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Environment, Climate Change and Low Carbon Economy Programme

'Environment Programme'

European Economic Area (EEA) Financial Mechanism 2014-2021

FINAL REPORT

Bragança, May 30, 2024

11_CALL#5 – SOILING- Innovative natural-based solutions for restoring ecosystem services in areas degraded by the great Picões fire, Portugal

i. Detailed description

Information regarding the participants in the Project:

SOILING project consists in assessing different field practices to reduce the soil loss and increase the soil organic carbon, as a strategy to mitigate the climate change. Field trials included the application of barriers to erosion control, the installation of field erosion fences and the direct application of natural-based solutions (NbS), soil conditioners (compost and biochar) obtained from main olive mill by-product, that is, the olive pomace. The field trials was applied on degraded and forest fire-affected soils, as in the Picões study case(14,000 ha burnt area), in Northeast of Portugal. Different biophysical parameters are being frequently monitored in field and with satellite images, whose main results will allow us to determine both soil loss rate and soil C storage in regions affected by fires, and establish paths for regenerate degraded soils in future years: *working together for a green Europe.*

To achieve this objective, the Polytechnic Institute of Bragança (IPB) in consortium with the Faculty of Sciences of the University of Lisbon (FCUL) and COLAB MORE have developed different natured based solutions (NbS) on an industrial scale, in particular a soil conditioner (more than 25 m^3), which has been applied to degraded soils, in the form of permeable barriers, in a pilot area (PA), whose plot occupies 60x60 m (1200 m^2) and that is being monitored in field and with Sentinel satellite images. To this end, IPB has installed more than 15 field erosion fences and different biophysical parameters (soil loss, C storage, physic-chemical properties, ecological restauration,…) are being monitored, that will allow us to determine the rate of soil loss in regions affected by fires in the past.

The project is divided into 10 activities: one management activity (Activity 0), two activities about the detailed terrain survey and instrumentation of the intervention area, that is, plots of more than 1200 m^2 and 48% slope; three activities to test the application of different NbS: compost -biochar- biological crust, where it was applicated more than 12 tons of SbN-compost (Activity 1, 2, 3). These activities constituted the most difficult part of the project, namely, the interventions' spatial distribution in field.

Another four activities involve monitoring biophysical parameters on the installed plots: soil loss rate, soil C storage, nutrients input/output, natural regeneration of biological crusts, sediments export rate to dam and water quality parameters (Activity 5, 6, 7, 8). The economic

evaluation activity was developed (Activity 9). The communication and dissemination activity (Activity 10) with high students was the most active activity, with monthly training and dissemination activities.

As a quality control system, two external audits were conducted to inspect the field test: visit to the PA and the composting plant where the NbS have been produced and the experimental tests have been carried out. The audit involved explaining all activities undertaken in field and outlining the next steps up to project end. In October, during the field trip, the auditor inspected both field trials: the place where the compost is produced, in Quinta do Prado (Vilaflor), and the place where the compost was applied as NbS in the erosion plots in Picões (Alfândega da Fé). In march 2024, the auditor inspected the state of all activities to project end. We received the first report of the on-site verification carried out on our project in December (2023/12/21) and the second report in April with all non-conformities resolved.

Term and Financing

The SOILING project received firstly a notable budget cut of ~30%, as it was the last project approved in this Call5. It had a significantly lower budget than requested, which was make it difficult to achieve all the activities budgeted in the application until project end. According to the Consortium Contract, signed on 2022, at clause 6 about *Term and Financing*, the current financing rate was 54.27% and a maximum financing amount of €194,537.12 (article 5). However, according to article 6: "*the financing rate referred may be increased to 85% from the moment the program's release is authorized… thus reaching a maximum financing amount of €304,692.73*". SOILING consortium was pending on reliable information on the decision concerning the possibility of increasing the funding rate up to 85%. Finally, this decision arrived in January of 2024. Understandably, such decision was crucial for the designed or for redesigning the project management and implementation strategies during the last months of its time span. Contacts with SGA staff repeatedly confirmed that the possibility existed and could be materialized at the appropriate moment. And this effectively occurred early in 2024.

For this reason, the SOILING consortium had to request an extension of the project physical execution period (including reprogramming the project budget), in order to guarantee the project end execution.

Table 2 presents the execution schedule of the activities until April 2024 to guarantee the end all the objectives and indicators. An addendum to Consortium Contract was signed (date 12/31/2023) between the promoter and partners in order to extend the project execution period from December 2023 to April 2024.

The reasons explained will be substantiated in detail along the present document to be recorded as a formal statement in this Final Report.

Project execution rate

Table 1 presents the current status of each project activity (ongoing/ overdue/ completed). A column has been included with the project physical execution rate (regardless of compliance with the indicators), where it can show as, in the final reporting period (April 2024), all activities have been completed.

Delays

Firstly, delays in field tests were due to the difficulty in obtaining licenses from landowners and the difficulties in accessing PAs in the summer months (May to September 2023), due to the high risk of forest fires, but were successfully resolved in October 2023.

Secondly, there were delays in hiring human resources (master's level) in the first reporting period. In the last, some fellows received FCT grants to monitor the field trials (for next 4 years), which will ensure the continuity of the SOILING project.

Thirdly, there were delays in the acquisition of equipment due to the rise in market prices in 2023. The main delay in a project activity is due to the difficulty in acquiring specific equipment due to financial constraints.

Finally, the project was running on schedule and key project indicators were achieved.

Summary of the activities carried out:

During all project time, monthly face-to-face or by videoconference meetings were held between IPB and partners. The meetings followed a guide, where the status of the activities in execution according to the calendar was addressed (Table 01).

Table 1. Summary of activities carried out; information regarding partner involvement, in particular with regard to donor country partners; information concerning the participants in the Project.

ID	Name Activity	Start Date	End date	State point (ongoing/ overdue/ completed)	Execution rate	Comments
A0	Project management	2022-07-01	2024-04-29*	Completed	100%	Very active activity
A1	Detailed terrain survey and interventions' spatial distribution patterns	2022-07-01	2023-12-31	Completed	100%	Activity 1 finished in December.
A2	Instrumentation of the intervention area	2022-07-01	2023-12-31	Completed	100%	Activity 2 finished in December.
A3	Formulation, application and monitoring of the NbS: OP-based compost	2022-07-01	2023-12-31	Completed	100%	Activity 3 finished in December.
A4	Formulation, application and monitoring of the NbS: OP-based biocharP	2022-07-01	2024-04-29	Completed	100%	Activity 4 will continue collecting data for the next 18 months.
A5	Biocrusts installation	2022-10-01	2024-04-29	Completed	100%	A5 will continue taking data for 18 months.
A6	Field process monitoring	2023-04-01	2024-04-29	Completed	100%	A6 will continue taking data for 18 months.
A7	Soil-driven ecosystems services' evaluation: monitoring erosion, C sequestration and nutrients	2023-04-01	2024-04-29	Completed	100%	A7 will continue taking data for 18 months.
A8	Spatial monitoring soil degradation processes and water quality trough remote sensing	2023-04-01	2024-04-29	Completed	100%	A8 will continue taking data for 18 months.

ID	Name Activity	Start Date	End date	State point (ongoing/ overdue/ completed)	Execution rate	Comments
A9	Economic assessment of the environmental measures applied	2023-10-01	2024-04-29	Completed	100%	Activity 9 finished in April.
A10	Project's promotion and dissemination	2022-07-01	2024-04-29	Completed	100%	Very active activity.

