LIFE20 PRE/IT/000007

Summary for decision makers

PROTOCOL FOR DESIGN, IMPLEMENTATION AND MAINTENANCE OF THE NBS FOR DRYLANDS

This project has received funding from the *European Union's LIFE 2020 Program for the Environment and Climate Action* under grant agreement No LIFE20 PRE/IT/000007
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Introduction

The NewLife4Drylands (NL4Dl) project aimed to monitor the application, scalability, and replicability of Nature-Based Solutions (NBS) for the restoration of drylands by using satellite-based indicators. The project adopted a multifaceted approach that involved establishing a protocol for NBS in drylands, encompassing the identification of drylands characteristics and the design of NBS, and overseeing mid-term and long-term restoration efforts.

The NL4Dl Protocol has primarily adopted the approach and the structure of the International Principles and Standards for the Practice of Ecological Restoration (SER, 2019), Principles and Guidelines for Ecological Restoration in Canada's Protected Natural Areas (Canadian Parks Council, 2008) and Ecological Restoration for Protected Areas (IUCN, 2012), adapting them to the specific needs of ecological restoration of mediterranean drylands. These documents represent international references for ecological restoration activities in natural and semi-natural environments. Consulting these documents is recommended for interested parties (such as practitioners, academics, and decision-makers) who wish to investigate and explore specific issues related to a site in need of restoration activities.

In the Protocol, the elements depicted in the reference documents (SER, IUCN and Canadian Parks Council) are tailored and further elaborated, particularly concerning activities for restoring degraded soils using NBS. The Protocol also explores the integrated use of ground-based and Remote Sensing (RS) data to identify indicators for evaluating the effectiveness of planned solutions. This approach is geared towards fostering adaptive, evidence-based and interdisciplinary management of the ecological restoration process.

The Protocol follows the principles and input of the cited documents and integrates the NL4Dl project outputs into ecological restoration activity in drylands (through planning, design, implementation, and maintenance) that are:

- a procedure for assessing existing degradation processes and monitoring ecosystem restoration interventions (such as NBS) in degraded drylands, combining RS techniques with in-field gathered data. It serves to evaluate the effectiveness of restoration activities and improve sustainable land management on a long-term basis;
- an operational tool, the Decision Support Web tool, which identifies the best sustainable solutions (Nature-Based Solutions) based on degradation processes. It includes indices and indicators related to each degradation process and enables end-users to monitor the effectiveness of these solutions. This tool guides the users in evaluating available NBS for restoration activities in soil-degraded areas and provides relevant monitoring elements. It aims to reduce the knowledge effort, minimize subjective analysis, and help prioritize options.

The collective use of these tools paves the way for an informed decision-making process regarding land and soil restoration, alongside identifying best practices that can be replicated in similar contexts.

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Therefore, the Protocol serves the following main functions:

- defining a process that addresses both the process of restoring soil degradation and the medium and long-term monitoring of the proposed restoration solutions' effectiveness. The process also aims to raise awareness of the needs and opportunities of NBS in drylands;
- serving as a guide for identifying specific/local solutions (NBS) for dryland restoration, starting with identifying degradation processes through a catalogue of NBS applicable in the Mediterranean context, based on Nl4Dl project experience;
- supporting restoration practitioners and planners (such as biologists, ecologists, naturalists, engineers, architects, agronomists, foresters, geologists, surveyors, etc.), as well as local decision-makers and administrators (such as Protected Areas staff) in effectively addressing the need for restoration activities in areas with degraded soils.

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Integrated pathways to effective ecological restoration: the proposed process

The process provides recommended steps for an ecological restoration activity in drylands. The proposed pathway (Figure 1) represents the adaptive process that plays a crucial role in creating an effective, harmonized, and collaborative ecological restoration effort.

