Agroforestry and carbon sequestration

Reference 2

Kuyah, S; Whitney, CW; Jonsson, M; Sileshi, GW; Oborn, I; Muthuri, CW; Luedeling, E. 2019 Agroforestry delivers a win-win solution for ecosystem services in sub-Saharan Africa. A meta-analysis. Agronomy for Sustainable Development 39, 47 doi: 10.1007/s13593-019-0589-8

Background and objective

Hypothesis is that agroforestry reduces trade-offs between provisioning (crop yield) and regulating/maintenance ecosystem services (soil fertility including soil organic carbon). This meta-analysis addresses the following questions: 1) What is the impact of agroforestry on crop yield, soil fertility, erosion control, and water regulation?; 2) Under which ecological conditions (agro-ecological zone, elevation, and soil type) does agroforestry have a positive or a negative effect?; 3) What is the impact of management (site of trial and agroforestry practice) on agroforestry's effect on crop yield, soil fertility, erosion control, and water regulation?; 4) How do different shrub and tree species differ regarding their potential to regulate these ecosystem services? Here, only results regaring soil organic carbon are reported.

Search strategy and selection criteria

A literature search was conducted in Web of Science covering all years from 1945 until June 2018. Other sources include a recent structured vote count review, a meta-analysis and a narrative review. All studies and bibliographies were screened for other relevant publications. 1)Paper published in a peer-reviewed scientific journal; unpublished literature and grey literature were excluded. 2) Study conducted on a research station or farmer's field in SSA. 3) Study investigated the effect of trees on ecosystem services with a suitable control, i.e., a tree-based system compared with tree-less, or investigation beneath tree crowns compared with investigation outside tree crowns. 4) Original field observation or experimental studies, excluding laboratory studies, greenhouse experiments, modeling studies, anecdotal observations, and reviews. 5) Studies reporting quantitative information on the sample size and the mean value of the response variable.

Data and analysis

Response Ratios (RR) were calculated for all pairs (agroforestry and non-agroforestry) of independent data points, hereafter referred to as observations. Bootstrapping methods were used to estimate 95% confidence intervals around weighted means of RR for different categorical variables through the application of 10,000 iterations using the boot package in the R programming language 3.4.2. Analyses of trade-offs were performed on studies that recorded both yield and soil fertility or water regulation. The percentage of observations belonging to win-win, trade-offs, and lose-lose situations was calculated and the data were plotted in a Cartesian plane to facilitate visualization. Spearman's rank correlation tests were performed between effect sizes of different ecosystem service indicators to determine whether they co-varied positively.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
73	Agricultural systems in sub-saharian Africa.	Agroforestry practices: alley cropping, dispersed intercropping, hedgerow, planted fallow, and crops planted under tree canopies in parkland agroforestry systems.	Non-agroforestry practices (includes sole cropping, continuous cropping without trees, and plots outside tree crowns in the case of parklands).	Ratio of SOC in agroforestry to SOC in non-agroforestry practices.	81%

Results

- Soil organic carbon was improved by a factor of 1.2 (RR 1.2; 95% CI 1.2–1.3) in agroforestry compared to non-agroforestry systems.
- Agroforestry also improved SOC for all categories of agro-ecological zones (humid, semi-arid) and elevation (Lowland, Highlandand) compared to controls.
- Compared to controls, agroforestry improved SOC for all soil types except on Andosols. The low response could be attributed to a saturated fertility effect.
- Agroforestry with all types of woody vegetation (alley cropping, biomass transfer, hedgerows, Intercrop, mulch, planted fallows) had a significant effect on SOC, compared to controls. The differences among agroforestry practices and woody perennials used were not statistically significant.
- The differences among woody perennials (trees, shrubs, N-fixing, non-fixing) used were not statistically significant.

Factors influencing effect sizes

Type of soil. Correlation between SOC and total N (rs 0.433, N = 45, P < 0.05), and SOC and available P (rs = 0.277, N = 49, P < 0.05) were positive and significant.

Conclusion

SOC showed a strong increase in agroforestry compared to non-agroforestry systems. Trees increase SOC by photosynthetic fixation of carbon from the atmosphere, and by transferring this carbon to the soil via litter and root decay. It was infered that trees were the main source of soil organic carbon, since crop residues are usually removed with the harvest.