D6.9 Restoration Demo at Sicily Lagoon

31/03/2024

WP6

Lead beneficiary: UC

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REST-COAST

Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity

This project receives funding from the European Union's Horizon 2020 research and innovation programme, under Grant Agreement 101037097

Prepared under contract from the European Commission
Grant agreement No. 101037097
EU Horizon 2020 Coordination and Support Action

Project acronym:	**REST-COAST**
Project full title:	**Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity**
Start of the project:	01.10.2021
Duration:	54 months
Project coordinator:	Prof. Agustín Sánchez-Arcilla, Universitat Politècnica De Catalunya (UPC)
Type:	Restoring biodiversity and ecosystem services
Call:	H2020-LC-GD-2020-3
Deliverable title	Restoration Demo at Sicily Lagoon
Deliverable n°	D6.9
Nature of the deliverable:	Demonstrator
Dissemination level:	Public
WP responsible:	WP6
Lead beneficiary:	UC
Citation:	Musumeci, et al. Restoration Demo at Sicily Lagoon. Deliverable D6.9. EU Horizon 2020 REST-COAST Project, Grant agreement No 101037097
Due date of deliverable:	Month n° 30
Actual submission date:	Month n° 30

Deliverable status:

Version	Status	Date	Author(s)
2.0	Final	29 March 2023	Rosaria Ester Musumeci, Massimiliano Marino, Enrico Foti, Luca Cavallaro Agata Di Stefano, Laura Borzì, Saverio Sciandrello, Rosario Grasso Paolo Galasso

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Preface

This document illustrates the demo materials and activities by the UC team to demonstrate the benefits of Nature restorations, starting from the experience gained at the Sicily Lagoon pilot site The materials have been designed to address a variety of target groups, such as site managers of Sicilian coastal wetlands, water and environmental authorities, civil protection, regional and local administrations, professionals, NGOs, high-school teachers and students, university students, and the general public. They will be illustrated in the following.

The materials range from posters and videos to presentations and educational activities, for active involvement, particularly of young generations. The aim is to raise awareness on the threats of climate change and on the potential of large-scale Nature-based Solutions (NbS) for coastal restoration to provide biodiversity (BDV) improvement and ecosystem services (ESS) to reduce risks related to water pollution, coastal flooding and erosion. In particular, as it will be shown later on, depending on the communication target, demonstration of effectiveness of restoration has been and will be conveyed using a variety of strategies. For example, in the case of decision-makers and general public an emotional approach has been adopted, e.g. by highlighting the landscape enhancement of precious ecosystems through beautiful images of unrestored and restored areas of the Sicily pilot site. In the case of professionals, teachers and student, a data-driven evidence-based approach has been preferred. For example, field data and modelling results useful to assess the performance of NbS and delivery of ESS have been shared with professionals at specific events, while with students a hands-on approach has been considered, to allow them to understand relevant processes and evaluate different options for active restoration in a changing climate.

Summary

The present report aims at providing an overview of the restoration activities undertaken within the Sicily lagoon pilot site of the REST-COAST, including a presentation of demonstration activities meant to show how restoration actions can significantly contribute to enhancing biodiversity and mitigating the impacts of climate change on coastal and riverine ecosystems.

The document is structured to provide a comprehensive view of the efforts carried out at the Sicily Lagoon pilot site, starting with an introductory section that highlights the significance of the pilot site. This section delves into the various benefits of restoration.

The document reports the specifics of the demonstration activities carried out at the site. It covers the production of a restoration demo video, the organization of several courses, and the organization of and participation to dissemination events aimed at scientific dissemination, engagement of civil society, professionals, and students through technical conferences, courses, and field visits.

The core of the document focuses on the demonstration activities themselves, detailing the hands-on restoration actions undertaken, the modelling activities performed, and the establishment of the CORE-PLAT. Finally, the report evaluates the demonstration value of these activities and explores their potential for replication in similar contexts.

List of acronyms

AIOM Italian Association of Offshore and Marine Engineering
BDV Biodiversity
DICAR Department of Civil Engineering and Architecture
DSBGA Department of Biological, Geological and Environmental Sciences
ECSA Estuarine and Coastal Sciences Association
ESS Ecosystem services

EU	European Union
ISPRA	Superior Institute for Protection and Research of the Environment
IUCN	International Union for Conservation of Nature
LIPU	Italian League for Protection of Birds
MIT	Massachussets Institute of Technology
NbS	Nature-based Solution
SPA	Stiftung Pro Artenvielfalt
WWF	World Wildlife Fund

1 Introduction to Pilot Site

The "Pantani della Sicilia Sud-Orientale" (Lagoons of South-Eastern Sicily) is nestled in the southeastern tip of Sicily, Italy, as part of the Mediterranean's coastal wetland ecosystem. This region spans roughly 3500 hectares across a 90-kilometer stretch of coastline, featuring a network of eight primary lagoons that seamlessly integrate with the surrounding dunes and beaches. The beaches, predominantly narrow and sandy, are punctuated by rocky promontories and islands. These lagoons receive water primarily through small catchment areas, ranging between 1-10 square kilometres, particularly during the intense flash floods seen from October to December. Seasonally, the water levels within these lagoons exhibit significant fluctuations, oscillating between 1 to 2 meters in the winter to complete dry conditions during the summer months.

Among these wetlands, the Cuba-Longarini complex is the largest, covering about 350 hectares (Figure 1). The Cuba lagoon to the East spans roughly 80 hectares, while the Longarini lagoon to the West covers about 180 hectares. Positioned along the central migratory route of the Mediterranean, this area witnesses the annual migration of birds, making it a crucial winter haven for numerous waterfowl species and a breeding ground for fish and crustaceans.
Thanks to its unique climatic conditions and rich biodiversity, the site has gained international recognition, being designated as part of the Natura 2000 network, which includes both Special Areas of Conservation (SACs ITA090003) and Special Protection Areas (SPAs ITA090029) under the European Union's Habitats and Birds Directives. Several species within this area are categorized as vulnerable or endangered, as listed on the IUCN Red List of Species.