In this view, it is crucial to recognize that restoration is not linear and that some steps and actions may be undertaken simultaneously, in a different order, or repeated. This is because adaptive management requires an iterative process of defining goals and objectives, conducting field trials to fill information gaps and test multiple alternative approaches, learning from restoration through effective monitoring and evaluation, and applying lessons learned to planning, implementation and ongoing management.

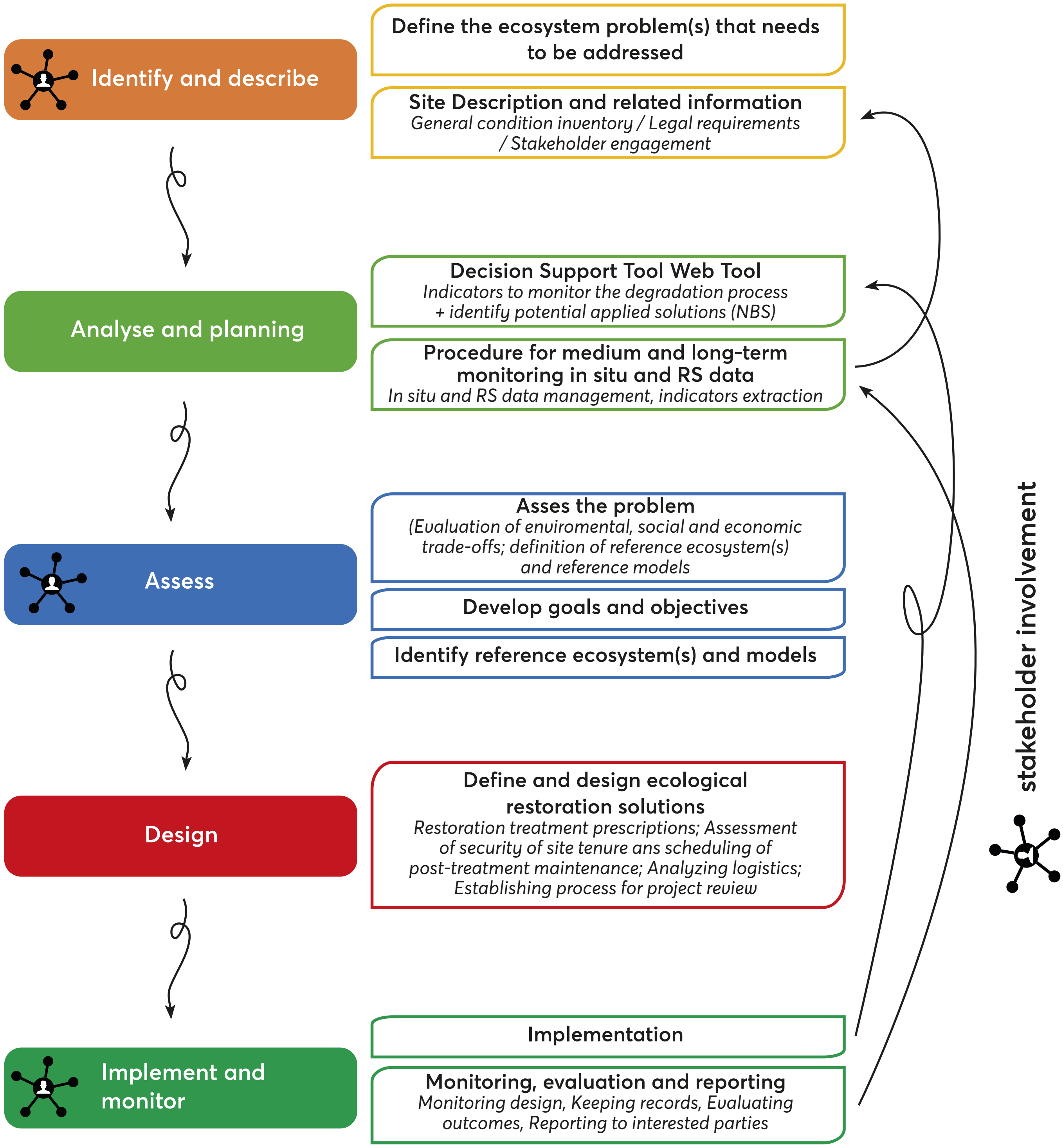

Fig. 1 The process for planning, implementing and maintaining ecological restoration activities in drylands

