Agroforestry and carbon sequestration

Reference 5

Feliciano, D; Ledo, A; Hillier, J; Nayak, DR. 2018 Which agroforestry options give the greatest soil and above ground carbon benefits in different world regions? Agricolture, Ecosystem and enviroment, 254, 117-129. doi: 10.1016/j.agee.2017.11.032

Background and objective

Climate change mitigation and food security are two of the main challenges of human society. Agroforestrysystems, defined as the presence of trees on external and internal boundaries, cropland, or on any other available niche of farmland, can provide both climate change mitigation and food. 1)identify agroforestry systems implemented in different regions of the globe; 2) quantify the sequestration potential of different agroforestry systems and; 3) understand the factors influencing carbon sequestration.

Search strategy and selection criteria

Peer reviewed studies were selected through the ISI-Web of Knowledge, Google Scholar, and Scopus. The searches were performed using several words related to agroforestry systems and carbon sequestration (or the same terms in Spanish or Portuguese). The terms were used separately or in combination with each other. The reference lists of the published reviews on the topic were also searched for eligible studies through snowballing. 1)Above ground carbon sequestration per year (Mg C ha−1yr−1) or total carbon storage per hectare (Mg C ha−1) before and after implementation of the agroforestry system; 2) Soil carbon sequestration per year (Mg C ha−1yr−1) or total carbon storage per hectare (Mg C ha−1) before and after implementation of the agroforestry system (covering soil carbon only and not tree roots); 3) Land use before and after the implementation of the agroforestry system; 4) Time since implementation of the agroforestry system (age of the agroforestry system in number of years); 5) Climate; 6) Country.

Data and analysis

The mean above ground and soil carbon sequestration was calculated for each agroforestry system in the six world regions identified. In addition, the mean, minimum, and maximum were calculated. A more detailed analysis was undertaken for agroforestry systems implemented in tropical climates because soil and above ground carbon was more often reported in these studies. The calculations were undertaken with IBM SPSS Statistics 24. To better understand the changes with respect to time since implementation, forest plots were created using Microsoft Excel 2010 and the R statistical platform (R Core Team,2017). To identify the factors, a set of General Linear Mixed Models (GLMM) were fitted. The potential covariates tested were: the effect of time after conversion, climate, continent, land use before change, current agroforestry system, and land use change (type of change)

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
40 for above-ground carbon + 46 for soil carbon	Agroforestry applied to different land use systems worldwide.	Agroforestry systems: silvopastoral, improved fallow, agrisilvicoltural, woodlots, homegarden, shadow systems, boundary planting.	Non-agroforestry practices on soil.	1)Absolute above-ground and soil carbon sequestration of different kinds of agroforestry (t C/ha*yr). 2) Difference of above-ground and soil carbon sequestration between agroforestry systems and non-agroforestry systems (t C/ha*yr).	62%

Results

- Difference in above-ground carbon sequestration is higher under transition from degraded land to improved fallows (12.8 tC ha−1 yr−1, SD1 = 5.4, n = 14), cropland to improved fallows (9.4 tC ha−1 yr−1, SD = 5.2, n = 5), and grassland to woodlots (8.3 tC ha−1 yr−1, SD = 5.2 n = 17)
- Difference in soil carbon sequestration is higher under transition from grassland to silvopastoral (4.4 tC ha−1 yr−1, SD = 0.86, n = 9), underutilised land to homegarden (3.8 tC ha−1 yr−1, SD 1.54, n 19), and cropland to improved fallow (1.9 tC ha−1 yr−1, SD = 1.9, n = 17)
- There are also negative (but non-significant) absolute changes in soil organic carbon under transition from cropland to woodlot (−0.5 tC ha−1 yr−1, SD = 2.57, n = 10), and grassland to agrisilvicultural (−0.8 tC ha−1 yr−1, SD = 0.98, n = 5).
- The most common agroforestry systems found in the literature on above ground carbon sequestration were shadow systems (n = 40) and woodlots (n = 34). Fig. 1B shows that the most common agroforestry systems found in the literature on soil carbon sequestration were agrisilvicultural systems (n = 52) and shadow systems (n = 24).
- Absolute means of above ground and soil carbon sequestration rates are, on average, higher in Tropical climates (around 5 tC ha-1 y-1), where above ground carbon sequestration is higher in improved fallows and boundary planting and soil carbon sequestration is higher in silvopastoral systems and home-gardens.

Factors influencing effect sizes

Above-ground carbon sequestration varies with time since implementation. This increment is larger if the previous land use is degraded or grassland. The sequestration potential of the above ground plant components is lower in arid, semiarid, and temperate regions than in tropical regions and in degraded sites, carbon sequestration potential is also lower than in fertile humid sites. Values will afterward depend on the agroforestry system. The main factors influencing Soil Carbon sequestration were the land use before the agroforestry system and the climate zone. The current agroforestry system was less important. Other factors influencing sequestration potential: plant characteristic, system characteristic, management factors, type of soil, agroecological conditions.

Conclusion

This study found that transition to agroforestry leads to net carbon storage in the system. This change is very clear for above ground carbon. Results for soil carbon sequestration were not so consistent, even though a positive increment in carbon was observed in most cases. Large differences in soil carbon sequestration values among the land use systems can result from biophysical and socio-economic characteristics of the system and/or methodological issues.