* it had approved to extend the project until April 2024

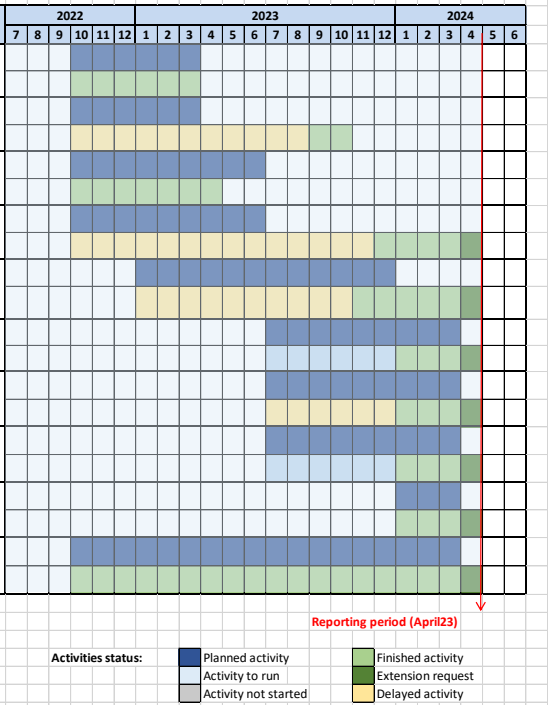
Gantt Chart

SOILING timeline, despite some delay on field trial and instrumentation PA, and the acquisition of equipment in previous report, was developed without major constraints as show below.

On the updated Gantt chart is shown on the updated Gantt chart proposed timeline (in dark blue) versus the actual stage of project's execution: finished activities (in green), to be executed (light blue), delayed (yellow) and not started (in grey) (Table 02).

Table 02. Diagram of Updated SOILING Gantt to 2024 April

Program Area	Activity ID	Activity Description	Indicador / Indicator	Promoter / Partner
A	1	Detailed terrain survey and interventions' spatial distribution patterns	Cartographic products	IPB
A	2	Instrumentation of the intervention area	Nº of Erosion fences (TE) installed	IPB
A	3	Formulation, application and monitoring of the NbS: OP-based compost	Germination index (according to EN 16086-2_2011)	IPB / COLAB
A	4	Formulation, application and monitoring of the NbS: OP-based biocharP	Increasing soil P content	COLAB/ IPB
A	5	Biocrusts installation	Chlorophyll a content	FCUL
A	6	Field process monitoring	Rate of soil loss that will potentially be transported to the dam	IPB/ COLAB
A	7	Soil-driven ecosystems services' evaluation: monitoring erosion, C sequestration and nutrients	Increasing soil C stock	COLAB/ IPB
A	8	Spatial monitoring soil degradation processes and water quality trough remote sensing	Maps obtained from satellite images	IPB/ COLAB
A	9	Economic assessment of the environmental measures applied	Economic assessment of ecosystem services	COLAB
A	10	Project's promotion and dissemination	Number of training sessions with technical stakeholders	IPB/ COLAB / FCUL



A1. Detailed terrain survey and interventions' spatial distribution patterns

The initial field reconnaissance of pilot area (PA) had been carried out in July 2022, in October 2022 the drone flight was carried out to obtain the digital terrain model (MDT). After processing the MDT data, in months February, March and April 2023, we returned to the field before installing the NbS. The aim of this reconnaissance field work was to confirm cartographic information already gathered in first reported and explore the off-road accessibility to PA. The reconnaissance work was very helpful for designing the SbN implementation strategy in PA, as such a strategy is very much dependent on accessibility constraints, limiting safe movement of personnel and material distribution during the installation of the experimental setup and later, during the field monitoring phase.

Throughout the year and until August 2023, we performed an administrative procedure to obtain permission from the owners to access private property. Due to the difficulty of accessing the initial PA (it is private property and it has not been possible to contact the owners), two alternative PA were identified, featuring similar geographic conditions: slope, vegetation, for example. In July 2023, we finally obtained permission from one of the owners to access one of the PAs. While we lacked of drone images for high precision analysis, we rely on a 10 m DEM to support the decision-making process for selecting and establishing new PA.

Finally, in October 2023, we carried out the long-awaited field campaign. The test consisted of clearing the shrubland of a plot of 1200 m2, with a slope of 48%, on the edge of Lagos de Sabor, to install barriers and erosion plots for monitoring the SbN. It took 5 days in the field, with 10 volunteers, doctorate students or research assistants, 4 full-time teachers, and a brigade of ICNF- Institute for Nature and Forest Conservation forestry firefighters.

In December 2023, a new drone flight was carried out for this alternative PA, enabling the integration of orthophoto and LIDAR images, thus connecting both the previous and the current area, using the georeferenced data processed.

A2. Installation of erosion measurement devices (silt fences)

Activity 2 suffered some delays during the project execution time due to the difficulties encountered in accessing the field plots of private property. In this case, one of the PA that was previously selected in Activity 1, turned out to be privately owned. As an alternative, two other

PA were selected within the Alfandega da Fé council, both of which have boundaries with the dam water line.

In October 2023, NbS were installed according to the experimental design and the erosion measurement devices were installed according to the location generated by the optimization algorithm developed. The tasks initiated on 4th October and finally 10th October of 2023. In field work, two teams were designated for tasks related to implementation area. One team was responsible for organizing and executing logistics to compost transportation from composting station to PA, while the other team focused on delineating and supporting the installation of erosion plots. The ICNF forestry firefighters deforested the vegetation cover within each erosion plot for soil interventions implementation, following instructions on which areas required cleared vegetation and which did not. They also assisted in creating pre-barriers using the cleared vegetation, later added NbS: olive pomace compost. After preparing the erosion plot area and delivering the NbS, the group, with the aid of a tractor, deposited the compost at specified locations. The compost was then moved to the previously located barriers. Subsequently, erosion traps were installed above and below each barrier. In the control area, where land cover remained intact, only one erosion trap was installed at the end of the 54 m. length.

The application of compost on PA's soils required to large scale machinery and effort of more than 10 people: 2 full-time professors, 6 fellowships from the IPB and 2 technicians from MORE staff. Moreover, national and regional regulatory bodies were also involved, namely ICNF workers, which contributed with additional 4 specialised HR and a 4x4 truck. These means were led by the responsible technician of AFLOCAF, the Forest Landowners Association of Alfândega da Fé Municipality.

A3. Formulation, application and monitoring of the NbS: OP-based compost

Considering that olive pomace (OP) is phytotoxic and should not be used directly on the soil, an aerobic composting process was conducted aimed at obtaining a non-phytotoxic organic compost or fertilizer (I class).

First field trial: From September 2022 to May 2023, the composting process proceeded until obtaining a high-quality compost. The experimental design consisted of seven treatments (composting piles) with different doses of OP (50, 100%), using different structuring agents: forest

biomass (FB) and almond shell (AS) or mixture (FBAS), aiming to evaluate how the pile composition (structuring agent doses) affects the phytotoxicity loss and consequently the quality of the final compost. The composting trial ended in 4-6 months, when a 100% loss of phytotoxicity was identified, together with a decrease in C/N and an increase in available organic N. At this time, activity 3 has finished and the compost will be applied to the field in the following months. In order to certify the compost quality as Class A, and according to national regulations, some samples of the final compost will be sent by MORE COLAB to a laboratory for the required certification analysis.

Second field trial: In July 2023, a second field test was carried out in static piles (25 m^3), comprising three treatments with different doses of OP (75, 80, 100%) and using almond shell (AS) as structuring agent. Monitoring results and piles characteristics are described in ANNEX 03.

The monitorisation of composting process, required the partial-time work of 1 professor, 2 fellowships from the IPB and COLAB staff.

