Assessing the Potential of Agroforestry Systems to Improve Soil Health and Climate Resilience

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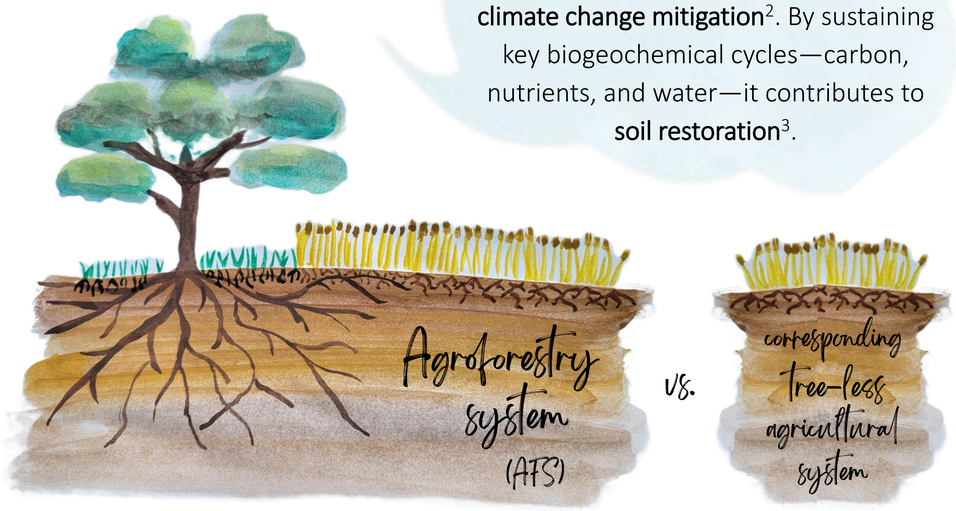
What is *agroforestry*?

Agroforestry is the intentional **integration of trees** into farmland, alongside crops and/or livestock, where woody and non-woody elements **interact** ecologically and economically[1].

Why does agroforestry matter?

Agroforestry is a nature-based solution that enhances **biodiversity**, strengthens agroecosystem **resilience**, and supports **climate change mitigation**[2]. By sustaining key biogeochemical cycles—carbon, nutrients, and water—it contributes to **soil restoration**[3].



What are our objectives?

Although research on agroforestry systems (AFS) has expanded[4], it often overlooks the complexity of soil health, focusing on a limited set of parameters. A deeper understanding of AFS and their impact on **soil** and **water dynamics** is essential to evaluate their role in building resilient agroecosystems. This thesis addresses this gap through the following three studies:

1 Second-Order Meta-analysis on the Impacts of Agroforestry on Soils

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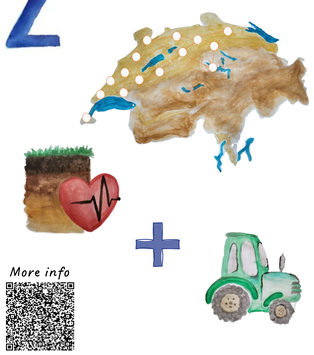
RESEARCH QUESTIONS

1. What **published evidence** exists on the effects of AFS on soil parameters?
2. What are the **effect sizes** of soil parameters in AFS compared to tree-less systems?
3. How do **climate** regions and **AFS practices** influence these effects?
4. How **reliable** are the observed effects?

METHODS

- Identification of Meta-analysis
- EU-iMAP protocol[5]
- Quality assessment
- Primary studies overlap
- Sensitivity analysis
- Random-effect & Robust Baysian Meta-Analysis[6]

2 Soil Health in 33 Silvoarable Agroforestry Systems



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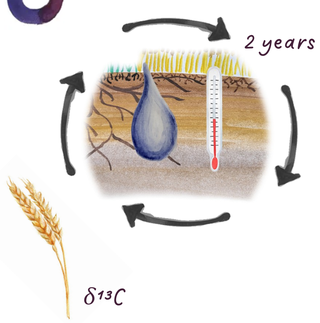
RESEARCH QUESTIONS

1. Do AFS influence the **physical**, **chemical**, and **biological** properties of soil?
2. How do AFS **characteristics**—such as system age, tree density, and species diversity—affect soil properties?
3. Which **agricultural practices** enhance the positive effects of AFS on soil health?

METHODS

- Network of 33 farms
- Measurement of soil biological, chemical, and physical parameters
- Survey on agricultural management practices, and use of *SoilManageR*[7] (tillage intensity and C input indicators)

3 Water Dynamics and Tree-Crop Competition



RESEARCH QUESTIONS

1. What are the **seasonal dynamics** of soil moisture, matrix potential, and temperature in AFS?
2. Is there evidence of **water stress** gradient in crops grown within AFS?
3. Does **water infiltration** increase near trees?

METHODS

- Sensor measurements (matrix potential, soil moisture, and T°) along transects at two depths in one AFS over two seasons
- Crop flag leaf and mature plant $\delta^{13}C$ signature, plus crop yield
- Water infiltration measurements

References: **1.** Leakey (2017). Chapter 1 - Definition of Agroforestry Revisited. Multifunctional Agriculture. https://doi.org/https://doi.org/10.1016/B978-0-12-805356-0.00001-5. **2.** Azhar et al. (2024). Regenerative Agroforestry for Soil Restoration, Biodiversity Protection, and Climate Change Mitigation. Regenerative Agriculture for Sustainable Food Systems. https://doi.org/10.1007/978-981-97-6691-8_13. **3.** Cardinael et al. (2020). Belowground functioning of agroforestry systems: recent advances and perspectives. Plant and Soil. https://doi.org/10.1007/s11104-020-04633-x. **4.** Köthke et al. (2022). The evidence base on the environmental, economic and social outcomes of agroforestry is patchy—An evidence review map. Frontiers in Environmental Science. https://doi.org/10.3389/fenvs.2022.925477. **5.** Schievano et al. (2025). Umbrella-review of meta-analyses – A methodological framework to support evidence-based policymaking. Publications Office of the European Union. https://doi.org/doi/10.2760/4592550. **6.** Bartoš et al. (2023). Robust Bayesian meta-analysis: Model-averaging across complementary publication bias adjustment methods. Research Synthesis Methods. https://doi.org/https://doi.org/10.1002/jrsm.1594. **7.** Heller et al. (2025). SoilManageR—An R Package for Deriving Soil Management Indicators to Harmonise Agricultural Practice Assessments. European Journal of Soil Science. https://doi.org/https://doi.org/10.1111/ejss.70102.

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