LanDS requirements and specifications

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

REACT4MED

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List of acronyms

CIHEAM Bari: Istituto Agronomico Mediterraneo di Bari
CLI: Command Line Interface
CY: Cyprus
CyI: The Cyprus Institute
CMS: Content Management System
D: Deliverable
DB: Database
DM: Decision Maker
DoA: Description of Action
EG: Egypt
ES: Spain
ERLL: Ecosystem Restoration Living Lab
GA: Grant Agreement
GR: Greece
HMU: Hellenic Mediterranean University
IDF: Intensity Duration Frequency
IL: Israel
INRA: Institut National de la Recherche Agronomique
IT: Italy
JSON: JavaScript Object Notation
LanDS: Land degradation Decision-Support
M: Month
ML: Machine Learning
MO: Morocco
MS: Milestone
NGO: Non-Governmental Organisation
PA: Pilot Area
PAL: Pilot Area Leader
PDS: Participatory Development Solutions
PP: Project Partners
PRIMA: Partnership for Research and Innovation in the Mediterranean Area
SH: Stakeholder
SOFTW: SoftWater s.r.l.
TR: Turkey
TUC: Technical University of Crete
UH: University of Haifa
UOS: Osnabrück University
UTAEM: Turkish International Agricultural Research and Training Center
UV: Universidad de Valencia
WFS: Web Feature Service
WMS: Web Map Service
WP: Work Package
WS: Workshop

Executive Summary

Deliverable D4.1 describes the main features and requirements of the LanDS toolbox foreseen at this stage of the project, following the outcomes elaboration of the stakeholders' involvement process in the Ecosystem Restoration Living Labs according to WP4 scopes. The LanDS development is driven by a co-creation approach, involving stakeholders and decision-makers in the design and evaluation of the toolbox, to ensure portability and maximise the effectiveness of the toolbox. This involves a tight collaboration with WP3 and pilot area leaders, who are our first source of information in the different study areas, but also with WP2, which reviews and provides significant literature and broad-level biophysical and socio-political indicators, including earth-observed land productivity and climatic trajectories, on which the LanDS also builds on. Combining state-of-the-art indicators with background and new site-specific knowledge from the living labs, the LanDS will support better-informed land restoration actions and more sustainable water management, allowing – at a later stage of the project – public and private actors to identify investment opportunities based on the criteria of maximum cost-effectiveness and impact (in collaboration with WP5 and WP6).

The concept of the LanDS was introduced in the first run of the living labs to collect stakeholders' feedback for better shaping the purposes and functionalities of the toolbox. The LanDS is composed of the following five tools: (1) a geo-referenced data repository to collect site-specific data from the living labs and broader scale information from global or regional public repositories; (2) a data viewer, i.e., a web interface to serve as the most powerful access point to the data repository; (3) an indicators library, i.e., a set of processing routines to implement a set of indicators both quantifying land degradation processes and land restoration action effects; (4) a machine learning procedure to identify potentially suitable areas in the Mediterranean for up or out-scaling of restoration measures; (5) a web interactive dashboard, providing a harmonised land degradation assessment and evaluation of impacts of restoration measures with the support of a user-friendly interface. The web dashboard will enable the comparison and integration of different data, information, and project results, targeted to decision and policy makers or international agencies officers. Finally, future projections of climate and land-use change, and socio-economic scenarios will facilitate the detection of potential degradation trends in medium and long-term time horizons, orienting policy recommendations and support decision-making processes.

This report expands Milestone MS4.1 (Stakeholders Feedback collected), which presents a broad characterisation of the pilot areas and main outputs collected from the first round of workshops run until the end of February 2023.

1 Introduction

REACT4MED aims to extend the potential application of the land restoration actions promoted in the Ecosystem Restoration Living Labs (ERLLs) running in the different pilot areas (PAs), to the Mediterranean scale. Within the project, Work Package 4 (WP4, Science-based decision support toolbox) efforts are focused on developing a scientific Land degradation Decision-Support Toolbox (LanDS) and applying it at different spatial and temporal scales. The LanDS development is driven by a co-creation approach, involving stakeholders (SHs) and decision-makers (DMs) from ERLLs in the design and evaluation of the toolbox, to ensure portability and maximise the effectiveness of the toolbox. This involves a tight collaboration with WP3 and PA leaders, who are our first SHs and information source in the different study areas, but also with WP2, which reviews and provides significant literature and broad-level biophysical and socio-political indicators, including earth-observed land productivity and climatic trajectories, on which the LanDS also builds on. Thus, combining state-of-the-art indicators with background and new site-specific knowledge from the ERLLs, LanDS will support better-informed land restoration actions and more sustainable water management, allowing – at a later stage of the project – public and private actors to identify investment opportunities based on the criteria of maximum cost-effectiveness and impact (in collaboration with WP5 and WP6). Finally, restoration out-scaling will be further supported beyond the lifetime of the project by open access to the decision support tools developed. An overview of the REACT4MED WPs interaction and planning during the project's lifetime is shown in Figure 1 (from the Description of Action - DoA, i.e., Annex I of the GA).

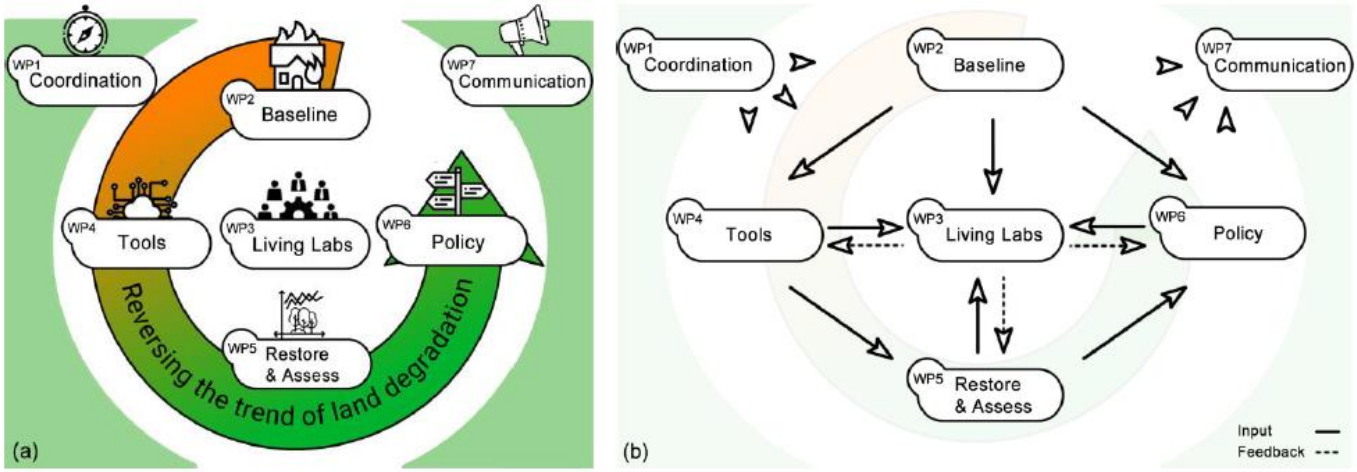

Figure 1 REACT4MED Work Package (WP) structure (a) and information flow within its conceptual framework (b).

In this context, Deliverable 4.1 (D4.1, LanDS requirements and specifications) consists in a report which defines the specifications and requirements of the LanDS, integrating the outcomes of the co-design process that emerged in the first round of ERLLs workshops (WSs). This toolbox (see Figure 2) is composed of five different tools performing different tasks: (1) a geo-referenced data repository serving as a knowledge base by collecting site-specific data and resources from the ERLLs (WP3) as well as broader scale information from global or regional public repositories (WP2); (2) a set of visual analytics tools linked with this repository allowing the effective sharing and access to data among project partners (PP) and SHs and supporting the dissemination of project outcomes (WP7); (3) an indicators library implemented as a modular and generalized code library applicable to different geographical contexts based on collected data and indicators identified in WP2; (4) a machine learning procedure to identify potentially suitable areas in the Mediterranean for up or out-scaling of restoration measures; (5) a web interactive dashboard, providing a harmonised land degradation assessment and evaluation of impacts of restoration measures, as well as a user-friendly interface. In a final phase, plausible combinations of future climate and land-use change, and socio-economic scenarios will facilitate the detection of potential degradation trends in medium and long-term time horizons, providing useful insights to orient policy recommendations and support decision-making processes (WP5 and WP6).

