

Changes in key soil health indicators in cocoa landscapes around Téné Forest Reserve, Middle-West Côte d'Ivoire

Ngbala Fulbert¹, Tondoh Ebagnerin Jérôme¹, Baidai Yannick², Lokossoué Kouassy Richmond¹, Kouassi Jean-Luc³

¹UFR des Sciences de la Nature; Université Nangui Abrogoua, Abidjan; ²African Marine Expertises, Abidjan;

³Département FOREN, INP-HB, Yamoussoukro

Background

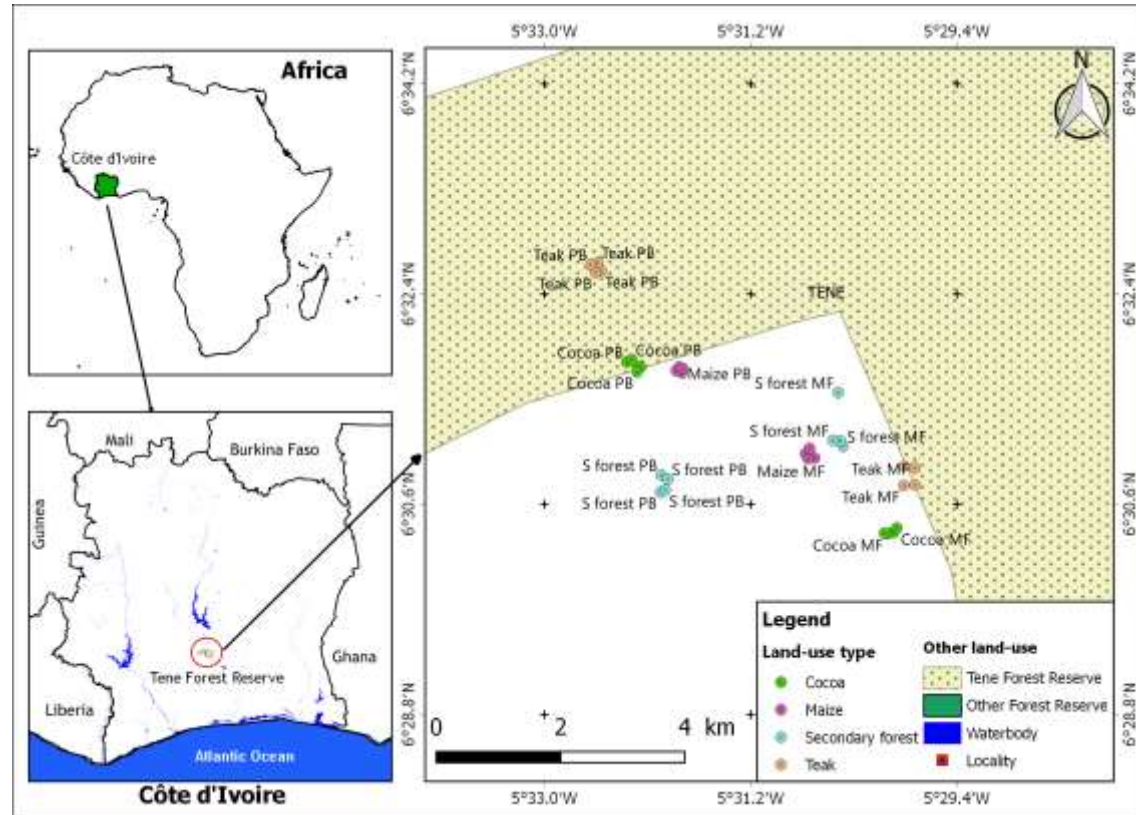
- Almost 80% of forest cover including protected areas has disappeared in Côte d'Ivoire owing to agricultural expansion
- As a response, the government created a network of protected areas including 234 Classified Forests (CFs) in the 1960's
- This plan didn't yield the expected results as more than 6 million hectares of the CFs are still illegally used for cocoa farming (MINEF, 2018)
- For instance, the Téné CF targeted by this study lost up to 10% of its forest cover estimated at 2,2159 hectares between 2019 and 2020 (UK Space Agency, 2020)
- To protect the existing CFs from further degradation, sustainable cocoa intensification seems the way to go in view of reaching a win-win deal between SODEFOR and cocoa growers

