# Supplemental Information

## Supplemental methods

### Calculation of 10-20 cm average carbon content

During field data collection, because the auger length (15 cm) didn't match the target soil sampling depths (10 cm each), we could only accurately sample and analyse the 0-10 cm and 20-30 cm soil depths for SOC content. The SOC content of the intermediate 10-20 cm soil depth had to be estimated based on these first two measurements.

To reduce the bias in this estimation, we used the standard assumption that SOC content $c(x)$ decreases as an exponential function of soil depth $x$:

$$c(x) = C_0 \cdot exp(-\lambda \cdot x)$$

where $C_0$ is the carbon content at the surface (depth $x = 0$) and $\lambda$ is the rate at which the carbon content decreases with soil depth. Under this assumption, we can calculate the mean SOC content between depths $x$ and $x + \Delta$ as:

$$\bar{c}(x, x+\Delta) = \frac{1}{\Delta}\int_{x}^{x+\Delta} C_0 \cdot exp(-\lambda \cdot x)dx$$

$$\Rightarrow \bar{c}(x, x+\Delta) = \frac{C_0}{-\lambda \cdot \Delta}\left[exp\big(-\lambda \cdot (x+\Delta)\big) - exp(-\lambda \cdot x)\right]$$

$$\Rightarrow \bar{c}(x, x+\Delta) = \frac{C_0}{\lambda \cdot \Delta} exp(-\lambda \cdot x)[1 - exp(-\lambda \cdot \Delta)]$$

The average SOC contents between 0-10 cm, 10-20 cm and 20-30 cm can respectively be written as:

$$C_{0,10} = \frac{C_0}{10\lambda}\big(1 - exp(-10\lambda)\big)$$

$$C_{10,20} = \frac{C_0}{10\lambda} exp(-10\lambda)\big(1 - exp(-10\lambda)\big)$$

$$C_{20,30} = \frac{C_0}{10\lambda} exp(-20\lambda)\big(1 - exp(-10\lambda)\big)$$

We can thus write:

$$\frac{C_{20,30}}{C_{0,10}} = \frac{\frac{C_0}{10\lambda} exp(-20\lambda)\big(1 - exp(-10\lambda)\big)}{\frac{C_0}{10\lambda}\big(1 - exp(-10\lambda)\big)} = exp(-20\lambda)$$

$$\Rightarrow \lambda = \frac{log\left(\frac{C_{0,10}}{C_{20,30}}\right)}{20}$$

We can also write:

$$\frac{C_{10,20}}{C_{0,10}} = exp(-10\lambda)$$

$$\Rightarrow C_{10,20} = C_{0,10} \cdot exp\left(-10 \cdot \frac{log\left(\frac{C_{0,10}}{C_{20,30}}\right)}{20}\right)$$

$$\Rightarrow C_{10,20} = C_{0,10} \cdot \left(\frac{C_{20,30}}{C_{0,10}}\right)^{\frac{1}{2}}$$

**Choice of climate and soil covariates**

As described in the "Carbon stocks model" section of the Materials and Methods, we hypothesized that C stocks (both AGC and SOC) are affected by climate and soil characteristics, together with land use (in this case, AFS type) and other spatial differences (in our case, a site effect).

We selected the following set of variables to represent the effect of climate: mean annual temperature (BIO1), mean annual precipitation (BIO12), annual precipitation variability (BIO15) over the period 1981-2010. These bioclimatic variables were extracted from CHELSA V2.1 (Karger et al. 2017). These variables were all highly correlated in our dataset (Figure S3a). We performed a principal component analysis after scaling and centering these three variables: the first component explained 98% of the variance in our dataset (Figure S3b). We therefore decided to keep only one variable to represent this climatic gradient: mean annual temperature, which was most correlated with the first component of the PCA (Figure S3b), and has been shown to influence C stocks in other contexts (Wiesmeier et al. 2019; Muller-Landau et al. 2021).

