Advancing soil carbon sequestration solutions: A decision-support tool for achieving net-zero goals

Christhel Andrade Díaz[a]*, Hiba Shreim[a], Lorie Hamelin[a]

[a] TBI, Université de Toulouse, CNRS, INRAE, INSA, Toulouse, France *Corresponding author: (andraded@insa-toulouse.fr)

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The results are available upon request. Do not hesitate to contact the lead author.

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1 INTRODUCTION

How can soil carbon sequestration (**SCS**) strategies for **arable lands** be **prioritized** based on their balance of **effectiveness**, **feasibility**, **cost**, and **side-effects**, to support **national-scale** planning for climate-smart agriculture?

We developed a decision-support framework integrating/defining:

- Meta-analyses of 50+ strategies (*here 26 are shown*)
- Multi-criteria decision analysis (PROMETHEE, GAIA, Pareto)
- 8 Key Performance Indicators (KPIs) weighted by stakeholder-defined priorities

2 METHODOLOGY

1 Review

- Identifying SCS strategies *(>20)*
- Screening studies *(>270 meta-analyses)*
- Data extraction & harmonization

2 KPI

- Set criteria *(quantitative & qualitative)*
- Set cutoffs
- Adjust weights based on decision-maker priorities

3 MCDA

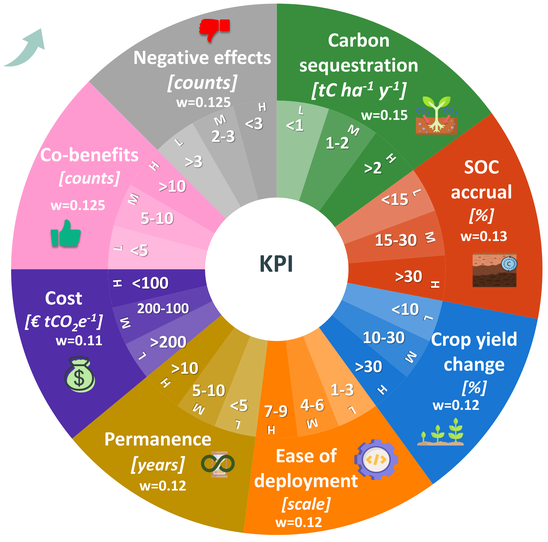
- Scoring strategies
- Apply PROMETHEE
- Rank options

- KPI: Key Performing Indicators
- MCDA: Multicriteria Decision Analysis
- PROMETHEE: Preference Ranking Organization METHod for Enrichment Evaluations
- GAIA:Geometrical Analysis for Interactive Aid

- L: Low performance
- M: Intermediate performance
- H: High performance
- SOC: soil organic carbon
- C-seq: Carbon sequestration

- w: weight

Weights reflect expert-defined priorities across 8 KPIs. Higher weights (e.g., C-sequestration, SOC change) guide the ranking outcome.

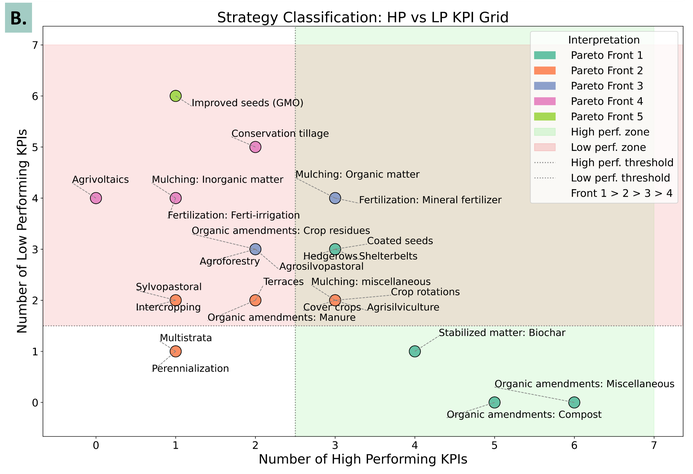


3 RESULTS

A.

