss VSL (value of a statistical life) in public, but may set VSL for internal discussions and/or refer to societal norms of acceptable individual or societal risk. *De facto*, decisions about acceptable risk already consider VSL.

Outstanding challenges: Integrating ground- and space-based monitoring, recognizing and studying risky but little-known volcanoes, forecasting phreatic and plinian eruptions, developing numerical models with real-time predictive value, integrating government and academic efforts in both physical and social volcanology, and ensuring that volcanological information addresses decisionmakers' needs.