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Offsetting Emissions through On-Site Carbon Accounting in Agroforestry: The Case of Carbon Neutral Certified Coffee in Costa Rica

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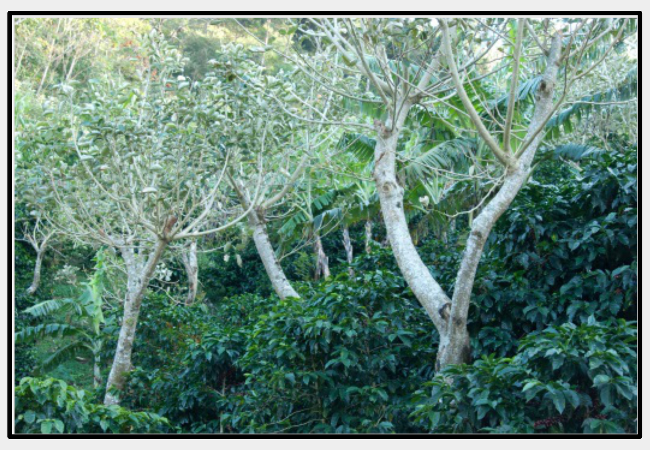
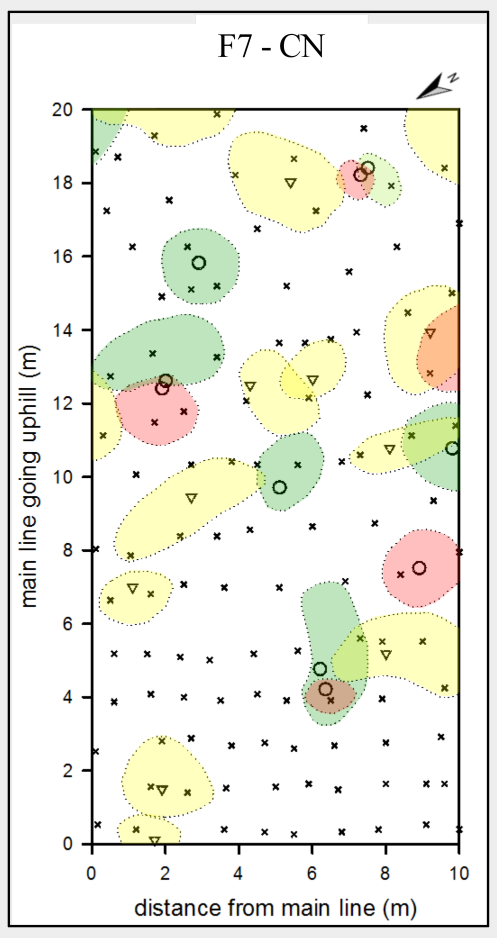
INTRODUCTION AND OBJECTIVE

Agriculture is not only affected by **climate change** but also contributing significantly to it; 19-24% of greenhouse gas emissions originate from the agri-food sector (Smith et al. 2014). Carbon related standards and certifications such as the Publically Available Specification (PAS) 2060 for **carbon neutrality** are on the rise. However, the biogenic carbon sequestration (CS) by agroforestry systems is **not accounted** for in such life cycle assessment based certifications so far. Therefore, compensation of GHG emissions remains subject to offsetting by obtaining international carbon credits. **Carbon offsetting** has been often criticised for its lacking transparency and sustainability. Whereas, accounting for on-site CS could incentivize agroforestry production systems and address consumers demand for low-carbon and sustainable agri-food products.

We selected the **pioneer case** of the coffee cooperative Coopedota in Costa Rica for this study. Coopedota produces the world's first carbon neutral certified coffee in compliance with PAS 2060.

The **objective** was to analyse the CS potential of coffee-agroforestry-systems at Coopedota and estimate to which extent it could compensate the coffee's carbon footprint.