A4. Formulation, application and monitoring of the NbS: OP-based biocharP

In what concerns Activity 4, it is important to highlight that this activity was delayed due to the acquisition of a lab equipment that was planned to be purchased: a pyrolysis furnace. The administrative process of acquiring the pyrolysis oven was initiated by IPB, the project leader since the initial time. After consulting three international companies to adapt to the budget in 2023 (modality, type, power, capacity, materials, price, delivery date), the public contracting process has begun, consisting of the international publication of the offer. This process took around 6 months until the offer was awarded to the best supplier and after going through an adjudication tribunal. Finally, the offer was awarded to a foreign company, with which an agreement was reached with the base price and the final purchase proposal for this equipment from the IPB responsible body.

In order not to delay the biochar production, it was produced in a muffle furnace (on a medium production scale) to obtain enough material to carry out laboratory and semi-field tests and, later, it was tested on a laboratory scale.

During 2023, the previously produced OP-based biocharP were analysed using different techniques.

It was decided to carry out an experimental design in semi-field conditions, on the IPB campus, where a rainfall simulation trial was carried out on soil trays with 5 treatments previously decided in the project. However, the rains and low temperatures of autumn/winter have not allowed the test to be carried out outdoors. So, it was decided to carry out the experiment in the IPB greenhouses. At this time the tests were carried out under controlled conditions. The results are presented in this report.

In the other hand, it was decided to carry out a bibliographic review article that will allow optimizing the industrial process once the pyrolysis oven is installed. The article was sent to an international peer review journal in early 2024.

The administrative process required the partial-time work of 1 professor from IPB and 1 postdoctoral fellowship from COLAB staff.

A5. Biocrust installation

During the project, the FCUL team (i) selected biocrust moss species, i.e., soil inoculants, based on the study of a post-fire chronosequence, (ii) collected three moss species, (iii) processed the collected mosses, (iv) established 24 experimental plots in Picões, and (v) assessed biocrust establishment.

During May-August 2023, the FCUL team developed an experimental design based on the addition of biocrust inoculum. To test the influence of inoculum type on biocrust growth and ecosystem recovery, different inoculum types were created, based on four species previously selected: *Ptychostomum capillare*, *Ceratodon purpureus*, *Homalothecium aureum*, and *Hypnum cupressiforme*.

In October 2023, the FCUL team collected three moss species: *Ptychostomum capillare*, *Ceratodon purpureus*, and *Hypnum cupressiforme*. Owing to its low frequency in the Iberian Peninsula, it was not possible to collect *Homalothecium aureum* in the amount necessary to establish experimental plots. Moss colonies were then broken into small fragments and cleaned with water over a 2 mm mesh sieve. Moss fragments were slowly air-dried over a 72-hour period to prevent damage from rapid desiccation.

In December 2023, the FCUL team, in collaboration with IPB, established 25 x 25 cm plots to test the influence of moss inoculum type on biocrust growth. Experimental treatments included control plots and seven different combinations of species, in different proportions, applied to 20% of the plot surface, resulting in a total of 24 plots.

In April 2024, the FCUL team recorded active moss cover, an indicator of chlorophyll *a* content and, therefore, photosynthetic biomass. In general, plots inoculated with a single species had higher moss cover than plots inoculated with a combination of species. Both *Ptychostomum capillare* and *Ceratodon purpureus* increased in cover over the course of the experiment, when inoculated separately, highlighting their potential as soil restoration materials.

A6. Field process monitoring

The activity consisted of monitoring the biophysical variables of interest, that is, erosion rates or losses of soil, as well as monitoring the NbS applied in the field.

The field process monitoring comprised two stages. Firstly, remote estimation of sediment transport from the slopes directly to the reservoir was conducted by integrating the Revised Universal Soil Loss Equation (RUSLE) with GIS. This integration enabled the quantification of the actual sediment load and the potential reduction achievable by implementing contour barriers at various intervals of slope length (10 meters, 20 meters, 30 meters, and 60 meters).

Since October of 2023, monthly field campaigns are underway for sediment collection in the erosion traps installed above and below each contour barrier within the intervention area

Project sustainability: Once the project ends in April 2024, it is intended to continue with monthly field monitoring for at least the first 18 months post-project, in order to have solid results on soil loss in the Soiling pilot area. . In parallel, the monitoring of erosive processes by remote detection is intended, based on the analysis and interpretation of satellite images from the Sentinel 2 program.

A7. Soil-driven ecosystems services' evaluation: monitoring erosion, C sequestration and nutrients

The activity consists of the evaluation of ecosystem services in the intervention area, that is, the evaluation of changes in in Soil Organic Carbon (SOC) stock according to IPCC methodology and adapted to Portugal.

Considering the growing worry to decarbonizing Europe, and the abundance of burned areas in Portugal, the Land Use Changes (LULUF categories) in Mediterranean regions with high risk of desertification becomes a strategy to achieve the goal of zero emissions in 2050. Land Use Changes can result in an increase or decrease in Soil Organic Carbon (SOC) stock, being crucial

the quantifying of SOC to anticipate potential future scenarios. The importance of SOC is such that, since 2013, the quantification of SOC losses due to LULUCF Changes in the EU is mandatory.

In the study area of the project, it was decided to apply the methodology recommended by the Intergovernmental Panel on Climate Change (IPCC) to evaluate the SOC loss due yo land use changes, that is, changing the total area from Mediterranean shrubland (*Erica ssp*) to natural hardwood forest (*Quercus suber*).

Cartographic data of each land use (FL- forest land and GL- grassland non tree) were obtained from Portugal's Land Occupation Chart (COS, 2018). And the reference data for SOC, corresponding to Level 1 of the methodology (data of national scale), from Portugal's National Inventory of Greenhouse Gas Emissions (NIR-PT, 2021). SOC level from Mediterranean shrubland to natural forest was compared in a time scale of 40 years for soil resource.

To obtain scale 2 data (regional scale), the SOC data from Lima et al., 2023 were used, while the SOC data from the intervention area (plot scale) were obtained after exhaustive soil sampling. Soil sampled consisted in sampling 56 soil samples at different depths (0-10 e 0-20 cm) and spatial distribution. The samples were processed and the SOC was measured by the calculation method in a certified laboratory.

A8. Spatial monitoring soil degradation processes and water quality trough remote sensing

In June 2023, during A SUSTEC Summer school, an internal training activity was carried out for members of the SOILING team on geospatial techniques to analyse water quality. A theoretical and practical class was developed on the use of Sentinel Images, with the objective of applying the SNAP and RUS programs of the European Copernicus program for monitoring water quality in Lagos de Sabor.

This activity included 2 tasks. On the one hand, the collection of satellite data to obtain a spectral index to assess water quality. In this activity, data from the Sentinel mission of the ESA Copernicus Program were used: freely accessible data, with a temporal resolution of 3-5 days and a spatial resolution of 10 m. To acquire and explore Sentinel images in the intervention area, the CREODIAS and SentinelHub platforms were used, and tasks were carried out in the cloud. Image interpretation and processing were carried out using SNAP software (The Sentinel Application Platform), available at no additional cost. As a result, images were obtained from the Sentinel 2 Satellite, with geographic and atmospheric correction and without nines coverage.

The analysis of Sentinel satellite images allowed us to obtain a spectral index to assess water quality: the NDVI index - Normalized Vegetation Difference Index. Based on spectral data, it was possible to discriminate differences in the turbidity of the reservoir, resulting from the sediment load that produces a change in the chemical and biological composition of the water column. On the other hand, the spectral index data were calibrated with the field data. Water samples were taken from the reservoir and the biometric variables of the phytoplankton were evaluated: biomass, biovolume, IGA and chlorophyll a content.

A9. Economic assessment of the environmental measures applied

This activity aims to carry out a cost-benefit assessment of the soil protection measures tested in this project (SbN) taking into account the ecosystem services provided, based on the physical rates of erosion control and C fixation calculated in the previous activities. In order to evaluate the potential economic impact of the measures applied, it was necessary to combine Soil loss evaluation through Universal Soil Loss Equation (USLE) and geoprocessing, Intergovernmental panel on climate change (IPCC-2006) and National Inventory report (NIR-Portugal) databases.