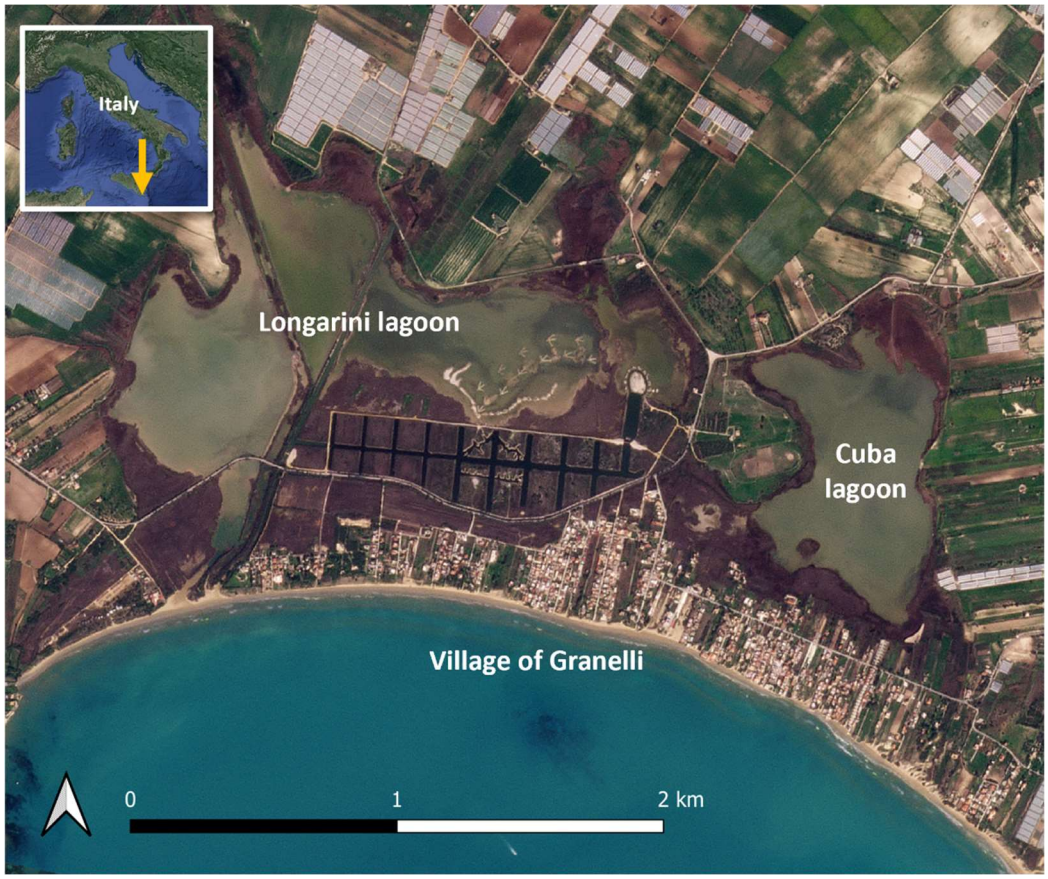

Figure 1: Aerial view of the Sicily pilot site, the Cuba-Longarini lagoons

Figure 2: The lagoons of the South-East of Sicily, Longarini lagoon (a), Cuba lagoon (b), pink flamingos with Granelli village in the background (c), greenhouses (d).

However, this ecologically valuable region is under threat from human activity. Over the past fifty years, there has been a noticeable shift from traditional farming to intensive agricultural practices, adversely affecting the water quality and the area's overall hydrological stability. Concurrently, its popularity as a tourist destination has led to urban expansion at the expense of wetlands and dunes. The town of Granelli, located between these lagoons and the sea, disrupts the natural dune barrier, diminishing the area's resistance to flooding and erosion (Musumeci et al, 2022a; Marino et al., 2023a). This disruption is compounded by the threats of climate change, with increasing occurrences of extreme storms, more intense Medicanes, and hazard related to sea-level rise by the end of the century, posing a significant risk to the region's sustainability and ecological integrity (Musumeci et al, 2022b).

1.1 Benefits of restoration

In response to these environmental challenges, Stiftung Pro Artenvielfalt (SPA), the Italian branch of a German pro-biodiversity foundation, has been actively engaged in restoration efforts in the region. From 2014, the foundation embarked on an ambitious restoration effort for the Cuba-Longarini lagoons in south-eastern Sicily. This multifaceted project involved several key activities: land acquisition, perimeter fencing, waste clean-up, re-naturalization, invasive species management, biodiversity surveillance, direct conservation measures, anti-poaching enforcement, and infrastructure development to facilitate public engagement.

Throughout this period, Stiftung acquired approximately 410 hectares of marshland and adjacent areas, underscoring a significant commitment to habitat preservation. Following acquisition, around 7.1 km of fencing was installed to protect sensitive areas from illegal activities like dumping, poaching, which had previously marred these natural habitats.

One of the most tangible impacts of their work was the removal of over 300 cubic meters of waste, including household appliances, car tires, and numerous shotgun cartridges, significantly revitalizing the ecological integrity of the lagoons. Moreover, the project saw the planting of over 2000 trees and shrubs native to the Mediterranean maquis, enhancing biodiversity and providing essential habitats for wildlife. This afforestation effort not only rehabilitated the landscape but also contributed to the ecological connectivity between the lagoon areas.

