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GIS methodologies for local tsunami risk assessment – validation for the 2009 South Pacific tsunami in American Samoa

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On September 29th, 2009 at 6:48 AM local time, a series of earthquakes generated near the Tonga trench (15.509°S, 172.034°W) triggered a tsunami that reached the shores of Tonga, the Independent State of Samoa, and American Samoa. Effects of the tsunami were seen on several other Pacific islands. Devastation was widespread, resulting in 9 fatalities in Tonga, 149 in the independent State of Samoa and 34 in this study's region of focus, American Samoa, which was selected mainly because of better data availability. Pago Pago, the capital on the main island of Tutuila, was especially affected by the tsunami because of its natural deep water harbor. Leone, located on the southwest coast of the island, was hit directly by waves propagating northeast from the earthquake's epicenter. The villages of Poloa, Amanave, Alao, and Tula were also heavily damaged, but Leone and Pago Pago sustained some of the most wide-spread damage on Tutuila due to the combination of large populations with environmental and geographic factors.

Following the disaster, teams from several nations evaluated damages and evidence of inundation levels. This study seeks to use information (including population, building types, infrastructure, inundation, flow depth, damages, and death tolls) gathered after the tsunami by researchers in American Samoa in order to validate a pre-existing GIS tsunami vulnerability and risk assessment model. The tsunami inundation, damage, and mortality information found from journal papers, reports, newspaper articles, internet, personal communication with local agencies, photos, aerial views, and satellite images, was applied to deduce population density, building vulnerability, and the cause and location of tsunami deaths. The GIS model was adapted for optimal use of the available data.

In the GIS model the mortality risk is a "product" of hazard, exposure, and mortality. The hazard is represented by the maximum tsunami flow depth, the exposure is described by the location of the population at a given time of the day, and the mortality is a function of flow depth and building vulnerability. Normally a certain tsunami scenario with a corresponding return period is applied for vulnerability and risk assessments. However, in this study the maximum flow depth was obtained by back modeling the 2009 South Pacific earthquake and tsunami, aiming at validating the GIS model approach for building vulnerability and mortality only. Our model successfully estimated the degree of mortality resulting from this tsunami, based on comparisons with the observed deaths.