Soil Carbon Accumulation in Agroforestry Systems - A metanalysis study based on Bayesian statistics

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# Abstract

Agroforestry Systems (AFS) are based on the presence of trees in consortium with other tress, croplands, or animals in productive plots.

# Introduction

Agroforestry Systems (AFS) are complex agro-ecosystems based on the presence of trees in consortium with other tress, croplands, or animals(Nair et al., 2021). It can be classified by in 8 major types: Alley cropping, Fallow, Hedgerows, Multistrata Systems, Parklands, Shaded perennial-crop systems, Silvoarable systems and Silvopastures (Cardinael et al., 2019; Nair et al., 2009).

Using data extracted from 174 references from the recent literature, this study aims to clarify the lack of information about the effect of AFS on the deeper SOC accumulation.

Considering the Soil Organic Carbon (SOC) Stocks from different AFS and calculating the yearly SOC accumulation rate, based on the stocks of the control areas and age of the AFS, we used a Random Trees model to estimate the distribution of the SOC in the first 50 cm of soil.

We present an estimative of the SOC accumulation/loss rates, based on five scenarios of previous land use of the AFS: cropland, forest, grassland, plantation, and shrubland.

# Materials and Methods

## Data mining

This study was initially conducted with a literature review aiming studies related to AFS and SOC Stocks, including SOC Content and bulk density. Among the research engines, for this study it was used: ISI—Web of Knowledge, Google Scholar, Scopus, Research Gate, and Scielo.org.

In order to increase the number of potential references, it was used the following keywords: soil AND (‘carbon stock\*’ OR ‘carbon pool\*’ OR ‘carbon sequestration’ OR ‘carbon concentration’) AND (agroforest\* OR parkland\* OR homegarden OR multistrata OR hedgerow OR windbreak OR shelter-belt OR ‘live fence’ OR ‘tree intercrop\*’ OR silvo\*arable OR silvo\*pasture OR ‘rotation\*wood\*’ OR tree\*fallow\* OR fallow OR (tree\* AND ‘improve\* fallow\*’) OR (tree\* AND relay\*crop\*) OR (tree\* AND alley\*crop\*)) (Cardinael et al., 2019).

Them it was filled a table with several parameters found in the papers, including Location, Climate Classification according to Köppen, Physical Property of the Soil, AFS Description, Previous Land Use, Age of System, SOC Stock from the AFS and from the Control plot, following the IPCC guidelines (IPCC, 2022).

Over 400 peer reviewed papers have been examined and 174 have been considered for this study.

## SOC Stocks Considerations

Almost all the papers considered in this study reported SOC Stock from the AFS. For the occasions of SOC content and bulk density report, it was calculated the SOC Stock. In the special cases where the bulk density information wasn’t available, the SOC Stock was calculated using the average bulk density per soil type (Batjes, 1996).

All the SOC Stocks values of the soil profile were considered in this study. A function in the RStudio® program was created to describe the distribution of SOC Stocks for every cm. And for this study, it was used the first 50 cm of soil.

To calculate the SOC rate (positive values for accumulation and negative for loss) it was considered the difference between the SOC Stocks of the AFS and the SOC Stocks of the Control site, divided by the years since the implementation of the AFS (equation 1):

(1). The values are expressed in in t C ha-1 (Cardinael et al., 2019).

## Agroforestry Classification

Graphical user interface, text

Description automatically generatedIn this study were considered 8 types of AFS, proposed by Cardinael et al. (2019) and presented in the table 1.

## Previous Land Use

Text

Description automatically generatedFor the 174 papers considered in this study, the previous land use of the AFS area, was classified according to the table 2.

## Data analysis

The SOC Stocks profile were separated by the AFS classification. Then, it was calculated an average per cm. The soil profiles that do not have all the SOC Stock values until the depth of 50 cm, had the values estimated by a machine learning script aiming to increase the reliability of the data used in this study.

The RStudio software version 2019.09.2 Build 382 (R Development Core Team 2013), at a significance level of <0.05, was used for statistical analyses and graphs presentation.

# Results

# Discussion

# References

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