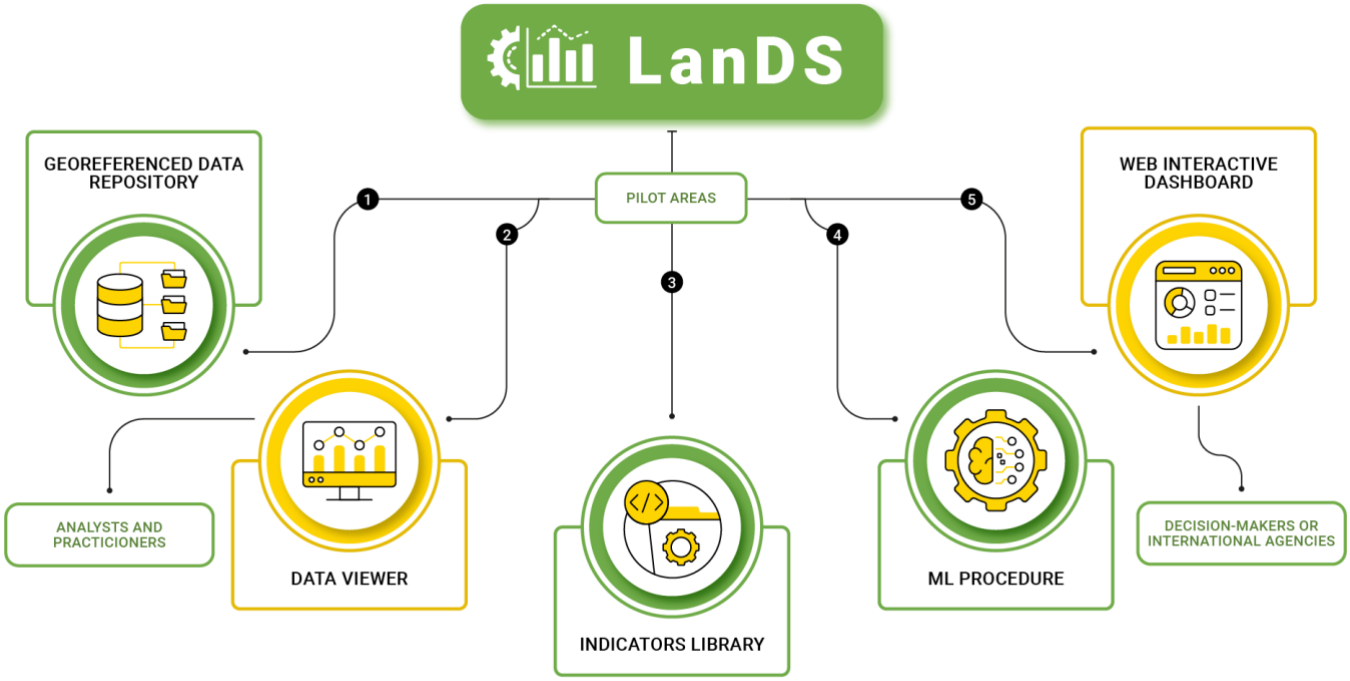

Figure 1 Scheme of the LanDS toolbox, composed of five main tools, to be developed until the end of the project (April 2025).

The report is structured as follows: after this introduction, we first describe the methods applied to engage SHs in the co-design process of the first loop of ERLLs (Section 2), and then define the requirements and specifications of the LanDS toolbox (Section 3). These start with a broad characterisation of the PAs, to then present the different SHs feedback collected in the ERLLs so far, elaborated in a flexible way, based on the workshop formats and LanDS purposes. We conclude with some final remarks and a brief overview of the next steps (Section 40). The references and the Annexes complete the document.

2 Methods

The LanDS co-design process took place in the context of the first meeting of the ERLLs organised by each Pilot Area Leader (PAL), based on a method guide developed by WP3, which is reported in the Annex 1 of this report. We have contributed to the LanDS-related part (Sections III and IV of Annex 1), starting from a broad pilot characterisation, and further planned in online meetings and information exchange with PALs and WP3 leading partner (UOS). The stakeholders involved in the workshops belong to different target groups, from farmers, to researchers and analysts, to policy and decision-makers.

2.1 Co-design in ERLLs

The first round of REACT4MED ERLLs started with the first workshop on the 1st of December 2022 in Bethlehem, Israel (IL), following a plenary project meeting on 28-30 November in Haifa, hosted by the University of Haifa (UH). Table 1 reports the full schedule of the first round of ERLLs in the PAs until February 2023. The identification numbers and the names of the PAs are referred to Table 1.2 of the DoA (expanded in Table 2 of this report). The only exception is made for the Turkish PA, which was renamed Lower Gediz, to consider a larger area also including Menemen, as well as more SH groups, as indicated by the Turkish PAL.

Table 1 Schedule of the first round of REACT4MED ERLLs in the PAs until February 2023. The identification numbers and the names of the PAs are referred to Table 1.2 of the DoA (expanded in Table 2 of this report), except for the Turkish PA, which was renamed Lower Gediz, to include a larger area and SH groups, as indicated by the Turkish PAL.

#	Pilot area	1st round of ERLLs	Format	SoftWater participation	Co-design activities
6	Bethlehem of Galilee (IL)	1 Dec. 2022	1-day WS	In-presence	LanDS session included (presentation and follow-up interviews)
7	Lower Gediz (TR)	21 Dec. 2022	1-day WS	Online	LanDS session included (presentation and interactive activities)
4	Canyoles (ES)	14 Jan. 2023	1-day WS	-	LanDS concept introduced
2	Heraklion (GR)	27 Jan. 2023 2 Feb. 2023	2-days WS involving different target groups and agenda	Online	LanDS session included (presentation and interactive activities) on the second date (involving target groups with higher technical skills)
1	Troodos Mountains (CY)	1 Feb. 2023	1-day WS	-	LanDS concept introduced and follow-up interviews
3	Stornara and Tara (IT)	7 Feb. 2023	1-day WS	In-presence	LanDS session included (presentation and interactive activities)
5	Merchouch (MO)	WS has not been held yet			
8	Tamia (EG)	WS has not been held yet			

Looking at Table 1, it can be observed that the workshops have been held with different formats and contents, depending on the PAL and the SH groups involved in this first stage. Within each meeting, the LanDS part was adapted in a flexible way, according to PAL indications and WP3 guidance (more details are provided in the next Section 2.2).

2.2 Driving questions

The driving questions that we tried to address in the ERLLs for the LanDS co-design process are mainly oriented to collect SH feedback on issues, data, maps, indicators and actions useful to shape the LanDS

toolbox, as well as its main purposes and functionalities. Despite the different formats of the workshops, the main narrative followed to present the LanDS in the ERLLs includes the following key points:

- introduction to the lands co-design process;
- starting from the Rich Pictures exercise outcomes, follow-up on issues identification (see Section I of Annex 1);
- zoom on the specific Pilot Area;
- introduction to the lands concept and main purposes;
- overview of the next steps.

Starting from REACT4MED scope of extending the potential application of the land restoration action(s) promoted in the ERLLs, we introduced the LanDS co-design process targeting the following questions:

- which information do you have, either quantitative or qualitative, about land degradation processes in your area?
- which are the main drivers and barriers to broaden the land restoration process?

Consequently, to shape the main purposes of the LanDS data repository, data viewer, and indicators library (see Section 3.3), we proposed the following questions to the PAs and, thus, to the stakeholders (the addressed target groups are indicated in brackets):

- which are the land degradation issues in the agricultural sector of your area? (target groups: all)
- which land restoration practices do you apply, or do you know of? (target groups: all)
- which data/information/indicators exist to measure the land degradation issues in your area? (target groups: analysts and practitioners)
- which data/information/indicators exist to measure the performance of restoration practices in your area? (target groups: analysts and practitioners)

The discussions held in the ERLLs after posing those questions and outcomes emerged are meant to lead us to data, maps, and existing or adopted tools to be integrated into the LanDS and to shape its development.

Since the session on issues identification was usually scheduled previously to the LanDS session, we took advantage of its outcomes (rich pictures of issues and problems in the PA) showing them in our presentation, to make the linkage to the next steps to be introduced.

In the Annex 2, we report the LanDS presentation held in the Lower Gediz (TR) ERLL as an example.