A10. Project's promotion and dissemination

Considering Activity 10- Project's promotion and dissemination, several actions took place, including events and initial project promotion. General information about the project is already available at project website: https://www.soilingeeagrants.com/ and the events have been promoted before happening and afterwards in social networks: https://www.facebook.com/soilingeeagrants This initiative provides a broader reach and visibility, enabling the expanded dissemination of the actions and results of the SOILING project.

It represents a significant step in the project's promotion and dissemination strategy, increasing its visibility, expanding its reach, and fostering meaningful engagement with the public, effectively sharing the project's activities and results and strengthening the group as a whole. Since the creation of the website, SOILING has participated in the organization of national and international events and the editing and publication of 2 scientific books and 1 informative book. In addition, SOILING's participation has been registered in several national or international congresses, workshops, seminars or summer course.

ii. Results achieved

Evaluation of the Project's results during the accumulate period 2022-2024 in terms of activities, result indicators, communication plan (Table 03).

Table 03: Key performance indicators achieved during the project's execution period.

Nº	Activity	Indicator	Measurement unity	Material execution rate (%)	Sources of verification provided
0	Project management	Nº Interim project Reports	6	100%	4 Interim Reports: Interim report Nº1 (+ Appendix I or Interim report 0), Interim Report Nº 2, Interim Report Nº 3 e Interim Report Nº 4 and Final report
1	Detailed terrain survey and interventions' spatial distribution patterns	Nº Cartographic products	8	100%	8 maps to be reported in Interim Report No. 4.11_Call#5_ Entregavel1_A1
2	Instrumentation of the intervention area	Nº of Erosion fences (TE) installed	15	100%	29 TE Installed at the moment; to be reported in Interim Report No. 4. 11_Call#5_ Entregavel2_A2
3	Formulation, application and monitoring of the NbS: OP-based compost	Germination index	80	100%	GI in 2 trials to be reported in Interim Report No. 4. 11_Call#5_ Entregavel3_A3
4	Formulation, application and monitoring of the NbS: OP-based biocharP	Increasing soil P content	30	100%	P content in lab conditions to be reported in Interim Report No. 4 and Final Report
5	Biocrusts installation	Increase in chlorophyll a	25	100%	To be reported in Final Report
6	Field process monitoring	Maximum rate of soil loss (t/ha)	2	100%	To be reported in Final Report
7	Soil-driven ecosystems services' evaluation: monitoring erosion, C sequestration and nutrients	Increasing soil C stock	0,5	100%	To be reported in Final Report

Nº	Activity	Indicator	Measurement unity	Material execution rate (%)	Sources of verification provided
8	Spatial monitoring soil degradation processes and water quality trough remote sensing	Maps obtained from satellite images	2	100%	To be reported in Final Report
9	Economic assessment of the environmental measures applied	Economic assessment of ecosystem services	1	100%	To be reported in Final Report
10	Project's promotion and dissemination	Number of training sessions with technical stakeholders	6	100%	Interim Report No.1 (Appendix III) and No. 2 (Appendix II), Interim Report Nº 3 e Interim Report Nº 4 and Final Report

The global material execution rate of the project is estimated at 100 %, being all activities completed. Verification sources for all activities are sent as an annex to this report.

A1. Detailed terrain survey and interventions' spatial distribution patterns

PA is part of the following territorial units: Alfandega da fé Municipality (AMA, 2018); Municipality Association of the Baixo Sabor (AMBS, 2014). The potential spots for installing SbN in PA have been defined by accessibility criteria, as the rugged terrain of PA drastically limits vehicle circulation to transport personnel and materials. A new drone flight was carried out for this alternative PA, enabling the integration of orthophoto and LIDAR images, thus connecting both the previous and the current area. Processing of georeferenced data was carried out.

In the before reporting period, deliverable 1 was delivered: Deliverable No. 1: Cartographic products: MDT; Basic cartography; Map of optimized distribution of interventions (ANNEX 01).

A2. Instrumentation of the intervention area

It should be stressed that SbN was set in place in these spots in contour bunds, so that a sequence of difficult operations was performed before and after SbN installation. In the former case, these are opening an access path from the unpaved road, clearing shrubs in the experimental areas, ranging vegetation residues on contour belts, transporting SbN to the experimental areas, where they will be set in place. It should be noted that the PA is on the steepest hillslopes draining to Lagos de Sabor (ca. 48%), which makes the use of heavy machinery

difficult and manual work must be carried out with extreme occupational safety and prevention measures. The criteria adopted to define potential location of SbN was accessibility, in addition to hydrological criteria conditioned by the length of the 60 m slope, covering an area of 1200 m2, in the form of a 60 m x 60 m quadrilateral. By combining the field survey with drone imagery geoprocessing, it will accurate identification of areas with higher flow accumulation within the implementation site was achieved.

In the field, minor adjustments were made to the implementation area. The length of erosion plots was reduced to 54 meters, as 60-meter length would have been to close to the lake border. Additionally, one more erosion plot with barrier was added, bringing the total to seven. The area was demarcated using Centimeter GPS, measuring tape, and stakes inserted at each plot vertex. Vegetation was cleared by a tractor, excluding the control area, which remained intact.

In the before reporting period, deliverable 2 was delivered: Deliverable No. 2: No. erosion fences (ANNEX 02).

A3. Formulation, application and monitoring of the NbS: OP-based compost

To produce the olive pomace (OP) compost it was made two different composting field trials. Both experimental runs of the composting process of OP were done at the Acushla Biological Olive-oil. The company provided the OP by-product, space and equipment (front backhoe, irrigation system,...) to execute the composting trials and a partial-time worker, given that all trials were made on an industrial scale (more than 100 m3 compost was obtained).

The first experimental design sought to solve the high phytotoxicity issue present in OP based compost. For that seven composting piles of 12-16m^3 were prepared, using OP, and trying two kinds of structuring agents, almond shell (AS), and forest biomass (FB), to see how the phytotoxicity loss would be affected. Due to the positive results of the previous trial, the second composting experiment sought to diminish costs and therefore turn the activity more rentable for the employer, while maintaining the quality of the final compost. For that, it was designed three piles using the OP, and AS, with different proportions, but keeping the usage of OP above 75%. The chosen treatments aimed to increase the cost-benefit while maintaining the quality of the final compost.

Periodic monitorisations of composting piles took place, to collect samples for physicochemical analysis. The sampling was done weekly for the first month, biweekly for the second month and monthly from the third month.

Several samples were collected, summing up a total of 15 samples, per field trip, a total of 120 samples. Physicochemical analysis (T, %wet, ρ, pH, EC, OM, C/N, O/C, H/C, GI) were performed for each one of the (15x8) samples collected for the period of report. Results for composting processes can be consulted on the present document.

In the before reporting period, activity 3 has finished and the quality of the compost and biostimulant capacity has been tested. Deliverable No. 3 is delivered: Germination Index (Phytotoxicity Test, according to EN 16086-2_2011) (in %) (ANNEX 03).

A4. Formulation, application and monitoring of the NbS: OP-based biocharP

Having achieved the goals proposed for the biochar production in laboratory conditions as well as its enrichment with P and Mg, further lab trials were needed to anticipate potential experimental constraints and limitations upon field application.

An experiment was designed to understand the proposed NbS performance in preventing water erosion under lab rainfall simulation conditions, those experimental design, as respective treatments and dosages are summarized in ANNEX 4.

In order to understand the role of biochar in soil loss, were measured the following parameters Runoff (E, 9 replicates), Suspended Sediment (PS, 6 replicates), Sediment Front and Splash (SP and I, 3 replicates). During the 30 minutes of rain simulation, 3 samples of water were collected, per tray, at 6-10, 16-20 and 26-30 minutes. Considering each treatment had 3 samples (trays), we had a total of 9 samples per treatment (3 per sample x 3 per time of sampling).