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Step 1 - Identify and describe

Description

This step includes identifying and evaluating the causes, extent, and intensity of degradation, considering the site and its context. Preliminary data collection should record the status of current biotic and abiotic conditions and detect the characteristics of degradation drivers and threats while also setting the framework for the legal requirements associated with the restoration activities and the stakeholder engagement process. At this stage of the process, the information must be shared with local stakeholders.

Intermediate steps

1. **Define the ecosystem problem(s) that need to be addressed** - The problem statement is a key component of the restoration process. When defined precisely, it helps outline the necessary responses and the monitoring requirements needed to assess the effectiveness of solutions. Regardless of the available information base, the problem statement should include the following :
   a. A detailed description of the problem.
   b. An analysis of the immediate and underlying causes of the problem.
   c. A justification for why restoration is appropriate and likely to be successful.

2. **Site Description and related information**
   a. *General condition inventory* - Before detailed planning can proceed, preliminary information about target ecosystems should be collected to assess their condition and define any ongoing degradation phenomena and/or restoration challenges. The baseline inventory documents the causes, intensity, and extent of degradation and describes the effects of degradation on the biota and physical environment relative to the ecosystem attributes such as the absence of threats, physical conditions, species composition, structural diversity, ecosystem function, and external exchanges.
   b. *Legal requirements* - National, regional, provincial, and municipal legislation, regulations, and policies applicable to the project that are not necessarily linked with nature protection domains (e.g., archaeological, landscape, and hydrogeological regimes) should be thoughtfully identified and consulted. This precaution may be fundamental to anticipating mismatches and preventing conflicts between existing legal prescriptions (i.e., where those objectives are based in law) and restoration objectives, which may lead to delays or failures.
   c. *Stakeholder engagement and communication activities* - Stakeholders can help prioritize the distribution of restoration actions across the landscape, set project goals (including desired level of recovery), and contribute knowledge about ecological conditions and successional patterns to improve the development of reference models. Engaging stakeholders in participatory monitoring is also beneficial. This engagement should begin at the conceptual phase or well ahead of project initiation, allowing stakeholders to help define the vision, targets, goals, and objectives. Early involvement also facilitates gaining permission for the proposed work and ensures stakeholders can contribute their skills, knowledge, and financial, and human resources to the development, implementation, maintenance, and long-term monitoring. Engagement and training activities should continue throughout the project to provide committed, informed and collaborative knowledge; meet social expectations; build capacity and a sense of ownership; maintain support and inputs.

Recommendations

1. The problem statement is a key component of the restoration process: if defined with sufficient precision, the problem statement is crucial to define the necessary responses and the monitoring requirements needed to assess the effectiveness of the solutions.
2. The baseline inventory should detail the causes, intensity, and extent of degradation. It should also describe how degradation impacts the biota and physical environment concerning various ecosystem attributes, including the presence or absence of threats, physical conditions, species composition, structural diversity, ecosystem functions, and external interactions.
3. Conducting a thorough review of all local, regional, and national regulations and prescriptions related to both nature and non-nature protection regimes will help ensure the timely execution of the restoration process.
4. The most effective way to involve stakeholders and support meaningful information sharing is through direct contact and fostering a sense of participation.

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Step 2 - Analyse and plan

Description

According to the defined framework, the analysis and planning step focuses on identifying appropriate solutions and monitoring indicators. The Decision Support Web Tool developed within the NL4DI project can guide users through the evaluation phase, following the proposed procedure (the dual approach) and using data useful for monitoring the ecosystems where restoration interventions are taking place.