3 Requirements and specifications

In this section, we first describe the different PAs included in REACT4MED, expanding the general characterisation introduced in the DoA (specifically in Table 2.1) with the integration of additional information provided by PALs and retrieved in the literature or previous projects (see Section 3.2), to then present the different inputs and feedback collected by the SHs during the first round of ERLLs (see Section 3.2), which are considered interesting for WP4 scopes. As indicated in Table 2, we included PA leaders among SHs involved in the LanDS co-design process, because they will act, all along the project, as a bridge between PA needs and LanDS development activities, and then the representatives of the various target groups involved in the workshops. Notably, the information gathered from the different PAs was elaborated and adapted in a flexible way, depending on each PA and on the format of the corresponding workshop held (see Table 1 for reference). In Section 1.3.1 and Table 1.2 of the DoA, which is expanded here in Table 2 building on the knowledge basis that exists at the local scale shared by PALs in previous project meetings, as well as on literature research and outcomes of past and ongoing projects with similar aims as the ones of REACT4MED.

3.1 Pilot areas characterisation

The characterisation of the PAs is considered a fundamental step to frame and shape WP4 technical developments. Such analysis starts from the project's concept overview provided in Section 1.3.1 and Table 1.2 of the DoA, which is expanded here in Table 2 building on the knowledge basis that exists at the local scale shared by PALs in previous project meetings, as well as on literature research and outcomes of past and ongoing projects with similar aims as the ones of REACT4MED.

Table 2 Overview of REACT4MED Ecosystem Restoration Living Labs in the Pilot Areas (expanded from Table 1.2 of the DoA).

#	Pilot area	Threat	SLWM practices	Committed SHs
1	Troodos Mountains (CY)	Soil erosion, due to the main issues: • land abandonment • extensive construction of terraces by mechanized land work • loss of fertile topsoil • large erosive rainfall events (> 100 mm/d)	• Communal mountain terrace maintenance • Capacity building (restoration activities initiated during the RECARE project[1] and 3PRO-TRODOOS[2])	PAL: CyI Ministry of Agriculture, Rural Development and Environment, mountain communities, Trodoos Development Company, Farmer unions, SMEs
2	Heraklion (GR)	Soil erosion, due to the main issues: • overgrazing and fires • groundwater pumping and salinity intrusion • water stress due to droughts • land abandonment and urbanisation	• Afforestation (shift to silvopastoral system with over 25 ha of newly forested land) • Native plants selection, native greening (restoration activities initiated during the CASCADE project[3])	PAL: HMU Region of Crete, Dept of Environmental Planning, landowners and land managers, SMEs (agricultural consultants)
3	Stornara and Tara (IT)	Salinisation and groundwater decline, due to the main issues:	• Advanced irrigation systems and improve distribution management	PAL: CIHEAM Bari Farmers' Water Use Association, Water Consortium, Regional

[1] https://www.recare-hub.eu/case-studies/peristerona
[2] https://3pro-troodos.cyi.ac.cy/en/
[3] https://www.cascadis-project.eu/messara-greece

#	Pilot area	Threat	SLWM practices	Committed SHs
		• lower precipitation, summer droughts • inefficient irrigation water distribution • sandy/ alluvial soils • distributed private wells (~ 6000) for groundwater pumping and salinity intrusion increase	• Remote technology and sensors to monitor water use efficiency • Water harvesting developing farm storage reservoirs	authority (Puglia Region), environmental agency (ARPA Puglia)
4	Canyoles (ES)	Soil erosion and degradation, due to the main issues: • bare soils, soil sealing (water losses) • water stress due to droughts • high production of citrus (commercial) • tillage, drip-irrigation and intense fertilization (herbicides)	• Chopped pruned branches as mulch to control/reduce soil and water losses • Farmer awareness campaigns/ capacity building • EU subsidies to favor drip irrigation (straw mulching restoration activities initiated during the RECARE project[4])	PAL: UV Farmers, owners, citizens, regional and local and national governments, organic farming committee, farmers' unions
5	Merchouch (MO)	Soil quality degradation and erosion, as well as water deficit, also due to high climate variability	Promotion of conservation agriculture, diversified cropping systems, and integrated soil fertility management	PAL: INRA Departments of agriculture and environment, Extension service, Research & Development, Higher Education, NGOs, Farmers, Service providers and private sector
6	Bethlehem of Galilee (IL)	Biodiversity decline	Orchard transformed into a food forest	PAL: UH Farmers' unions, organic farming committee, Ministry of Agriculture, Rural Development and Environment, Ministry of Environmental Protection
7	Lower Gediz (TR) (formerly, Menemen)	Soil salinity, alkalinity, due to the main issues: • droughts • loamy and salty-alkaline, insufficiently to poorly drained soils • sediment alluvium deposit and river banks erosion • high gw salinity in the rainy period and	• Plant growth-promoting rhizobacteria, green manure, enhancing organic matter, enhancing drainage • Selection of new species for the region, e.g. *Calendula officinalis* • Farmer unions and volunteers in different regions	PAL: UTAEM Ministry of Agriculture and Forestry, Chamber of Farmers, Water Users' Association, Research Institutions, Cooperatives

[4] https://www.recare-hub.eu/case-studies/canyoles-river-basin-spain

#	Pilot area	Threat	SLWM practices	Committed SHs
		irrigation period, measurements of groundwater levels and conductivity maps for salinity assessments can be found in (Korkmaz et al. 2015) • sediment alluvium deposit and river banks erosion • wrong practices in water and land management • decreasing soil productivity	• Irrigation control/ monitoring systems • Land reclamation (sustainable groundwater management is being explored also in the ongoing RESERVOIR project[5], funded by PRIMA)	
8	Tamia (EG)	Soil salinity and erosion	Soil amendments, mulching, drainage, modern irrigation, salt-tolerant varieties	PAL: PDS Ministry of agriculture, Fayoum University, Farmers association

Most of the PAs are struggling with soil erosion and salinisation caused by different issues, such as climate extremes, overexploitation of groundwater resources, and overgrazing, against which some of the already initiated or potential restoration actions proposed by the PALs are:

- conservation agriculture (MO);
- terracing (CY), e.g., (Camera et al. 2018);
- cover crops/ mulching (ES, EG), e.g., (Prosdocimi et al. 2016);
- afforestation (GR), e.g., (Jucker Riva et al. 2017);
- higher-efficient irrigation technology (IT, EG), e.g., (Giordano et al. 2013);
- soil amendments (TR, EG);
- higher-efficient irrigation technology (IT, TR, MO).

The problem of loss of biodiversity (IL, GR) can be addressed e.g., by planting native species. Notably, native greening contributes to social, economic, and environmental sustainability, because of their potential in restoring ecological balance, create a microclimate, stimulate plant growth, and in such a way support ecosystem services (Christoforidi et al. 2022).

The involvement of local stakeholders in the different PAs is essential to ensure bottom-up support and to maximize capacity-building benefits and, thus, productive livelihoods, food security, and employment. The broad and interdisciplinary expertise of the project partners in environmental monitoring such as remote sensing (GR, IL, IT), irrigation modelling (IT, TR, MO, GR), soil health (ES, CY, GR, IT, TR), and vegetation health (GR, IT, MO, TR, EG) is an asset to cross-fertilise knowledge and further advance the ongoing or potential land restoration actions.

3.2 Stakeholders feedback collected

The first round of ERLL workshops provide a number of significant information, useful for the LanDS development. The SH feedback collected is based on the methods presented in Section 2, depending on the different approaches implemented during the first workshop in each PA (see Table 1). The effort of

[5] https://reservoir-prima.org/

elaboration made by WP4 was supported by WP3 and fed by the material shared by PALs so far, which results in a summary of the main issues, data, maps and/or existing indicators (qualitative and/or quantitative information), actions/solutions and additional interests pointed out during the workshops by the SHs in the different PAs, when the information is available.

The postprocessing of the available material collected after the first round of ERLLs until end of February 2023 is reported in Tables 3-7, respectively for the PAs in Cyprus, Greece, Italy, Israel, and Turkey. Notably, in all workshops, SHs expressed their intention to be further involved in future project activities.

Table 3 Outcomes of the SH feedback collected in PA1 Trodoos Mountains (CY), after WP4 elaboration, according to the methods described in Section 2.