Invasive species posed a significant threat to the native flora and fauna, prompting periodic and seasonal eradication efforts. Species such as *Acacia saligna* and *Opuntia ficus-indica* were systematically removed, mitigating their adverse impacts on the ecosystem.

The foundation also focused on detailed animal and plant biodiversity monitoring, publishing findings that contribute to scientific knowledge and conservation strategies. Direct conservation interventions included creating nesting sites and habitats for a variety of species, alongside implementing anti-poaching and illegal fishing measures to safeguard the area's wildlife. Some of the actions have been supported by the LIFE Marble Duck project. These include the construction of artificial islands (Figure 3a) to support bird nesting, breeding, and feeding; the development of biodiversity wetland niches to enhance lagoon water circulation and provide shelter for vulnerable species (Figure 3b); the creation of channels between the Cuba and Longarini lagoons to facilitate ecological exchange (Figure 3c); and the installation of a barrier between the Longarini lagoon and the sea, enabling water level management to further protect the lagoon's ecosystem (Figure 3d).

Infrastructure improvements were made to enhance visitor experience and accessibility, including parking areas, visitor rest spots and observation platforms. These facilities aim to foster a deeper public engagement with Nature and awareness of conservation challenges.

The foundation has engaged in educational projects with schools and universities since 2016, offering guided tours year-round to promote environmental education and stewardship. This comprehensive approach to restoration and conservation has not only improved the ecological status of the Cuba-Longarini lagoons but also set a benchmark for similar initiatives globally, demonstrating the profound impact of dedicated environmental stewardship.

Since 2022, Stiftung has embraced the vision of REST-COAST by collaborating with University of Catania towards the assessment of coastal wetland naturalization solutions to improve biodiversity but also to contribute to ecosystem services related to natural hazard mitigation (flooding and erosion) and water quality improvement. Within the collaboration, a sensor monitoring network was installed to measure environmental variables such as lagoon and groundwater levels, salinity, temperature, and weather-related variables like rainfall and air temperature. Additionally, field surveys were conducted to assess macrobenthos assemblage, vegetation cover, and habitats, in order to characterize the abiotic and biotic dynamics at the pilot site. The collection of the above data is fundamental not only to increase knowledge but also to support daily management of the site. Within REST-COAST, the performance of ongoing restoration actions to improve biodiversity and provide water purification and flood and erosion risk reduction are under evaluation through numerical modelling, in order to take into account present and future scenarios and additional options for restoration.

Figure 3: Ongoing restoration actions at Cuba-Longarini pilot site, artificial islands for bird nesting (a), coastal marshes restoration (b), restored channel between Cuba and Longarini lagoons (c), barrier and gate for lagoon water level regulation (d)

2 Sicily Lagoon demonstrations

The overarching vision of the REST-COAST project in Sicily is to catalyse a shift in governance, elevating awareness among private and public authorities and stakeholders regarding the value of coastal restoration actions as a strategic response to climate change. This initiative aims to underscore the importance of ecosystem-based solutions in enhancing coastal resilience and sustaining biodiversity. In pursuit of this goal, a series of initiatives have been undertaken to engage a broad spectrum of participants in the dialogue on restoration and its benefits.

2.1 Restoration demo video

To further enhance the impact of their restoration efforts and to educate a wider audience about the importance of functional coastal ecosystems in climate change mitigation, University of Catania has produced a demonstrative video (available official REST-COAST's web platform and social media) for the Sicily lagoon pilot site. The video serves as a crucial tool for raising awareness among civil society, policymakers, stakeholders, and the educational community at all levels about the project and the general importance of coastal restoration.
The video content features vivid imagery of the site (Figure 4), highlighting the dire consequences of wetland and coastal ecosystem degradation as well as the main restoration actions undertaken at the site. By visually showcasing these aspects, the video aims to bring the reality of these environments and the urgency of their preservation to a broader audience.

Figure 4: Frames of the Sicily lagoon restoration videos, artificial islands for bird nesting and Granelli town (a), Granelli eroding shoreline (b), greenhouses (c), pink flamingos flying over the Longarini lagoon (d).

Integral to the video are interviews with key figures involved in the REST-COAST project and coastal conservation in Sicily (Figure 5):
Rosaria Ester Musumeci, the scientific responsible of the Sicily REST-COAST pilot site, shares insights into the restoration efforts and the critical role of research in guiding effective conservation strategies.
Carlo Cappuzzello, representing Stiftung Pro Artenvielfalt in Italy, discusses the foundation's commitment to biodiversity and the collaboration between REST-COAST and his foundation.
Giancarlo Perrotta, manager of the Forestry Agency of the Sicilian Region and director of the Vendicari Lagoon Natural Reserve, speaks on the challenges of managing conservation and public fruition in these sensitive areas. He draws parallels between the newer initiatives in the Cuba-Longarini lagoons and the longstanding efforts in Vendicari, a natural reserve that has seen implementation of conservation measures since the 1984.
Massimiliano Marino, REST-COAST postdoctoral researcher at University of Catania, highlights the benefits of coastal restoration and the multidisciplinary approach embodied by the REST-COAST project, emphasizing the integration of various scientific and practical perspectives in addressing coastal degradation.

