Agroforestry and water retention

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 (including soil nutrients, soil erosion control, 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 water regulation 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. Criteria: 1) Paper published in a peer-reviewed scientific journal; unpublished literature and grey literature were excluded. 2) Study conducted on a research station or farmer's field in SSA. 3) Study investigated the effect of trees on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 water regulation parameters (infiltration rates and soil moisture content) in agroforestry to water regulation parameters (infiltration rates and soil moisture content) in non-agroforestry practices.	81%

Results

- Agroforestry improved infiltration rates (RR 2.7, 95% CI 2.1–.5) and soil moisture content (RR 1.6; 95% CI 1.1–1.2), compared to the control.
- Water regulation was more strongly improved under agroforestry in semi-arid than in humid locations
- There were no significant differences among elevations and types of trial.
- The effects of agroforestry on water regulation were significantly greater on Lixisols (RR > 1 = 100%) compared to Luvisols and Nitisols.
- NA

Factors influencing effect sizes

Climate zone: higher effect in semi-arid than in humid locations. Type of soil: The effects of agroforestry on water regulation were significantly greater on Lixisols (RR > 1 = 100%) compared to Luvisols and Nitisols.

Conclusion

Agroforestry practices significantly improves water regulation, compared to non-agroforestry practices. This happened for all types of agroforestry, ecological zone, elevation, type of perennials used.