A classification of mitigation strategies for natural hazards: implications for the understanding of interactions between mitigation strategies for volcanoes

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Volcanic unrest generates a complex mix of numerous hazards with differing spatial and temporal scales that poses significant challenges to developing successful mitigation systems . Recent natural disasters such as the tsunami of T?hoku demonstrate the need to reexamine mitigation system functionality, especially those complex systems combining multiple mitigation strategies. A systematic classification of mitigation strategies is presented as a basis for understanding how different types of strategy within an overall mitigation system can interfere destructively, to reduce the effectiveness of the system as a whole. We divide mitigation strategies into three classes according to the timing of the actions that they prescribe. Permanent mitigation strategies prescribe actions such as construction of SABO dams or land use restrictions: they are frequently both costly and ''brittle'' in that the actions work up to a design limit of hazard intensity or magnitude and then fail. Responsive mitigation strategies prescribe actions after a hazard source event has occurred, such as lahar evacuations, that rely on capacities to detect and quantify hazard events and to transmit warnings fast enough to enable at risk populations to decide and act effectively. Anticipatory mitigation strategies, commonly used in the mitigation of volcanic hazards, prescribe use of the interpretation of precursors to hazard source events as a basis for precautionary actions, but challenges arise from uncertainties in hazard behavior and the interpretation of precursory signals. We provide examples of interactions between mitigation strategies that have caused, or have the potential to cause, the overall mitigation system to greatly underperform relative to expectations. We propose that the classification presented here would enable consideration of how the addition of a new strategy to a mitigation system would affect the performance of existing strategies within that system, and furthermore aid the design of integrated mitigation systems.