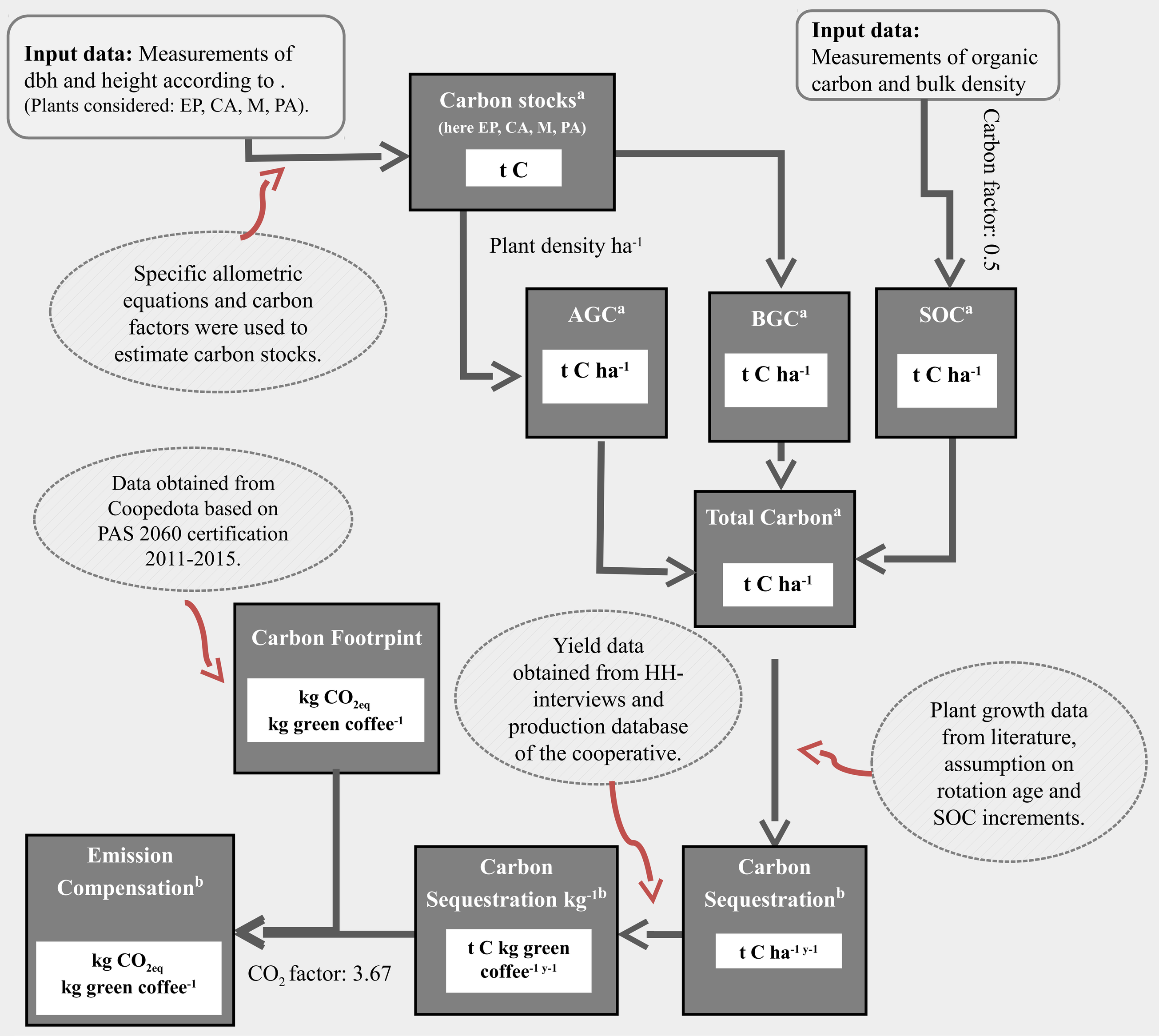


Coffee-agroforestry farms at Coopedota and an example of transect visualization.

METHODOLOGY

I. Data sampling. In 2015 we measured carbon stocks in 8 selected farms (F1-F8). Based on the measured data and data from literature a carbon accounting model was developed.

II. The carbon accounting model (Fig. 1). CS rates were related to coffee quantities produced by using yield data. Finally the emission compensation potential was estimated, relating the CS to the coffee carbon footprint. The simulation covered a time period of 19 years (2010-2028).



Legend: AGC (Aboveground carbon), **BGC** (Belowground carbon), **SOC** (Soil organic carbon), **EP** (*Erythrina poeppigiana* –shade tree), **CA** (*Coffea arabica*), **M** (*Musa sp.*), **PA** (*Persea americana* –Avocado), **dbh** (diameter at breast height), **HH** (Household).
a: measured data in 2015, **b:** simulated data 2011-2028.