Intermediate steps

1. **Identification of NBS and indicators** - Understanding degradation phenomena, identifying appropriate solutions, and selecting suitable monitoring indicators is inherently complex. The NL4DI Decision Support Web Tool can be used to guide users in exploring relevant degradation phenomena, potential restoration solutions (NBS), and useful indicators for assessing changes through remote sensing and field measurements. This tool facilitates high-level calculations and provides indicators via the EO Browser, allowing users to adapt parameters to specific contexts. Understanding the connections between degradation processes, NBS, and indicators is crucial for prioritizing the analysis of primary phenomena for which appropriate indicators are available and for selecting NBS to address specific issues. Relevant information should be collected and assessed meticulously before and during the exploration phase, ensuring that the working scale aligns with the spatial resolution of the satellite data considered. If, upon applying the Protocol, new phenomena or dimensions emerge as necessary, a fresh exploration to identify different solutions or indicators should be undertaken.
2. **Indicator extraction and ecosystem monitoring** - The procedure for indicator extraction involves a detailed assessment of phenomena through specific in situ and RS indicators. Validation of RS-derived maps is performed using in situ data. By applying the dual bottom-up and top-down approach proposed by the NL4DI project, and using RS data alongside in situ measurements, this process enables the evaluation and monitoring of restoration interventions and their effects on ecosystems. If the assessment reveals a lack of relevant information or data needed to accurately understand phenomena or monitor solutions, it is recommended to return to Step 1 for further exploration.

Recommendations

1. The Decision Support Web Tool can be useful in deciding and understanding which categories of land degradation processes need to be prioritized. The prioritization is often necessary due to limited resources and the simultaneous need for timeliness and effectiveness.
2. Information for data management should be included and analyzed in the early stages of data collection.
3. Due to the complexity of degradation processes, both in situ and satellite observations should be carefully assessed and collected based on the target process to be monitored and its environmental context.
4. The working scale should be chosen based on the level of detail required for investigation. This could be at the single tree level or the landscape level and should align with the spatial resolution of the satellite data being considered.
5. For the validation of mappings obtained with remote sensing techniques, in situ data availability is essential. Additionally, field inspections may be necessary for ground truthing. The collection of in situ observations as well as the processing and analysis of satellite images require highly technical skills.
6. To define the structural and functional state of the ecosystem under study, a *dual approach* is necessary: this approach should integrate both top-down and bottom-up approaches.

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Step 3 - Assess

Description

The assessment step focuses on evaluating and determining the most appropriate restoration objectives and associated activities, based on the ecosystem definition, specific goals, and the potential positive and/or negative impacts of the restoration activities. At this stage of the process, decisions must be made and developed in consultation with relevant stakeholders and experts (identified in step 1), considering ecological, socio-economic, and cultural contexts, as well as costs, benefits, and legal and financial constraints.

Intermediate steps

1. **Develop goals and objectives** - Clear and measurable goals and objectives are essential for restoration activities to identify the most appropriate solutions, ensure a common understanding among all stakeholders, and measure progress. The goals must be explicit and realistic, considering the time frame, the available social capital, and the potential positive and/or adverse effects, such as alterations in ecosystem structure or function on ES. Objectives should represent the changes and immediate outcomes needed to achieve the target and goals for any distinct spatial areas within the site. They should be stated in terms of measurable and quantifiable indicators within identified time frames.
2. **Identify reference ecosystem(s) and models** - Restoration plans should identify native ecosystems and develop appropriate models based on multiple indicators, such as the presence of threats, physical conditions, species composition, structural diversity, ecosystem function, and external exchanges. Reference models should not aim to freeze an ecosystem at a specific point in time; instead, they should be developed with a focus on understanding temporal dynamics. This approach helps create feasible and relevant restoration designs that allow local species to recover, adapt, evolve, and reassemble. In addition, multiple reference models may be needed for a restoration project, and these models require adjustments over time-based on project monitoring results. Identifying an alternative reference ecosystem when needed according to local conditions requires skilled ecological judgement. Trial treatments, best designed as collaborations between scientists and practitioners, can help identify the most suitable ecosystem to be used as the basis for the reference model.
3. **Ecosystem services (ES) assessment** - Planning an ecological restoration activity must consider the potential positive and/or adverse effects, such as alterations in ecosystem structure or function. Mapping and assessing ecosystem status and ES during the restoration process can prevent problems at later stages and support stakeholder involvement and communication activities. The ES assessment integrates ground data and existing thematic data layers with RS observations to account for temporal variations in ecosystem services supply compared to the baseline.
4. **Cost-Benefit Analysis** - Evaluating the costs and benefits associated with implementing NBS helps decision-makers make informed choices about resource allocation. Conducting a Cost-Benefit Analysis (CBA) for NBS involves evaluating the financial and non-financial costs and benefits associated with implementing these solutions. NBS refers to approaches that use nature and ecosystems to address various environmental and societal challenges. By conducting an accurate costs and benefits analysis, decision-makers can make informed decisions that consider NBS's economic, environmental, and social impacts.

