

The impact of sea level rise and climate change on fresh groundwater occurrences and volumes below atoll islands.

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Abstract

Freshwater lenses are important freshwater resources on Small Islands Developing States (SIDS), especially during droughts. Sustainable groundwater management is urgent due to climate change, population growth, and unsustainable extraction. Additionally, sea level rise will irreversibly impact these lenses. We used the SIDS modelling framework, developed by Deltares in 2021 to assess the effect of these stresses on the freshwater lenses. It is an open-source Python-based toolbox that utilizes the iMOD-WQ software to generate a density dependent groundwater model. To quantify the impact of flood events on the freshwater lens iMOD-WQ is coupled with the flood event software SFINCS.

For this analysis, a generic boomerang island shape is used. It is assumed that no measures will be taken to maintain the island shape and size. The analysis shows there is a significant impact on the freshwater lens due to sea level rise. A sea level rise of 25 cm reduces the total freshwater lens volume by 20%, 50 cm results in a 50% reduction, and a 1 m sea level rise leads to an 80% reduction. The freshwater lens is pushed upwards by sea level rise resulting in extra drainage and evapotranspiration at the surface leading to shrinkage of the lens. Also, the reduction in island size causes the freshwater volume to decrease.

In addition to the impact of the steady rise in sea level, an increase in the frequency of flooding due to storm surges is expected. The overtopping of saline water onto the freshwater lens instantaneously decreases the amount of freshwater. A 10-20% decrease occurs during a 50-year flood event, and the system takes up to one year to recover to the initial situation. The combination of sea level rise, an increase in overtopping events, and continued overexploitation will greatly reduce the freshwater lens volumes on islands.

This analysis underscores the considerable impact of sea level rise on atoll islands, affirming the vulnerability of Small Islands Developing States (SIDS) to climate change.

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