Fig. 1: structure of the carbon accounting model.

RESULTS

Table 1: Average carbon sequestration rates over all years (2010-2028) and all farms

Carbon pools	t C ha^{-1} yr^{-1}	t CO_2eq ha^{-1} yr^{-1}
AGC *E. poeppigiana*	0.81 ± 0.57	2.97 ± 2.09
AGC Coffee	-0.04 ± 1.91	-0.15 ± 7.00
BGC (Coffee and *E. poepp.*)	0.14 ± 0.59	0.51 ± 2.16
SOC	0.8	2.93
Total C without SOC	**0.91 ± 2.64**	**3.34 ± 9.68**
Total C	**1.71 ± 2.64**	**6.27 ± 9.68**

Total CS on average reached 1.71 ± 2.64 t C ha-1 yr-1 (Table 1), which is comparably low, but in the range of findings from existing literature on coffee-agroforestry-systems in Central America (Noponen et al. 2013, Andrade et al. 2014). This CS rate would compensate the coffee carbon footprint of 2.79 kg CO2eq kg-1 green coffee (average footprint of Coopedota coffee) from 2014 onwards, when coffee renovation was limited to 5% ha^{-1} (Fig. 2). On average it compensated the footprint by 164% (Table 2).

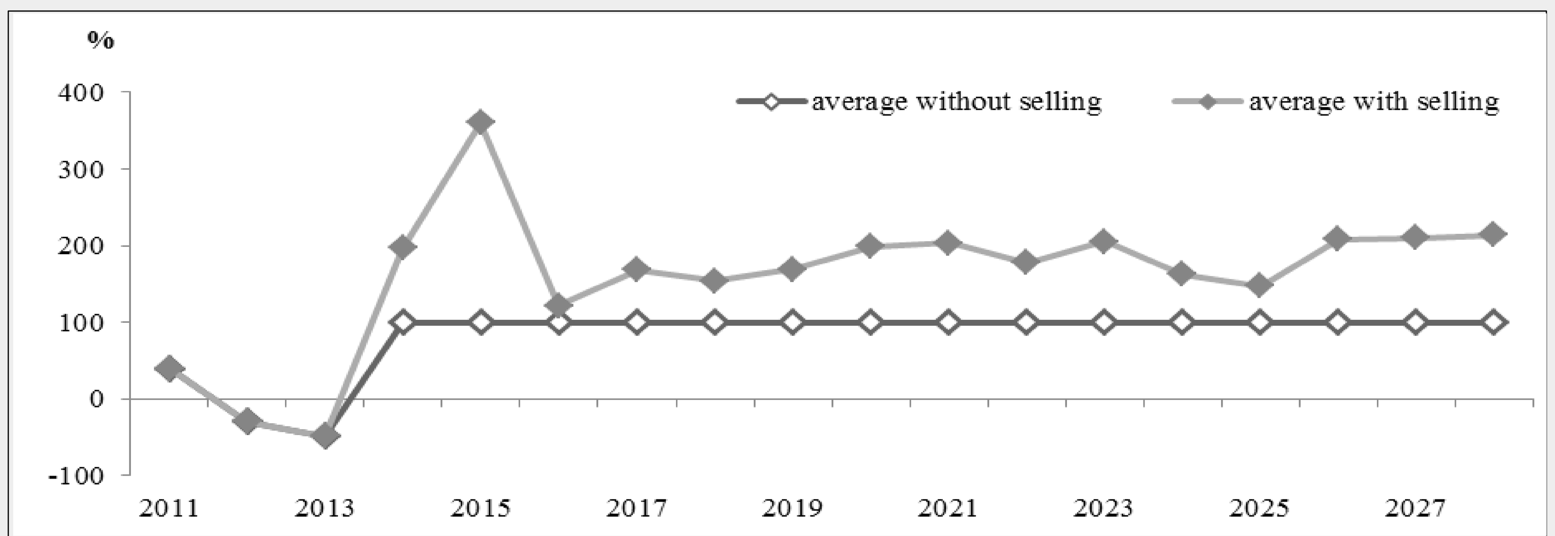


Fig. 2: Compensation of emissions (average over all farms). The unfilled symbols illustrate the scenario where the cooperative can only account for on-site sequestration but cannot sell remaining sequestration as carbon credits. The filled symbols represent the case in which the cooperative can sell carbon credits.

