FARMING SYSTEM DESIGN FOR SUSTAINABLE AGRIFOOD SYSTEMS: THEORIES AND PRACTICES

Proceedings of the 8th International Farming System Design Conference

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25 - 29 August 2025
Palaiseau (France)
Campus Agro Paris-Saclay

The MEDITAE framework: enhancing agroecological diagnosis in co-innovation platform

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Introduction

The transition towards agroecology requires learning about agroecosystem functioning (Prost et al., 2023). The co-innovation approach promotes learning and generates actionable knowledge to support sustainability transitions (Rossing et al., 2021). At the farm system level, co-innovation involves characterization, diagnosis, redesign, monitoring and evaluation (Dogliotti et al., 2014). However, current diagnosis methods do not capture the ecological processes underpinning agroecosystem functioning and fall short of nurturing an agroecological perspective. Here we present the Assessment and Diagnostic Framework to Inform Agroecological Transitions (MEDITAE, Spanish acronym: Marco de Evaluación y Diagnóstico para Impulsar Transiciones AgroEcológicas) and its application to five case study vegetable farms in Uruguay.

Methods

The MEDITAE framework was co-developed and applied in a co-innovation project, where the research team proposed the framework structure and farmers provided feedback. The project ran from 2019 to 2023 and involved five farms (three organic, two conventional) in Canelones, Uruguay. The framework was discussed and applied after six-ten farm visits (characterization phase). During these visits, informal discussions, mutual knowledge and trust were developed. Discussions of researchers and farmers revolved around the processes underlying the core concepts of MEDITAE and which indicators could be used to describe these processes performance and linked practices. These indicators were used at all five farms.

Results

The MEDITAE framework

MEDITAE connects six foundational socio-ecological processes underlying agroecosystem functioning (Altieri, 1999) to farm performance and management (Fig. 1). Each process is described in terms of its main components, their interconnections with other components of the farm system, and their relevance for agroecosystems´ functioning from an agroecological perspective. *Performance indicators* (such as nutrient and soil organic carbon balance, pest incidence, and family income) are proposed to assess agroecosystem functioning, and *practice-based indicators* (such as crop rotation, tillage frequency and intensity, and input use) are used to assess management practices that may explain performance. The choice of the indicators is flexible and should be tailored to specific situations (e.g. type of production system and location) to inform the six key processes in a meaningful way.

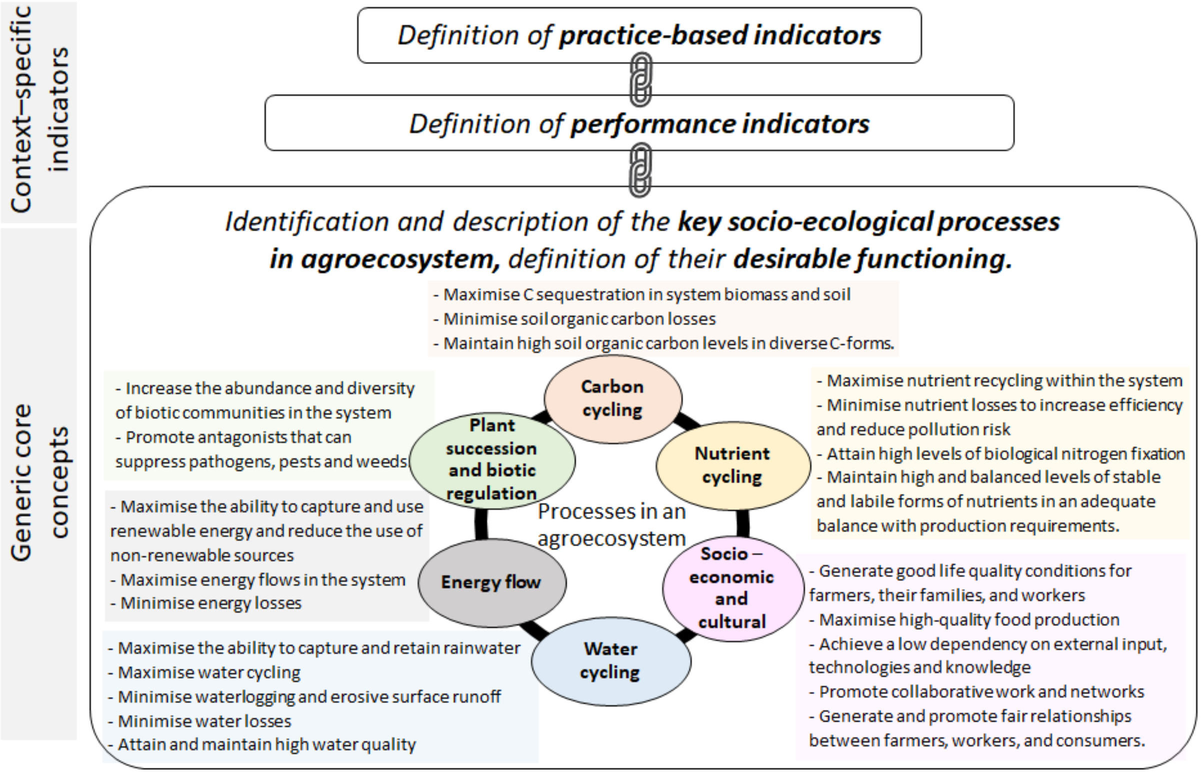

Figure 1. The MEDITAE structure: from generic core concepts to context-specific indicators.

