SINGLE-IMPACT FICHE – AGROFORESTRY

IMPACT: CARBON SEQUESTRATION

Data extracted in June 2020

Note to the reader: This fiche summarises the impact of Agroforestry on CARBON SEQUESTRATION. It is based on a review of 13 peer-reviewed synthesis research papers, each involving 21 to 138 individual papers.

1.WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT:
  Out of the 13 synthesis papers dealing with this type of impact, 10 show positive effect of agroforestry on carbon sequestration compared to land use without trees (including cropland and pastureland) at the global scale, in Europe and in other continents (see **Table 1**). Two synthesis papers report an uncertain effect in West Africa (one compared to croplands, and one unspecified, and a third one reports an uncertain effect compared to forest across several continents). Two synthesis papers report a negative effect on carbon sequestration compared to forest or compared to both forest and pastureland. See **Table 2** for details.

Table 1. Summary of effects. The numbers between parenthesis indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in the next section.

		Effects (all studies)				Effects (only studies including EU)			
Impact	**Comparator**	Positive	Negative	No effect	Uncertain	Positive	Negative	No effect	Uncertain
Increase carbon sequestration	Land use without trees	10 (8)	0	0	1	5	0	0	1
	Forests	0	2	0	1	0	2	0	1

- QUALITY OF THE SYNTHESIS PAPERS *The quality score summarises 16 criteria assessing the quality of three main aspects of the synthesis papers: 1) the literature search strategy and studies selection; 2) the statistical analysis; 3) the potential bias. Details on quality criteria can be found in the methodology section of this WIKI.*

2. IMPACTS

The main characteristics and results of the 13 synthesis papers are summarized in **Table 2**. Summaries of the meta-analyses provide fuller information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices.

Table 2. Main characteristics of the synthesis papers reporting impacts of agroforestry systems on carbon sequestration.

	Reference	Population	Geographical scale	Intervention	Control	Conclusion	Quality score	Global effect
1	Muchane, MN; Sileshi GW; Gripenberg, S; Jonsson, M; Pumariño, L; Barrios, E. 2020	Crop production systems in tropics.	Humid and sub-humid tropics in all continents.	1)simultaneous agroforestry where trees and crops occur on the same piece of land during the same cropping season (e.g. alley cropping, intercropping, multi-storey agroforests); and 2) sequential agroforestry where trees and crops occur on the same piece of land but in a temporal sequence as part of a rotation (e.g. improved fallows).	Crop monoculture	While the effect of agroforestry may vary with soil, climate, crop type and tree management, this analysis has demonstrated that agroforestry practices significantly increase SOC compared to crop monocultures.	75%	Positive, compared to crop monocultures.
2	Kuyah, S; Whitney, CW; Jonsson, M; Sileshi, GW; Oborn, I; Muthuri, CW; Luedeling, E. 2019	Agricultural systems in sub-saharian Africa.	Sub-Saharan 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).	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.	81%	Positive, compared to non-agroforestry practices on cropland.
3	De Stefano, A; Jacobson, MG. 2018	Different land use systems.	Global (mostly located in Northern, Central, and Southern America, Africa, and Asia).	Agrisilviculture, Silvopasture, Agrosilvopasture.	Two datasets were studied, including: 1) Full dataset: Agriculture, pasture/grassla	The conversion from forest to agroforestry leads to losses in SOC stocks in the top layers, while no significant differences were detected when deeper layers were included. On the	75%	Positive, compared to: agriculture or pasture/grassland. Negative, compared to forest.