Objectives and hypotheses

- Assess the status of soil health in cocoa landscapes in and around the Téné CF using three key soil health indicators – pH-H₂O (pH), soil organic carbon (SOC), and mean weight diameter (MWD)
- Design context-specific nature-based cocoa cropping practices to address soil degradation
- The study assumed that soil degradation is (i) driven by soil health deterioration, (ii) can be rapidly assessed by key soil health indicators including pH, soil organic carbon and mean weight diameter and be widely used to design land restoration plans around and within the Ivorian CFs

Study sites

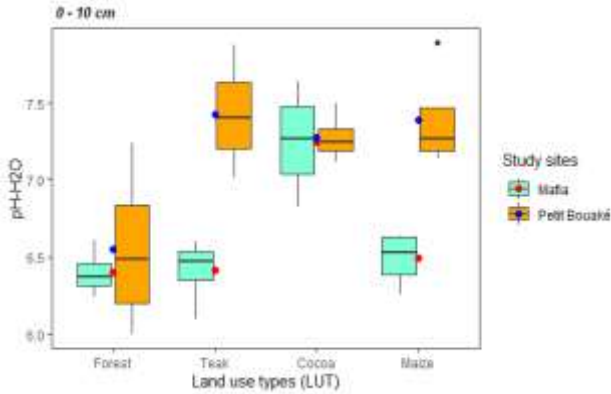
- Semi-deciduous forest area located in the Centre-West Region of Côte d'Ivoire (6°30' N latitude, 5°31' W longitude)
- Part of main cocoa growing zones In the 1970s characterized today by a high rate of deforestation
- Two cocoa landscapes tied to Mafia and Petit Bouaké settlements surrounding the Téné CF



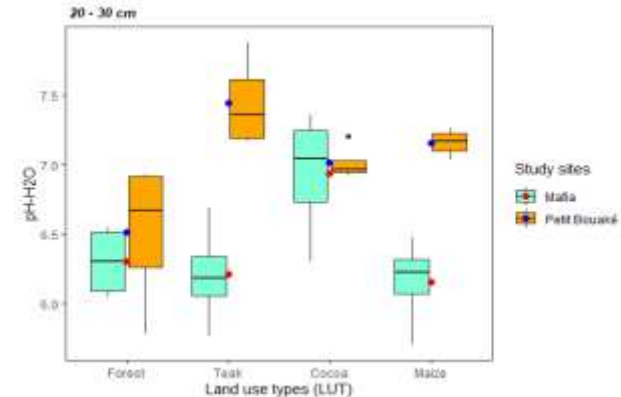
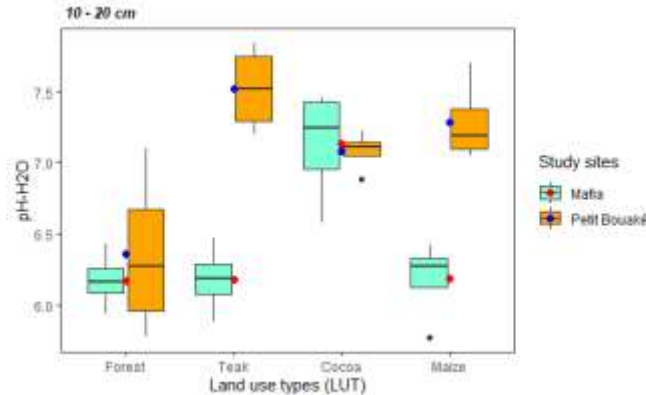
Methodological approaches