PA1: Trodoos Mountains (CY)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
• Climate extreme events (e.g., floods, droughts) • High slopes/ difficult terrain for farming • Fragmented and small size of agricultural plots • Use of machinery (costly) for mountains terracing • Missing know-how on mountain terracing • Soil erosion /loss of topsoil • Land abandonment • Small and ageing number of farmers	High-resolution data for the design of sustainable land management practices: • soil texture • available water capacity (field capacity, wilting point) • bulk density • soil depth • saturated hydraulic conductivity of soil • pH of soil • soil organic carbon • saturated hydraulic conductivity of bedrock • effective porosity of bedrock • mean, min and max annual rainfall • rainfall intensity duration frequency (IDF) curves • land slope • upstream area • time of concentration • shear strength parameters (cohesion, friction angle) • land zonation	Main restoration action in focus is the use of terraces in the region. Some potential solutions and measures that are included in the new Rural Development Program (2023-2027) of Cyprus have been presented by the CyI. Further, the SHs have proposed the following solutions to the land degradation problems in Cyprus: • green manure (measure Nitrogen content) • incorporate chopped pruning residues into soil and add them as a mulch layer on topsoil • use of artificial soil and a mixture of compost with inactive (mineral soil) materials • reduce slopes by terraces with conservational design and defined construction methods (measure soil organic matter) • avoid the use of heavy agricultural machinery • ensure maintenance of terraces • need for professional drystone construction crew/partnerships • maintenance of green buffer zones • vegetation on the terrace edge and façade and maintenance of natural vegetation if possible • soil cover	SHs interest in general to be informed and learn, specifically about the following: • where to make or rehabilitate terraces • how to make terraces (hydrologic and geologic engineering design, considering economic efficiency and environmental impacts) • identifying areas of good and bad practices • targeting issues for further research and cooperation • list of existing policies and subsidies on issues identified by stakeholders • manual for mechanized terraces and restoration activities

PA1: Trodoos Mountains (CY)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
		• no-tillage (measured by soil loss/year and change of yield/year) • establish cooperatives for centralised management of resources • use of soil-forming plants	

Table 1 Outcomes of the SH feedback collected in PA2 Heraklion (GR), after WP4 elaboration, according to the methods described in Section 2.

PA2: Heraklion (GR)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
• Climate change: high temperatures, extreme rainfall, floods, fires • Land use change (reduction of arable land) • Overgrazing • Difficult accessibility to the lands (high slopes) • Overexploitation of groundwater leading to salinization • Intensive farming • Improper use of chemicals • Burning of prunnings (rather than mulching or incorporation in the soil) due to the lack of equipment	• Soil texture and fertility • Soil losses per year • Erosion rate • Precipitation • Percentage of precipitation stored in the soil • Land slope • Planting density • Fire-risk assessment per region • Local weather data • Microclimate forecasts • Agricultural alerts • Biodiversity indicators	• Assessment of good practices of land restoration in general • Precision agriculture • Assessment of biodiversity for each practice • Good practices being implemented on established cultivations • Terraces and productivity assessments • Cultivations of native species adapted to local conditions • Use of organic matter • Use of microorganisms • Assessment of the correlation between biodiversity, pollution and production • Quality assessment of olive oil on non-intensive cultivations • Green manure • Foresting degraded lands • Water resources management	Willingness in being further involved in the project and contribute to: • record biodiversity data • recording methods of degradation and restoration • sharing data in the study site • dissemination of good practices • share outcomes in education initiatives

Table 2 Outcomes of the SH feedback collected in PA3 Stornara and Tara (IT), after WP4 elaboration, according to the methods described in Section 2.

PA3: Stornara and Tara (IT)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
• Water Scarcity and/or non-adequate water supply • Fixed irrigation quota and water distribution based on rotation every 10 days • Water losses • Groundwater pumping though private wells (uncontrolled) and consequent salinity intrusion and chemical contaminants • Problems with open channels and pressurized water systems • Modern and innovative agricultural systems are still weakly implemented • Soil data are missing at the farm level	• Soil maps • Salinity measurements • Climate data • Water availability data	• Feasibility study to define the most suitable crops to be cultivated based on soil type and climate conditions (e.g., use of crops that are less water-demanding) • Alternative water sources should be considered to increase the availability of irrigation water • Increase water storing capacities through the creation of new reservoirs/ promote rainwater harvesting • Improve the efficiency of resources management through technology innovation and precision irrigation agriculture (e.g., remote control irrigation technologies and software for irrigation monitoring) • Collect real-time climate data from the nearby weather stations and promote laboratory analysis of soil and water to establish indicator thresholds values	• The lack of adequate water supply system and salinity control could be managed if adequate measures and actions are implemented • New infrastructures (reservoirs) to collect water are needed in the regional territory and/or at farm scale • An efficient supply system based on demand instead of rotation need to be implemented • Modernization of the irrigation network (from open channel to pressurized) could improve the efficiency and reduce the losses • Financial support for efficient and advanced technologies for irrigation and fertilization management at farm level

Table 3 Outcomes of the SH feedback collected in PA6 Bethlehem of Galilee (IL), after WP4 elaboration, according to the methods described in Section 2.

PA6: Bethlehem of Galilee (IL)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
• Climate change • Arid climate, rainfall intensity and runoff • Soil erosion, bare soils • Fires • Use of chemicals (herbicides, pesticides) • Intensive farming and intensive tillage • Lack of biodiversity and monoculture	• Field measurements (soil, microbiome) • Remote sensing data	• Organic farming and market • Gardening • Precision irrigation and fertigation • Research on bio-chemo-geo-hydrological processes in soils to improve yields. soil health and fertility • Enhance Nitrogen use efficiency • Quantify leakiness from agricultural activities by	• Technologies, indicators (easy to understand), and decision support models for local management • Long term measurements and easy-to-understand indicators • Biodiversity and agroecology • Setting standards for soil degradation • Control of greenhouse gases from agricultural activities

PA6: Bethlehem of Galilee (IL)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
• Conservation agriculture • Changing supply and demand due to unexpected events (e.g., COVID-19) • Lack of machinery for sustainable farming (costly) • Urbanisation (non-agricultural use of fertile lands) • Socio-economic issues		combining remote sensing with soil measurements to minimize water losses • Adaptive water and land management • Plants protection and control of diseases • Children education	• Soil conservation and planning • Food security • Dissemination of the Food Forest good practices • Capacity building and knowledge exchange, farmers networking

Table 4 Outcomes of the SH feedback collected in PA7 Lower Gediz (TR), after WP4 elaboration, according to the methods described in Section 2.

PA7: Lower Gediz (TR)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
• Climate change (decrease in precipitation) • Wrong irrigation management and agricultural and manure applications (e.g., excessive tillage, excessive irrigation -> inundated lands; lack of awareness on fertilization and pest management), soil and water erosion, high water table • Illegal wells and salinity intrusion (drainage problem and intrusion of seawater) • industrial wastes in agricultural lands (widespread use of chemicals, polluted irrigation water) • Deforestation and erosion • Non-agricultural use of fertile agricultural lands/urbanization • Decrease in biodiversity • Lack of soil analyses data • Lack of traceability of scientific data	• A regional database (5 years of data, e.g., temperature, crop diversity, plant spacing) is needed: it should be created and publicly displayed • Soil analysis, meteorological, and irrigation efficiency data (including water usage and water quality) must be collected and turn available • Monitoring environmental indicators in the region	• Green manure • Reduced or none soil tillage • Compost, diversification of natural fertilizers • Increasing organic matter, organic manure • Increasing the use of materials with high water holding capacity, such as zeolite • Increasing the carbon ratio • Expanding the usage of cover cropping • Increasing the use of technology in agriculture • Increasing the use of soil moisture sensors by farmers, via Website Platforms and mobile phone apps	• Supporting the data with construction and cadastral plans • Interest in identifying potential areas that represent local problems of land degradation (and the effects of the restoration actions • Interest in future climate and socioeconomic scenarios • Rapid separation of agricultural/industrial areas • Training modules on the application of new agricultural technologies addressed to farmer unions and NGOs • Economic analysis of sustainable restoration practices should be conducted

PA7: Lower Gediz (TR)			
Issues	**Data/maps/indicators**	**Actions/solutions**	**Interests/suggestions**
		• Cleaning of old drainage channels • Subsidies for farmers to ensure their participation in restoration actions • Use of renewable energy sources • Ensuring the dissemination of reduced tillage techniques • Reducing the use of pesticides by ensuring the dissemination of disease-resistant varieties developed by research • The importance of carbon farming should be emphasized • Shallow plowing • Irrigation systems need to be improved • Use salt-tolerant crops in some areas	

3.3 LanDS toolbox

The Land degradation Decision-Support (LanDS) is a toolbox targeted to support REACT4MED participants (partners, stakeholders, and policy makers) in its different tasks and stages. Figure 2 presents the five tools composing the LanDS: they will be released during the entire duration of the project. The present section identifies technical specifications and requirements for each one of them, starting from the characterisation of the pilot areas (Section 3.1) and from input and feedback gathered during the first run of ERLL meetings, as reported in Section 3.2.