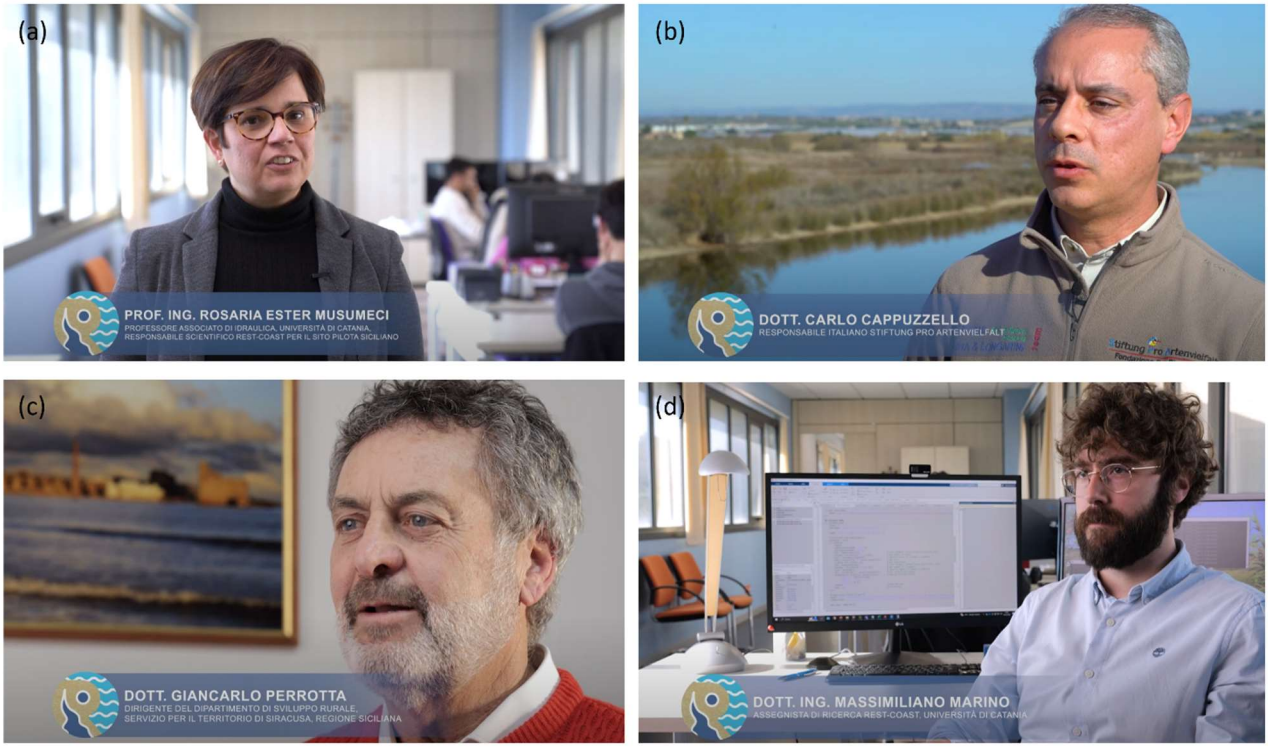

Figure 5: Frames of the Sicily lagoon restoration video interviews: Rosaria Ester Musumeci, scientific responsible for REST-COAST Sicily lagoon pilot site (a), Carlo Cappuzzello, italian responsible for Stiftung Pro Artenvielfalt (b), Giancarlo Perrotta, manager of Azienda Foreste, Sicily Region (c), Massimiliano Marino, REST-COAST Postdoctoral researcher at University of Catania (d).

The Sicily Lagoon demonstrative video aims not just to inform but to inspire action by illustrating the tangible results of restoration projects and the potential for positive change when diverse stakeholders collaborate. By sharing these messages, the video contributes to building a collective understanding and commitment to preserving coastal ecosystems as vital natural assets in the fight against climate change.

2.2 Courses

2.2.1 High school courses

OUI project laboratory *"Geologia marina: l'esplorazione dei fondali - Marine Geology: ocean exploration"* and "*Onda su Onda: il ruolo dell'ingegneria costiera* – Wave by Wave: the role of coastal engineering"
As part of the project "*Ovunque da qUI*" (OUI), the University of Catania scheduled courses and lab activities for the last year high-school students. The courses involve school and university teachers and aim to consolidate skills expendable in the world of university and work. One of the laboratories was set at the Biological, Geological and Environmental Department of the University of Catania. The title of the laboratory is "*Geologia marina: l'esplorazione dei fondali* - Marine Geology: ocean exploration"**.** The laboratory was attended by 15 students. Marine geology, coastal dynamic evolution, grain-size and benthic analysis of sediment samples were the main contents of the laboratory. The students were invited to observe micro- and macrobenthic samples using a stereomicroscope and the ecological meaning of the species was explained; seafloor detection tools, e.g. side scan sonar, were also shown and an explanation of the acquisition phases and post-processing data were provided to the students (Figure 6).
Another laboratory named *"Onda su Onda: il ruolo dell'ingegneria costiera* – Wave by Wave: the role of coastal engineering" has been organized by the Department of Civil Engineering and Architecture of the UC. Over the last couple of years, the lab has been attended by tens of students. In this case the aim is to present new approaches for management of the coastal zones and the mitigation of coastal erosion, through laboratory activities at small scale wave flume of the Hydraulic Laboratory of the UC (Figure 6).

Online training course for secondary school teachers of mathematics, physics, and natural sciences. (7 March 2023, online)
"Il restauro ambientale costiero: Una strategia di adattamento ai cambiamenti climatici" held on March 7, 2023, was an online training course for secondary school teachers of mathematics, physics, and natural sciences. It was aimed to enhance the capacity for resilience and adaptation to climate-linked risks and natural disasters through large-scale coastal restoration and NbS. The course emphasized the integration of climate change mitigation strategies into national planning and sought to improve education and institutional capabilities to address climate change effectively. Additionally, it highlighted the international commitment to mobilize substantial financial resources for developing countries, focusing on support for the least developed nations, small island states, and marginalized communities. Also a presentation of the EU Natural Restoration Law was provided.