					nd, forest, forest plantation, uncultivated/other land uses; 2) Reduced dataset: Agriculture, pasture/grassland, forest plantation	other hand, 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.		
4	Chatterjee, N; Nair, PKR; Chakraborty, S; Nair, VD. 2018	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)	Global. Arid and semiarid (ASA), lowland humid tropics (LHT), Mediterranean (MED), Temperate (TEM). 30 Countries (Asia, Africa, North America, Latin America, and Europe)	Agroforestry systems (AFS): Agrosilvicolture, silvoarable, silvopasture, agrosilvopasture, multistrata agroforestry, protecting systems	Non-agroforestry land use practices: cropland, forests, pasture, or uncultivated land	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.	100%	Positive, compared to agricultural land and pasture/grassland. Uncertain compared to forest.
5	Feliciano, D; Ledo, A; Hillier, J; Nayak, DR. 2018	Agroforestry applied to different land use systems worldwide.	Global (Africa, Asia, Australia, Europe, Latin America, and North America).	Agroforestry systems: silvopastoral, improved fallow, agrisilvicoltural, woodlots, homegarden, shadow systems, boundary planting.	Non-agroforestry practices on soil.	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.	62%	Positive, compared to non-agroforestry practices (cropland and grassland/pastureland).
6	Bayala, J; Kalinganire, A; Sileshi, GW; Tondoh, JE. 2018	Arable land in Sub-Saharan Africa.	Sub-Saharan Africa covering an area from humid to semi-arid zones.	Plots with one agroforestry practice among alley cropping, improved fallow, mulching and parkland.	Plots without alley cropping, improved fallow, mulching and parkland.	The results revealed an increase in soil organic carbon of different types of agroforestry systems, over their corresponding treeless control plots.	50%	Positive, compared to non-agroforestry systems.
7	Felix, GF; Scholberg, JMS; Clermont-Dauphin, C; Cournac, L; Tittonell, P. 2018	Cropping systems with trees in Semi-arid west Africa.	Semi-arid west Africa (Sudano-Sahelian Africa, including Senegal, The Gambia, Mauritania, Mali, Burkina Faso, Northern Benin, Niger, Nigeria, and Northern Cameroon)	Plots under or at the vicinity of tree canopy. Plots receiving ramial wood as soil amendment.	Plot outside the area of canopy influence. Plot not receiving ramial wood as soil amendment.	Presence of trees, shrubs and ramial wood amendments had overall positive effects on soil carbon in the large majority of case studies.	50%	Uncertain
8	Shi, LL; Feng, WT; Xu, JC; Kuzyakov, Y. 2018	Croplands or pastures in all pedo-climatic zones.	Global. 6 continents and 16 countries, ranging from temperate to tropical climatic zones. Most of the studies were in Asia and in tropical areas.	Agroforestry practices: alley cropping, windbreaks, silvopastures, and homegardens.	Adjacent plot with crop or pasture, without trees.	All four main Agroforestry systems—alley cropping, windbreaks, silvopastures, and homegardens—sequestered significantly more C than did cropland (or pasture).	75%	Positive, compared to cropland or pasture.
9	Torralba, M; Fagerholm, N; Burgess, PJ; Moreno, G; Plieninger, T. 2016	Agricultural land, pasture, forestry land in the EU.	Europe	Agroforestry (silvoarable, silvopasture and mixed).	1)Agricultural land, 2)pasture land, 3) forestry land (natural and planted).	Agroforestry reduced biomass production in relation to forestry and pasture. However, biomass results should be taken with caution as some of the authors that found such effects acknowledge the difficulty to assess productivity in agroforestry systems, as the biomass usually considers only the woody or the non-woody elements of the system, but not both together, giving a partial assessment of the biomass production in the system.	81%	Negative, compared to pastureland and forests.
10	Sileshi, GW. 2016	Faidherbia trees on arable land (arid zones).	Global (Arid zones)	Agroforestry: Scattered Faidherbia albida trees in crop systems	Open area or patches taken furthest from the tree trunk, in the same	Faidherbia induces significant improvement in soil properties (including soil organic C, with a significant increase of 46%) under its canopy, with spatial	44%	Positive, compared to open areas without trees.

					field as the intervention.	patterns that vary with distance from the trunk in a predictable manner.		
11	Kim, DG; Kirschbaum, MU; Beedy, TL. 2016	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).	Global (not defined)	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)	Overall, agroforestry was estimated to contribute to mitigating 27 +/- 14 t CO_2 equivalents ha-1 y-1 at least for the first 14 years after establishment, compared to arable land or pasture.	75%	Positive, compared to arable land or pasture land.
12	Sinare, H; Gordon, LJ. 2015	Cropland and pastureland in Sudano-Sahelian zone of West Africa.	Sudano-Sahelian zone of West Africa.	Presence of woody vegetation.	Not specified	No clear conclusion available.	50%	Uncertain
13	Ziegler, AD; Phelps, J; Yuen, JQ; Webb, EL; Lawrence, D; Fox, JM; Bruun, TB; Leisz, SJ; Ryan, CM; Dressler, W; Mertz, O; Pascual, U; Padoch, C; Koh, LP. 2012	11 key land cover/land use transitions in South Eastern Asia that involve swidden agriculture.	South-eastern Asia.	The associated land covers for the transitions are the following: forest; logged over forest; orchards and tree-plantations; rubber plantations; agroforest; grassland, pasture, or shrublands; oil palm plantations; and permanent cropland.	NA	The analysis of plot-level carbon outcomes highlights that in some instances, lengthening fallow periods of an existing swidden system may produce substantial carbon benefits, as would conversion from intensely cultivated lands to high-biomass plantations and some other types of agroforestry.	31%	Positive effect of agroforestry compared to short-fallow swidden and intermediate-fallow swidden.

3. KNOWLEDGE GAPS

- Optimal designs of agroforestry systems in European conditions. Six synthesis papers out of 13 did not report data for Europe. Spatial (including soil depth) and temporal distribution of soil C is still poorly known.