3.3.1 Geo-referenced Repository

The Geo-referenced Repository (also referred to simply as “repository” from now on) is the first building block of the LanDS: it is targeted to be a cross-cutting source of data and information for all the other tools, potentially accessed and populated by all project partners and by ERLLs stakeholders (MS4.2, due at M12). In order to fulfil this goal, the following features are needed:

- data included in the repository can be at different spatial scales and resolutions, ranging from very detailed data collected in the ERLLs to datasets from high (e.g., 100 m, 1 km) to low resolution (e.g., 50 km) produced at the global scale from international agencies and research institutes and

published through open access data repository (e.g., Copernicus Climate Data Store[6]). The different scales should be managed by categorizing data for at least three different spatial entities: pilot area, country and Mediterranean region;

- the repository has to manage both measured and simulated data, the latest referring to both past and future periods. Different scenarios have to be considered to allow comparisons;
- two different approaches for data upload have to be set up:
    - a command line interface (CLI), to process massive quantities of data, following a predefined data structure and producing data immediately available to visualization and processing tools;
    - a guided user interface, accessible through most common web browsers, to allow all registered users (e.g., PALs, partners and eventually qualified SHs from different ERLLs) to upload any kind of data, with limited constraints on data format. These data will be immediately available in the repository, but they will require a post-upload validation and processing step to be available for the Data Viewer and other tools. This processing will be operated through a software component, namely a *parser,* developed ad hoc as part of the Indicator Library tool;
- a minimum set of metadata has to be included for each dataset. DataCite's Metadata Schema minimum and recommended terms[7] can be used as a benchmark, consistently with the approach adopted by Zenodo repository[8];

Information gathered from the PA characterisation (Section 3.1) identify a vast and diverse assortment of datasets to populate the repository including:

- **Static distributed dataset,** considered as not changing over the time frame of the project. These data can be stored as raster files and eventually combined/compared with regional datasets presenting the same information at different scales. Examples of this kind of dataset are soil texture, soil depth, saturated hydraulic conductivity of soil and other soil features data reported in Table 3, PA1 (Cyprus).
- **Dynamic distributed dataset,** expected to change over time horizons considered by the project, like:
    - distributed climate data time series, reported as relevant by all PALs (e.g., precipitation, temperature);
    - soil degradation on going processes, like soil erosion (relevant for PAs 1, 2, 4, 5 and 6) or salinisation (relevant for PAs 3, 7 and 8);
    - land zoning or use changes (PA1 and 2), surface and groundwater availability (PA3), crop diversity (PA7).
- **Lumped information**, either static or dynamic, related to specific sites, like mean, min and max annual rainfall of a given station and its related intensity duration frequency (IDF) curves (PA1) or water use efficiencies parameters of irrigation districts (PA3).

[6] https://cds.climate.copernicus.eu/#!/home
[7] https://schema.datacite.org/
[8] https://zenodo.org/

To cope with this heterogeneity, the repository will be structured by two main components, able to manage effectively all type of data:

- a relational geo-database, including a catalog of all data present in the repository, able to manage lumped data, time series variables and indicators, geographic objects like points, lines and polygons;
- a semi-structured filesystem repository, where all spatially distributed data (e.g., raster time series) can be stored and labelled in order to ensure flexible and multiple categorizations of data.

Figure 3 presents the first version, still subject to changes before the next Milestone release (MS4.2 in M12), of the relational database (DB) scheme, a graphic representation of tables included, related fields and their relationships. The tables reported in the schema are meant to contain the following content:

- the **catalog** table contains description, location (link to the table **places**) and features of all uploaded datasets, which can be divided into three main categories, each one with its own child table: **parameters, indicators,** and **variables**;
- the **places** table includes all the relevant location (e.g., gauging stations, pilot areas, administrative boundaries) and their geographical representation in term of **points**, **lines** and **polygons**;
- the **charts** table contains the list of all chart types served by the platform, together with information and settings needed to activate the Application Program Interface in the Data Viewer (see Section 3.3.2). The related **chart_catalog** allows to link chart types and datasets;
- the **experiments** table allows to distinguish, if needed, datasets related to different model runs;
- the **scenarios** table allows to distinguish, if needed, datasets related to different climate or socio-economic scenarios.

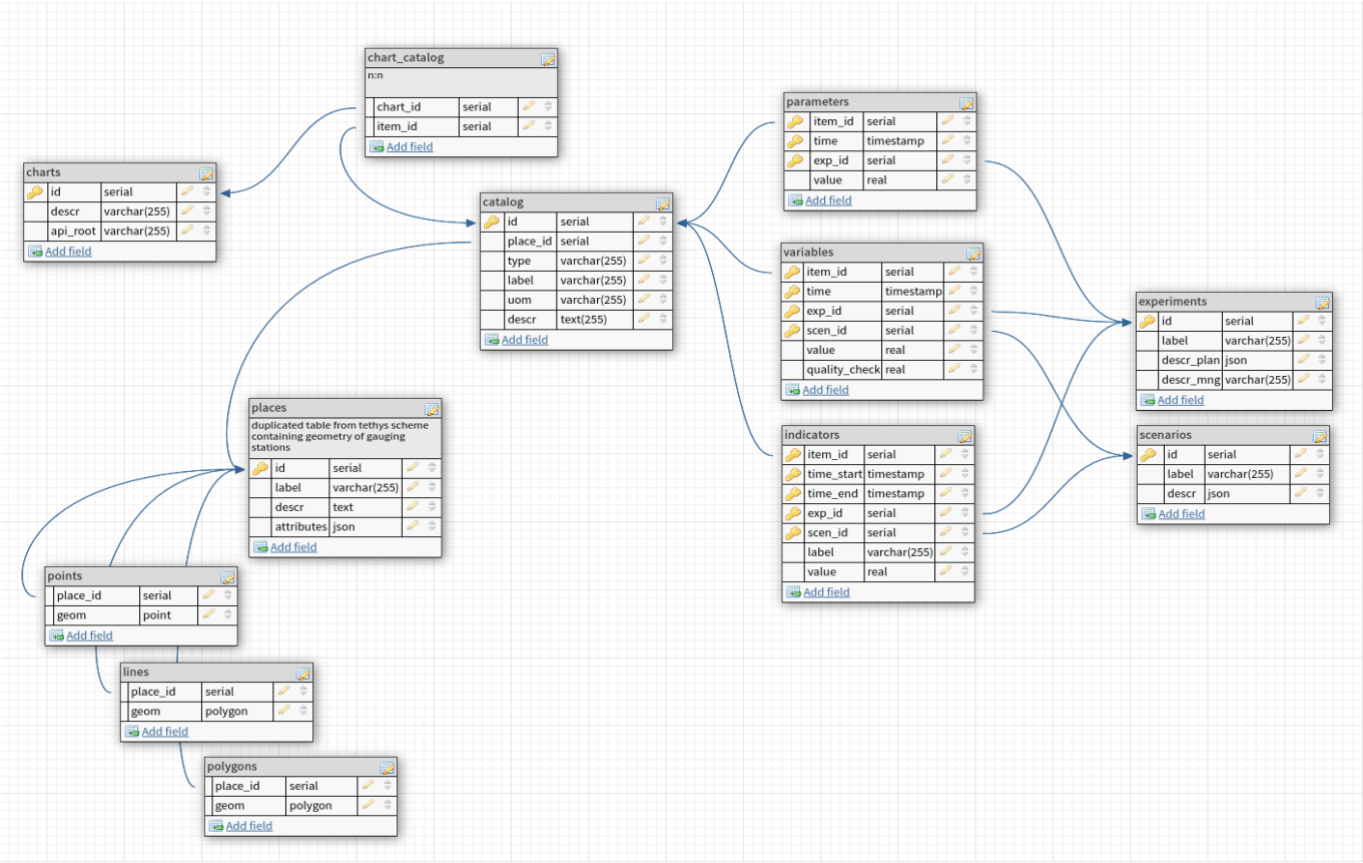

Figure 3 First version of the relational database scheme.

3.3.2 Data Viewer

The Data Viewer represents the easiest but, at the same time, most powerful access point to the data repository described in Section 3.3.1: a web interface providing the possibility to search, visualise and eventually download data included in the repository. This tool is targeted to analysts, scientists and ERLL practitioners and focuses on a single dataset at a time, giving the possibility to interactively explore its distribution in time and space. The data viewer will be fully presented in MS4.3, due at M18.

