OPEN SOURCE SOIL HEALTH MONITORING KIT

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SUMMARY

Smallholder farmers and supporting organizations often lack affordable, locally maintainable tools for relating soil measurements to management practices. We present a modular, open-source soil-health monitoring kit developed through participatory prototyping in Mendoza, Argentina. It integrates open hardware, accessible analytical protocols, interoperable data collection, and software for data integration and visualization. The main outcome is a documented, reproducible prototype covering the workflow from sampling and contextual data collection to analysis and interpretation. Hardware openness alone proved insufficient: reproducible protocols, contextualized ontologies, data interoperability, and participatory learning are equally important for community based science, FAIRer data practices, and agroecological commons.

KEYWORDS: community based monitoring, agroecology, active carbon, soil respiration

1 INTRODUCTION

Soil-health assessment can help farmers understand management effects, yet laboratory equipment and centralized services may be inaccessible to smallholder communities. Measurements without consistent metadata are also difficult to interpret, compare, and reuse. Since 2022, the Open Agroecology Laboratory has worked with two farmer organizations in Mendoza, Argentina, using open technologies as measurement instruments and mediators of collective learning (Castro et al., 2024).

Workshops revealed limited time for farmer-led records and a lack of open tools for continuous monitoring. We therefore co-developed and evaluated a modular set of tools for participatory experimentation and locally autonomous assessment, treating hardware, protocols, software, vocabularies, and practice as one open science technological infrastructure.

2 METHODS

During 2026, the Open Agroecology Laboratory worked with technicians from INTA and the National University of Cuyo. An initial prototype was refined through pilots and workshops; feedback from construction, sample processing, data entry, and interpretation informed successive changes.

The kit combines a 520 nm colorimeter, a pH/electrical-conductivity meter, a sensor-based respiration chamber, a low-cost incubator, and 3D-printed accessories. Protocols cover physical, chemical, and biological indicators, including texture, aggregate stability, particulate organic matter, pH, electrical conductivity, active carbon, phosphorus, macrofauna, circular chromatography, and respiration. Most were adapted from Vanek et al. (2018); aggregate stability uses SLAKES (Flynn et al., 2020), and the respiration chamber was developed within the project (Castro et al., 2026).

SurveyStack forms adapted to Common Farm Conventions and Argentine ontologies collect management and production-system context. A web application links these records with laboratory results and customizable visualizations. Evaluation comprised prototype operation, iterative refinement, and participant feedback rather than a controlled comparison of agronomic treatments.

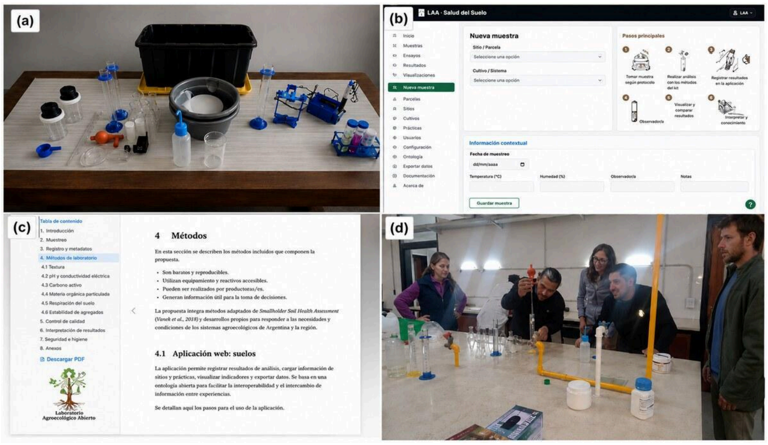

Figure 1. Kit components: (a) instruments; (b) web application; (c) open manual; and (d) participatory evaluation workshop.

3 RESULTS AND DISCUSSION

The documented, reproducible prototype covers the full workflow from sampling and contextual data collection to analysis, visualization, and interpretation (Open Agroecology Laboratory, 2026). Participants jointly performed analyses and related indicators to management. Autonomous operation encouraged appropriation of the methods and understanding of how measurements are produced.

A shared ontology created a basis for comparing observations across territories. Context remains essential because meaningful reference ranges depend on soil type, production history, and sampling procedures.

Limitations included time for recording, adaptation across contexts, calibration and maintenance, and data governance. Interoperability does not guarantee responsible reuse: communities must decide how information is shared. Thus, protocols, contextualized ontologies, interoperability, and participatory learning are as important as hardware openness.

4 CONCLUSIONS

Open science hardware can support participatory soil health monitoring when embedded in accessible protocols, interoperable data, and collective interpretation. Regional calibration, maintenance, local benchmarks, and community-led governance remain priorities for autonomous assessment and agroecological commons.

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