We selected the following set of variables to represent the effect of soil properties on C stocks: clay content (<2 $\mu$m), silt content (2-50 $\mu$m), sand content (50-2000 $\mu$m), and pH. These variables were measured on our soil samples analysed in the Cirad laboratories (see section "Field inventories"). After scaling and centering these variables, we performed a principal component analysis: the first component explained 70% of the variance in our dataset (Figure S4b). We therefore decided to retain only one variable to represent this edaphic gradient: clay content, which was the most highly correlated with the first component of the PCA (Figure S4b) and has been shown to be a good predictor of SOC stocks in other contexts (Wiesmeier et al. 2019).

## Supplemental tables

***Table S1:*** *Soil characteristics of the sites (average over 0-30 cm), presented as mean values with 95% confidence intervals (in parentheses). Units are: in g/kg for clay, silt, sand, carbonate, organic C and total N contents; in cmolc/kg for CEC, Ca, K, Mg and Na; and no units for C:N and pH. The confidence intervals were calculated by propagating a 12% error on the lab-provided values and obtaining site-level estimates through bootstrapping plot values (1000 simulations). Organic carbon content (difference of the total carbon – dry combustion method – and the carbonates contents - calcimeter); total nitrogen content (dry combustion method); pH in water (soil:deionized water ratio of 1:2.5) ; CEC - cation exchangeable capacity - and exchangeable cations (Ca, K, Mg and Na) at soil pH [Cobaltihexamine method; Orsini and Remy, 1976].*

| | Clay | Silt | Sand | Organic C content | Total N content | C:N | Carbonate content | pH | CEC | Ca | K | Mg | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gariuai | 281 (222-346) | 487 (428-553) | 233 (193-276) | 31.3 (27.3 - 35.6) | 2.6 (2.3-3) | 12.2 (11.3 - 13.1) | 252 (145-367) | 7.3 (6.8-7.9) | 22.8 (19.2 - 26.6) | 20.7 (17.1 - 24.4) | 0.28 (0.18 - 0.38) | 0.92 (0.7-1.19) | 0.18 (0.16 -0.2) |
| Osso - Luga | 536 (485-584) | 302 (277-328) | 164 (135-196) | 20 (17.2 - 23.1) | 1.7 (1.5-2) | 11.6 (10.7 - 12.6) | 229 (156-315) | 8.6 (8.1-9.1) | 33.8 (30.5 - 37.1) | 28.5 (25.9 - 31.4) | 0.82 (0.7-0.96) | 2.77 (2.35 - 3.24) | 0.98 (0.63 -1.4) |

***Table S2:*** *Description of 5 agroforestry systems in Central Timor-Leste.*

| Typology adapted from Nair (1993) | Usual location | Typical plot size (ha) | Time since installation | Previous land use |
|---|---|---|---|---|
| Crop system including a fallow phase (CF) | Flat and slope lands | 0.3 to 1.25 | 0 to 3 years | SP (pasture, savanna or secondary forest), FG |
| Silvopasture (SP) | Rocky and superficial soils, slope lands, fallow lands (rice, CF…) | 200 to 500 (village scale) | > 50 years | Savanna, forest |
| Young agroforest (YA) | Close to a stream and/or closed to village centre | 0.2 | 2 to 10 years | CF, SP (pasture, savanna or secondary forest), FG |
| Home garden (HG) | Village centre (attached to houses) | 0.3 | > 5 years | CF, YA |
| Forest garden (FG) | Close to a stream (can be dry during the dry season) | 0.5 | > 50 years | HG, YA |

***Table S3:*** *Correspondence between Tetum names and scientific names used in this study.*

| Scientific name | Tetum name |
|---|---|
| *Acacia leucophloea* | ai-kasi |
| *Albizia chinensis* | ai-samtuku |
| *Albizia julibrissin* | ai-roat, ai-samtuku |
| *Albizia saman* | ai-matan dukur |
| *Aleurites moluccanus* | ai-kamii |
| *Alstonia scholaris* | ai-hanek |
| *Alstonia sp.* | ai-doti metan |
| *Amaranthus sp.* | bayam fuik, bayam |
| *Amorphophallus paeoniifolius* | maek fuik |
| *Ananas comosus* | ai-nanas |

