

Tracing the complementary and competitive water use patterns in a *Theobroma cacao* (cocoa) agroforestry system: A stable isotope approach

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1. Introduction

- Cocoa (*Theobroma cacao*) is often grown alongside large shade trees and other crops like banana.
- The shade created produce climate conditions that benefit cocoa growth.
- However, the benefits may be offset by the competition for water among plants.
- Understanding this potential competition is important especially under a changing climate, which can increase the demand for water by plants.
- We used stable water isotopes tracers to quantify the patterns and depths of water uptake among cocoa, shade trees and banana in a tropical agroforest.

2. Field site and methods

- Cocoa agroforest – San Juan estate, Trinidad and Tobago; upper site and lower site
- Rainfall – collected every two weeks for $\delta^{18}\text{O}$ and $\delta^2\text{H}$ from August 2021 to September 2023.
- Three sampling campaigns May 2022 (end of dry season), January 2023 (end of wet season) and May 2023 (end of dry season).
- Soil samples 5, 15, 25, 50 and 75 cm below the surface; Xylem cores from cocoa, banana, immortal and cedar (shade trees).
- Stream water was collected and used as a proxy for mobile water.

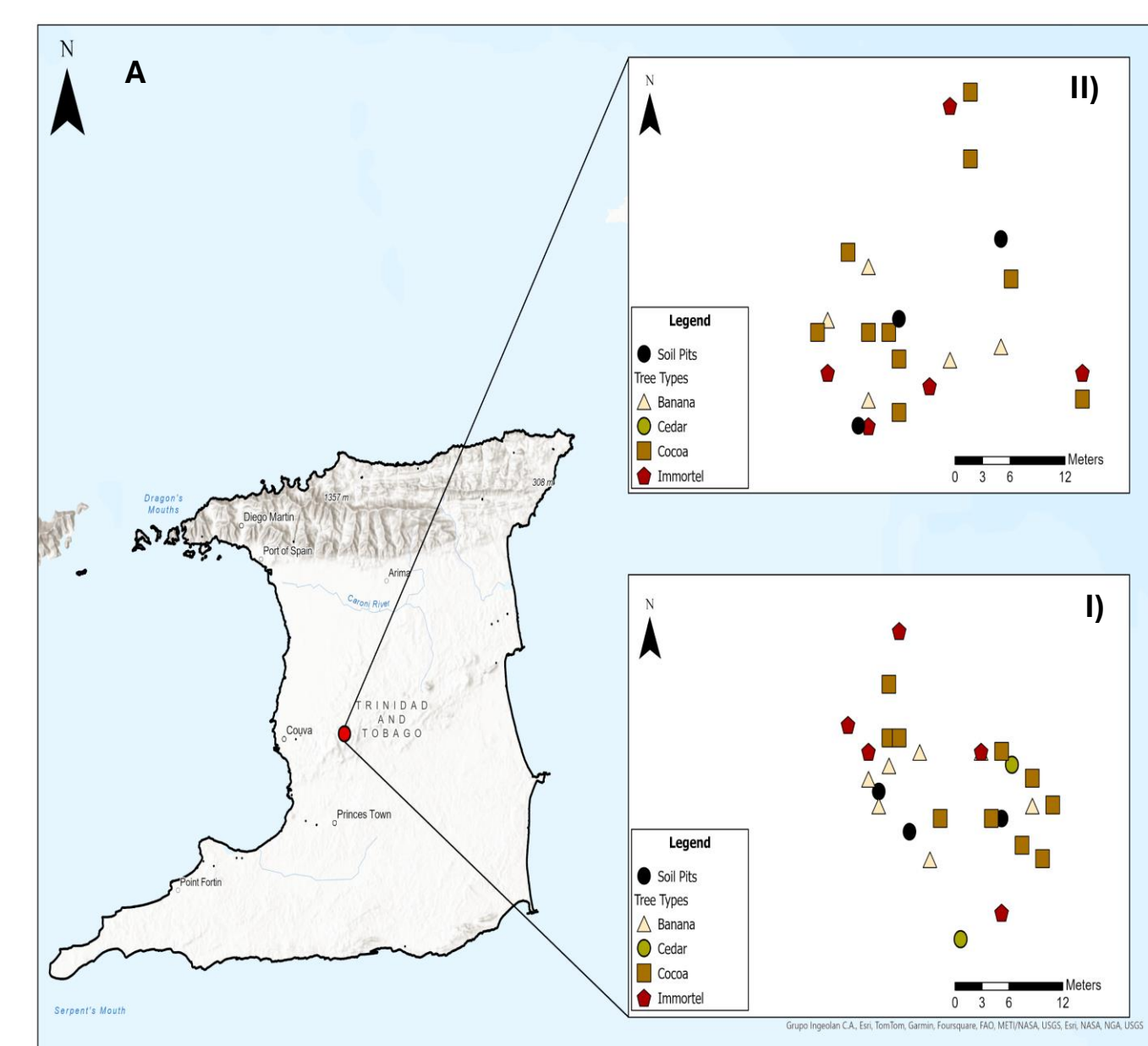


Figure 1A. San Juan Estate cocoa agroforest and the sampling sites for soils, cocoa, banana and shade trees at I) upper site and II) lower site.

