Database on technical aspects of coastal restoration projects

Deliverable D1.1

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WP1

Lead beneficiary: Eurecat (EUR)

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REST-COAST

Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity

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1 Preface

Heathy coastal habitats provide some of the most productive and biodiverse environments with an important and often underappreciated potential for ecosystem services delivery. Both the United Nations Decade on Ecosystem Restoration and the European Green Deal recognize the need to massively accelerate global restoration of degraded ecosystems, to fight the climate crisis, enhance food security, provide clean water and protect biodiversity on the planet. The scale of restoration is, thus, a key issue.

The REST-COAST project (Large scale RESToration of COASTal ecosystems through rivers to sea connectivity) is an EU Horizon 2020 research project (Grant agreement No. 101037097) that aims at demonstrating that upscaled coastal restoration can provide a low Carbon solution to climate adaptation and disaster risk reduction for threatened low-lying coastal systems, combined with gains in their biodiversity conservation status.

Within REST-COAST, the main goal of work package 1 (Hands-on restoration of coastal ecosystems and upscaling potential: technical aspects) is to identify and implement the most suitable technical solutions for the coastal restoration and defining the approach for its upscaling. One of the tasks needed to achieve this main goal is gathering and structuring information on the technical aspects of past and ongoing coastal restoration projects.

2 Summary

A database gathering and structuring information on technical aspects of past and ongoing coastal restoration projects (including REST-COAST pilot sites) was developed and made accessible through the project web page and the European Knowledge Centre on BDV. The database has a total of 550 coastal restoration projects and sites characterized by 175 fields or descriptors regarding projects and restoration sites identification and location, ecosystem and habitat types targeted by the restoration actions, information on land use change due to restoration, biodiversity and key species targeted by the restoration projects, human activities affecting the restored area, restoration techniques used, main restoration results, monitoring activities performed to evaluate restoration performance (e.g. water and sediment quality and dynamics, taxonomic groups at both community and population levels), ecosystem services addressed by the restoration projects and technical barriers and enablers identified during or after the restoration projects. Besides the restoration site identification and location descriptors, only 12 database fields are descriptive (of the type string). All the other variables are numerical (mostly binary), allowing an objective information gathering and analysis. Regarding this issue, it is important to mention that, although including restoration projects outside of Europe (from the USA and Australia) this database is not meant to be a repository of coastal restoration projects. Its main function is to gather relevant information to perform analyses that can be useful for the up- and out- scaling exercise (task 1.4) to be performed between months 37 and 48. It is also expected that some of the analyses outputs can assist in the ongoing pilots' hands-on restoration (task 1.2), especially in the co-development actions that are being performed by the coastal restoration platforms (CORE-PLATS) and in the development of a common set of biodiversity and ecosystem services indicators to assess restoration performance (task 1.3). Given this applied character of the database, the main efforts regarding data collections were focused towards having a good coverage of the European coastal types.

3 List of abbreviations

EU	European Union
CORE-PLAT	Coastal Restoration Platform
ESS	Ecosystem Services
BDV	Biodiversity

4 Introduction

The need for massively accelerate large scale restoration of degraded coastal ecosystems to fight the climate crisis, enhance food security, provide clean water and protect biodiversity on the planet has been recognized by many intergovernmental organizations such as the European Union and United Nations, among others. Extensive efforts to restore coastal ecosystems worldwide show that the efficiency of restoration efforts is strongly site and technical solution dependent (Kenney et al. 2013, Hardy and Wu 2021), i.e., one same restoration technique performs differently depending on the habitat type, the site-specific biodiversity, the land use or the human activities affecting the area to be restored. To evaluate the success of restoration projects on coastal habitats, including the performance of the technical solutions used, different metrics have been developed (Neckles et al. 2002, Zhao et al. 2016, Prado et al. 2017, Fennessy et al. 2019). In short, there is a wide array of techniques to restore coastal ecosystems and metrics to evaluate their performance in different habitat types.

While evaluating the performance of local scale restoration is important to guide more effective restoration actions in the future (Couvillion et al. 2013), the information obtained from the evaluation has limitation to apply to a broader area or to other sites with different geomorphic and physical settings. There is a need to synthesize the data from different restoration projects in order to conduct evaluation at a broad European scale required for up-scaling restoration, i.e., move toward landscape approaches to coastal ecosystem restoration rather than the usual patch-specific approach.