Recommendations

1. Restoration plans should clearly outline the vision for the restoration process and the ecological and social targets.
2. Social goals should be explicit and realistic, considering the available social capital and time frame in the area.
3. Ecosystem reference models should focus on understanding temporal dynamics to develop feasible restoration designs that allow local species to recover, adapt, evolve, and reassemble.
4. Mapping and assessing the status of the ecosystem and its services during the restoration process can prevent future issues and support stakeholder involvement and communication activities.

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Step 4 - Design

Description

Identification of the most effective NBS for the local situation should be based on both the restoration problem assessment and context inventory, and the definition of the ecosystem reference models. The restoration objectives, specific targets and assessment of the potential positive and/or negative impacts of the restoration activities should be considered.

This step should include a detailed definition of all the operative information and features.

Intermediate steps

1. **Solutions identification** - To identify solutions that can prevent/mitigate or rehabilitate the areas starting from degradation processes, the NL4Dl project developed a Decision Support Web Tool to identify a set of sustainable restoration solutions (NBS) as well as RS and in situ indicators to monitor the degradation processes before and after the restoration's activities.
2. **Restoration solutions prescriptions** - Plans should contain clearly stated solutions prescriptions for each distinct restoration area, describing what, where, and by whom treatments will be undertaken, and their order or priority. Plans should both describe actions to be undertaken to eliminate and mitigate, or adapt to causal problems, and identify and justify specific restoration approaches, descriptions of specific treatments for each restoration area, and prioritization of actions.
3. **Assessment of site tenure security and scheduling of post-treatment maintenance** - Evidence of potential for long-term conservation management of the site is required before investing in restoration. Restoration plans should both identify site-tenure security to enable long-term restoration and allow appropriate ongoing access for monitoring and management. Additional information should be taken for site maintenance after project completion to ensure that the site does not regress into a degraded state.
4. **Analyse logistics** - Analysis of the potential for resourcing the project and of likely risks is required before undertaking the restoration plan. To address practical constraints and opportunities, plans should identify funding, labor and other resources that will enable appropriate treatments; undertake a full risk assessment and identify a risk-management strategy for the project; develop a project timetable and rationale for the duration of the project; identify ways to maintain a commitment to the project's targets, goals, and objectives over the life of the project; obtain permissions and permits and address legal constraints applying to the site and the project.
5. **Establish a process for project review** - Plans include a schedule and time frame to carry out stakeholder and independent peer review as required and implement plan review considering new knowledge, changing environmental conditions, and lessons learned.

Recommendations

1. Plans should contain well-defined solutions for each restoration area, describing what, where, and by whom treatments will be undertaken, and their order or priority.
2. Evidence of potential for long-term conservation management of the site is required before investing in restoration.
3. Identify a plan for site maintenance after project completion to ensure that the site does not regress into a degraded state.
4. Identify funding, labor (including appropriate skill level), and other resources that will enable appropriate treatments (including follow-up treatments and monitoring), until the site reaches a stabilized condition.
5. Obtain permissions and permits and address legal constraints applying to the site and the project, including land tenure and ownership claims.