The requirements for this component are the following:

- it is accessible only to registered users, exploiting, whenever available, the same authentication information (user and password) created for data upload on the repository. Restricted access rules are set and enforced whenever requested by the data provider;
- it includes both an interactive map viewer and a charts library, to present data changing across time and space, considering the different scales identified in the data repository (i.e., pilot area, country and Mediterranean region);
- it exposes the whole data catalog, with enhanced filters based on location, time, keywords and data types, to support data exploration by different users;
- it publishes metadata information to clearly identify a data source and quality;
- it allows data export functionalities to download data in tabular format or images from map and charts.

Figure presents a first mock-up of the data viewer interface with dataset categories, a detailed list with download possibilities and interactive chart functionalities.

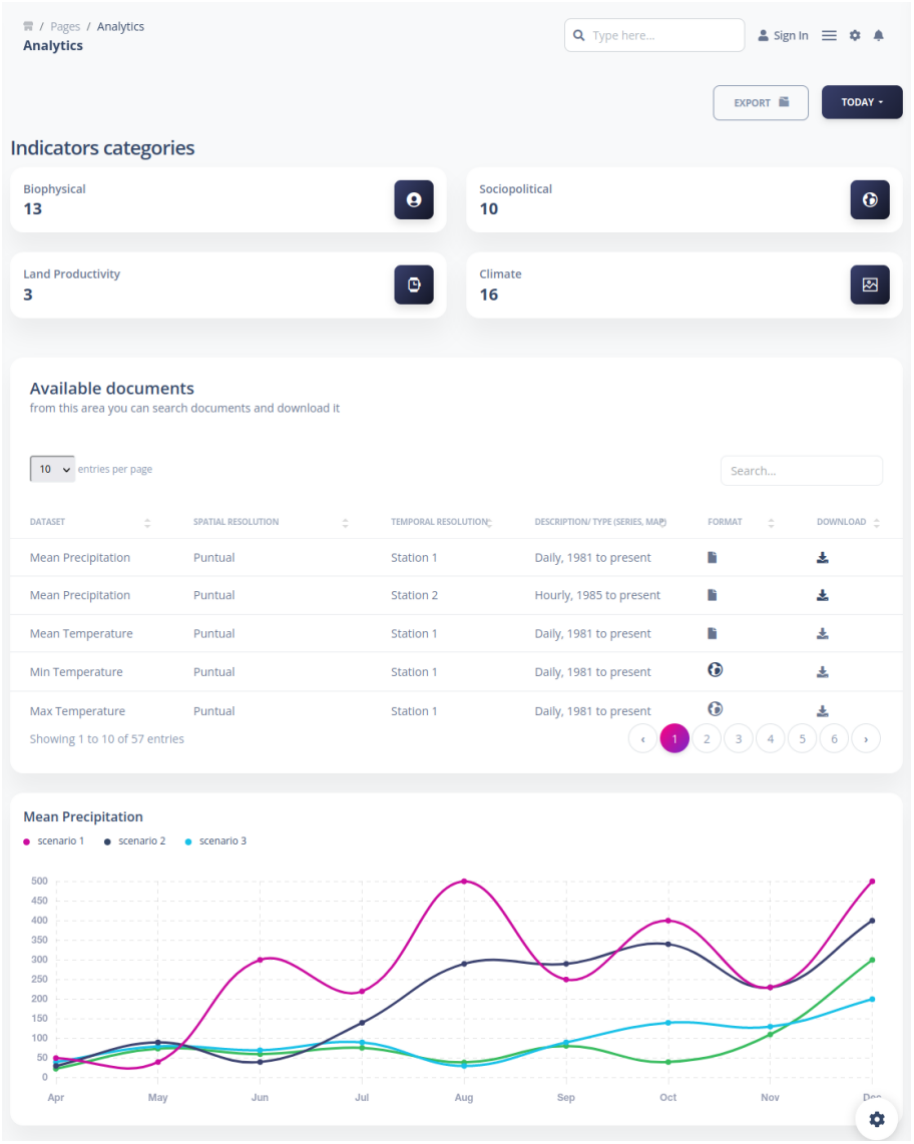

Figure 4 First mock-up of the data viewer interface with dataset categories, a detailed list with download possibilities and interactive chart functionalities.

3.3.3 Indicators Library

The Indicator computational code Library (or indicator library) is a set of processing routines, that implement a set of indicators both quantifying land degradation processes and land restoration action effects. The library of standardized indicators will be fully described in MS4.4, scheduled for M20. Indicators will be selected from the set of biophysical and socio-economic indicators identified in WP2 and WP3 and will then be used to support the assessment of implemented restoration actions in WP5. Input data, as well as computed output, will be stored in the data repository (Section 3.3.1) and made available in the visualisation tools (Data Viewer and Web Dashboard), in order to provide a quick and effective way to analyse and compare information across different PAs, assess possible future scenarios and extend the analysis up to the Mediterranean regional scale.

The requirements for this tool include:

- it has to be released as open-source software, in order to ensure the possibility to re-use, change and modify it beyond the lifetime of the project;

- it needs to be able to manage different data formats and types, both lumped and spatially distributed data, stored either in relational geo-database or in the filesystem;
- given the different spatial (from the specific PA to the Mediterranean region) and temporal (from past observed data to multiple future scenarios) scales considered, it should support an on-demand approach for output, plot and map generation, rather than an exhaustive process of computation of all possible indicators at all possible location. Developing a set of Application Programming Interface (API) allows to satisfy this requirement;
- given the large extent of data requested considering the Mediterranean scale, special attention needs to be paid to code efficiency and speed, eventually considering parallel computational tools.

Figure 5 presents the relations between the first three tools of the LanDS: the **indicators library** reads the input data and parameters from the **repository** and writes indicators metadata (e.g., label, description, unit of measurement) in the *catalog* table, or output in the *indicators* table. At the same time, the indicators library is providing input to the **data viewer**, through the API for indicators chart and map generation.

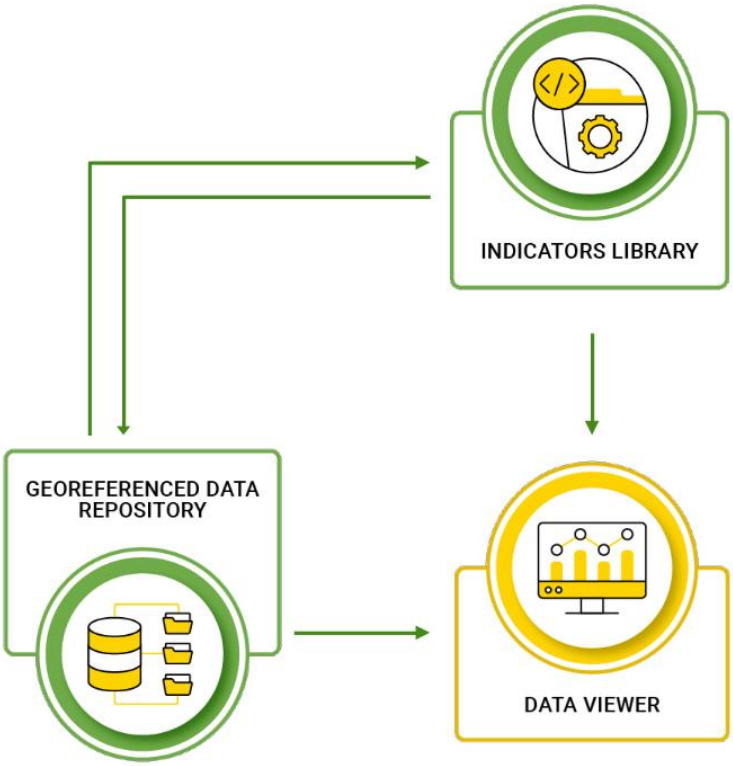

Figure 2 Representation of the relations between the first three tools of the LanDS.

3.3.4 Machine-learning Procedure

LanDS includes a machine-learning based tool (MS4.5, scheduled for M24) to support the identification of potentially suitable areas for up or out-scaling of restoration measures promoted by REACT4MED. This tool considers both present and future situations, taking advantage of the future scenarios identified in Task 2.4. Considering the fact that there is no unique, mature and generally adopted solution to perform this task, a number of different approaches and Artificial Intelligence (AI) techniques will be investigated and tested, ranging from the most consolidated one (e.g., those focused on dimensional reduction like the Principal Component Analysis) to other more sophisticated related to clustering and eventually involving also deep learning techniques, exploiting recent advancement and research done in this field (Sahour et al. 2021; Ezugwu et al. 2022; An et al. 2023).

Procedure outcomes will be shared with partners and SHs taking part in the ERLLs, in order to include their expert judgement in the development of the tool and in the assessment of the different techniques that will be tested.