The REST-COAST D1.1 deliverable main goal was collecting, synthesizing and structuring information on the technical aspects of past and ongoing coastal ecosystem restoration experiences in a database available to all the REST-COAST partners and scientific community, in general, through the project web page and the European Knowledge Centre on BDV, respectively. This database will be useful for the pilots' hands-on coastal restoration co-development activities (task 1.2) that are being performed by the coastal restoration platforms (CORE-PLATs), in the development of a common set of biodiversity (BDV) and ecosystem services (ESS) indicators to assess restoration performance (task 1.3) and, especially, for the subsequent up-scaling exercise to be performed between months 37 and 48 (task 1.4).

5 Methods

The design of the database structure was carried out in a stepwise and adaptive manner considering the opinion of the REST-COAST partners participating in task 1.1 of work package 1 (WP1) and the needs of the future database use in the others WP1 tasks (fig. 1). First, the Eurecat team (WP1 lead beneficiary) proposed a first database structure and gathered/introduced the information of some past restoration projects undertaken in the Ebro delta with a straight relationship with the REST-COAST Spanish core pilot. Then, Eurecat sent this first version of the database (including the data gathered) to the relevant REST-COAST partners (pilot sites' leaders and other task 1.1 participants) and asked for their feedback on its structure (e.g., missing or redundant fields). Moreover, the pilot sites' leaders added coastal restoration projects relevant or with a straight relationship to their sites into the database, following the co-designed structure.

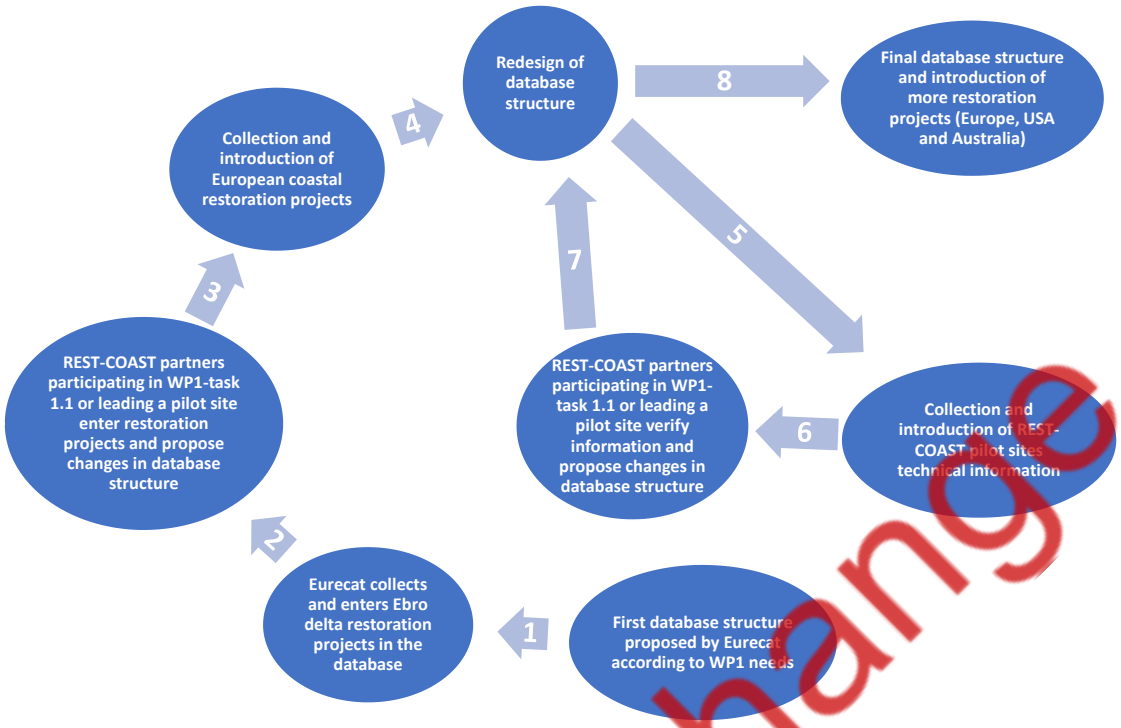

Figure 1. Schematic representation of the database development process.