Important for high CS rates are high shade tree densities (if possible) in the coffee plantations, due to their high potential in CS, their importance in BGC and the considerable litter input that increase the SOC.). Factors, determining the potential whether a complete compensating of the coffee CF can be achieved, were found to be (from most influential to least influential): (i) carbon sequestration rate ha-1, (ii) coffee yields ha-1 and (iii) carbon footprint of the coffee product.

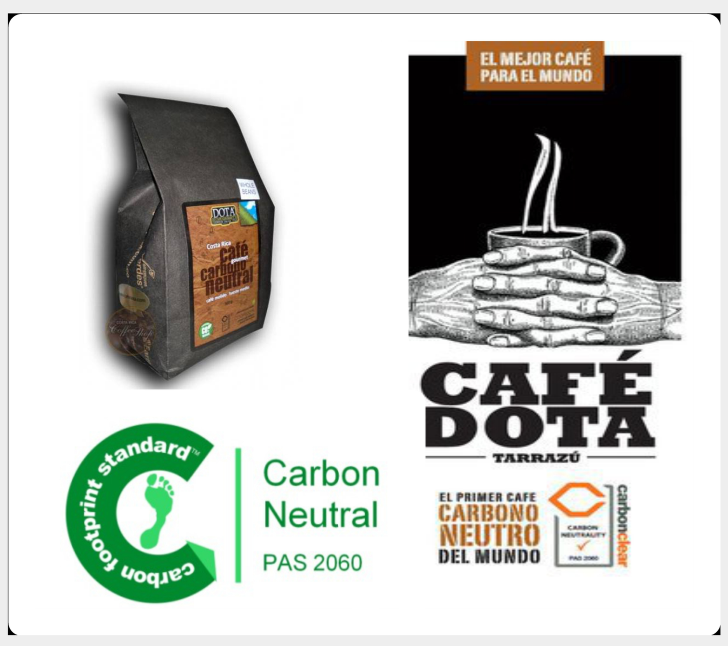
Table 2: Average emission compensation rate in all 8 farms between 2011 – 2028

	F1	F2	F3	F4	F5	F7	F8	mean
CS kg^{-1}	1.57 (± 2.99)	0.87 (± 11.01)	10.98 (± 8.12)	6.13 (± 6.21)	5.62 (± 5.85)	2.75 (± 1.85)	5.72 (± 4.34)	4.81 (± 3.45)
ECR (%)	56 (± 94)	46 (± 305)	375 (± 283)	209 (± 204)	189 (± 205)	91 (± 54)	185 (± 149)	**164** (± 93)

CS: carbon sequestration in kg CO_2eq kg^{-1} green coffee; **ECR:** Emission compensation rate in %;The coffee **carbon footprint** was taken from Coopedota as carbon footprint along the complete coffee value chain until the stage of disposal, with an average of **2.97** kg CO_2eq kg^{-1} green coffee.

CONCLUDING REMARKS

- Coffee-agroforestry-systems show a high potential to compensate the coffee carbon footprint, particularly when coffee plant renovation is limited to 5% ha-1.
- It is essential to balance **sufficient carbon sequestration** (particularly shade trees) with high levels of **productivity** to increase the potential for carbon offsetting inside the product value chain, also known as **"insetting"**.
- Accounting for on-farm carbon sequestration can counteract the "greenwashing" image of offsetting practices, it can reduce off-setting costs and incentivize tree incorporation into plantations. With this it enhances **environmental sustainability** as well as **sustainable livelihoods** through farm diversification.



Carbon neutral labeled coffee

Coffee farmers with the technical advisor of Coopedota

Selected references:

Andrade et al. (2014). The carbon footprint of coffee production chains in Tolima, Colombia. In: Sustainable agroecosystems in climate change mitigation. Wageningen Academic Publishers; p. 53–66.

Noponen et al. (2013). Sink or source-The potential of coffee agroforestry systems to sequester atmospheric CO2 into soil organic carbon. Agric Ecosyst Environ. 175, pp. 60-68.

Smith et al. (2014). Mitigation of Climate Change Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.