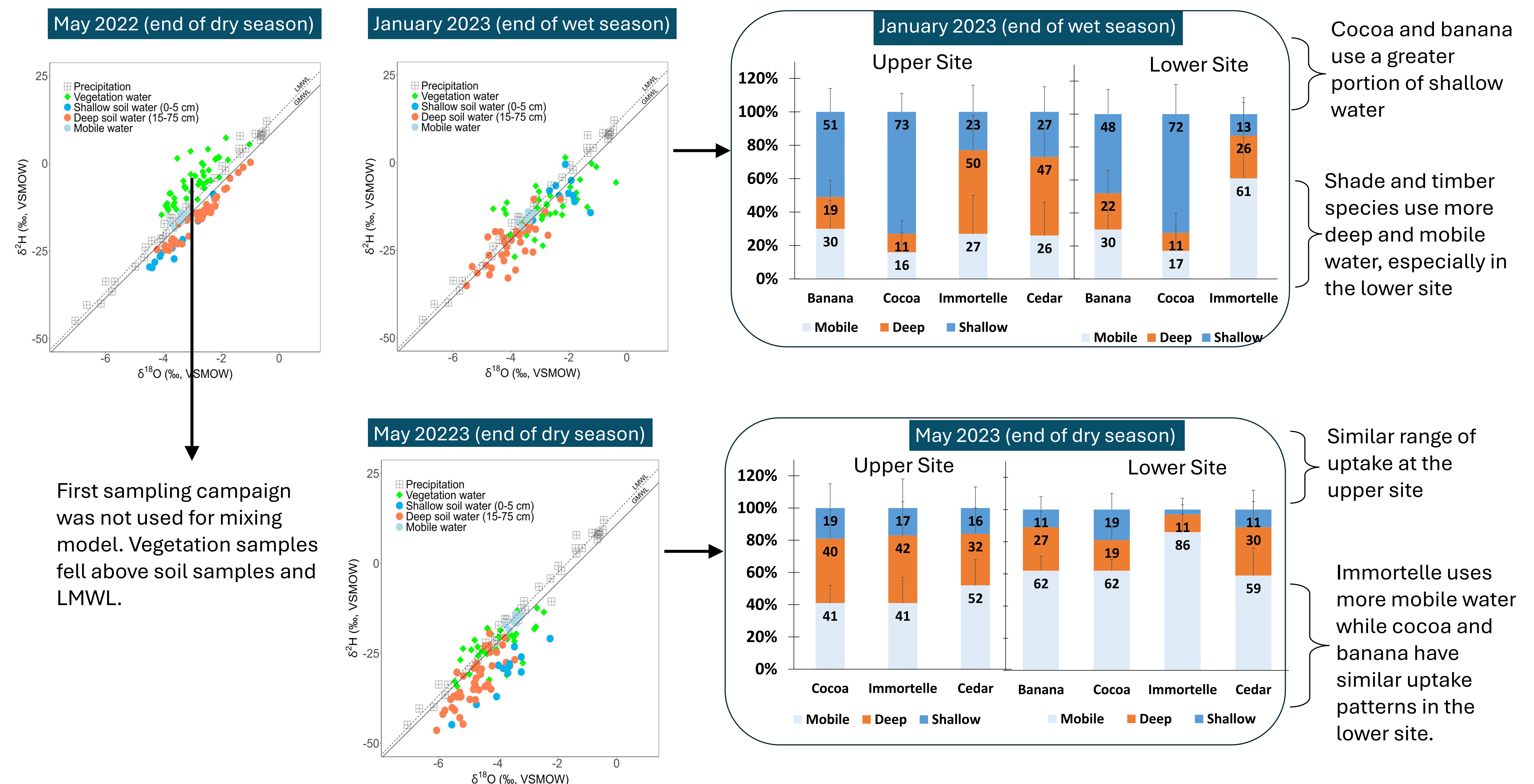


Figure 1B. Soil pit digging and soil sample extraction for texture, moisture and isotopes, Figure 1C. Coring of xylem in a large Immortelle shade tree.

- Cryogenic vacuum extraction was used to extract water from the soil and vegetation samples.
- Elementar Isoprime isotope ratio mass spectrometer was used to determine the $\delta^2\text{H}$ and $\delta^{18}\text{O}$ of the extracted water.
- MixSIAR endmember mixing modelling was used to determine the proportional water uptake of the various vegetations.

3. Results

- Three end members sources were identified: Shallow soil water (<5 cm); Deep soil water (15 – 75 cm); and Mobile water.



4. Conclusions

- We present some of the first work using stable isotopes to quantify the soil water uptake patterns in tropical, cocoa agroforest systems.
- Seasonal and topographic differences were observed.
- More deep soil and mobile water was used by shade and timber trees at the end of the wet season; Similar patterns of shallow and deep soil water uptake was observed in the dry season.
- Higher proportions of mobile water was used in the dry season, suggesting that shade trees may tap into deep soil water and there may be water redistribute to shallow rooted cocoa.
- The first sampling campaign yielded interesting results with all vegetation samples falling about soil and the LMWL.

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