

Towards biodiversity-friendly production: evidence from coffee, cacao, and banana in the American tropics



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INTRODUCTION

The BioFinCas project is developing management recommendations for coffee, cacao and banana farms in the American tropics. To achieve this, understanding how different cropping systems can deliver biodiversity and production together, and help increase resilience, is essential. For the baseline knowledge of the project, we evaluated systems along complexity, shade, and input intensity pathways, on a crop-by-crop basis.

METHODS

- Systematic review and meta-analysis, ROSES guidelines.

- 86 studies, 2,024 effect sizes (ES), 13 countries, American tropics.**

- Database row → Paired comparison between control and intervention.

- Management pathways:

- Higher vegetation complexity, higher shade cover, and lower input intensity

- Outcome domains:

- Biodiversity, crop yield, carbon balance and economics

3-level meta-analytic models were fitted to each crop × pathway group.

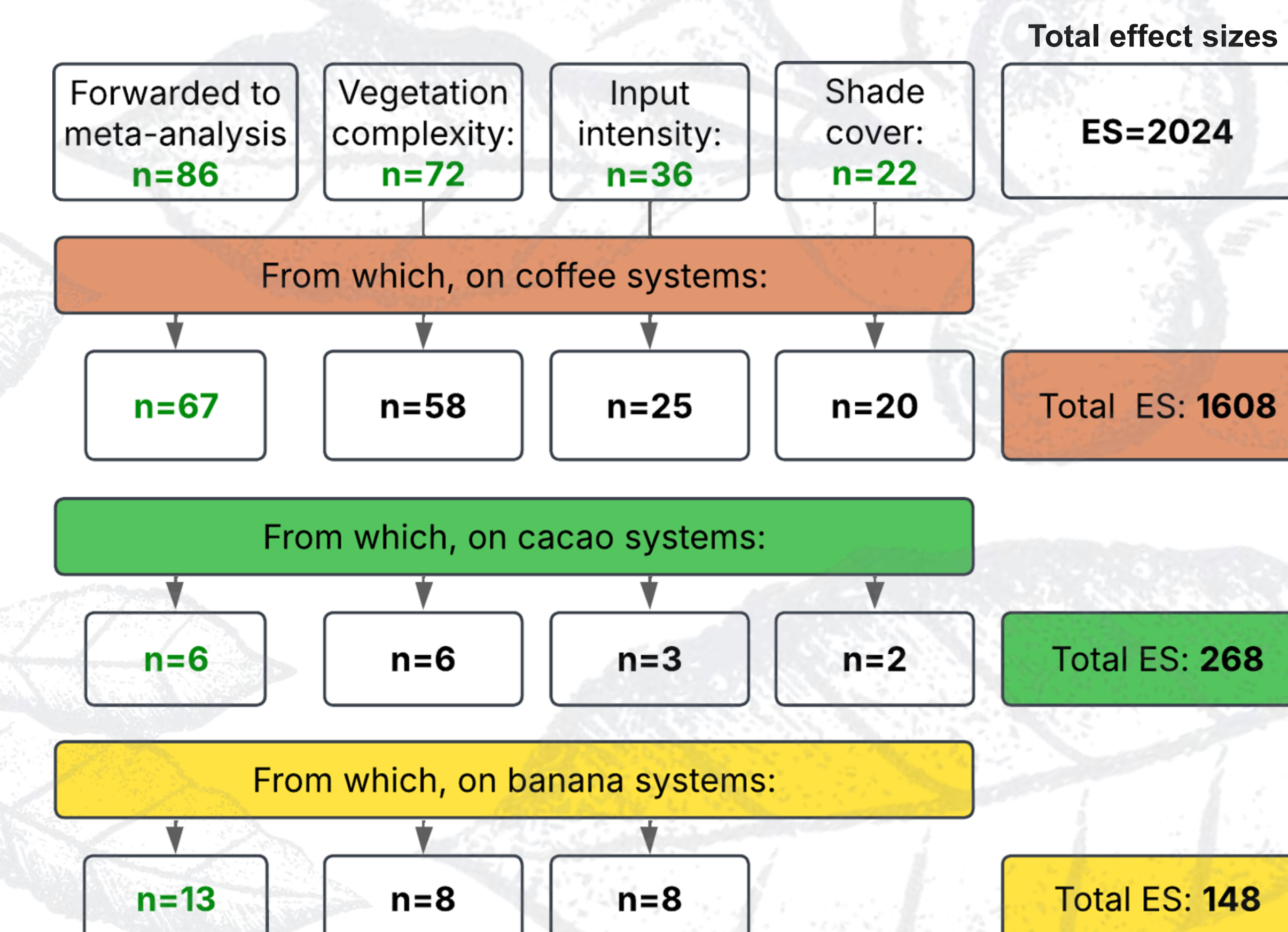


Figure 1. Studies and ES by crop / management pathway. Banana has no shade results