The requirements for this tool include:

- it has to combine knowledge and expertise coming from ERLLs, local information related to site-specific constraints or barriers with regional datasets;
- it should handle and extract information from both data that can be considered static in the time horizons considered by this project and dynamic datasets, like future climate and socio-economic scenarios, bio-physical variables and indicators provided;
- it should consider a huge amount of candidate inputs to take into consideration the different causes and processes of land degradation, eventually involving ERLL experts in the input selection and screening;
- at the same time, it should also adopt an approach of parsimonious modelling, to increase the possibility of use of this tool in scarce data systems;
- it should provide as output valuable information able to provide insights to orient policy recommendations and support decision-making processes.

3.3.5 Web Interactive Dashboard

The LanDS Web Interactive Dashboard (web dashboard now on) is conceived as a structured web tool to compare and integrate different data, information and project results, targeted to decision and policy makers or international agencies officers. Together with the data viewer (Section 3.3.2), the dashboard represents the second user interface to LanDS toolbox and it is composed of a set of visual analytics tools providing a clean, intuitive, and robust way to analyse and compare data and scenarios.

The purposes of the LanDS web dashboard can be expressed in terms of questions that it will be able to answer:

1) Given an existing land restoration action:
   - which would be a suitable area for broader application?
   - how is the performance of this action in your area?

2) Given a specific location:
   - which land degradation issues exist?
   - which restoration actions are suitable?

3) Under future socio-economic or climatic scenarios:
   - which is the expected hotspot for land degradation in your area?
   - which land restoration actions would be more suitable to be applied?

Visualisations available in the web dashboard will be defined in collaboration with the ERLLs, during the testing stage of the LanDS prototype, happening after its release, scheduled for December 2023 (M20). Target users will be the ERLL participants, especially those coming from institutions (see Table 1) and other policy makers or institutional subjects involved in WP6 activities.

The requirements for this tool include:

- easy-to-use interface, with no specific skills or knowledge required to be used;

- clear identification of take-home messages identified by REACT4MED and of data evidence supporting them;
- possibility to compare data across different spatial and temporal scales, both through interactive maps and charts;
- potentially unrestricted access, directly through the project website.

3.3.6 Technologies

Considering the experience and the tools developed in previous international projects by SoftWater members (e.g., DAFNE H2020 project, H2020 Project Ô), the following open-source software projects will be considered as starting point for the development of the LanDS:

- Postgresql[9] + PostGIS[10] for the creation of relational GeoDatabase: one of the most advanced and modern relational database managers. Its spatial extension PostGIS allows the managing and processing of geographical data, while its capability to manage also JSON structured data allows an extra-flexibility for application development and data storage;
- QGIS Desktop[11] and Server for styling and publishing maps on the web: QGIS server allows managing different kinds of input data, includes the possibility to publish standard web services like Web Map Service (WMS) and Web Feature Service (WFS) and leverages on QGIS desktop for fine-tuned map styling;
- Openlayers[12] and Leaflet[13] for creating interactive web maps, exposing information published by the map server;
- FastAPI[14] as a web framework for building APIs with Python programming language, with a modern, high-performance and scalable approach;
- Python code libraries for indicators computation, geographical data management, interactive charts generation, machine-learning: pandas, geopandas, rasterio, xarray, plotly, sci-kit learn, keras, dask;
- Drupal[15] as Content Management System: a framework that can be tailored and customized to create simple websites or complex web applications. It has a number of standard features out-of-the-box, like easy content authoring, reliable performance, and excellent security, but it gains popularity because of its flexibility and modules library, to expand functionalities and customize the appearance.

[9] https://www.postgresql.org/
[10] https://postgis.net/
[11] https://www.qgis.org/it/site/
[12] https://openlayers.org/
[13] https://leafletjs.com/
[14] https://fastapi.tiangolo.com/
[15] https://www.drupal.org/

4 Conclusions

This deliverable describes the LanDS, the scientific Land degradation Decision-Support Toolbox under development in WP4, which contributes to the REACT4MED scope of outscaling the potential application of the land restoration actions promoted in the Ecosystem Restoration Living Labs to the Mediterranean area. The LanDS aims to be a comprehensive innovative toolbox integrating data storage, computational, and visualisation tools, with a machine learning-based procedure for the identification of target restoration areas.

The concept of the LanDS was introduced in the first run of the ERLLs to initiate and establish the co-design process, and consequently collect stakeholders' feedback to better shape the purposes and functionalities of the toolbox. To do so, we applied the methods guide defined within WP3 on the one hand, and broadly characterise the different pilot areas on the other, based on project material, literature, and the outcomes emerged from the first ERLLs. At the moment of delivering the present report, two workshops are still missing (PA5 in Morocco and PA8 in Egypt) and, thus, their outputs could not be included. Nevertheless, they are currently in a planning stage (expected to be held in March); thus, we will consider a potential extension of the LanDS requirements afterwards, if needed.

The positive feedback gathered from the stakeholders in the different pilot areas in this first round of meeting and their interest in being further involved in the upcoming ERLLs is considered a successful step forward towards the challenging objectives of REACT4MED.

In a couple of months (M12), we will complete MS4.2 (Geo-referenced data repository: ready to be populated by project partners), followed by MS4.3 and MS4.4 (respectively, Data Viewer at M18 and Library of Indicators at M20). By the end of the year (M20), we will prepare the second deliverable D4.2 (LanDS toolbox prototype), which will present the LanDS prototype, including the first versions of the geo-referenced data repository, the visualisation tools and the indicators library, ready to be shared with partners and stakeholders for testing and feedback gathering. At that stage, a further round of partners and stakeholders feedback collection in the context of the ERLLs is expected to occur at the beginning of the next year, in January 2024.

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Annex 1: WP3 Methods Guide

I. Rich pictures: a visual dialogue

Purpose	A rich picture illustrates the richness and complexity of a given situation. By collecting inputs from different perspectives, it aims to help participants perceive the complexity of the entire situation. Participants from various backgrounds can bring in their perspectives, at the same time they visualise the perspectives brought to the table by other participants. The method is used to make various aspects of a problem situation, interconnections and influences quickly visible in order to identify aspects the project should focus on or address. Drawing rich pictures is thus a first step to structure the messiness of the problem situation in reality and builds the basis to decide upon areas of interventions that a project wants to focus on and what needs to be considered in doing so. The method offers a non-threatening and humorous way to illustrate perspectives and conflicts. Even though drawing can be the most efficient way for some, basic symbols and text can also be used.
Preparation and materials	• Name tags marked for different groups (e. g. colour dots or colour of paper) • Guiding questions for facilitators (one facilitator for 5-7 people) • One table per group on which a big sheet of paper is lying. • 6-8 chairs around one table so that every participant and the facilitator have good access to the sheet of paper • Pins or masking tape to attach the posters on the wall afterwards • Every participant has a colourful marker in their hands • More markers are available at the table • Every group is accompanied by a facilitator and a minute taker
Steps	1. The participants take place on the table to which they are assigned (indication on their name tags). 2. Short introduction by the Pilot Area Leader to the idea and structure of the rich picture method, its rules and its goals (question to answer) to the plenary. 3. In the groups: • Start with the basic problem situation (degraded soils). • The participants in a group jointly illustrate the problem situation from their various backgrounds and experiences. • Participants illustrate their perspectives and explain them as they draw. Ideally drawings, and symbols should be used, text should only be used as a fall-back option.

	• Although discussion is not encouraged, participants can react to the contributions of others in written/drawn form. • Write down the 5 main challenges arising from your rich picture. 4. Afterwards, the groups come together in the plenary. The facilitators briefly present what their groups have found out about the problem and what is important to them based on the 5 identified main challenges. 5. After the plenary, the pictures are put on walls so that participants can go back to them during the breaks. 6. The discussions will be digitalised and send to the participants after the workshop.
Questions assisting the process **(as a print out on each table)**	Main question: "**What causes soil degradation in agriculture in your area?"** • How are you affected by the problem? How can you influence soil degradation? • Where do the problems come from? Draw the context, the causes and effects and any other relevant social, economic, political, environmental feature or issue. • Which other stakeholders relate to soil degradation and how? Draw the relations of stakeholders to each other. • Make sure your drawing includes both facts and subjective information. • You can use a legend or some words to explain stakeholders or problems, but do not use too many words.
Output / Outcome	• Several posters illustrating a given problem situation from different perspectives. • A better understanding of the complexity of the problem situation. • An opportunity for participants to bring in their perception as well as perceive other participants' points of view. • After the workshop, the different rich pictures, should be combined to a joint picture of the problem situation. This can also be used in subsequent workshops to illustrate the situation as perceived by the participants.
Roles of participants	Groups should be assigned in ways that participants meet that otherwise do not frequently work together in order to combine different perspectives in one group. As all participants possess knowledge on (aspects of) the problem situation, each perspective is equally relevant and will contribute to a common understanding of the problem situation. Participants should contribute to the rich pictures ideally in drawn contributions. If participants are not willing or able to participate in this way, the facilitator should take up their verbal contribution and paint/write this on their behalf.
Role of facilitators	• Encourage all participants to draw their point of view on the paper. Make sure that everyone participates. If someone does not participate, assist the person by drawing for them.