Figure 6: Project OUI laboratory: *"Geologia marina: l'esplorazione dei fondali"* and *"Onda su Onda: il ruolo dell'ingegneria costiera"*

2.2.3 University students

XBeach modelling course for MSc Port and Coastal engineering students (October 2023 – January 2024, University of Catania)

An XBeach modelling course with MSc students was held in the Port and Coastal engineering class at the Water and Transport Engineering Master Course, held at the Department of Civil Engineering and Architecture, University of Catania by Prof. Rosaria Ester Musumeci and Massimiliano Marino. The course focused on coastal hydro-morphodynamic modelling and delved into modelling on some case studies in the South-East of Sicily, including several Sicilian coastal wetlands and beaches, besides the REST-COAST pilot site (Cuba-Longarini lagoons), namely the Saline di Priolo, Riserva di Vendicari, Siracusa, and Portopalo. The focus was on coastal protection, erosion reduction, and assessing the impact on surrounding activities and cultural heritage, providing students with practical insights into managing and safeguarding coastal zones also using NbS (Figure 7)

Figure 7: Final presentations of the XBeach hydro-morphodynamic modelling project (16 January 2024)

Intensive short course for UC-DSBGA PhD students "Coastal monitoring and nearshore and offshore seafloor mapping" (22-26 January 2024, Catania)

An intensive 18-hour course was run from 22nd to 26th of January 2024 by Dr. Laura Borzì and Prof. Salvatore Distefano of the Department of Biology, Geology and Environmental Sciences (DSBGA). The course was split into two parts, the first part focused on coastal monitoring (12 hours, Dr Laura Borzì), and the second part (6 hours, Prof. Salvatore Distefano) introduced seismic-stratigraphic and bathymetric data acquisition and processing. The course had the aim to attain the PhD students a thorough understanding of marine and coastal zone dynamics at various levels of organization, but also acquired quantitative and qualitative data-interpretation skills and developed technical skills to interpret results of experiments addressing marine and coastal problems employing a wide range of multidisciplinary approaches.

Innovative Research and Management for coastal restoration - REST-COAST Summer School Workshop (13-15 March 2023, Universidad de la Republica Uruguay, Maldonado, Uruguay)

The "Innovative Research and Management for Coastal Restoration - REST-COAST Summer School Workshop" was held from March 13th to 15th, 2023, at the Universidad de la Republica Uruguay in Maldonado, Uruguay by Dr. Massimiliano Marino. During this workshop, the activities surrounding the restoration of Mediterranean coastal wetlands within the REST-COAST project were presented. This event served as a platform for exchanging insights on cutting-edge research and management strategies dedicated to coastal restoration, with a particular emphasis on the Mediterranean region's unique challenges and solutions. Participants had the opportunity to delve into the specifics of the REST-COAST project's approach to revitalizing coastal wetlands, exploring innovative methods and practices that contribute to the conservation and enhancement of these critical ecosystems.

Reinventing coastal wetlands - Joint MIT and University of Catania Summer School 2024 (Syracuse, June 2024)

The Summer workshop is scheduled to take place in Syracuse on the 14th-28th of June 2024, which will bring together 24 students from both the University of Catania and the Massachusetts Institute of Technology (MIT, USA) to engage in an in-depth analysis of coastal restoration case studies, including REST-COAST pilot site and other site were outscaling is foreseen (Figure 8). Different aspects of restoration study will be addressed, from disaster risk reduction, to biodiversity protection and cultural heritage preservation. The program is designed to foster a collaborative learning environment where students can explore innovative approaches to coastal wetland restoration and management. By examining real-world scenarios, participants will gain valuable insights into the complexities of coastal ecosystems and develop strategies to address the challenges of preserving and enhancing these vital natural resources.

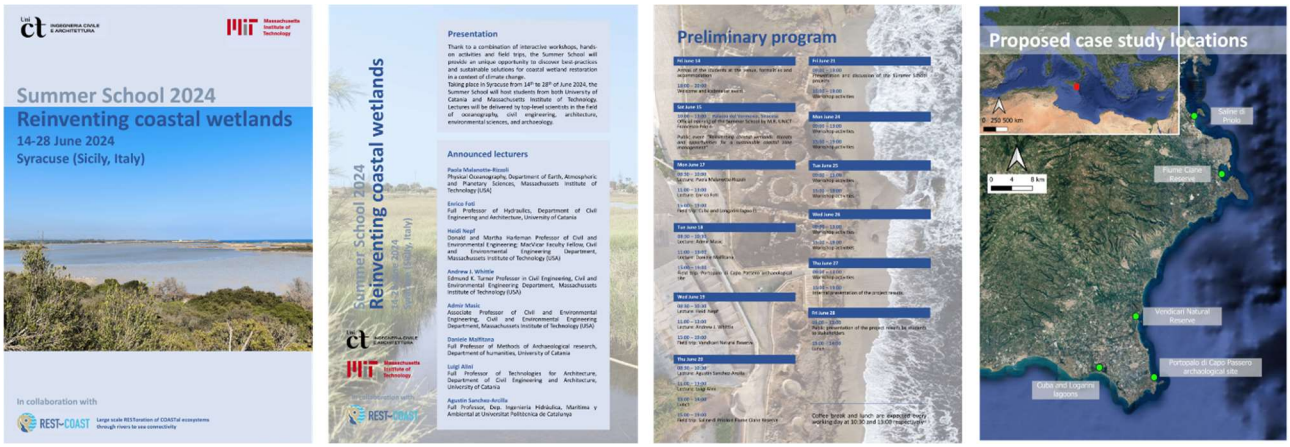

Figure 8: Leaflet of *Reinventing coastal wetlands - Joint MIT and University of Catania Summer School*

2.2.3 Professionals

Giornata Mondiale dell'Acqua – Difesa, restauro e valorizzazione delle aree costiere (University of Reggio Calabria, 21 March 2023)

In the context of the Water World Day, a full day course for professional engineers was organized in cooperation with the National Engineering Council titled *"Difesa, Restauro e Valorizzazione delle Aree Costiere* - Defense, Restoration and Valorisation of Coastal Areas" at University of Reggio Calabria, Italy. A presentation with the title *"Il restauro costiero come opportunità per la valorizzazione del territorio* – The restoration of coastal areas as opportunity for valorization of the environment" intended to raise awareness on coastal wetland degradation, practices of restoration and opportunities for the territory, starting from the experience of the REST-COAST project (Figure 9).