| Scientific name | Tetum name |
| --- | --- |
| *Annona muricata* | ai-ata |
| *Annona squamosa* | ai-ata fuik |
| *Arachis hypogaea* | fore rai |
| *Areca catechu* | bua |
| *Arenga sp.* | tua metan, tali metan |
| *Artocarpus altilis* | kulu tunu |
| *Artocarpus camansi* | kulu modo, kulu musan (modo) |
| *Artocarpus heterophyllus* | kulu jaka |
| *Artocarpus sp.* | kulu |
| *Averrhoa carambola* | karambola |
| *Bambusa sp.* | au kinur |
| *Borassus flabellifer* | akadiru |
| *Cajanus cajan* | tunis |
| *Canna edulis* | kontas |
| *Capsicum sp.* | aimanas |
| *Carica papaya* | aidila |
| *Ceiba sp.* | ai-lele fuik |
| *Chenopodium sp.* | aidila filipina |
| *Chromolaena odorata* | kromolaena |
| *Citrus grandis* | jambua |
| *Citrus latifolia* | derok masin |
| *Citrus sp.* | derok |
| *Cocos nucifera* | nu |
| *Colocasia esculenta* | talas, talas mean, talas fuik |
| *Corypha utan* | tali tahan |
| *Cucurbita maxima* | lakeru |
| *Curcuma longa* | kinur |

| Scientific name | Tetum name |
| --- | --- |
| *Cymbopogon sp.* | du'ut morin fuik, du'ut morin |
| *Dioscorea sp.* | fehuk, kombili |
| *Erythrina sp.* | ai-dik |
| *Eucalyptus alba* | ai-bubur |
| *Gliricidia sepium* | ai-gamal |
| *Gmelina arborea* | ai-teka filipina |
| *Gossypium sp.* | kabas, kabas fuik |
| *Imperata cylindrica* | du'ut manu laen |
| *Ipomoea batatas* | fehuk midar |
| *Jatropha curcas* | ai-oan mutin |
| *Lantana camara* | lantana |
| *Leucaena leucocephala* | ai-kafe |
| *Mangifera indica* | has |
| *Mangifera sp.* | has fatuk |
| *Manihot esculenta* | ai-farina, ai-farina borasa |
| *Maranta arundinacea* | kontas kinur |
| *Moringa oleifera* | marungi |
| *Musa sp.* | hudi |
| *Nicotiana tabacum* | tabaku |
| *Pachyrhizus erosus* | sinkumas |
| *Pennisetum sp.* | du'ut malae |
| *Persea americana* | abokati |
| *Piper betle* | malus fuik |
| *Planchonia sp.* | ai-kasa |
| *Plumeria sp.* | ai-santu antonio |
| *Prosopis sp.* | ai-tarak tasi |
| *Psidium guajava* | goiava |

| Scientific name | Tetum name |
|---|---|
| *Pterocarpus indicus* | ai-na |
| *Punica granatum* | rumaun |
| *Santalum album* | ai-kameli |
| *Schleichera oleosa* | ai-dak |
| *Sesbania grandiflora* | ai-tori, ai-turi |
| *Solanum melongena* | brinjela |
| *Sterculia foetida* | ai-nitas |
| *Swietenia mahagoni* | ai-mahoni |
| *Syzygium aqueum* | jambu air |
| *Tamarindus indica* | sukaer |
| *Tectona grandis* | ai-teka |
| *Theobroma cacao* | ai-kakau |
| *Timonius sp.* | ai-katimu |
| *Vicia sp.* | koto moruk |
| *Vigna unguiculata* | fore-tali |
| *Zea mays* | batar |
| *Ziziphus mauritiana* | ai-lok |