In a second phase, European coastal restoration projects were selected from literature (scientific publications and technical reports) and public databases. Most of the selected projects were found in the LIFE public database because they were the ones with a more complete information on the technical issues of the restoration actions. The CORDIS EU research database was also explored using the "search" engine, but no relevant results were obtained. One of the queries performed was: i) identification and entry in the REST-COAST project (https://cordis.europa.eu/project/id/101037097) and; ii) identify all the projects of the same relevant fields of science (natural sciences->biological sciences->ecology->ecosystems->coastal ecosystems). This query resulted in 19 projects from different EU programs, but none of them (except REST-COAST) had relevant information for the database. Other more general queries were performed, but with similar results. For example, we performed the following query using per-established filters and key words: "applicationDomain/code='funda','env','agri' AND /project/relations/categories/euroSciVoc/code='/27/81/489/','/23/49/323/','/23/49/335/','/23/49/317/','/23/45/277/','/23/45/287/883/','/23/45/287/351/','/23/45/289/','/23/55/' AND ('restor*')". Again, 19 projects were retrieved but relevant information for the database was found.

Although the main coastal restoration projects source was the EU LIFE program, the resulting database was very complete (all the European coastal types were represented). However, at this stage, the database was not very practical because most of the variables characterizing the cases (coastal restoration projects/sites) were descriptive and, therefore, would not allow performing the analyses needed to undertake the upscaling exercise in task 1.4 (months 37-48 of the project). To overcome this deficiency in the database, the descriptive variables of type string were kept to a minimum (12, excluding the fields used to identify and locate the restoration projects or sites) and all the other categorical variables were recoded as binary. In this way, not only will further analysis for the upscaling exercise be feasible, but it will also be easier to enter new data.

The data of the already introduced coastal restoration cases was adapted to the new database structure. Then, the data was filtered, and both its homogeneity and quality were assessed. As a result, some of the restoration

projects were deleted from the database and the information of some of the remaining European projects was corrected and improved. Moreover, since the hands-on restoration in all REST-COAST pilot projects is already underway, their information was entered into the new database and sent to the pilot project leaders, who gave feedback on the new structure and the correctness of the information entered. From that moment on, the database was enriched with coastal restoration projects from USA and Australia. Although MedPan and IUCN were not participants of task 1.1, they contributed to the identification of USA and Australian sources of information regarding technical aspects of coastal restoration actions.

6 Results

The result of this DEMO deliverable was a database gathering information on the technical aspects of coastal restoration projects, mainly from Europe, but also from the USA and Australia. The database gathers a total of 550 coastal restoration projects/sites characterized by 175 fields or descriptors regarding project and restoration site identification and location, ecosystem and habitat types targeted by the restoration actions, information on land use change due to restoration, biodiversity and key species targeted by the restoration projects, human activities affecting the restored area, restoration techniques used, main restoration results, monitoring activities performed to evaluate restoration performance (e.g. water and sediment quality and dynamics, taxonomic groups at both community and population levels), ecosystem services addressed and technical barriers and enablers identified during or after the restoration projects (Table 1).

Field group	Fields and types of variables	Source
Project/site identification and location	project.id (S), project.reference (S), site.name (S), lat.wgs84(dd) (D), long.wgs84(dd) (D), year.start (I), year.end (I), financing.instruments (S), budget.site (I), budget.project (I), region (S), country (S), coastal.area (S), continent (S), REST-COAST.pilot_number (I)	REST-COAST team, Hale et al. 2012, SEWPaC 2012, USCB 2019
Ecosystem type	ecosystem.seagrass_medows (B), ecosystem.shellfish_oyster_reefs (B), ecosystem.coral_reefs (B), ecosystem.salt_marshes (B), ecosystem.coastal_lagoons (B), ecosystem.bays (B), ecosystem.beaches (B), ecosystem.dunes (B), ecosystem.mangroves (B), ecosystem.estuaries (B)	Jordan & Fröhle 2022
Habitats and land use	key.habitats (S), land.use.change (B), land.use.initial (S), land.use.final (S)	Galparsoro et al. 2012, Prado et al. 2019, Chytrý et al. 2020,
Taxonomic groups and key species targeted by the restoration	taxa.microbiome (B), taxa.phytoplankton (B), taxa.phytobenthos (B), taxa.zooplankton (B), taxa.macroalgae (B), taxa.seagrass (B), taxa.halophytes (B), taxa.vegetation.other (B), taxa.macroinvertebrates (B), taxa.invertebrates (B), taxa.fish (B), taxa.amphibians_reptiles (B), taxa.birds (B), taxa.mammals (B), key.species (S), species.number (I)	REST-COAST team

