Risk to Water Security on Small Islands: A Numerical Modeling Approach

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The aim of this research is to characterise risk to water security for small islands. This is achieved by modeling the spatial and temporal impact from major stressors affecting water resources on small islands, and then evaluating the risk to water security through an integrated assessment framework. Numerical density-dependent flow and transport modeling is used to evaluate the response of the freshwater lens on Andros Island in The Bahamas to various climate change and human stressors including: sea level rise, changes in recharge, and increased pumping. SEAWAT models showed a reduction of freshwater lens volume by up to 24% under projected sea level rise and reduced recharge. The response time of the freshwater lens increased with stressor magnitude, resulting in a longer lens adjustment period. In addition, greater upconing was observed for pumping scenarios simulated under projected climate change conditions than under current conditions. The impact of a 2004 storm overwash event on Andros Island was simulated using HydroGeosphere. Results show that potable water is restored one month sooner when timely remedial actions are implemented; however, if delayed by four days or more, there is no improvement in recovery time. To extend the research more broadly, simulations of overwash for various island types observed worldwide were conducted. Dominant factors affecting freshwater lens response include vadose zone thickness and geologic heterogeneity, such as low or high permeability zones, whereas the dominant factor affecting freshwater lens recovery is recharge rate. A framework to characterise risk to water security was developed specific to an island hydrogeological setting. A freshwater lens susceptibility map was generated using the results of the numerical modeling. Hazard threats from climate change and human stressors (derived from numerical modeling and a land-use survey) were overlaid on the susceptibility map to represent vulnerability. Combining vulnerability with loss (or consequence) yielded a risk to water security map. High risk areas are largely concentrated within the developed areas near high chemical hazard activities, as well as along portions of the coastline. These maps were provided to local partners to inform water management policies and raise awareness about factors impacting water security.