Results suggest biochar application lead to lower rates of E, PS, SP and I when applied into soil on 1:10 ratio (biochar:soil) and that results may be enhanced when combined with compost. Combination of 10% of both compost and biochar (COMP_10+BIO_10) revealed to be the most satisfactory treatment to prevent runoff and soil loss. Additionally, also phosphate determination, showed that combination of compost and biochar are more stable than biochar alone (P leaching may potentially lead to water eutrophication on the reservoir). Though, are not significant differences between compost+biochar treatments (5% and 10 %), results show that the most advantageous treatment is COMP_10+BIO_10 (lower P leaching and soil loss rates).

Nevertheless, there are significant differences between this treatment and control condition on PS and SP parameters, which suggest the need of further investigation towards the definition of an optimal compost/biochar ration, mitigating erosion and promoting water quality conservation.

Nevertheless, all treatments tested showed low contents of phosphate on collected water after drainage (maximum PO_3^{4-} eq. concentration= 3.1 mg); this highlights the stability of biochar thus, nutrients incorporation, considering that phosphate's leaching to water was 0,59% for each rain event (>99% phosphate fixation into soil). Detailed results can be consulted on Annex 4.

On the other hand, a bibliographic review has been carried out on the types of biochar that can be obtained from olive pomace and stone. This review will allow optimizing the manufacturing conditions of biochar in a pyrolysis oven (temperature ramp, raw material, activator, reducing atmosphere), in order to obtain the desired physicochemical characteristics in Biochar (specific surface, porosity,...) to apply to degraded soils.

At this time, laboratory and semi-field tests have been carried out to determine its relevant physical-chemical characteristics and quality of the Biochar-P has been tested. Deliverable 4: Increase of P in the soil (%) (ANNEX 04).

A5. Biocrust installation

In field campaigns, three moss species were identified and collected: *Ptychostomum capillare*, *Ceratodon purpureus*, and *Hypnum cupressiforme*. Owing to its low frequency in the Iberian Peninsula, it was not possible to collect *Homalothecium aureum* in the amount necessary to establish experimental plots.

The FCUL team recorded active moss cover, an indicator of chlorophyll *a* content and, therefore, photosynthetic biomass. In general, plots inoculated with a single species had higher moss cover than plots inoculated with a combination of species. Both *Ptychostomum capillare* and *Ceratodon purpureus* increased in cover over the course of the experiment, when inoculated separately, highlighting their potential as soil restoration materials. (ANNEX 05)

A6. Field process monitoring

The values obtained from the remote estimation of soil erosion indicates that Lagos de Sabor receive an annual sediment influx of 1181 tons, corresponding to an erosion rate of 6.51

ton/year/ha. The most effective erosion control estimative was achieved with 10-meter contour barriers, resulting in a total drainage to the reservoir of 263 ton/year, representing an erosion rate of 1.45 ton/year/ha and signifying a total reduction of 78%.

The 56 samples collected (with 3 replicates and 2 depths) in the pilot area in field campaign of 2023 were analysed and indicates that the soils predominantly are eutric Leptosols, spanning from loam to sandy loam textures and exhibiting a range of acidity from moderately acidic to extremely acidic.

The data obtained from sediment traps (from October 2023 and April 2024) were accumulated in 6 months and weighing. The recorded weights of the sediments captured by the traps ranged from 11.68 grams to 37.89 grams. However, it's important to note that these values should not yet be construed as direct indicators of sediment load, and it is necessary to have a temporal sequence of data for many years (ANNEX 06).

A7. Soil-driven ecosystems services' evaluation: monitoring erosion, C sequestration and nutrients

Results of applying the methodology recommended by the IPCC to evaluate the SOC loss due to changes in land use, that is, changing the total area from Mediterranean shrubland (Erica ssp) to natural hardwood forest (Quercus suber), depend on the scale (tier).

At national scale (tier 1), the results indicated an increase in the COS stock for the area of intervention, with an average increase of 1 ton/ha year. Although the Level 1 methodology of IPCC is simplified, it is useful, allowing for an approximate estimate of SOC using readily available data. It is concluded that the change in land use from shrubland to hardwood forest is beneficial in relation to SOC, increasing the total stock of the area by almost 1200 tons.

The land use change that will take place due to the change from bush (SOC= 47 ton/ha) to forest (SOC= 86 ton/ha), corresponds to a difference of 39 ton/ha, which indicates an increase of 82% in SOC. Considering a time horizon of 40 years until the forest is mature, hardwood forests compared to shrublands will contribute to increasing SOC at a rate of approximately 1.3 tons per hectare per year, this is an increase in SOC of 2% per year. (ANNEX 07)

A8. Spatial monitoring soil degradation processes and water quality trough remote sensing

Of all the variables measured in the phytoplankton of the reservoir's water column, the variable that best correlated with the NDVI spectral index, obtained by Sentinel 2 satellite

imagery, was the chlorophyll a content, which is greater the higher the NDVI, thus detecting rapid processes of turbidity or eutrophication in waters due to erosive processes.

After calibrating this spectral index with field data, we were able to make a very accurate calculation of the reservoir's water quality using remote sensing. It can be shown that the areas with the greatest turbidity coincide with the areas that receive the greatest sediment load. As a consequence, turbidity reduces the trophic group of chlorophytes (and adds cyanobacteria), having a direct effect on the reflectance (NDVI) of the water surface.

As the annual sediment load that drains into the reservoir is the cause, in part, of these differences in turbidity in the water, it can be considered a good indicator to monitor the effect of soil protection measures on erosion control and water quality. (ANNEX 08)

This type of remote approach would make it possible to develop a methodology in the future for early monitoring of eutrophication in the reservoir, which will allow for timelier field intervention.

A9. Economic assessment of the environmental measures applied

Considering results obtained from A7 (SOC increase up to ~1200 ton in 40 years, 1.3 tons per hectare per year) is possible to consider economic evaluations and impacts of the project, through Carbon Credits Market (Portugal: Decreto-Lei n.º 4/2024 de 5 de Janeiro de 2024). According to "Energy taxation, carbon pricing and energy subsidies" (Review No 01/2022) from European Court of Auditors (Portugal 23,80 €/ ton C and UE_27: 56,63 €/ ton C), applied measures may contribute to the fixation of an amount of SOC quoted in 30,94 €/ per hectare per year, which would mean ~928,2 ton per year in the project intervention area.

Moreover, the NbS applied will mitigate erosion and prevent soil loss into Baixo Sabor reservoir. Considering data provided by MOVHERA, company which is responsible for maintaining and operating the hydropower plant, AHBS has 1,095 x 10^9 m^3 of capacity and a lifetime of 75 years. When considering results from A7, using USLE and geoprocessing (actual erosion rate of 1.45 ton/year/ha) it is possible to understand that absence of land use and soil management strategies can lead to a low decrease of reservoir's capacity in 75 years. Therefore, the implementation of innovative and effective land management measures in the current situation seems to have little effect on the water reserve, but could lead to an improvement in water quality and electrical energy production in the reservoir.

In terms of energy production, the present scenario (actual erosion rate of 1.45 ton/year/ha), may represent some loss of of energy produced by the hydroelectric plant during its useful life, making it very difficult to make an economic assessment.

Additionally, SOILING project implemented innovative, ecologic and cost-effective soil management strategies which mitigate erosion, fosters desertification combat with positive economic outcomes.

A10. Project's promotion and dissemination

Considering the project's Communication Plan, some goals have already been achieved. Firstly, project information has been made available on this website: https://www.soilingeeagrants.com/ and the events have been promoted before happening and afterwards in social networks: https://www.facebook.com/soilingeeagrants

The dissemination actions gathered several entities, both public and private, targeting different audiences, from children to students and researchers, partners and the general public. The implementation of consolidated communication strategies allowed and will continue to allow the maximization of results and sensibilization of a wider population.