Field group	Fields and types of variables	Source
Human activities affecting restoration sites	human.activity.agriculture (B), human.activity.fishery (B), human.activity.aquaculture (B), human.activity.hunting (B), human.activity.salt_pans (B), human.activity.livestock (B), human.activity.tourism (B), human.activity.scubadiving (B), human.activity.mooring (B), human.activity.industry (B), human.activity.shiping_ports (B), human.activity.urban_areas (B), human.activity.mining (B), human.activity.other (S)	Borja et al. 2020, Chen et al. 2022, Jordan & Fröhle 2022, Perni & Martínez-Paz 2023
Restoration techniques	restoration.active (B), restoration.passive (B), restoration.techniques.morphology_reshape (B), restoration.techniques.dredging (B), restoration.techniques.beach_nourishment (B), restoration.techniques.sediment_traps (B), restoration.techniques.management.water (B), restoration.techniques.management.sediments (B), restoration.techniques.management.vegetation_grazing (B), restoration.techniques.infrastructure.removal.dike_berm (B), restoration.techniques.infrastructure.removal.dam (B), restoration.techniques.infrastructure.removal.debris_litter (B), restoration.techniques.infrastructure.bypass.dike_berm (B), restoration.techniques.infrastructure.bypass.dam (B), restoration.techniques.infrastructure.construction.dike_berm (B), restoration.techniques.infrastructure.construction.canal (B), restoration.techniques.infrastructure.construction.water_treatment_plant (B), restoration.techniques.infrastructure.construction.wetland_artificial (B), restoration.techniques.infrastructure.construction.reef_artificial (B), restoration.techniques.infrastructure.construction.fences (B), restoration.techniques.infrastructure.construction.wind_barriers (B), restoration.techniques.biota.removal.vegetation (B), restoration.techniques.biota.removal.fauna (B), restoration.techniques.biota.translocation.vegetation (B), restoration.techniques.biota.translocation.fauna (B), restoration.techniques.biota.stock.vegetation (B), restoration.techniques.biota.vegetation.anchor (B), restoration.techniques.biota.vegetation.artificial_substrate (B), restoration.techniques.biota.stock.native_fauna (B), restoration.techniques.remediation (B), restoration.techniques.land_abandonment (B), restoration.techniques.public_use_restriction (B), restoration.techniques.other (S)	Klein et al. 2001, Zhao et al. 2016, Bayraktarov et al. 2016, Billah et al. 2022
Restoration results	restored.surface(ha) (I), restoration.results (S)	REST-COAST team
Monitoring	monitoring.period.start(yr) (I), monitoring.period.end(yr) (I), monitoring.morphology (B), monitoring.dynamics.surface_water (B), monitoring.dynamics.ground_water (B), monitoring.dynamics.sediment	Stokes et al. 2016, Zhao et al.