- Four most widespread types of land uses, namely secondary forest, cocoa plantations, teak plantations, and maize fields were chosen
- Cocoa plantations were of 26-year-old, while teak plantations aged 13 years
- Maize fields established in rotation with fallows had an estimated average age of 5 years
- The sampling depth interval of 0-30 cm was used as more than 60 % of the stock of C is reported to be accumulated (Chaudhury et al. 2016) and considered as the standard depth recommended to assess SOC stocks (IPCC 2006)
- In each of the plots, soil sampling was carried out in four clusters in which soil samples were collected at five locations using an auger at the following depth ranges (layers): 0-10 cm, 10-20 cm, and 20-30 cm
- Key soil health properties: pH, SOC, MWD

Variation of pH across landscapes

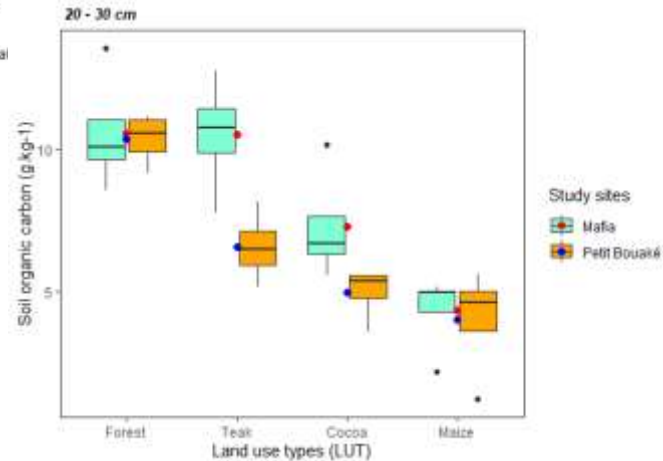
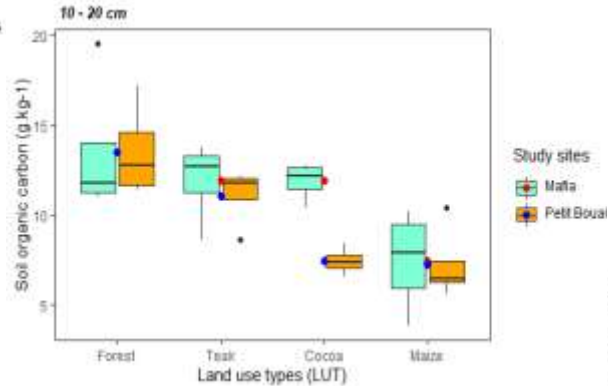
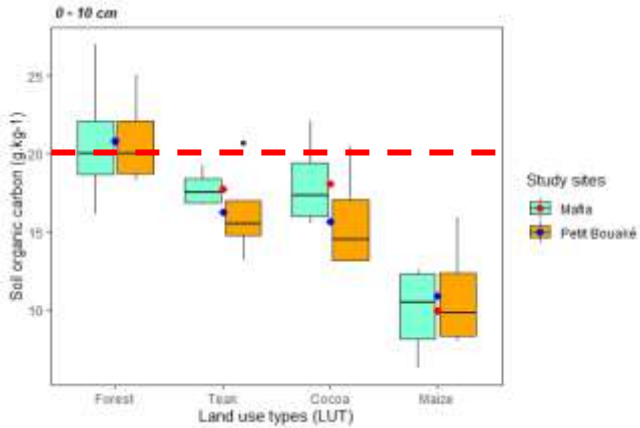