As result of the communication plan, SOILING counts with: Table 04.

Table 04. List of dissemination and social communication activities carried out until May 2024.

Type of promotion and dissemination actions	Number of planned actions (goal)	Number of actions performed	
Website	1	1	https://www.soilingeeagrants.com/
Social network	1	1	https://www.facebook.com/soilingeeagrants
Project social media posts	1/month	1/month	https://www.facebook.com/soilingeeagrants

Publications on partners' websites and partners' social networks	1	1	https://morecolab.pt/2022/09/28/projeto-soiling/ https://morecolab.pt/projeto-soiling/ newsletter_2023 (morecolab.pt) (10) More - Colab Montanhas de Investigação | Facebook https://www.linkedin.com/posts/morecolab_eventos-jornadas-t%C3%A9cnicas-de-regenera%C3%A7%C3%A3o-activity-7184224453390725121-T6BK?utm_source=share&utm_medium=member_desktop https://www.linkedin.com/posts/morecolab_projetos-parceiro-montanha-activity-7139949714560499712-rwQn?utm_source=share&utm_medium=member_desktop
Scientific publications	**4**	15	2 publications at the 6th International Risk Congress, Coimbra, May 2023
			2 publications at the 16th International Water Congress, Coimbra
			7 publications at the II National Congress of Soil Sciences, Bragança, 28-30 June 2023
			1 publication in Scientia Meetings, 14 June, Lisboa.
			1 Book of Abstracts, 2nd National Congress of Soil Sciences, IPB, Bragança,

			28-30 June 2023, 85 pp. (ISBN 978-972-745-322-1)
			1 Field Guide Book, 2nd National Congress of Soil Science, SPCS, IPB, 28-30 June 2023, Bragança, 96 pp. (ISBN 978-972-745-323-8)
			1 publication in Sustentability (review in April 24).
Non-Scientific Publications: Dissemination books	1	3	Manual book for schools: World Soil Day 2022, Soils: Where Food Begins, Bragança, 39 PP. (ISBN 978-989-33-4220-6)
			O solo na Escola. World Soil Day 2023, 65 pp (ISBN 978-989-33-5584-8) http://hdl.handle.net/10198/26577
			1 Technical dossier: "Good Composting practices for agro-industrial waste"
Flyers	1	1	
Posters	1	1	
Sending information for publication on the EEA Grants PT app	All months	All months	Almost every month
Participation in conferences and seminars	6	16	2 participation in 16th International Water Congress, Lisbon (21 to 24 March)
			1 Workshop on National Forest Day and World Tree Day, Bragança (March 21)

			1 Seminar of Ecosystems services and Carbon Markets, Bragança (April 14, 2023)
			1 Exposition of the 2023 SciComPt Congress, Bragança (May 4 and 5, 2023)
			2 participation in 6th International Risk Congress, Coimbra (23 to 26 May 2023)
			6 Participation in 2nd National Congress of Soil Science, Bragança (June 28 to 30, 2023)
			1 Scientia Meetings, Lisboa (14 june)
			1 AQUACONSOIL
			1 World Bioestimulant Congress
Organization of seminars or Workshop /Congress	6	6	I SOILING Workshop: Roadmap through territories susceptible to desertification: problems, experiences and solutions, 14-15 December 2022, Bragança
			90 Café de Ciência: The importance and beauty of soil diversity, by Jorge Mataix, President of SECS, 14 Dec 2022, Bragança
			World Soil Day 2022: Here There Is Science: Soils: Where Food Begins, 10 Dec 2022, Bragança
			2nd National Congress of Soil Science, SPCS, IPB, 28-30 June 2023, Bragança
			SusTEC Summer Course, Bragança (14, 15 julio 2023)

			Target Audience: Environmental technicians, researchers and IPB students
			Presentation of the book "**Soil at School: Guide for educators"**, 5 Dec 2023, Centro de Ciencia Viva, Bragança
			100% Kids Ciência, 9 Dec 2023, Centro de Ciencia Viva, Bragança
Training actions	6	8	**Training Course: Ecology day,** IPB, Bragança. *Target Audience:* Training course for forestry and environmental technicians, forestry companies, municipal council technicians, ICNF, accredited by IPB with > 120h.
			Sessions 1-2: Soil restoration training with Mediterranean plants, September 15 and 25, 12 h.
			Session 3: Field trip. Recognition of Mediterranean species and seed collection in native forests of the Lagos de Sabor (non-burned area of Picões), October 3, 10 h.
			Session 4: Pre-treatment of the collected seeds (definfection, selection,), November 16-17, 40 h
			Session 5: Disinfection and cold stratification, in plant nurseries, November 24, 4 h

			Session 6: Preparation of substrates and sowing of seeds, 6,000 seeds in 120 tabuleiros, January 15-18, 2024, 40 h
			Session 7: Pre-germinative test, February 27, 8 h
Technical Days for post-fire recovery of the slopes of the Baixo Sabor reservoir	1	1	**Final project** Jornadas Técnicas para a Regeneração de Solos – *SOIL REGENERATION TECHNICAL DAY:* (1) Facebook
Communication with the media and media presence at project events	1		Podcast "90 seconds of science" by Antena 1

The SOILING project carried out a series of activities and participated in events as part of its promotion and dissemination strategy. These actions aim to increase the project's visibility, strengthen its recognition among funding parties and regulatory entities, stimulate the industrial sector in the interior regions of Portugal, promote circular economy policies, and foster knowledge transfer between academia and the business sector. The means and instruments of dissemination were carefully selected to achieve effective, efficient, and viable communication.

During the period from September to December 2023, our focus was on actively disseminating information through various channels and events to reach a wide and diverse audience:

a) Communication with the media:

In 2023, we recorded a segment on the project's activities for the "90 Seconds of Science" podcast on Antena 1, which has just been broadcast (15/01/2024): 90 seconds of science in Portugal.

b) National and international Congress:

- In September, Soiling project participated in the *AquaConSoil event*, held from 11 to September 15, 2023, at the University of Life Sciences in Prague, Czech Republic. This event provided an opportunity to share about the project, learn, and collaborate in creating innovative NbS for the sustainable use and management of soil, water, and sediment resources.

- In November, we participated in the *Farm to Fork event*, held from 16 to November 18, 2023, at the Cine Teatro Avenida, Castelo Branco, Portugal. The work "Strategies to mitigate post-wildfire erosion in NE Portugal through the optimized placement of contour barriers and traps" was presented by scholarship holder Vinícius Okada.

- Also, we highlight the active participation in the *I-Danha Food Lab*, held from 17 to November 19, 2023, in Monsanto, Portugal. Attendance and involvement in the event provided an opportunity to share the project's initiatives, thus contributing to disseminating the research objectives and results.

- Soiling project was at *22n Encontro Nacional de Ecologia*, Faro, 22-25 November 2023, where Monteiro did the oral presentation: Changes in bryophyte functional composition during post-fire succession.

- In December, Soiling project was at the *World Congress of Biostimulants* that took place in Milan Italy, with more than 700 people registered, where the members of the project had the opportunity to present SOILING.

