Agroforestry and greenhouse gas

Reference 1

Kim, DG; Kirschbaum, MU; Beedy, TL. 2016 Carbon sequestration and net emissions of CH4 and N2O under agroforestry. Synthesizing available data and suggestions for future studies. Agriculture, Ecosystems & Environment 226: 65-78. doi: 10.1016/j.agee.2016.04.011

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. Here, only data regarding GHG emissions are reported.

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 applied to cropland: 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).	Cropland (for type 1 intervention) and adjacent agricultural lands (for type 2 intervention)	1)Mean (and 95% confidence intervals) of net methane (CH4) and nitrous oxide (N2O) emissions under agroforestry; 2)Mean (and 95% confidence intervals) differences in net CH4 and N2O emissions between agroforestry and adjacent agricultural fields.	75%

Results

- Soils under agroforestry had a net negative CH4 emission (i.e. Uptake by CH4 oxidation) of −1.6 ± 0.5 kg CH4 ha−1 y−1, and net N2O emission of +7.7 ± 1.7 kg N2O ha−1 y−1 .
- The largest CH4 uptake was reported for improved fallow systems (−3.2 ± 0.5 kg CH4 ha−1 y−1), and improved fallow, shaded perennial-crop systems, and riparian buffers had the largest N2O emissions of 9–10 kg N2O ha−1 y−1; shifting cultivation and tree plantations had quite low emissions of little over 1 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. Differences in emissions between agroforestry and agriculture were: −0.1 ± 1.4 kg CH4 ha−1 y−1 and −2.7 ± 10.6 kg N2O ha−1 y−1.
- Soil N2O emissions were observed to be reduced under shifting cultivation, tree plantations on arable land and riparian buffers, with one observation from a riparian buffer giving a dramatic reduction in N2O emissions by almost 30 kg N2O ha−1 y−1
- Combining C sequestration in biomass and the soil with changes in net emissions of CH4 and N2O emissions, it was estimated that a shift to agroforestry can mitigate 27.2 ± 13.5 t CO2 eq ha−1 y−1. The contribution of CH4 and N2O emissions reductions to this figure is relatively small (around 10%).

Factors influencing effect sizes

Any reduced net CH4 emissions in agroforestry (i.e. greater uptake) compared with agriculture was probably mainly related to greater soil pore space in soils under agroforestry compared with agricultural fields, as reflected in reduced soil bulk density under agroforestry.

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.