RESULTS

Figure 2. Effect of management pathways on outcomes, by crop. % Δ against control. 95% confidence intervals. Empty cells = no study reports

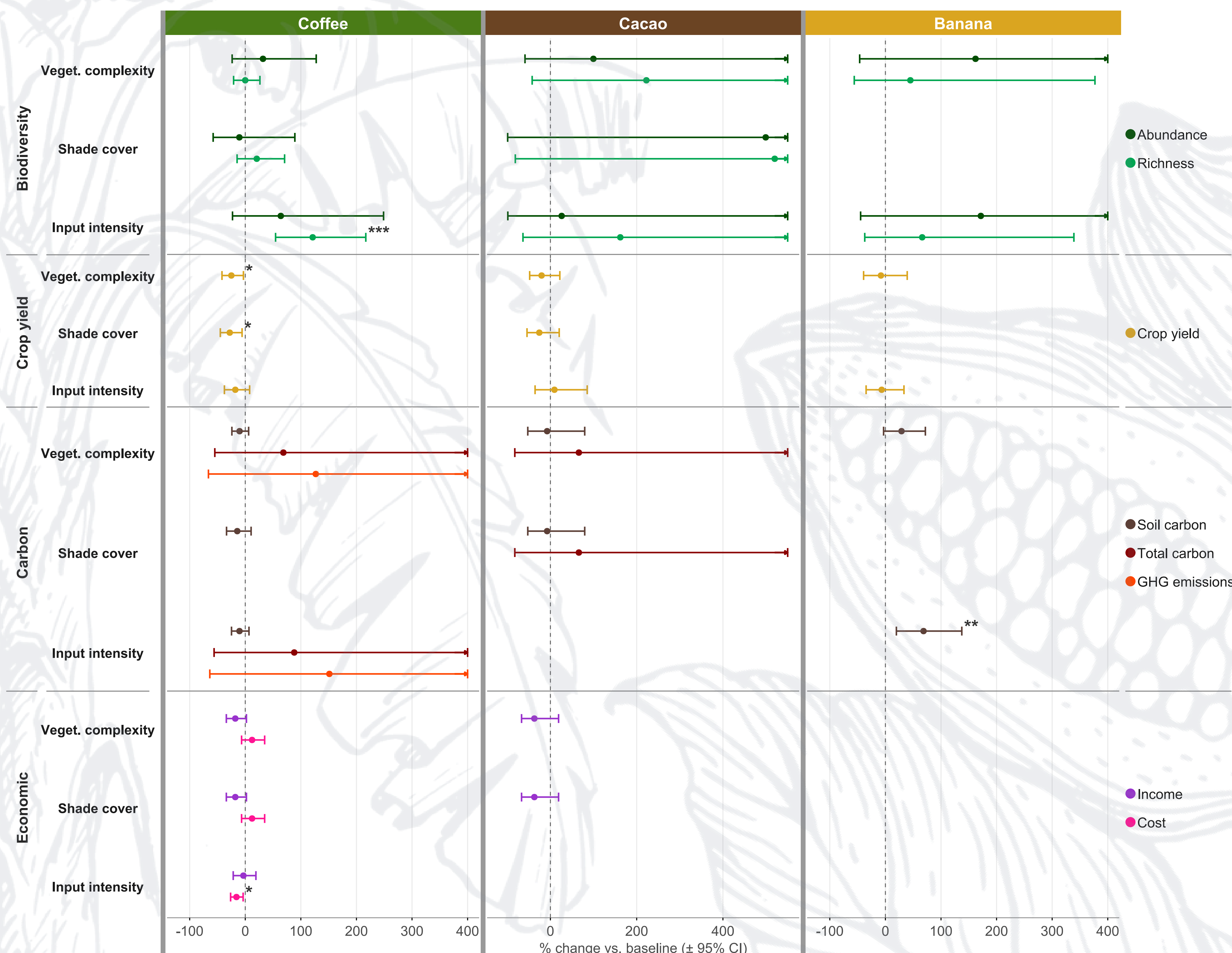


Table 1. Coffee only: results for the crop with best coverage

Coffee	Vegetation complexity	Shade cover	Input intensity
Richness	-0.1% [-21, 26] n=29	+20.7% [-15, 71] n=12	+121.3% [55, 217] n=10
Crop yield	-25.1% [-42, -3] n=8	-27.9% [-45, -6] n=3	-17.9% [-38, 8] n=4
Soil carbon	-10.3% [-24, 6] n=10	-14.4% [-34, 11] n=3	-10.4% [-25, 7] n=7

- Coffee → **79%** of all ES. Cacao **13%**, banana **7%**.

- Economic results → Single study.

- In **coffee**, richness response depends on pathway. Yield and soil carbon do not.
- Richness shows funnel asymmetry across 38 studies (Egger's test, $p = 0.004$). Smaller studies → larger gains.

- One significant result outside coffee.
Banana soil carbon / reduced inputs +69% [20, 138] n=3.

DISCUSSION

What this means for recommendations

Indications:

- In coffee, yield falls under shade cover and vegetation complexity, with no confirmed biodiversity gains under either.
- Error bars are often very large. Systems are complex and there are unaccounted drivers of the examined effects.

Gaps

