Agroforestry and carbon sequestration

Reference 11

Background and objective

In spite of the recognized potential of C sequestration in agroforestry and the many valuable individual studies that have been carried out, there have been few comprehensive and quantitative summary reports of net C sequestration rates and net changes in overall GHG emissions under various types of agroforestry. 1)Summarise C sequestration rates and net GHG emissions across available studies; 2) discuss the underlying mechanisms and drivers of responses; and 3) identify knowledge gaps and highlight future research questions.

Search strategy and selection criteria

Data were acquired by searching existing peer-refereed literature published between 1950 and 2015, using the Web of Science and Google Scholar with search terms such as carbon sequestration, carbon storage, carbon stocks, the different greenhouse gases (CH4 and N2O), and types of agroforestry. Studies that reported annual biomass increments (above-ground, below-ground or total biomass), soil C sequestration rate or annual CH4 and N2O emissions in field measurements, or provided enough information from which annual sequestration rates and emission rates of non-CO2 greenhouse gases could be estimated through unit conversions and/or extrapolation of given data.

Data and analysis

From the collected data of biomass and soil C sequestration rates in agroforestry and the net difference in soil CH4 and N2O emission rates between agroforestry and adjacent agricultural lands, mean responses and 95% confidence intervals were calculated. To determine the relationship between either above-ground or total biomass C sequestration rates and soil C sequestration rates, a Pearson correlation analysis was used.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
56 on net rates of change of biomass and/or soil carbon (C) stocks + 15 on net changes in the emissions of methane (CH4) and nitrous oxide (N2O)	Agroforestry practices on arable land and pasture land (home gardens, intercropping, live fences, parklands, riparian buffer, shaded perennial-crop systems, shelterbelts, silvopasture, improved fallow, rotational woodlots, tree plantations on arable land, and shifting cultivation).	Agroforestry practices categorized into two distinct types: tree-crop coexistence types where trees and agricultural crops are grown together (type 1); and tree-crop rotation type where trees and crops are grown alternately on the same piece of land (type 2).	Agriculture (for type 1 intervention) and adjacent agricultural lands (for type 2 intervention)	1)Means (and 95% confidence intervals) of carbon sequestration rates in the soil, above and below-ground biomass, total biomass and total soil and biomass in agroforestry systems; 2) Mean (and 95% confidence intervals) of net methane (CH4) and nitrous oxide (N2O) emissions under agroforestry; 3)Mean (and 95% confidence intervals) differences in net CH4 and N2O emissions between agroforestry and adjacent agricultural fields; 4) Calculated net GHG mitigation as difference of means.	75%

Results

- The data showed high variability in net C sequestration rates in both biomass and soils depending on the type of agroforestry, with reported C increments ranging from 0.3 to 7.7 t C ha-1 y-1 in biomass, and 1.0 to 7.4 t C ha-1 y-1 in soils.

- The highest reported soil C sequestration rates of more than 8 t C ha-1 y-1, were for the first year after agroforestry establishment. Averaged across all observations, soil C sequestration rates were about 2 t C ha-1 y-1 in youngest stands that gradually diminished with time since stand establishment.

- Overall, type 1 agroforestry stands (at an average age of 14 years) sequestered 7.2 +/- 2.8 t C ha-1 y-1, with biomass and soil C sequestration contributing about 70% and 30% of that increment, respectively.

- Soils under agroforestry oxidised 1.6 +/- 1.0 kg CH4 ha-1 y-1 and emitted 7.7 +/- 3.3 kg N2O ha-1 y-1

- Comparing agroforestry and adjacent agricultural lands, only minor differences in net CH4 and N2O emissions were found, with no clear overall direction of change.

Factors influencing effect sizes

Effect on soil carbon sequestration rate diminishes over time, and depends on the type of agroforestry system considered.

Conclusion

Overall, agroforestry was estimated to contribute to mitigating 27 +/- 14 t CO2 equivalents ha-1 y-1 at least for the first 14 years after establishment, compared to arable land or pasture.