Université de Neuchâtel
Centre d'hydrogéologie
et géothermie

MSc in Hydrogeology and Geothermics

Thesis topic proposal 2024

Eco-hydrogeological modelling in Nouakchott City (Mauritania): tree-planting to alleviate saturation excess flooding

Context and objectives

Despite a warm and dry climate, the city of Nouakchott (Mauritania) has been facing constant flooding for almost a decade, making part of the city inhabitable and posing long-term health threats. The flooding comes from a rise in the groundwater levels that reach the topographical surface, thereby creating ponds throughout the neighborhoods and throughout the year. Shallow groundwater levels are maintained by sea intrusion from the Atlantic Ocean and by the infiltration of leaks from the domestic water network and wastewater from individual septic systems. Certain ponds are permanent while the flooding area almost doubles during rain season (~100 mm/yr). Therefore, the only solution to alleviate flooding is to lower groundwater levels at the city scale.

The EIRA project, a collaboration between EPFL and the Region de Nouakchott (Nouakchott city hall), aims to assess how planting trees in the city could help to increase the resilience of the community to urban flooding (https://eira.epfl.ch/). The tree water uptake, represented by transpiration, will lower the groundwater levels, thereby increasing the soil water storage capacity and directly alleviating flooding. Ultimately, the EIRA project goal is to provide scenarios for an integrated and sustainable afforestation strategy for Nouakchott.

The selected candidate of this master project will build a 3D transient groundwater flow model using scarce historical data and reconstructed flooding observations in the Nouakchott area. They will perform a state-of-the-art calibration of the model to further simulate several tree-planting scenarios to quantify the impact on groundwater levels and flooding, both at the city scale and the household/bloc scale. These scenarios will account for different planting patterns and dewatering capacity of various tree species, and will be based on planting rules determined with the Region de Nouakchott. The results will be extensively used by the Region de Nouakchott. More specifically, the selected candidate will answer these specific questions:

- What is the most effective planting pattern that maximizes groundwater drawdown at the city scale and at the local scale?
- What is the spatio-temporal extent of the expected residual flooding?

Methodology

As a starting point, conceptual models simulating the influence of different tree-planting densities will be developed. The conceptual results will provide the basis to develop a 3D groundwater flow model and to explore tree planting scenarios. The selected candidate will have access to the lithology description of 20 observation wells; manual measurements on a network of observation wells since 2015 (2 to 10 campaigns per year, 13 to 20 observation wells); high-resolution time series of groundwater level (automatic sensors) on 5 observation wells since February 2023; transpiration time series for 5 tree species found in Nouakchott based on sap flow measurements since February 2023; spatio-temporal mapping of flooding in Nouakchott using sentinel-2 images for the 2017-2023 period; temperature and precipitation time series from Nouakchott airport weather station; land cover classification, tree cover characterization, and tree transpiration estimates in Nouakchott from recent student projects (2023-2024);detailed topography.

The selection of tree species will be discussed with the Region de Nouakchott, as well as the possible tree-planting patterns and available areas for tree planting. The results of the projects will support a publication in a peer-reviewed journal.

Supervision and collaboration

The project will be supervised by Prof Philip Brunner at Université de Neuchâtel and Prof Paolo Perona and Dr Emmanuel Dubois at EPFL. The selected candidate will mostly be in touch with Dr Dubois who conducted the field work and established a first simplified groundwater flow model in steady-state.

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