Groundwater Recharge and Piezometric Depression Dynamics: Investigating Hydrological Processes in the Chari-Baguirmi Region (Lake Chad, Africa)

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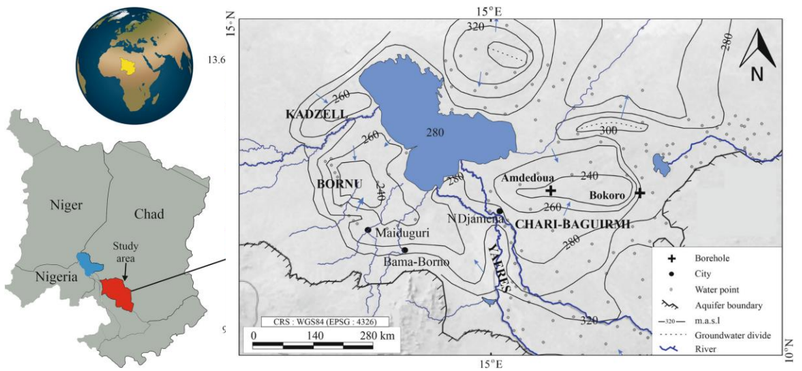
Introduction

Naturally occurring large piezometric depressions far below of expected values are found in some regions of Africa. The prevailing hypotheses attribute this phenomenon to insufficient rainwater infiltration (Abderamane et al., 2016; Leblanc et al., 2003). Exfiltration processes have been also assumed, but according to literature, when groundwater level is greater than 10 m deep generally, the water table is not under direct evapotranspiration (Wilson et al., 1997).

In the Chari-Baguirmi region, SE of Lake Chad, groundwater level is around 40 m below ground surface at boundaries and more than 50 m deep at central part.



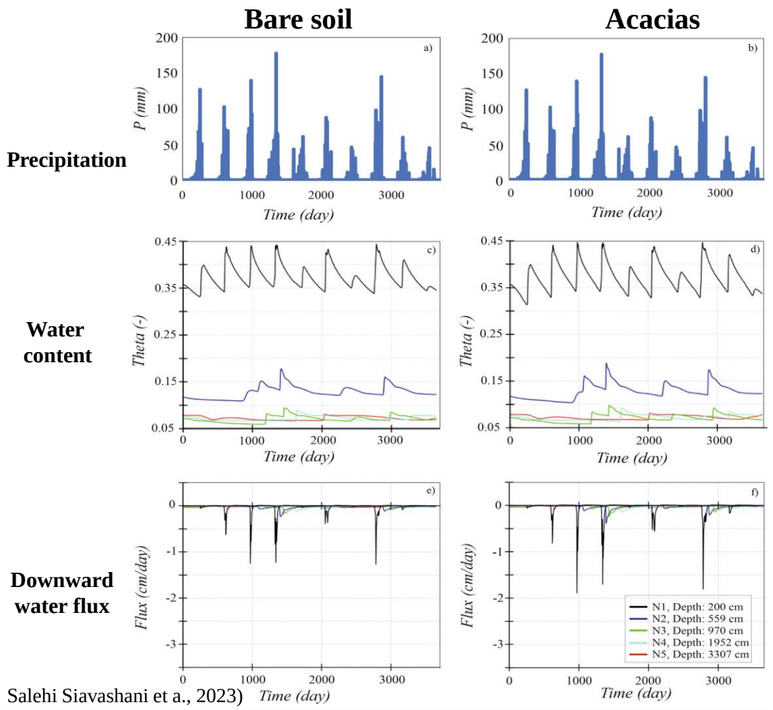
The Chari-Baguirmi piezometric depression (Vaquero et al., 2021)

To investigate the different hydrological processes that take place in the vadose zone of the Chari-Baguirmi piezometric depression, numerical simulations were conducted with HYDRUS-1D. The numerical flow model have been carried out for the 2005-2015 time period. The central part of depression (Amdedoua) under bare soil and acacias cover and groundwater level at 40 m deep, was selected for the water balance components simulation along soil profile.

Methods and results

The code HYDRUS-1D (Simunek et al., 2015) was applied to the 42 m length of the *Amdedoua* soil profile, characterized by a low-permeability silty layer on the topmost soil surface profile. Simulated results along time and depths are shown here. The Darcy–Richards equation is the governing equation for water flow:

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial x}\left[K(\theta)\left(\frac{\partial h}{\partial x} + \cos\beta\right)\right] - S$$



Salehi Siavashani et a., 2023)

The rainfall impact is restricted to upper soil due to a thick silty surface layer, with negligible aquifer recharge (12%). From the present model outcomes, no upward water flux (positive outputs) is observed under the present climate conditions, which highlights the possible piezometric depression cause, likely from past climate-driven conditions.

Water balance results from 2005 to 2014 (10-year simulated period), Amdedua

Parameters	Bare soil	Acacias
Precipitation (P) (mm × 10)	715	715
Recharge (I) (mm × 10)	86	83
Runoff (R) (mm × 10)	78	86
Transpiration (T) (mm × 10)	0	66
Evaporation (Ev) (mm × 10)	556	484
HYDRUS-1D relative water balance error (%)	0.001	0.2

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