## Supplemental figures

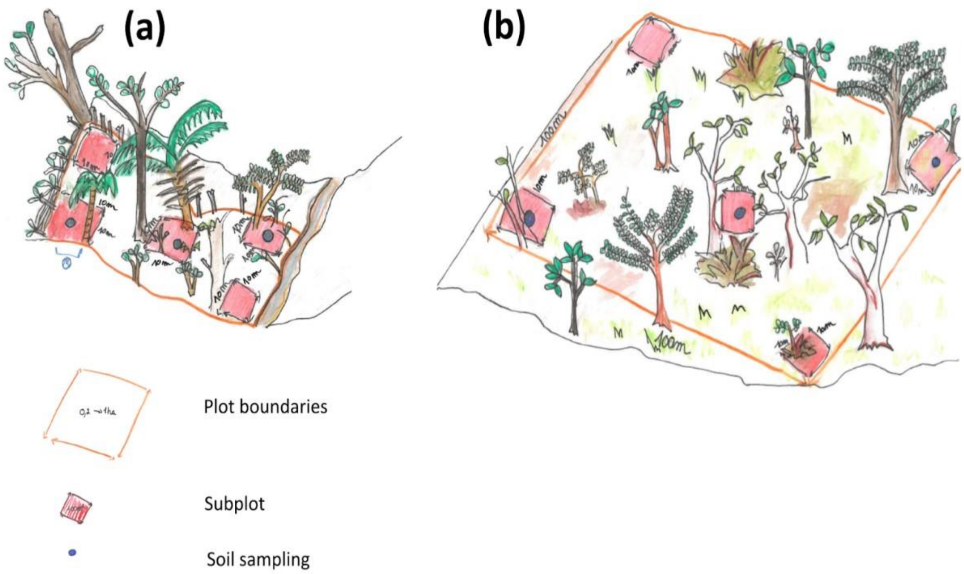


*__Figure S1:__ Plot sampling design. (a) Typical plot < 1 ha, in all AFS except SPs. (b) Typical 1-ha plot in SPs. Red areas are the five 10x10 m subplots, and blue dots are the three soil sampling locations.*

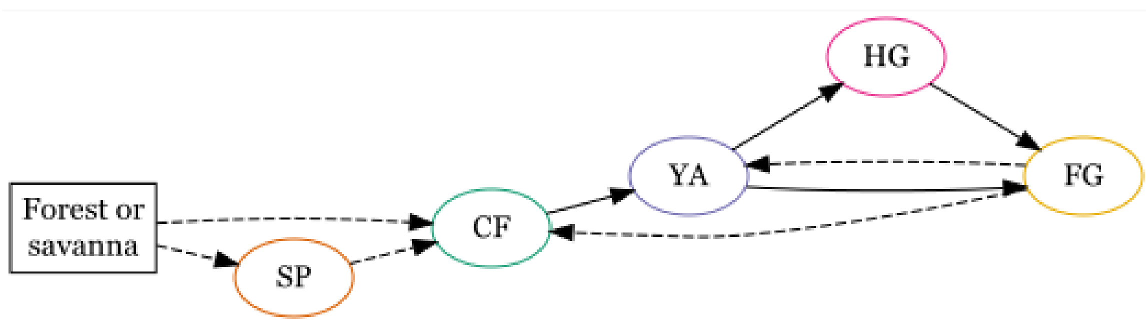


*__Figure S2:__ Typical sequence of AFS in the sites included in this study. Transitions between two systems are represented by arrows: dashed arrows represent transitions that usually include tree removal, whereas solid arrows represent transitions where trees are planted and/or the AFS is left to regenerate naturally. These transitions may vary according to the farmer's strategy and available resources (Cogné and Lescuyer, 2024).*

