Enhancing preparedness through probabilistic impact and loss forecasting at Awu volcano North Sulawesi, Indonesia

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Understanding how volcanic hazards translate into real-world impacts enables the development of proactive risk mitigation strategies. We combined probabilistic tephra fall hazard simulations with building exposure and vulnerability information to forecast the expected damage and financial losses from a VEI 4 eruption of Awu volcano. Awu is located on Sangihe Island, Indonesia, where the entire population of ~140,000 lives within 45km of the volcano. With a history of deadly eruptions and recent unrest, there is an urgent need for actionable risk information. Using satellite imagery, we classified building roof types to estimate exposure, and applied Bayesian inference to develop a hybrid vulnerability model tailored to the local typologies. Our impact forecasts show a 95% probability of at least $11 million USD (~18 $\times$ 10^{10} IDR) in losses, a 50% probability of at least $39 million USD (~62 $\times$ 10^{10} IDR), and a 5% probability of at least $165 million USD (~264 $\times$ 10^{10} IDR). Losses are concentrated in northern districts, particularly around the island's capital, Tahuna. We found that standard triggers for volcanic risk financing, such as eruptive column height and eruption timing (month), may not reliably predict losses. Instead, column height, month, erupted mass, and grain size all play a role. Simulating 100 million loss scenarios, captured uncertainty across hazard and vulnerability components, revealing major differences between losses based on the median hazard footprint and those from median loss estimates. This impact-focused approach supports preparedness and response capabilities for Awu and offers a scalable framework for other volcanic settings.