**9.4% of sampling points had values outside 5.5-7.5
=> pH is not a constraint for cocoa farming**



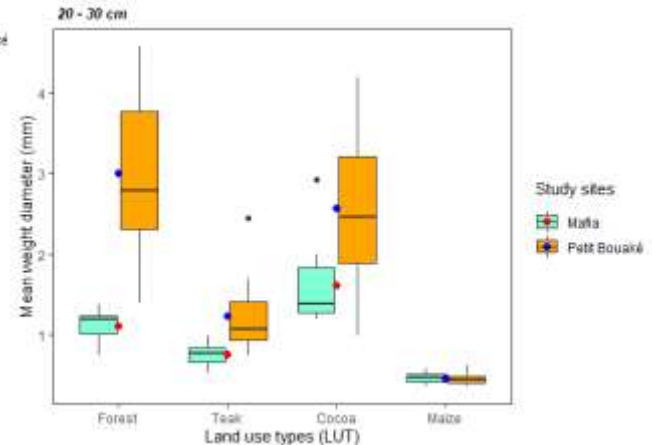
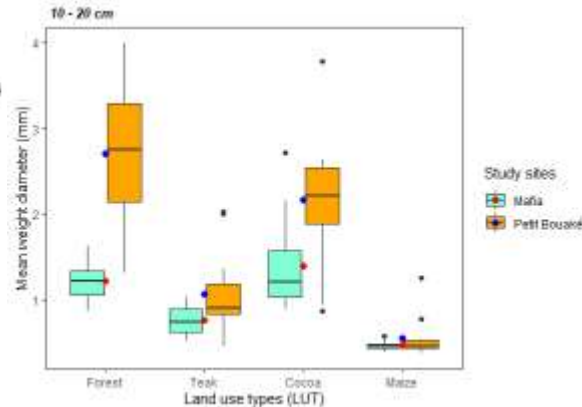
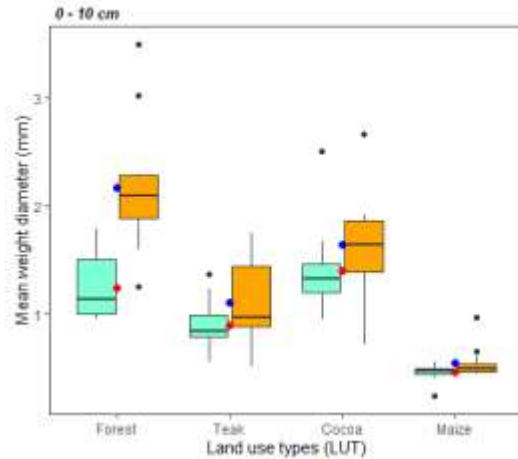
Variation SOC across the landscapes

**7.3% of sampling points had values below 20 g kg⁻¹
=> depletion of SOC indicator of deteriorated soil health**



Variation of MWD across landscapes

**Incredibly low values of soil aggregate stability
=> Degradation of soil structural stability => physical degradation**