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Step 5 - Implement and monitor

Description

This step includes all the technical and communication activities necessary to respond to any unexpected events during the work, as well as the short and long-term site needs of the site once the planned implementation activities have been completed allowing adaptive management of the restoration process for corrections and modifications to the actions foreseen in the planning and design phase and providing the opportunity to share lessons learned. At this step, the involvement and discussion with the local stakeholders are crucial.

Intermediate steps

Implementation

a. ***Protect the site from potential damage*** - No further or lasting damage should be caused by the restoration works in the area impacted by the project, including physical damage, and chemical or biological contamination.
b. ***Engage appropriate participants*** - Treatments should be carried out responsibly, effectively, and efficiently by or under the supervision of, suitably qualified, skilled, and experienced people. Wherever possible, stakeholders and community members should be invited to participate in project implementation.
c. ***Incorporate natural processes*** - All treatments should be undertaken in a manner that is responsive to natural processes and that fosters and protects the potential for natural and assisted recovery. Primary treatments should be adequately followed up by secondary treatments. Additionally, interim treatments to reduce adverse effects should be planned for and implemented, along with appropriate aftercare treatments.
d. ***Respond to changes occurring on-site*** - Following the applied adaptive management, corrective changes will be defined to adapt to unexpected ecosystem responses and additional work and research as needed.
e. ***Ensure compliance*** - All projects must ensure full compliance with work, health, and safety legislation.
f. ***Communicate with stakeholders*** - All project staff will communicate regularly with key stakeholders in line with the communication plan. Citizen science initiatives are recommended.

Monitoring

a. ***Design the monitoring process*** - Monitoring is geared to specific targets and measurable goals and objectives identified at the start of the process. Once the degradation process and the indicators are determined, baseline data are collected, and milestones or trigger points should be determined to gauge whether the rate of progress is on track.
b. ***Keep records*** - Adequate and secure records of all project data, including documents related to planning, implementation, monitoring, and reporting are maintained to inform adaptive management and enable future evaluation of responses to treatments.
c. ***Evaluate outcomes*** - Evaluation of the work outcomes is carried out, and progress is assessed against project targets, goals, and objectives. To ensure an accurate assessment of the monitoring results, the use of the evaluation tool is recommended.
d. ***Report to interested parties*** - Reporting involves preparing and disseminating progress reports that detail evaluation results for key stakeholders and broader interest groups.

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Recommendations

1. Monitoring and adaptive management may dictate restoration interventions after an initial project or stage has been completed.
2. Treatments should be carried out responsibly, effectively, and efficiently by suitably qualified, skilled, and experienced individuals or under their supervision. Whenever feasible, project implementation should involve stakeholders and community members.
3. All treatments are carried out in a way that is responsive to natural processes and promotes the potential for natural and assisted recovery. Primary treatments should be adequately followed up by secondary treatments as necessary.
4. Activities should be regularly assessed, with progress analyzed to adjust treatments as required (i.e., using an adaptive management framework), especially where treatments are innovative or being applied at a large scale.
5. Monitoring needs are reassessed throughout the project and resources are reallocated or expanded accordingly.
6. Monitoring methods should be easy to use and implemented through participatory processes.
7. Project managers must ensure that monitoring is carried out to determine whether goals are met and to provide learning and adaptive opportunities.
8. Involving stakeholders in project design, data collection, and analysis can improve collaborative decision-making, provide a sense of ownership and engagement, motivate stakeholders to maintain longer-term interests, and strengthen stakeholder capacity and empowerment.