Figure 9: *Giornata mondiale dell'acqua – Difesa, restauro e valorizzazione delle aree costiere* (University of Reggio Calabria, 21 March 2023)

2.3 Dissemination events

2.3.1 Civil Society involvement

European Research Nights 2022 (DICAR e DSBGA, 30 September 2022)
SHARPER night Catania took place on Friday 30 September 2022. For the European Researcher's Night a joint stand between the DICAR (Department of Civil Engineering and Architecture) and DSBGA (Department of Biology, Geology and Environmental Sciences) of UC was organized. Students, PhD, researchers and professors were involved. The event aims to spread the knowledge of the research professions in an informal and stimulating context and, in this case, the REST-COAST project was promoted with posters, videos and lab demonstrations (Figure 10).

Figure 10: REST-COAST @ Sharper Night 2022

Special session at ECOMED 2023 "Rigenerazione delle aree costiere e dei porti: la risposta anticipata agli effetti del cambiamento climatico" (19-21 April 2023, Catania, Italy)
ECOMED is a yearly exposition focused on the Mediterranean, created as a meeting point for the demand and supply of ideas and technologies that promote sustainability and circularity for the Mediterranean. It aims to shift the center of gravity for the circular economy towards the South, connecting the most strategic sectors of Made in Italy with stakeholders, institutions, and companies from across the Mediterranean basin. ECOMED aims at promoting and connecting national and international experiences and figures, highlighting those committed to fostering ecological, energy, and digital transitions in water management, waste, resources, renewable energy sources, and sustainable mobility. In the context of the EXPO, In the context of the EXPO, the session titled *"Rigenerazione delle aree costiere e dei porti: la risposta anticipata agli effetti del cambiamento climatico* - Regeneration of coastal areas and ports: the anticipated response to the effects of climate change" hosted presentations about innovative strategies and solutions for the regeneration of coastal areas and ports as proactive responses to the effects of climate change (Figure 11). This session aimed to showcase approaches to enhance the resilience of coastal and port areas against rising sea levels, increased storm frequency, and other climate-related challenges. It emphasized the importance of integrating ecological, energy, and digital transformations in the planning and redevelopment of coastal infrastructures.

Figure 11: ECOMED 2023 special session banner and photos (21st of April 2023)

REST-COAST stakeholders kickoff meeting

The REST-COAST kickoff stakeholder meeting took place on March 17, 2023, in Marianelli, hosted by Forestry Agency of Syracuse (Figure 12). This gathering brought together key public authorities, universities, and private sector representatives to explore the restoration benefits for the areas targeted by REST-COAST. The discussions focused on identifying main barriers to and enablers of successful restoration, facilitated through thematic roundtable sessions. This collaborative approach aims to build consensus and mobilize concerted action towards realizing the project's ambitious goals, reinforcing the commitment to a sustainable and resilient coastal ecosystem.

Figure 12: REST-COAST stakeholders kickoff meeting, poster and photos (17 March 2023)

2.3.2 Scientific dissemination

XXXVIII Convegno Nazionale di Idraulica e Costruzioni Idrauliche
4-7 September 2022
Reggio Calabria, Italy
Musumeci R.E., Marino M, Cavallaro L, Foti E, Grasso R, Spena MT, Sciandrello S, Tavillla G, Di Stefano A, Borzì L.
Il restauro ambientale costiero come strategia di adattamento ai cambiamenti climatici: il progetto REST-COAST
Oral presentation

ECSA 59: Using the best scientific knowledge for the sustainable management of estuaries and coastal seas
5-8 September 2022
San Sebastian, Spain
Musumeci R.E., Marino M, Cavallaro L, Foti E, Grasso R, Spena MT, Sciandrello S, Tavillla G, Di Stefano A, Borzì L.,
Nature restoration as climate change mitigation strategy at the coastal wetlands of the South-East of Sicily.
Poster presentation

Studi di Aggiornamento dell'Associazione Italiana Ingegneria Offshore e Marittima (AIOM) 2022
21-22 October 2022
Parma, Italy
Musumeci RE, Marino M, Cavallaro L, Foti E.
Il restauro ambientale costiero come strumento di mitigazione dei cambiamenti climatici
Oral presentation

International conference on coastal engineering (ICCE) 2022
4-9 December 2022
Sydney, Australia

Musumeci R.E., Marino M, Cavallaro L, Grasso R, Spena MT, Sciandrello S, Tavillla G, Di Stefano A, Borzì L., Foti E.
Does coastal wetland restoration works as a climate change adaptation strategy? The case of the South-East of Sicily
Oral presentation

Coastal Sediments 2023
11-15 April 2023
New Orleans, Lousiana (USA).
Musumeci R.E., Marino M, Cavallaro L, Foti E
Assessment of Coastal Restoration Measures to Mitigate Coastal Flooding in a Context of Climate Change: the Case of the South-east of Sicily Lagoons
Oral presentation

Coastal Sediments 2023
11-15 April 2023
New Orleans, Lousiana (USA)
Costa GP, Marino M, Caceres I, Musumeci RE
Coastal dunes: a Nature-Based Solution to face coastal hazards
Poster presentation

