

Interactions between erosion and saltwater intrusion on small islands and implications for future water security

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Abstract

Populations on small islands are often groundwater-dependent due to the lack of surface water resources, forcing residents to pump potable freshwater from the underlying aquifer known as the 'freshwater lens'. Government funding, media attention, and infrastructure aim to address *surface* impacts of extreme coastal storms; however, freshwater lenses *beneath the land surface* are also susceptible to degradation (salinization) during and following coastal storms. Previous research suggests that in a changing climate, water insecurity due to saltwater intrusion may often be the ultimate trigger driving the forced migration of island populations. Saltwater intrusion can be lateral due to increasing pumping, declining aquifer recharge, and rising sea levels, or downward due to coastal flooding.

We report on recent field and modelling investigations of saltwater intrusion into small-island aquifers in Atlantic Canada. Field sites include Sable Island, a remote sand island in the Northwest Atlantic; Lennox Island, a Mi'kmaq First Nation with a confined, bedrock aquifer; and Hog Island, a sandy barrier island protecting Lennox Island from waves in the Gulf of St. Lawrence. Results highlight the profound importance of coastal erosion as a mechanism that exacerbates surface coastal flooding extent and associated downward saltwater intrusion into aquifers. We provide field data from monitoring wells, geophysical instruments, wave buoys, and drone-based LiDAR elevation mapping to illustrate the interactions between coastal flooding, coastal erosion, and saltwater intrusion. We investigate these processes in a surface-subsurface hydrologic model. Field data and model results show that both gradual, decadal erosion and sudden, pronounced erosion during coastal storms can drive saltwater intrusion into island aquifers; however, the underlying mechanisms are distinct. Collectively, the results highlight that small-island freshwater management programs should explicitly consider the interactions and feedbacks between coastal erosion and saltwater intrusion and weigh these impacts when conducting risk analyses and feasibility assessments for coastal adaptation solutions.

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