Field group	Fields and types of variables	Source
	(B), monitoring.dynamics.carbon (B), monitoring.quality.surface_water (B), monitoring.quality.ground_water (B), monitoring.quality.soil (B), monitoring.quality.sediments (B), monitoring.primary_production (B), monitoring.secondary_production (B), monitoring.community.microbiome (B), monitoring.community.phytoplankton (B), monitoring.community.phytobenthos (B), monitoring.community.zooplankton (B), monitoring.community.macroalgae (B), monitoring.community.seagrass (B), monitoring.community.halophytes (B), monitoring.community.vegetation_other (B), monitoring.community.macroinvertebrates (B), monitoring.community.invertebrates (B), monitoring.community.fish (B), monitoring.community.amphibians_reptiles (B), monitoring.community.birds (B), monitoring.community.mammals (B), monitoring.population.microbiome (B), monitoring.population.phytoplankton (B), monitoring.population.phytobenthos (B), monitoring.population.zooplankton (B), monitoring.population.macroalgae (B), monitoring.population.seagrass (B), monitoring.population.halophytes (B), monitoring.population.vegetation_other (B), monitoring.population.macroinvertebrates (B), monitoring.population.invertebrates (B), monitoring.population.fish (B), monitoring.population.amphibians_reptiles (B), monitoring.population.birds (B), monitoring.population.mammals (B), monitoring.other (S), monitoring.techniques.observation_analysis (B), monitoring.techniques.eDNA (B), monitoring.techniques.remote_sensing (B), monitoring.techniques.acoustic (B), monitoring.techniques.video (B), monitoring.techniques.other (S)	2016, Cadier et al. 2020, Billah et al. 2022, Wee et al. 2023
Ecosystem services addressed in the restoration projects	ecosystem.services.food_provisioning (B), ecosystem.services.water_purification (B), ecosystem.services.climate_regulation (B), ecosystem.services.flood_prevention (B), ecosystem.services.erosion_prevention (B), ecosystem.services.other (S)	REST-COAST team, Galparsoro et al. 2014, Waltham et al. 2020
Restoration barriers and enablers	barriers.element_quantity.water (B), barriers.element_quantity.sediments (B), barriers.element_quality.water (B), barriers.element_quality.sediments (B), barriers.element.native_species (B), barriers.element.alien_species (B), barriers.expertise.ecology (B), barriers.expertise.engineering (B), barriers.tradeoff.BDV.ESS (B), barriers.tradeoff.socioeconomy (B), barriers.data.ESS (B), barriers.data.BDV (B), barriers.data.ecological_processes (B), barriers.monitoring.plans (B), barriers.maintenance.plans (B), barriers.room.restoration (B), barriers.room.adaptation (B), barriers.physical_context.logistics (B), barriers.other (S),	Sánchez-Arcilla et al. 2022

Field group	Fields and types of variables	Source
	enablers.processes_models.knowledge (B), enablers.planning_room_adaptation (B), enablers.planning_room_upscaling (B), enablers.long_term_monitoring (B), enablers.other (S)	
Other information	url(U), references (S), other.information (S)	REST-COAST team

Table 1. Structure of the database gathering technical related information from past and ongoing coastal restoration projects. The fields of the data base are grouped by descriptors' scope (restoration techniques, barriers and enablers, etc.). The variable types are shown: B – binary, D – decimal, I – integer, S – string, U – url. The sources of information used to formulate the fields (literature and REST-COAST team proposals) are also shown. For more information on the database fields' description please see sheet "Fields description" in "REST-COAST D1.1_Database.xlsx".

7 Conclusion

Although deliverable 1.1 (D1.1) is a DEMO, the present brief report was produced to contextualize the need and function of the database within REST-COAST and to explain how it was developed, including the structure design and data collection and gathering. The database contains information on the technical issues of coastal restoration actions, such as restoration techniques used, the monitoring program, the main restoration results and the barriers and enablers detected during or after the restoration. Moreover, the database gathers information on the ecosystem types, the main habitats, the land use and the human activities of each site, as well as the target taxonomic groups and species and the ecosystem services addressed by the restoration project, if any. Finally, a set of the database fields are devoted to identifying and locating the restoration sites. The main function of the database is contributing to the development of the upscaling exercise (task 1.4) to be performed between months 37 and 48 of the project. It is also expected that the database will assist the CORE-PLATS in the (re)design and execution of the pilots' hands-on restoration (task 1.2) and in the development of a common set of ecosystem services and biodiversity indicators to monitor and evaluate the pilots' hands-on restoration actions (task 1.3). Given the applied nature of the database, the main data collection and compilation efforts were aimed at obtaining a broad representation of European coastal types. However, and even though the database is not intended to be a simple repository of coastal restoration projects, it was decided to include some cases from outside Europe, more specifically the USA and Australia, countries with a long tradition and experience in coastal restoration. On the one hand, it broadened the database information on coastal restoration technical issues, which will help in the identification of barriers and enablers for scaling up REST-COAST pilots restoration. On the other hand, since the database is a living document, its structure including all coastal ecosystem types, will allow its future expansion to other continents and types of coastal habitats.

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