European Geophysical Union Assembly 2023
23-28 April 2023
Vienna, Austria
Musumeci R.E., Marino M, Cavallaro L, Foti E
Coastal restoration measures to mitigate coastal flooding in a context of climate change: the case of the South-East of Sicily
Oral presentation

SGI-SIMP Congress 2023 – The Geoscience paradigm: resources, risk and future perspective
19-21 September 2023.
Potenza, Italy
Borzì L., Barbagallo V., D'Andrea N.M., Distefano S., Marino M., Urso S., Tavilla G., Sciandrello S., Grasso R., Spena M.T., Cavallaro L., Di Stefano A., Foti E., Musumeci R.E.
Coastal human-induced changes in the context of Climate Change: the case study of South-east Sicily.
Oral presentation

Studi di Aggiornamento dell'Associazione Italiana Ingegneria Offshore e Marittima (AIOM) 2023
19-20 October 2023
Milano, Italy
Marino M, Musumeci R.E., Cavallaro L, Foti E
Adattamento ai cambiamenti climatici attraverso interventi di restauro costiero: uno studio modellistico nella Sicilia Sud-Orientale
Oral presentation

3 Demo activities

3.1 Hands-on restoration actions

3.1.1 Field surveys

Field surveys were performed to investigate abiotic and biotic variables and six and four sampling stations were chosen for the Longarini and Cuba lagoons, respectively (Figure 13). Sediment samples were collected seasonally in July 2022; December 2022; March 2023; July 2023; November 2023.

Figure 13: Map of the Longarini and Cuba lagoons and the sampling stations chosen for each lagoon. The Cuba lagoon area was covered by four surveys, and the wider area of the Longarini lagoon was sampled at six stations.

For each sample site, lagoon name, site number, abbreviation name and survey date were noted and the coordinates were determined by a Garmin Global Position System. At each station, the in-situ physicochemical parameters (i.e. dissolved oxygen, pH, salinity) were measured at surface water depths by a Hanna HI 98194 multiparametric probe (Figure 14).

Figure 14: Sediment sampling surveys at the lagoons. Each sampling station has its site name and acronym, coordinates and the date of the survey are also noted. For each site, three sediment samples were collected for grain-size, micro- and macrobenthic analyses.

The Phytosociological surveys were carried out according to Braun-Blanquet method. Phytosociological relevés were conducted for each sampling station within the Cuba lagoon. During this field analysis are considered: plot size, altitude, total coverage of the vegetation, height of vegetation and species occurrence. For each species was assigned a coverage value ranging from 1 (1-5% coverage) to 5 (75-100% coverage), while for the sporadic species + (<1% coverage). In addition, samples of the species belonging to the different sites were gathered in order to make herbarium specimens, which will be kept in the Herbarium of Catania (CAT). Finally, water analysis of the lagoon was performed by means of a multiparametric meter to obtain information about salinity, pH and dissolved oxygen.

Sedimentological and benthos surveys were performed for each sites collecting lagoon floor surface and sub-surface sediments devoted to grain-size analysis. About 200-300 g of sediments were collected and carefully preserved in polythene bags. The water content was reduced as much as possible. For the macrobenthic community survey, samples were performed deepening about 10 cm into the lagoon floor and ca. 500 g of surface sediments were collected and preserved in polythene bags; for the microbenthonic community survey, few mm of surface sediments were sampled and immediately washed and sieved (mesh size 63 µm) with lagoon water. The samples were thus preserved in 95% ethanol with Rose Bengal solution (2 g l−1) and cool-preserved (Figure 15).

Figure 15: Sedimentological and benthonic surveys operation. a) Labelling of the polythene bags and jar to store the samples; b) Performing sedimentological and benthonic sampling; c) Washing and sieving the microbenthonic sample; d) Microbenthonic samples mixed with Rose Bengal and ethanol solution.

3.1.2 Monitoring network

A monitoring network was designed and installed at the Cuba-Longarini lagoon pilot site. The network allows for the measurement of fundamental environmental variables of the lagoon and wetland area. Specifically the network consists of

- 3x multiparameter sensors to measure water level, salinity and temperature in the Cuba and Longarini lagoons (Figure 16a).
- 3x multiparameter sensors to measure water level, salinity and temperature of the aquifer in the surrounding area of the Cuba and Longarini lagoons (Figure 16b).
- 1x weather station to measure rainfall, air temperature, humidity, wind speed, solar irradiance in the pilot site (Figure 16c)

The monitoring network was installed between October and November 2023 and is fully operative since 07/11/2023. Data is collected with a sampling frequency of 15 minutes. The multiparamer sensor network is easily accessible through a graphical interface (Figure 17), whereas the weather station data are accessible through a dedicated app.