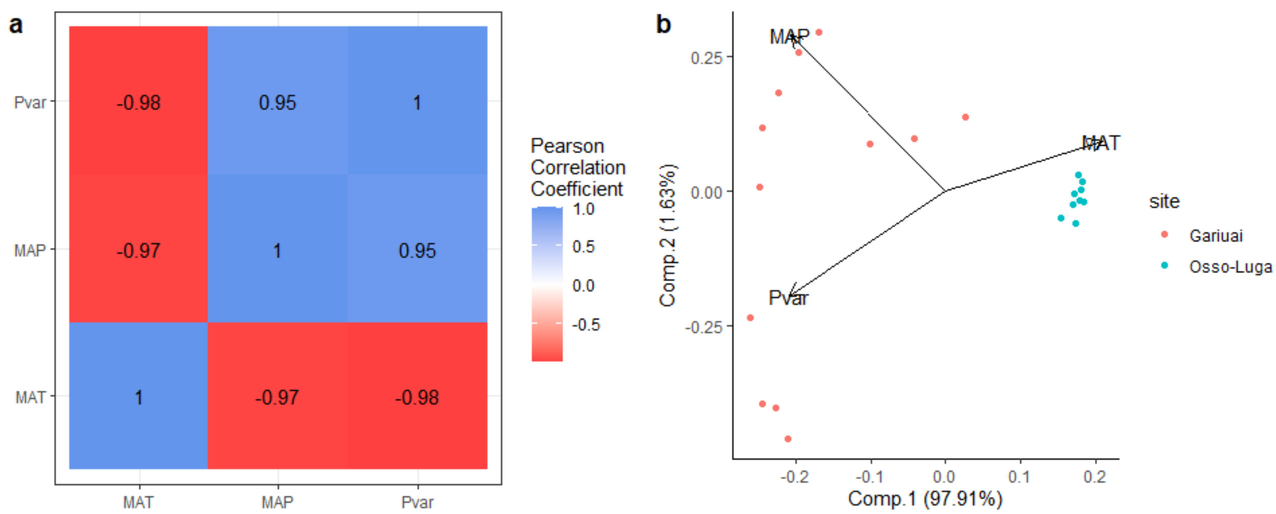


***Figure S3:*** *(a) Pearson coefficient of correlation matrix and (b) principal component analysis biplot, with three climate variables: mean annual temperature (MAT), mean annual precipitation (MAP) and precipitation variability (PVar). Values for the climate variables were extracted from CHELSA V2.1 (Karger et al., 2017) for each of the 30 study plots.*

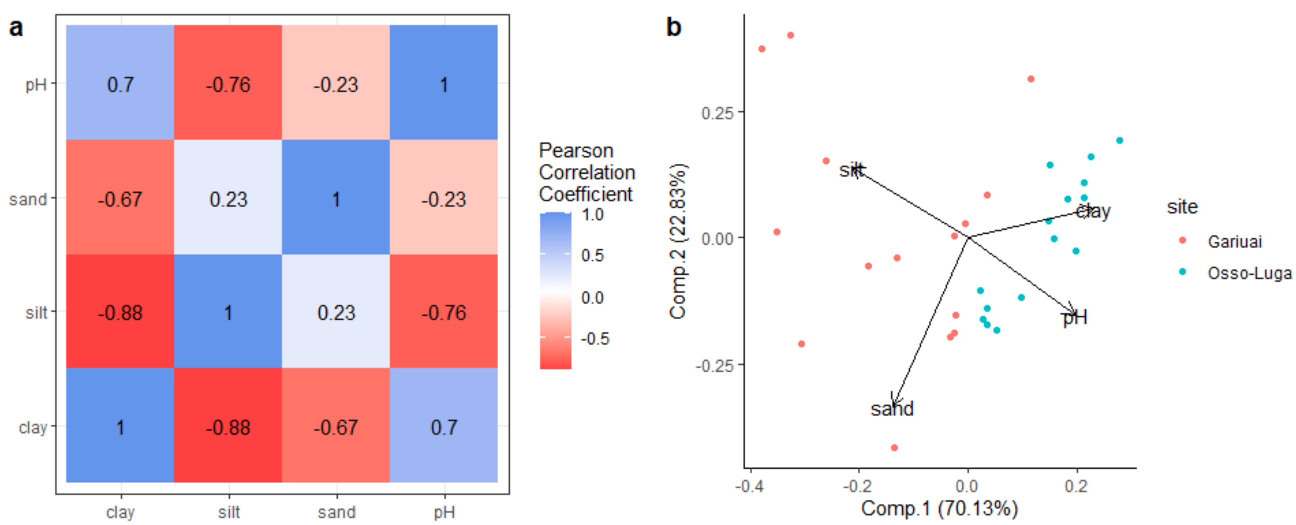


***Figure S4:*** *(a) Pearson coefficient of correlation matrix and (b) principal component analysis biplot, with four soil variables: clay, silt and sand content, and soil pH. Values for the soil variables were measured from in situ soil samples for each of the 30 study plots.*

## References

Cogné M, Lescuyer G (2024) The role of agroforestry in farmers' strategies and its contribution to the well-being of rural people in Timor-Leste. Forests Trees and Livelihoods 00:1–26. https://doi.org/10.1080/14728028.2023.2298986

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