Agroforestry and carbon sequestration

Reference 4

Chatterjee, N; Nair, PKR; Chakraborty, S; Nair, VD. 2018 Changes in soil carbon stocks across the Forest-Agroforest-Agriculture/Pasture continuum in various agroecological regions: A meta-analysis Agriculture, Ecosystems and Environment, 266, 55-67 doi: 10.1016/j.agee.2018.07.014

Background and objective

Tree-based land-use systems such as agroforestry are reported to have the potential to enhance C sequestrationboth above and below ground. The importance of managing such systems through appropriate agroecological (carbon) farming methods is increasingly being recognized as a promising strategy for enhancing soil carbon sequestration. The objective of this study was to undertake a statistically rigorous, quantitative assessment of the scattered results on soil organic carbon (SOC) stocks reported under various agroforestry systems, in comparison with those in agricultural, forestry, and pasture systems in different agroecological regions around the world through a meta-analytical approach.

Search strategy and selection criteria

The research articles on AFS used for the analysis were selected from peer-reviewed publications found in ISI Web of Science and Google Scholar, based on a search with keywords (alone or in combinations): agroforestry/ specific agroforestry system, soil organic carbon (SOC) stock, C sequestration, soil C stock, and soil C pool. Only those reports that included data on soil C stocks were included. Soil C concentration or stock per unit land area (Mg C ha−1 or equivalent). Paired sites were chosen for further analysis.

Data and analysis

Weighted response ratio for each category was calculated from the RR of individual pairwise comparisons. Analyses were performed with the packages metafor and ggplot2 and R version 3.4.0. Random effect models are considered where the heterogeneity of true effect size among studies arises from random variation around the mean effect sizes of population studies. If SD (standard deviation) values were missing from a study, other variance measures like standard error (SE) of means were used to calculate the SD, or error bars of the figures were used for SD estimation. The overall coefficient of variance (CV), without the missing SD, was generated and then multiplied with the means of missing SD to obtain the imputed SD. Meta-regression (ANOVA) was performed, to assess the relationship between the moderator variables or covariates.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
78	Agricultural systems in 4 different agroecological regions (Arid and semiarid, lowland humid tropics, Mediterranean, Temperate) and at differents soil depth classes (0-20, 0-40, 0-60,0-100)	Agroforestry systems (AFS): Agrosilvicolture, silvoarable, silvopasture, agrosilvopasture, multistrata agroforestry, protecting systems	Non-agroforestry land use practices: cropland, forests, pasture, or uncultivated land	Standardized difference of SOC between agroforestry and non-agroforestry systems.	100%

Results

- The conversion of cropland to agroforestry significantly increased SOC stocks at 0–15, 0–30, 0–100, but not at 0–60 and > 100 cm.
- Comparison of AFS vs. non-agroforestry cropland showed that, in general, percentage in SOC% stock increased under AFS across all agroecological regions and depth classes. The Silvoarable systems in the MED regions showed the lowest SOC% (1.4%).
- No significant differences were observed in the conversion from pasture/grassland to agroforestry (0–15, 0–30, 0–100, 0 ≥ 100 cm), while a significant increase was observed at 0–60 cm. SOC stocks were found significantly reduced when pasture/grassland were converted into agrisilvicultural systems (0–100 cm), probably due to the lack of perennial grasses.
- Comparing AFS vs. Pasture showed varying trends in SOC% stock improvements across different agroecological regions and depth classes, especially in the tropics. Within the 0–20 cm depth class, the highest SOC% stock was noted under Silvopastoral systems in LHT regions (151.6%). In the top soil (0–20 cm), the ASA region showed higher SOC% stock across Agrisilviculture (+15%), Agrosilvopasture (+12.8%) and a higher SOC stock of +89.4% in the Silvopasture systems. In the LHT region, SOC stocks were lower under all AFS practices; the Silvopasture systems within MED region too reported lower SOC% stock (–9.2%) in the top soil.
- The comparison of AFS vs. Forest showed a general trend line of lower SOC% stock under AFS across most agroecological regions and depth classes, with the exception of Multistrata systems in LHT region that reported higher SOC% (12.6% and 20.4%) up to a depth of 40 cm and 60 cm respectively. In the 0–100 cm depth, AFS vs. Forest reported higher SOC% stock under Multistrata systems and Agrosilvopasture, while Agrisilviculture had a decline (–26.8%; LHT). In the MED region, Silvopasture showed a higher SOC% by 56.1% over Forest within 0–100 cm.

Factors influencing effect sizes

Age of agroforest, soil depth, agroecological condition, and current agroforest type affect results

Conclusion

The conversion from agriculture to agroforestry increased SOC stocks in most of the cases. Significant increases were also observed in the transition from pasture/grassland to agroforestry in the top layers, especially with the inclusion perennial in the systems, such as in silvopasture and agrosilvopastoral systems. The conversion from forest to agroforestry lead to losses in SOC stocks in the top layers, while no significant differences were detected when deeper layers were included.