

Project: Drainage in Nouakchott – nature-based solution

Starting date: November 11th, 2025

Finish date (delivery): December 09th, 2025

***** IMPORTANT *****

In groups of 2 people, present the results of the project in a report-style document with a maximum of 10 to 15 pages (written in English). Hand in the Excel sheets associated with your simulations.

Questions:

1. Introduction and conceptualization (11/11/2025) – 10%

Establish a conceptual map of the mean annual water fluxes for the city in the current state and with a tree-planting solution by identifying the variables of the water budget. Is this water budget in steady-state or transient state? When possible, quantify the fluxes.

2. Groundwater flow modelling (18/11/2025) – 40%

2.1. Considering a steady state, establish a simple 2D planar hydrogeological model to map the groundwater levels in Nouakchott in the current situation. Using the simplified shape of Nouakchott, only represent a “strip” of Nouakchott that is 2 km long in the north-south axis.

Describe the boundary conditions that you used.

Compute the mean error and the mean absolute error of your model and comment if this error is acceptable for the model to be further used.

2.2. Plot a piezometric map of the current situation and describe the groundwater flow. Identify which neighborhoods are dealing with flooding.

2.3. Quantify the fluxes of the water budget for the simulated area. Is the water budget balanced?

3. Long term scenario: planting strategy (25/11/2025) –25%

3.1. List the benefits that the different tree species could bring to the city, and more generally the benefits from a tree-planting program in hot desert climates and in urban environments. Be inventive and broad, you can document your discussion based on scientific literature.

3.2. Using the transpiration rates estimated from the in-situ monitoring (**Table 2**), simulate the impact of tree-planting scenarios on the groundwater levels. Present the impacts of the best performing scenario (optimistic) and a more pessimistic scenario. Explain what motivated your choice in the scenarios.

Discuss your results in planar view (drawdown) and cross-section.

3.3. To which extent do you believe that the proposed scenarios are feasible considering that the city is already densely populated and the available space is

limited? What are the limitations of these tree-planting scenarios (engineering, funding, time frame, legal, social, political)? Suggest long-term implementation strategies that could increase the success of a tree-planting project. Pay particular attention to the social acceptance of the project (how to involve citizens in such a tree-planting program, where would be the ideal places to plant trees, why?).

4. Short term scenario: irrigation needs (02/12/2025) – 15%

Young trees will be planted following your indications for one of your scenarios (select one). In this scenario, several batches of 50 trees will be planted in the central reservation of the main streets of Nouackchott (straight line). However, these young trees will need irrigation for the first year. This temporary stage will limit the mortality rate of the plantation, thus maximizing the success of the tree-planting program.

- 4.1. Compute the minimum needs for each of the tree species that have been monitored considering that the local nurseries can only provide trees with a maximum circumference at breast height of 20 cm and with 8 leaf blades on Palm trees. To do so, use the allometric function (**Eq. 1**).
- 4.2. Design a conceptual micro-irrigation plan and technique, including calculation of rates and frequency of irrigation for one of your scenarios as well as the size of the ramps and the dripper. To do so, assume that irrigation occurs on a flat terrain, that the max dissipation per unit length is 0.3 mbar (diameter of the ramps and the dripper; $c_c=0.7$; Strickler coefficient, $C_g = 90 \text{ m}^{1/3} \text{ s}^{-1}$), and that the service pressure in the ramp is 1.2 bar in average. Estimate realistic values for the transport efficiency and the plot delivery efficiency. Maximum infiltration rate was estimated to be up to 10 mm h^{-1} and total irrigation time is 12 h d^{-1} . Considering that the installation can serve 50 trees at a time and that the plant density is 0.1 plant m^{-2} , calculate the handling flowrate required to provide the gross dose to a single line of 50 trees. As well, calculate the maximum number of trees and related surface that can be served per rotation cycle.

Data:

Allometric functions allow to link sapwood area to tronc diameter at breast height (*DBH*) and can be computed from the formula (Yaemphum et al., 2022):

$$\text{sapwood area} = 0.728 \times \text{DBH}^{1.998} \quad \text{Eq. 1}$$

With the sapwood area in cm^2 and the *DBH* in cm.

Other parameters:

$$\theta_{FC} = 0.23;$$

$$\theta_{TWP} = 0.14;$$

Rooting depth: 0.55 m (Juveniles).

Root lateral extension: 1 m^2

5. Discussion and conclusions (02/12/2025) – 10%

- 5.1. What are the limitations of your model? Discuss the limit of the simplifications and assumptions made in the model such as spatial resolution, input data, and every other aspect that you could think of.

5.2. Conclusion: Write one paragraph (approximately 10 lines) that summarizes the main question, the methodological approach, the proposed solutions, and the expected main results. Be concise and precise, but be sure that all of the main information is included, and that the paragraph is readable in less than 2 min.