A Machine-Learning-Based Procedure to Assess Land Degradation and Restoration Potential in the Mediterranean

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How can we scale local knowledge and sustainable solutions to broader territories without losing their contextual relevance? Land degradation is a pressing issue in the Mediterranean, where diverse environmental and socio-economic conditions exacerbate its impacts. While bottom-up approaches excel in leveraging existing skills, contextual knowledge, and practical problem-solving, their results often remain tied to specific territorial contexts. The challenge lies in generalising and extending these insights to new regions, enabling effective and scalable land management and restoration strategies.

The REACT4MED project (https://react4med.eu/), funded by PRIMA (https://prima-med.org/), promotes the creation of Ecosystem Restoration Living Labs (ERLLs) in diverse Mediterranean contexts to harmonize the assessment of soil degradation and evaluate the impacts of the implemented restoration measures.

In the context of this project, we explore the potential up- and outscaling of the project's restoration measures adopting a Machine-Learning-Based Procedure that integrates experts' knowledge from living labs and a machine-learning tool sourced with global and regional datasets.

This procedure defines homogeneous areas based on different kinds of indicators (e.g. climatic trends, socio-economic circumstances, land degradation severity) through a clustering algorithm to support policymakers in analysing the feasibility of upscaling the implemented restoration measures.

We established a methodological approach that encompasses a workflow structured as follows:

- Computing a large number of candidate inputs (biophysical, climate, and socioeconomic indicators) for a reference period.

- Selecting inputs with a data-driven approach, using correlation analysis and Principal Component Analysis (PCA).

- Performing clustering analysis (k-means) to delineate areas with similar characteristics across the Mediterranean region.

- Using the clusters to inform expert-based analyses, incorporating high-resolution datasets and local expert input to identify suitable areas for restoration actions.

The Machine-learning tool can be sourced with both historical and future climate and socio-economic scenarios and thus facilitates data-driven decision-making for land restoration, providing valuable insights for policy and action.

Built on an open-source technology stack, the ML tool has been released as open-source software at https://gitlab.com/lands-r4m/ml_tool and tested on the pilot areas of REACT4MED. This tool is a key component of Land Degradation Decision-Support Toolbox (LanDS), which is freely available at http://lands.soft-water.it.