- Better geographic and crop coverage (half of coffee evidence comes from Mexico).
- More studies with full descriptions of systems that enable precise categorization.
- Paired contrasts pooled together cannot show dose-response or reveal non-linearities in the examined relations.

Also needed

- Time component (multi-year studies).
- Better understanding of variations in functional diversity.

What comes next

In the BioFinCas project, we have run farm surveys. We expect to get finer understanding of how vegetation complexity, shade cover and input intensity occur in the same farm, and how they relate to biodiversity, carbon, yield and labor cost.

A multi-stakeholder process toward concrete recommendations by 2027, and implementation after.

CONCLUSIONS

Biodiversity outcomes depend on which management decisions are made, which was significant only for species richness in coffee.

Yield and soil carbon did not behave that way: in coffee, both fell under all three pathways.

For cacao and banana, the evidence cannot yet separate one pathway from another.

This synthesis is a baseline, not a recommendation. It helps us define gaps and needs.

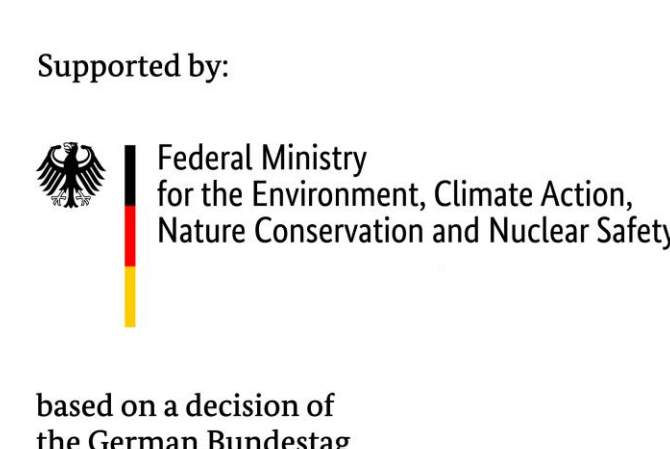
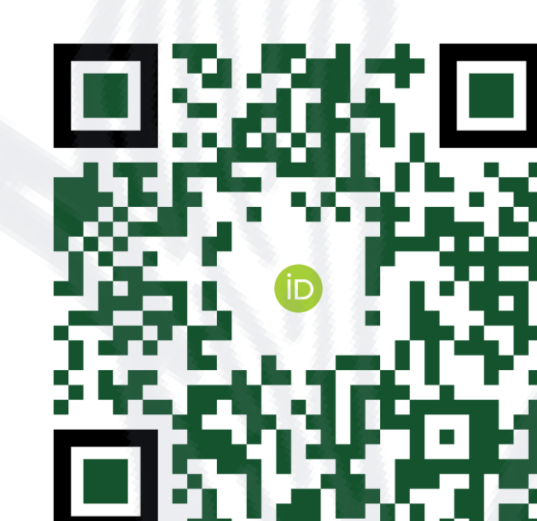
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