Application of framework

Performance indicators showed that all five vegetable farms had a weak performance on nutrient cycling and energy flow processes. Carbon and water cycling achieved good overall performance on two (organic) farms. The three organic farms had good overall performance on plant succession, biotic regulation, and socio-economic processes, while the conventional farms had weak performances. The main processes that needed to be strengthened on each farm were discussed and defined based on the results of the performance indicators and farmers' interests (Table 1). The discussion around the socio-economic and cultural aspects helped to understand the objectives and needs of the families, which was a guiding principle possible strategies and management practices that could be changed to improve performance. in the redesign phase. The discussion about the practice-based indicators focused on the

.

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5
Processes with good performance	Carbon, water, plant succession & biotic regulation, socio-econ.		Carbon, water, plant succession and biotic regulation, socio-econ.	Plant succession and biotic regulation, socio-economic	
Processes that need to strengthen	Nutrients, energy	All. Prioritized: socio-econ., carbon, plant succession & biotic regulation	Nutrient, Energy	Carbon, (water), nutrients, energy	All. Prioritized: socio-econ., carbon, plant succession & biotic regulation
Redesign Objectives	Maintain family income, involve new generations, reduce environmental and social impact (workload and stress).	Increase family income, improve soil quality and reduce environmental risks. Become agroecologically certified[1].	Consolidate and stabilize income, increase efficiencies, reduce environmental and social impact (workload and stress).	Stabilize family income, improve soil quality and biodiversity.	Increase income and stability (reduce stress), improve soil quality, reduce pesticide risks. More sustainable still conventional farm.
Redesign Strategies	i. Reducing crop areas, especially in field crops. ii. Crop rotations to reduce weeds, maintain SOC while adjusting organic amendments for pest and disease control, reducing over-fertilisation. iii. Manage non-cultivated areas and strips between fields and greenhouses	i. Expand greenhouse area to boost crop diversity, production, and rotation. ii. Crop rotations to increase SOC and control pests. iii. Advance biological control, reduce pesticides, increase vegetation strips. iv. Explore alternatives for good-quality water. v. Explore commercial options for crop diversity.	i. Pause area expansion, adjusting crop areas to reduce labor. ii. Crop rotations to maintain SOC while adjusting organic amendments to reduce over-fertilisation. iii. Adjust cropping timing. iv. Manage non-cultivated areas and strips between fields and greenhouses. v. Address workers' social benefits. vi. Improve farm records for decision-making.	i. Adjust production plan for efficiency, balancing crop areas and labor. ii. Reorganize crop rotation to boost SOC, nutrients, and reduce weeds. iii. Adjust cropping timing. iv. Consolidate non-cultivated areas between fields. v. Explore direct selling and crop diversification for income stability.	i. Reduce main crop area, add new crops for rotation and spring income. ii. Reorganize crop rotation to reduce soil disease and increase SOC. iii. Reduce herbicide use and adjusted fertilization. iv. Redefine commercial strategy to reduce post-harvest losses. v. Explore alternatives to increase irrigation water availability.

[1]In Uruguay agroecological is legally equivalent to organic.

Table 1. Summary of farm diagnosis and redesign of five vegetable farms (1, 3 and 4: organic management, 2 and 5: conventional management). The diagnosis and redesign strategies presented resulted from various discussion rounds between the research team and the farm families involved.

Discussion and perspectives

The MEDITAE diagnosis fostered collective reflections on how socio-ecological processes affected system performance and how they were influenced by farmers´ practices. These reflections helped to develop an agroecological perspective, fostered learning, and empowering farmers to change practices. MEDITAE provided a generic framework connecting a systemic farm characterization with the redesign and led to different redesign solutions than previous co-innovation projects that used other frameworks. The mechanistic approach of MEDITAE supports the evaluation of agroecology policy support, enhances agronomist training, supports technical advisors' work, and helps in framing inter- and transdisciplinary research. Finally, MEDITAE has a flexible structure that allows its application in other regions, systems, and scales.

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The correct citation of this book of abstracts is:

Farming System design for sustainable agrifood systems: theories and practices, proceedings of the 8th International Farming System Design Conference, Marion Casagrande, Marie-Hélène Jeuffroy, Gentiane Maillet, 2025. DOI: 10.17180/j9xc-fs91

The correct citation of articles in this book of abstracts is:

Authors, year, *title*. on: Farming System design for sustainable agrifood systems: theories and practices, proceedings of the 8th International Farming System Design Conference, Marion Casagrande, Marie-Hélène Jeuffroy, Gentiane Maillet, 2025. DOI: 10.17180/j9xc-fs91