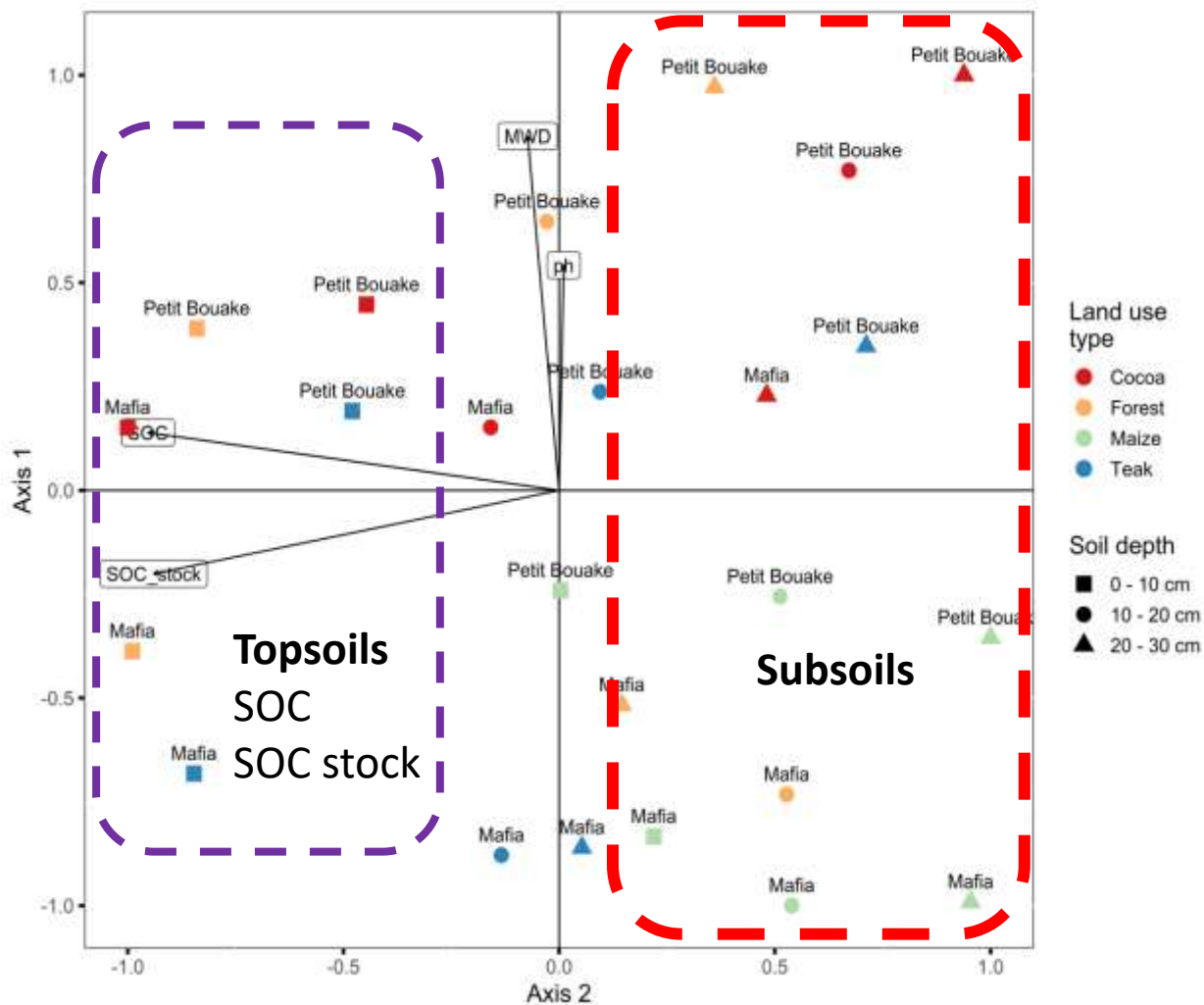


SOC sequestration across landscapes

Site	Soil depth (cm)	Land-uses		
		Teak	Cocoa	Maize
Petit Bouaké	0-10	-0.235	-0.002	-3.045
	10-20	+0.937	-1.598	-2.050
	20-30	-0.775	-1.673	-6.064
	20-30	+0.007	-0.951	-3.409
Mafia	0-10	+0.332	+0.537	-7.931
	10-20	+0.209	+0.158	-7.447
	20-30	+1.041	-0.708	-10.263
	20-30	+0.476	+0.094	-8.381

Teak plantations are the best system to store carbon in soils at various depths (+0.209 to +1.04 Mg C ha⁻¹ yr⁻¹) or along the soil profile (+0.007 to +0.45 Mg C ha⁻¹ yr⁻¹)

Drivers of land use segregation across landscapes



Take-home messages

- Most soil organic carbon contents at sampling plots are below the threshold level (20 kg ha^{-1}) required for cocoa farming, while soil pH is not detrimental to cocoa cultivation as values are typically between 5.5 and 7.5
- SOC concentrations and stocks are most likely to be used as indicators of soil health deterioration in the first 10 cm of soil in cocoa landscapes as they are sensitive to land use changes in both study landscapes
- Soil health can be replenished over a decade and beyond in teak and cocoa plantations due to increased soil organic carbon storage and soil aggregation stability
- Teak plantations with a potential rate of SOC increase of $+0.476 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$ in the top 30 cm thereby validate the **4 per 1000 theory** as they could stop the annual increase of carbon dioxide in the atmosphere and be recommended to fight against the global warming

Recommendations

- Good agricultural practices based on improved soil health practices, combined with cocoa agroforestry that relies on the integration of farmer-preferred trees, should form the foundation of the new cocoa cropping model in the surrounding areas of forest reserves
- Rapid assessment of soil health tested and scaled up across the surroundings of CFs threatened by cocoa growers prior to shifting to agroecological intensification of cocoa farming, a prerequisite to improved livelihoods among cocoa grower communities

Thank you!

Merci!

tondoh.e@outlook.com

e.tondoh@cgiar.org