	• It is not the goal to start a discussion, but to show one's own perspective and hear the perspective of others. Tell participants that they should rather draw than discuss their perspectives. While drawing, they may explain what they draw and therewith make their point clear.
Origin	Developed by Peter Checkland as one of the early steps of his Soft Systems Methodology

Sources

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II. Silent discussion

Purpose	The method silent discussion is used to activate all participants to partake in a discussion. For this, everyone takes turns in contributing their ideas, knowledge and opinions in written form on posters for different topics that have been prepared in advance. Contributions by participants that have already been written down can stimulate further thoughts and hence a similar effect as of a verbal discussion is reached, in a documented form. In the workshop, we aim to gather the stakeholder's input and opinion on the defined project activities. They are asked what is required for the various project activities to be of value to them. Also, they are asked, if and how they want to be engaged in the different activities, so they can be approached more targeted in the future.
Preparation and materials	• Five tables are prepared, each with a large paper on the five different project activities. At each table, several markers are available. • One paper is prepared for each of the activities (field experiments, LanDS design and co-creation, indicators and metrics, assessing good practices, capacity building workshop) in this form: Title: What is required of [insert respective activity] to be of value to you? • Print out of the respective activity descriptions on the table. • Moderation cards are provided, on which participants can specify, how they want to be engaged in this activity. They write their name and proposed contribution on it and attach it to the poster.
Steps	1. The participants gather in equally sized groups around the tables. 2. The Pilot Area Leader gives a short presentation on the project activities and introduces the method and rules of the **silent** discussion: • Written contributions only. • Participants can and should react to what others wrote: They can use lines, arrows or symbols to illustrate the connection between different points.

	• The contributions should remain focussed on the questions. 3. The participants start writing their comments on the paper and add the moderation cards with their information were suitable. Facilitators should remind the participants to remain focussed on the paper. 4. The participants are asked to walk through the room and add to the silent discussion on all activities they find interesting and relevant. 5. The discussions will be digitalised and send to the participants after the workshop.
Question	**What is required of the various project activities to be of value to you?** **How do you want to be engaged?**
Output / Outcome	• Written stakeholder input to the project activities regarding what is important to the stakeholders and indications for adaptation to local circumstances. Commitment of stakeholders and information about their engagement in different activities.
Role of participants	• Contribute their ideas and opinions regarding the presented project activities. • Discuss with others silently. • Indicate whether they are interested in participating in the respective activities and how they want to contribute.
Role of facilitators	• Help to maintain a silent and comfortable atmosphere. If participants start a discussion off paper, they are reminded that they should instead contribute their thoughts in writing. • Remind participants that they can add and relate to what other people have written. • Encourage participants to change the tables and come back at a later stage in order to react on other comments.

III. Break-out groups: Consolidating information on issues, actions and existing indicators relating to soil degradation in agriculture in your area

Purpose	The purpose of this session is to consolidate information from workshop participants on soil degradation issues and restoration actions in agriculture in your area as well as on indicators to measure these.
Preparation	• One room separate from parallel group on functionalities/requirements to LanDS • One big sheet of paper for each group • Moderation cards in three different colours • Tape/glue • Big pens

	• Pre-requisite: Clustering of information from rich pictures on issues, actions and existing indicators that have already emerged • Guiding questions for facilitators (one facilitator for 5-7 people) • Facilitator for each group
Steps	5 min for: 1. A short introduction of the task and repeating which information have already been collected during the session on problem definition (rich pictures). 2. The overall group is split up in break-out groups (of 5-7 people per group). Each group is assigned a facilitator, that ensures that everything that is said is captured in the poster. 25 min for: 3. Each group is starting with a selection of issues, actions and existing indicators that were mentioned during the problem definition. Each group receives moderation cards in three different colours (each group has the same selection of colours: red, blue, white). Each colour stands for one of the criteria (issues, actions and indicators) 4. Participants are asked to illustrate existing soil degradation issues (red), restoration actions (blue) and existing indicators to measure issues and performance of restoration actions (white) on differently coloured moderation cards. They should group and cluster them. 5. The groups are also asked to illustrate the relationship between the different information they come up with. Hence, the moderation cards are fixed on the large paper. Arrows, lines and symbols can be used to connect the cards. Written instructions are also possible. 6. The facilitator ends the session when the time is up or when the participants are satisfied with the results. 7. After the session has finished, the information will be documented, translated and used as input for WP 4.
Questions assisting the process **(as a print out on each table)**	• What are the land degradation issues in agriculture in your area? (red cards) • Which land restoration practices do you apply or do you know of? (blue cards) • How do you measure the land degradation issues and performance of restoration practices? (white cards)
Output / Outcome	• One poster per group illustrating issues, actions and existing indicators to assess these and relationships between different aspects. • A better understanding of the causal relationships underlying the problem situation.

Roles of participants	Groups can be assigned according to interests of participants. As with the rich picture, the focus of the exercise should be on the poster. Understanding and perspectives can be discussed, but the goal should always be to capture the findings on the poster. If participants are not willing or able to participate in this way, the facilitator should take up their verbal contribution and write this on their behalf.
Role of facilitators	Encourage all participants to contribute ideas on issues, actions and existing indicators. Keep the time and end the session.

IV. 1-2-4-All: Discussion of LanDS functionalities / requirements

Purpose	This method allows all participants to have their ideas heard and to collect many ideas at the same time while also consolidating them in the process. It prevents groupthink because it gives each participant the chance to first elaborate their own thoughts and then in stepwise discussions refine the initial ideas and enrich the pool of ideas within the group.
Preparation	• One room separate from the parallel group on issues, actions and existing indicators • Plenty of moderation cards for participants to write answers • Pens • Flipchart or poster attached to wall or pin board • Pins / tape / glue • Colour dots in three colours (practitioners, researchers, decision-makers) • One facilitator to moderate the session • Guiding questions for facilitator
Steps	1. Short introduction of the task. 2. Individual brainstorming in silence, notes can be taken. (2 min) 3. Discussion in team of two people. (3 min) 4. Discussion of two teams combined to a group of four people. (5 min) In this step, the group collects their most relevant ideas on moderation cards, one card per idea, the ideas should be readable from further away. 5. Discussion and ranking (10 min) The results are discussed in a plenary. The facilitator clusters the ideas on a pin board / poster / flipchart. Then the different ideas are rated, based on their value to different stakeholder groups. The guiding question for the ranking is: Who has an interest in which function? Stakeholders receive sticky points of the colour representing their stakeholder group (practitioners, researchers, decision-makers).

	The number of votes is calculated from the overall number of ideas: Approx. number of ideas / 3, rounding up -> no. of votes for each stakeholder
Questions assisting the process	• Question for the 1-2-4-All discussion: Do you think LanDS Dashboard purposes are relevant? • Which purposes would be interesting to you in addition to those presented? • Which functionalities do you expect of the LanDS Dashboard? Question for ranking: Who has an interest in which functionality?
Output / Outcome	• Pin board, poster or flipchart with different functionalities the tools can have that are identified as meaningful to the stakeholders. A ranking according to stakeholder groups gives an estimate of preferences and uses for different stakeholder groups. • A better understanding of the user needs and expectations.
Roles of participants	The focus of the exercise is to discuss and collect preferences for functionalities. Discussion is wished for and encouraged. The prominent ideas should be collected on moderation cards (at least in step 4. during the group discussion of four people).
Role of facilitators	Mediate the process: • Instruct the participants each time, they change arrangement of their discussion. • Timekeeping • Remind participants to write down the ideas on moderation cards visibly, one idea per moderation card during the group discussion. • In the plenary cluster the ideas in a suitable way on a pinboard, poster etc. • Explain the ranking scheme and distribute colour dots for each stakeholder group.

Sources

https://www.liberatingstructures.com/1-1-2-4-all/

Annex 2: LanDS presentation in the Lower Gediz (TR) ERLL