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Title

An Open and Participatory Living Lab Framework for Soil Respiration Monitoring: A Pilot Approach in Biodistricts

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Abstract

Soil respiration represents one of the largest carbon fluxes between terrestrial ecosystems and the atmosphere, serving as a critical indicator of soil biological activity by integrating microbial processes and root respiration (Raich & Schlesinger, 1992; Davidson & Janssens, 2006). Despite its importance, current monitoring is often hindered by high costs and low spatial resolution, limiting the accessibility of data for farmers and local policy-makers (Pumpanen et al., 2004; Bond-Lamberty & Thomson, 2010).

This study proposes a methodological framework for an open, scalable soil respiration monitoring system designed to operate within the **Living Lab** model. By utilizing **Biodistricts** as functional territorial units, the framework facilitates the co-creation of knowledge between researchers and land managers. The technical architecture integrates portable gas chromatography for high-precision validation with modular soil chambers and low-cost NDIR sensors to capture CO₂, CH₄, and N₂O fluxes. This hybrid approach addresses three fundamental research questions:

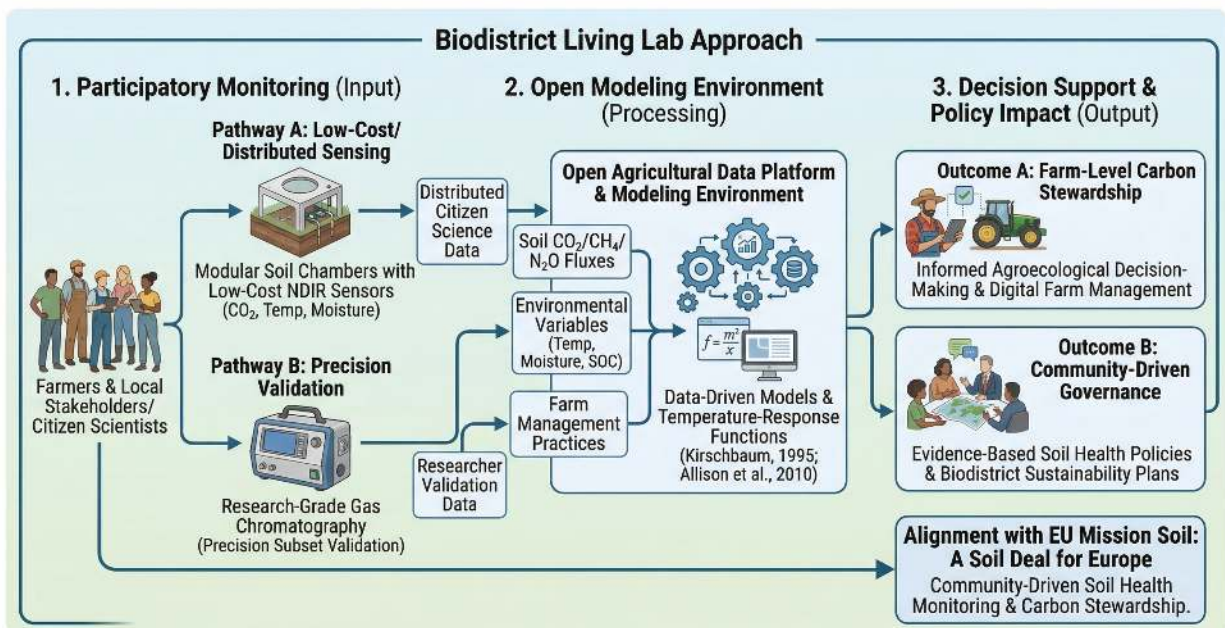
1. To what extent can distributed low-cost sensing arrays match the accuracy of laboratory-grade instrumentation at a landscape scale?
2. How does the active involvement of farming communities in participatory monitoring (Citizen Science) influence the adoption rate of carbon-sequestering practices?
3. Can an open-source modeling environment effectively integrate heterogeneous environmental data (moisture, temperature, Soil Organic Carbon) to provide real-time decision support for agroecological transitions?

Measurements are processed through an open modeling environment based on temperature-response functions (Kirschbaum, 1995; Allison et al., 2010), designed to interface with digital farm management systems and open agricultural data platforms.

By aligning with the **EU Mission: A Soil Deal for Europe**, this framework demonstrates how the Living Lab approach in Biodistricts can bridge the gap between high-level soil health policies and ground-level implementation. It provides a robust pathway for community-driven environmental governance, supporting carbon stewardship and the scaling of emerging innovations in soil monitoring technologies.

Keywords: Soil Carbon, Monitoring Systems, Living Labs, Biodistricts, Citizen Engagement, Open Hardware.

Figure 1: Conceptual Framework for Open & Participatory Soil Respiration Monitoring in Biodistricts.



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