- Participate on the *5th International Yale Symposium on Olive Oil*, co-hosted by BLC3 Technology and Innovation Campus and Yale School of Public Health, held in Oliveira do Hospital (Portugal) from 10 to 13 December 2023.

c) Training courses: Organization of seminars or Workshop / Technical seminars

In September, a training course for forestry technicians from State bodies (ICNF, municipalities) and IPB postgraduate students on reforestation began: *ECOLOGY DAY*: *"Propagation and planting of Mediterranean trees in the Sabor Lakes: Get ready to plant"*. The course organized by the IPB (with more than 120 hours) aims to train forestry technicians in soil recovery and reforestation techniques with native species from the Mediterranean environment and their adaptation to different drought conditions. The course began in 2023 and aims to

extend until 2024. The training course aims to create a forest greenhouse and reforest more than 6,000 plants in Lagos de Sabor, in order to provide continuity to EGRANT projects, such as SOILING. For reforestation, there will be support from several municipalities, municipal schools, the IPB student community, ICNF and volunteers from environmental associations. From different sessions of a theoretical and practical nature, attendees learn to recover plant material, seed germination techniques, preparation of forestry seedbeds and finally, growing of forestry. So far, the following training sessions have been carried out:

- Session 1-2: First meetings took place on 15th and 25th September at IPB, providing theoretical training about Mediterranean forest (12 h).
- Session 3: On 3th October, the second meeting was a field trip to collect seeds in Lagos de Sabor, covering various forests to collect cork oak, holm oak and juniper seeds (10 h).
- Session 4: Pre-treatment of the collected seeds (cleaning and selection of the best individuals), 16-17th November, 40 h
- Session 5: The third meeting, on 24th November, took place in the IPB Greenhouses, focusing on learning and carrying out seed stratification (10 h).
- Session 6: the fourth meeting between on 15th and 18th January, also in the IPB greenhouses was dedicated to sowing seeds (30h).
- Session 7: Pre-germinative test, 27th February, 8 h

In December 2023, the Centro de Ciência Viva (CCV) e IPB organized the 100% kids science workshop for children aged 5-12. On 9th December , this workshop was dedicated to "Soils", with the collaboration of more than 10 IPB monitors, giving 20 children the opportunity to learn practically about erosion, permeability, pollution, and soil degradation, exploring fundamental concepts of soil science and carrying out artistic activities such as painting using soil.

Within the scope of SOILING Project, IPB in partnership with MORE COLAB, promoted the Soil Regeneration Technical Day, in order to promote project's main results and outputs, as foreseen on the Communication Plan of SOILING. The event took place on 23rd April of 2024, at Dionísio Gonçalves Auditorium (Polytechnic Institute of Bragança) with possibility to attend remotely (*via* Microsoft Teams). The session counted with the honourable presence of the

Director of the General Secretariat for the Environment, Dr. Susana Escária whom intervention intended to promote European Economic Area (EEA) Financial Mechanism 2014-2021 and raise awareness for the main problematic addressed by the Environment Programme, namely the Desertification Combat. Attendees registration was performed via Google Forms (Jornadas Técnicas de Regeneração de Solos (123formbuilder.com)) where 90 entries were recorded; seven students also joined the session (physically) without registering, summing up a total of 97 participants.

d) Scientific publications

As a result of our participation in the *2nd National Soil Science Congress (II CNCS):* Soils in the Sustainable Development Goals, from June 28th to June 30th, where SOILING project had the opportunity to present 7 abstracts enabled the sharing of knowledge and results obtained by the project, a special issue of Revista de Ciências Agrarias has recently been published, edited by the SOILING senior team members and following a peer review process, which contains the extended version of works presented during the Congress and includes those produced by SOILING team members and collaborators.

Other Research article: Changes in bryophyte functional composition during post-fire succession. Submitted By FULB to Science of the Total Environment.

Additionally, a paper review (reported on 4RTCI) on biochar production and its potential application as soil fertilizer was already submitted to scientific journal Sustainability. The systematic review (manuscript ID: sustainability-2997337) was submitted on april 19th with the title “Biochars derived from olive mill byproducts: typology, characterization and eco-efficient application in agricultural - A systematic review.”

e) Scientific dissemination books

World Soil Day was celebrated in December with the book presentation for schools "Soil at School - A Guide for Educators" launched on 5th December at the Centro de Ciencia Viva in Bragança. The book presents didactic ideas designed to guide educators in teaching children about soil's importance in our live. More than 20 teachers from Bragança schools attended and were challenged to carry out Book activities in schools during 2023/2024.

Finally, it was to prepare a technical material Composting Dossier: “Good Composting practices for agro-industrial waste" Optimization of the agro-industrial waste composting process, by Zulimar Hernández and Tomás de Figueiredo, 2024, 36 pp.

All activities above mentioned were widely publicized on the project's official Facebook page and Soiling's dedicated website, playing a crucial role in extending the reach of project-related messages and providing easy access to detailed information about each initiative. Detailed records of all these events, including presentations, materials distributed, and participation, providing a complete overview of the project's promotion and dissemination actions, which constitutes Deliverable No. 10: trainer courses (ANNEX 10).

iii. Description of costs and financial impact assessment

The full description of costs associated to SOILING implementation is provided in the appropriate funding requirement document.

In the present section, a descriptive non-quantified approach is, therefore adopted.

IPB main deviations from budget relate to the contracting of research grants, permissions for access to fieldwork, equipment acquisition and displacements for field work. Furthermore, delays in the experimental setup in the field, already explained, also delayed the extent to which this budget category could be actually executed. The large share assigned in the budget to the acquisition of a pyrolysis furnace, an administratively complex process, justifies the delay of this activity. In both cases, actions to recover from delays were planned and implemented so that so that total execution was ended.

COLAB MORE suffered some delay in hiring human resources. COLAB main effective expenses concern HR hiring for preparing the planned implementation of Activity 3-4-6.

FCUL suffered some delay in the field and laboratory works too. FCUL main effective expenses concern HR hiring for preparing the planned implementation of Activity 5.

Evaluation of the financial execution of the Project (at each reporting moment, including possible deviations from the budget) is presented in Table 05,06,07.

The earlier stated requests for project extension and for project funding rate revision were finally approved. Furthermore, we formally did an additional request for tuned budgeted costs re-allocation to alternative budgetary categories. This request was justified by actual and

fully explainable low execution rates on certain categories, in contrast with other categories, where higher than predicted expenses were expected as necessary to ensure the adequate execution of project activities within the short time span left for its implementation. The budgetary re-allocation proposal was delivered as a document independent from the past Interim Report in 31/12/2023.

Consequently, all activities were finished, and the main results and indicators are presented in this Final Report.

Table 5: Financial execution rate (%) compared to the total cost, in the final reporting period (30 April 2024) and since the project's initial period (1 July 2022- 30 April 2024) by activity.

Entidades/ Atividades	Custo do Projeto	Despesa realizada até 30/04/2024			Taxa de execução financeira (%)
	(de acordo com o orçamento aprovado)	Total de despesa realizada	Total de despesa realizada e apresentada a PP	Despesa realizada a apresentar no último PP	
Total A0	15 454,44 €	16 067,87 €	6 162,13 €	9 905,74 €	103,97%
Total A1	10 157,40 €	6 039,99 €	2 839,99 €	3 200,00 €	59,46%
Total A2	10 638,84 €	10 478,86 €	9 995,54 €	483,32 €	98,50%
Total A3	45 895,27 €	38 189,86 €	26 283,17 €	11 906,69 €	83,21%
Total A4	74 483,69 €	62 347,35 €	26 188,58 €	36 158,77 €	83,71%
Total A5	45 778,20 €	46 919,71 €	25 192,12 €	21 727,59 €	102,49%
Total A6	58 233,89 €	44 600,45 €	3 171,81 €	41 428,64 €	76,59%
Total A7	15 626,58 €	15 079,37 €	861,72 €	14 217,65 €	96,50%
Total A8	20 222,65 €	15 103,91 €	861,72 €	14 242,19 €	74,69%
Total A9	8 305,88 €	0	0	0	0,00%
Total A10	53 665,21 €	33 260,18 €	13 319,27 €	19 940,91 €	61,98%

Table 06: Financial execution rate (%) compared to the total cost, in the final reporting period (30 April 2024) and since the project's initial period (1 July 2022- 30 April 2024) by activity and partner.