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Decision Support Web tool

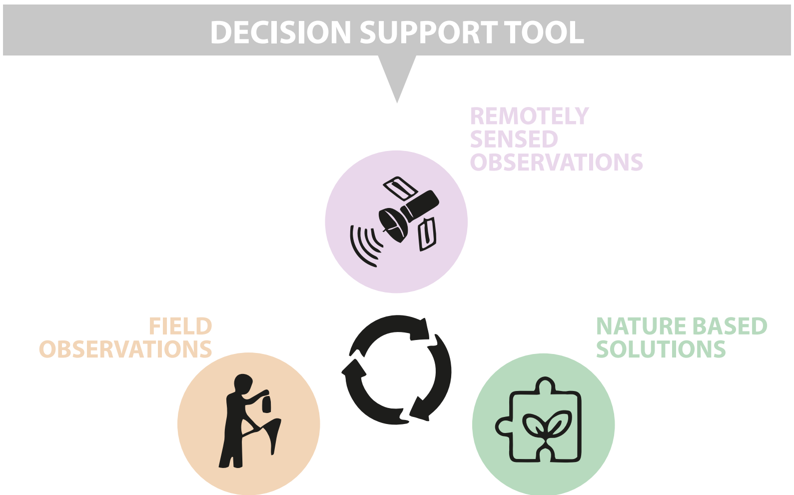
The Decision Support Web tool aims to provide a reference procedure for monitoring restoration activities based on NBS on degraded lands once the degradation processes have been identified.

The tool provides a workflow to guide end users in environmental management and planning through the identification of land degradation processes, the selection of viable monitoring indicators, and the most suitable NBS for that degraded land.

https://sites.google.com/view/newlifefordrylands/home-page

Land Degradation Processes

- Aridification
- Change in groundwater level / quality
- Decline in vegetation community functioning
- Decline in vegetation cover / biomass
- Habitat loss
- Hydrological modification
- Increase in invasive species
- Increase in weeds
- Landscape modification
- Overgrazing
- Soil erosion by water and wind
- Soil organic matter decline
- Soil salinization
- Soil surface compaction
- Trees encroachment



Features

- Guided Identification of the Land Degradation Process from a list of the most common in mediterranean areas
- Insight into the main causes of degradation with examples and Expert Based selection of Indicator and instructions to calculate with integrated EO Browser
- Guided procedure to the assessment of trend and status through selected and ad-hoc remote sensing and in-situ indicators
- Nature-Based Solutions that fits with the selected degradation process can be selected and further monitored

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Nature-based Solutions NBS

Ecosystem restoration (ER) and NBS have emerged as crucial approaches for addressing environmental challenges and promoting sustainability (UNEP, 2021). ER involves assisting the recovery of degraded ecosystems, while NBS leverage the power of nature to effectively tackle environmental problems (IUCN, 2020), including the restoration of degraded ecosystems. ER includes tailored strategies for specific ecosystems and is commonly used to reverse environmental degradation, usually with NBS. The concept of NBS originated in the late 2000s in the context of finding new solutions to mitigate and adapt to climate change effects whilst simultaneously protecting biodiversity and improving sustainable livelihoods. The definition of NBS, as adopted by UNEA (UNEA, 2022), has a significant relationship with land degradation: specifically, the definition recognizes that NBS are among the actions that are essential in the global effort to achieve the Sustainable Development Goals (SDGs), including addressing land degradation.

The concept of NBS can thus be defined as an umbrella concept that covers a wide range of ecosystem-related approaches, which can be classified as ecosystem restoration approaches. Examples of solutions to restore degraded lands can include reforestation and afforestation actions, regenerative agriculture practices, rehabilitation of degraded wetlands, restoring degraded landscapes to enhance their resilience to climate change, vegetated buffer strips to prevent soil erosion, land use planning, regulating development activities, creation and management of national parks, wildlife sanctuaries, and nature reserves.