Strategy group	SOC change [%]	C-sequestration [tC ha^{-1} y^{-1}]	Yield change [%]	Costs [€ tCO$_2$e^{-1}]	Effect
Crop diversification (Crops)	-5.3 – 49.2	0.01 – 2	0.32 – 62	28 – 120	C-seq
Crop diversification (Agroforestry)	-47 – 151.6	-5 – 6.8	-50 – 40	10 – 200	C-seq
Land management	-54.4 – 112.5	0.02 – 1	-18 – 30	10 – 740	C-loss reduction
Mulching	3.2 – 51	0.012 – 1.8	2 – 120.1	30 – 400	C-seq/C-loss reduction
Organic amendments	-21 – 98.2	0.09 – 6.1	-10 – 430	30 – 130	C-seq
Fertilization	-23.4 – 115	0.3 – 0.8	0.13 – 290	50 – 120	C-seq/C-loss reduction
Stabilized matter	0.25 – 297.1	0.2 – 3.27	-31.8 – 470	30 – 200	C-seq
Agritechnology	-5 – 20	0.54 – 2.10	-20 – 60	5 – >4000	C-seq

B.



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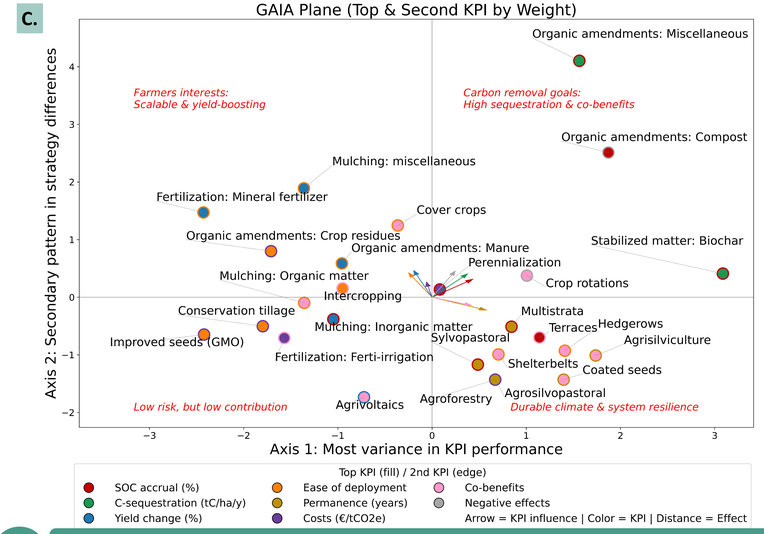

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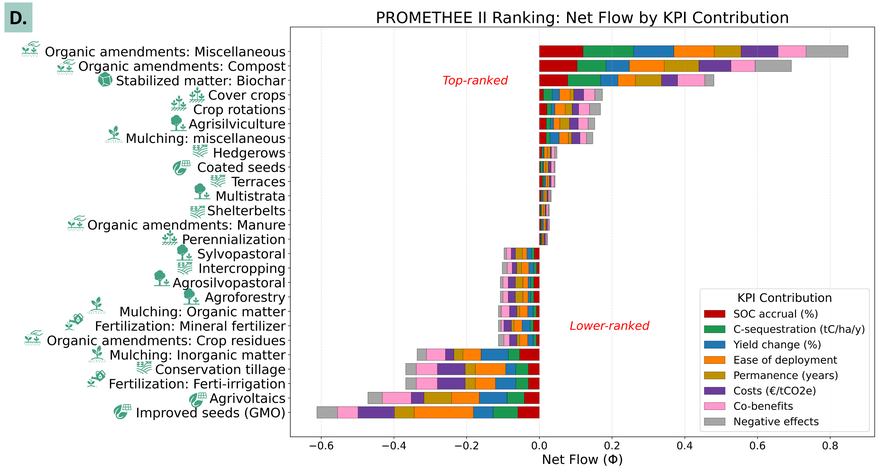

4 TAKE-HOME MESSAGE

Strategies in Pareto Front 1 (B) combine high performance and few weaknesses. Top-ranked strategies (e.g., Biochar, Compost, diverse amendments) show strong sequestration potential and broad performance, though may pose cost or feasibility challenges.

GAIA (C) & PROMETHEE (D) reveal strategy-KPI dynamics for policy support. **Top-right**: Drives climate mitigation through high carbon sequestration and ecosystem co-benefits. **Top-left:** attractive for farmer adoption (yield enhancing and scalable). **Bottom-right**: Supports resilient agroecosystems and durable carbon storage. **Bottom-left**: low impact strategies, limited mitigation potential.

*Next steps include **regional filtering (e.g., French)** for tailored strategy selection at national scale.*

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