Entidades/ Atividades	Custo do Projeto	Despesa realizada até 30/04/2024			Taxa de execução financeira (%)
	(de acordo com o orçamento aprovado)	Total de despesa realizada	Total de despesa realizada e apresentada a PP	Despesa realizada a apresentar no último PP	
A0					
IPB	8 428,00 €	8 431,43 €	2 648,05 €	5 783,38 €	100,04%
MORECOLAB	0,00 €	2 767,50 €	0,00 €	2 767,50 €	0,00%
FCUL	7 026,44 €	4 868,94 €	3 514,08 €	1 354,86 €	69,29%
Total A0	15 454,44 €	16 067,87 €	6 162,13 €	9 905,74 €	103,97%
A1					
IPB	10 157,40 €	6 039,99 €	2 839,99 €	3 200,00 €	59,46%
MORECOLAB	0	0	0	0	0,00%
FCUL	0	0	0	0	0,00%
Total A1	10 157,40 €	6 039,99 €	2 839,99 €	3 200,00 €	59,46%
A2					
IPB	10 638,84 €	10 478,86 €	9 995,54 €	483,32	98,50%
MORECOLAB	0	0	0	0	0,00%
FCUL	0	0	0	0	0,00%
Total A2	10 638,84 €	10 478,86 €	9 995,54 €	483,32 €	98,50%
A3					
IPB	21 679,64 €	17 521,33 €	17 521,33 €	0,00 €	80,82%
MORECOLAB	24 215,63 €	20 668,53 €	8 761,84 €	11 906,69 €	85,35%
FCUL	0	0	0	0	0,00%
Total A3	45 895,27 €	38 189,86 €	26 283,17 €	11 906,69 €	83,21%
A4					
IPB	52 921,94 €	41 824,43 €	9 122,62 €	32701,81	79,03%
MORECOLAB	21 561,75 €	20 522,92 €	17 065,96 €	3456,96	95,18%
FCUL	0	0	0	0	0,00%
Total A4	74 483,69 €	62 347,35 €	26 188,58 €	36 158,77 €	83,71%
A5					
IPB	0	0	0	0	0,00%
MORECOLAB	0	0	0	0	0,00%
FCUL	45 778,20 €	46 919,71 €	25 192,12 €	21 727,59 €	97,57%
Total A5	45 778,20 €	46 919,71 €	25 192,12 €	21 727,59 €	102,49%
A6					
IPB	34 648,73 €	30 102,40 €	2 933,45 €	27 168,95 €	86,88%
MORECOLAB	23 585,16 €	14 498,05 €	238,36 €	14 259,69 €	61,47%
FCUL	0	0	0	0	0,00%
Total A6	58 233,89 €	44 600,45 €	3 171,81 €	41 428,64 €	76,59%
A7					
IPB	10 755,56 €	10 673,04 €	861,72 €	9 811,32 €	99,23%
MORECOLAB	4 871,02 €	4406,33	0	4406,33	90,46%
FCUL	0	0	0	0	0,00%
Total A7	15 626,58 €	15 079,37 €	861,72 €	14 217,65 €	96,50%
A8					
IPB	14 685,40 €	11 684,21 €	861,72 €	10 822,49 €	79,56%
MORECOLAB	5 537,25 €	3419,70 €	0	3419,70 €	61,76%
FCUL	0	0	0	0	0,00%
Total A8	20 222,65 €	15 103,91 €	861,72 €	14 242,19 €	74,69%
A9					
IPB	0	0	0	0	0,00%
MORECOLAB	8 305,88 €	0	0	0	0,00%
FCUL	0	0	0	0	0,00%
Total A9	8 305,88 €	0	0	0	0,00%
A10					
IPB	26 230,50 €	17 596,32 €	2 610,75 €	14 985,57 €	67,08%
MORECOLAB	20 408,26 €	10 599,75 €	7 194,44 €	3 405,31 €	51,94%
FCUL	7 026,45 €	5 064,11 €	3 514,08 €	1 550,03 €	72,07%
Total A10	53 665,21 €	33 260,18 €	13 319,27 €	19 940,91 €	61,98%

Table 07: Financial execution rate (%) compared to the total cost, in the final reporting period (30 April 2024) and since the project's initial period (1 July 2022- 30 April 2024) by partner.

Entidades/	Custo do Projeto	Despesa realizada até 30/04/2024			Taxa de execução financeira (%)
	(de acordo com o orçamento aprovado)	Total de despesa realizada	Total de despesa realizada e apresentada a PP	Despesa realizada a apresentar no último PP	
IPB	190 146,01 €	154 352,01 €	49 395,17 €	104 956,84 €	81,18%
MORECOLAB	108 484,95 €	76 882,78 €	33 260,60 €	43 622,18 €	70,87%
FCUL	59 831,09 €	56 852,76 €	32 220,28 €	24 632,48 €	95,02%
Total	358 462,04 €	288 087,55 €	114 876,05 €	173 211,50 €	80,37%

iv. Description of the Project's contribution to achieving the overall objectives of EEA Grants and the 'Environment Programme'

The soil recovery action proposed by SOILING, intends to strengthen REDE NATURA 2000 UE network, considering that the studied area is comprised in protected 5210 habitat (Juniperus spp.) and surround by ZASNET UNESCO Biosphere reserve.

Moreover, SOILING is included on **Environment Program of EEA Grants** and therefore, contributing to improve environmental status and to reduce the negative impacts of pollution and other anthropogenic activities. These aims intend, in general, to mitigate climate change effects, which are of the main concerns expressed on Memorandum of Understanding — MoU, signed in Lisbon on 22 May 2017.

The proposed activities 1, 3 and 4 meet the goals established on the **National Action Plan to Combat Desertification** (NAPCD), namely the objectives 2.4, 3.1 and 3.4 and aligned with the "Environment Programme" concerning the limitations and constraints overtaking under climate change scenario: drought, water scarcity and susceptibility to desertification.

In particular, in activity 1, it has been tested that the application of a sediment algorithm, using high spatial resolution cartography (digital terrain model), that allowed identifying the areas with the greatest erosion risk and most susceptible to desertification and reduced the economic costs of interventions in the field. With SbN implementation in Activities 3-4, soils will possess higher humidity levels allowing drought mitigation and reducing fire susceptibility.

Besides the general purpose of PA's ecological recovery, the use of agro-industrial residues to produce compost and a biochar, allows not only the maximization of materials lifetime but also the creation of added value products. Such actions are answering to European appeals to foster **Circular economy** and Sustainability policies and stimulating industrial tissues of low-density regions. The location of SOILING's PA is by itself, in accordance with **EEA Grants Mission** to reduce social and economic disparities on European Economic Area and to strengthen bilateral relations among beneficiary and donor countries.

The implementation of SOILING proposed actions (Activities 6,7,8), will contribute to the creation of a recovered ecosystem with high ecological relevance, contributing to UE decarbonisation strategies.

The appended table (Table 8) aims to clarify the proposed milestones that were already accomplished during the period of execution, i.e., July 1st 2022 to 30 April 2024. The table below shows how SOILING project already contributed to achieve the initially expected outcomes.

Table 08: Expected results achieved during the period of report (July 1st 2022 to April 30st 2024).

Programme area Objetive	Expected result	Indicator	Activity	Project's contributions during the period of report
AP13/ Result 3	Resiliency boost and increases responsiveness to climate change in specific areas	Number of hectares presenting less susceptibility to desertification	A1, A3, A4	30 ha
Milestone 3.5	Desertification Combat Pilot-projects	Number of pilot-projects to Combat Desertification	A1	1

Project Promotor

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Date and Signature	Tomás de Figueiredo
Position	Principal Investigator

Programme Operator – Secretary General for Environment

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