The successful implementation of ER using NBS, relies on the application of strategies that address the specific challenges faced by degraded ecosystems, although it should be noted that in the very recent period, there has been a strong emphasis on the holistic approach to address challenges in the most integrated manner possible. By implementing these strategies, it can be needed to promote the recovery of ecosystems and harness their inherent resilience to achieve sustainable development. Below are provided examples of specific strategies that can be supportive in the context of different general concepts:

- *Ecological Restoration* focuses on returning a degraded ecosystem to its historic ecological structure, functions, and species composition. This strategy involves identifying the root causes of degradation, implementing appropriate interventions, and monitoring the progress of restoration efforts. Ecological restoration can include measures such as reforestation, habitat creation, reintroduction of native species, and the removal of invasive species.

- *Sustainable land management* integrates ecological, social, and economic factors to ensure the long-term productivity and resilience of ecosystems. This approach involves adopting practices that minimize soil erosion, enhance soil fertility, conserve water resources, and promote sustainable agricultural practices. Techniques such as agroforestry, conservation tillage, and precision agriculture are examples of sustainable land management practices that can contribute to ecosystem restoration.

- *Green Infrastructure* focuses on incorporating natural elements into territorial and urban planning and design to enhance ES and promote environmental quality. GI can contribute to ecosystem restoration by creating interconnected networks of habitats and supporting biodiversity conservation.

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Indices and indicators

The monitoring of land degradation processes is carried out mainly through satellite data (RS) and information obtained from field surveys. RS and in situ indicators are both important tools for monitoring and assessing soil degradation. However, each approach has its strengths and weaknesses, and their joint use can provide a complete and more accurate picture of the situation.

RS can investigate large areas quickly and easily, providing information on a range of soil properties, including land cover, vegetation, soil moisture, and soil erosion. This can be useful for identifying areas of potential soil degradation, tracking changes over time, and assessing the effectiveness of mitigation measures. However, RS also has some limitations. It can be difficult to interpret RS data, it can be affected by factors such as cloud cover and atmospheric conditions and the temporal availability of data largely depends on the type of satellite and its revisiting frequency, usually inversely proportional to spatial resolution.

In situ monitoring can provide more accurate and detailed data than RS. It can be used to measure soil properties such as texture, structure, organic matter content, and nutrient levels. This information can be used to assess the health of the soil and identify the causes of degradation. However, in-situ monitoring has, also, some limitations. It can be time-consuming and expensive so limited to small areas. In addition, in-situ measurements may not be representative of the entire area under study. The degree of uncertainty in this case depends, heavily, on the spatial heterogeneity of the study site.

By combining RS and in-situ monitoring, it is possible to overcome the limitations of each approach and obtain a more detailed and trustworthy representation of the conditions. RS can be used to identify areas of potential soil degradation and track changes over time. In situ monitoring can provide more detailed information on soil properties, validate RS outcomes and assess the effectiveness of mitigation measures.

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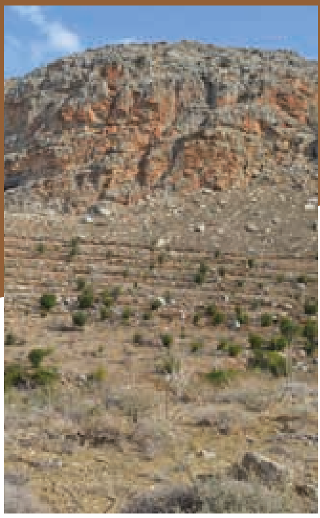

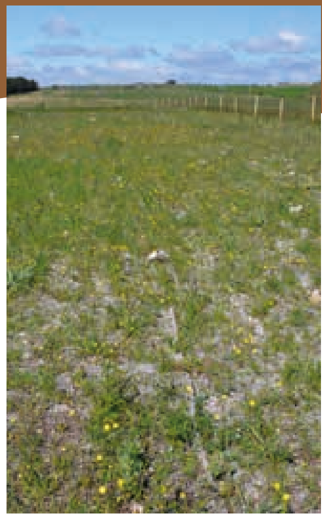

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