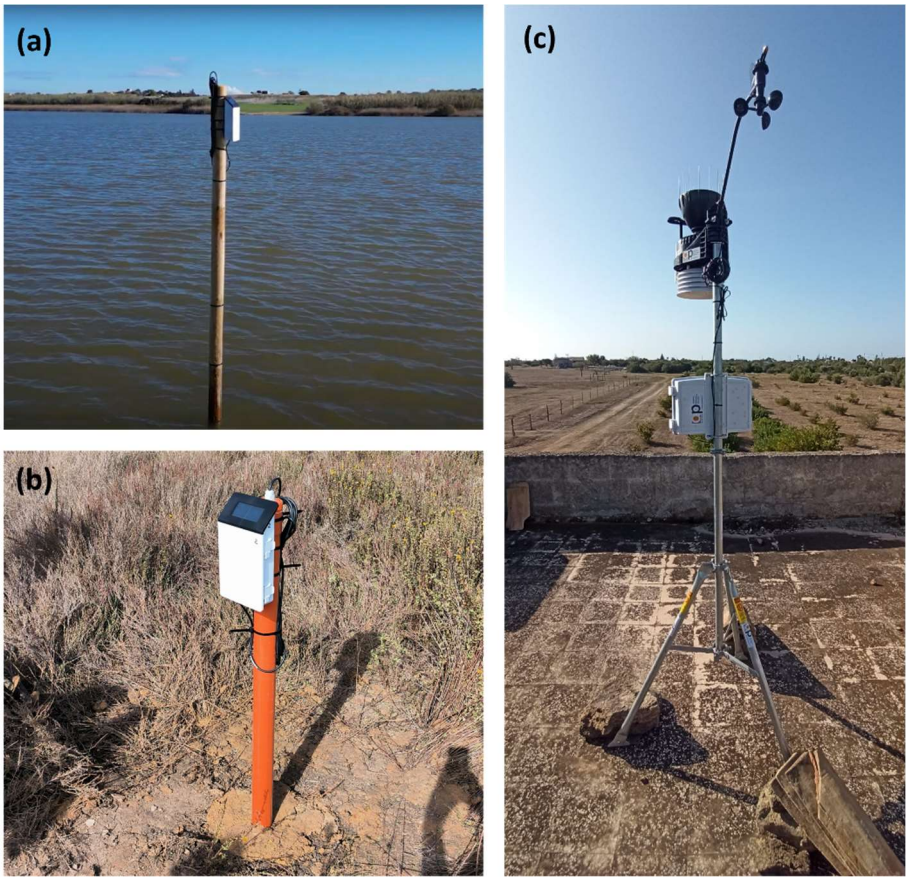

Figure 16: Sensors of the monitoring network: multiparameter sensor system to measure water level, salinity and temperature in the Longarini lagoon (a), multiparameter sensor system to measure water level, salinity and temperature for the groundwater at Longarini estuary (b), station to measure weather variables installed at Stiftung headquarters at the Cuba-Longarini pilot site (c).

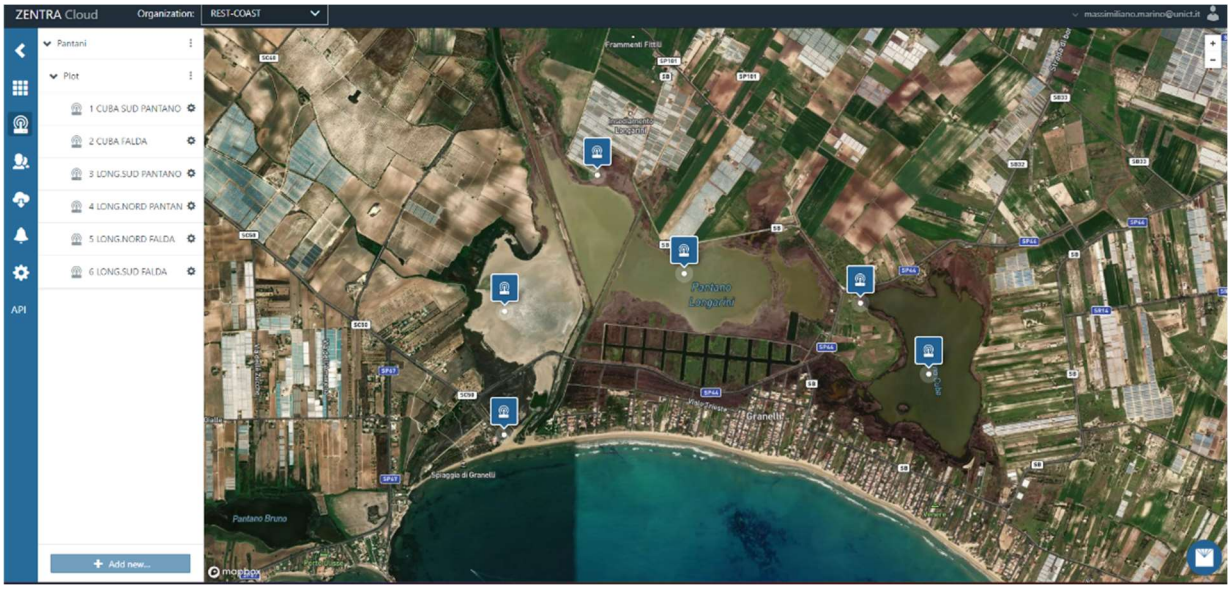

Figure 17: Graphical interface of the multiparameter sensors of REST-COAST Sicily monitoring network.

3.1.2 Modelling activity

Modelling activity was conducted in order to evaluate the effectiveness of Nature-based Solutions (NbSs) for mitigating coastal flooding and erosion at the pilot site. The study used a hydro-morphodynamic modelling framework, integrating SWAN and XBeach models, to assess the impact of dune restoration and seagrass meadow replantation (Costa et al., 2023). The models considered various climate change scenarios, projecting up to the year 2100 to determine the potential of NbSs in enhancing coastal resilience against heightened storm intensity and sea-level rise (Marino et al., 2023b).

The findings emphasize the critical role of NbSs in coastal defense strategies. Figure 18 shows the flooding maps for a RCP 4.5 scenario, simulating a storm characterized by significant wave height of 6.78 m, associated with a sea level rise projection of 0.51 m. The comparison between Figures 18a and 18b allows to quantify the flooded area reduction due to the presence of a dune revegetation action. Moreover, the activity allows to identify improvements for future research, such as incorporating hydrological discharge data to better replicate estuarine dynamics and evaluate compound flooding and the effects of lagoon vegetation on flood surges.

Despite demonstrating the benefits for flood and erosion control, this work also acknowledges the complexities involved in the practical application of NbSs. It suggests that an adaptive, integrated approach to coastal management is essential, one that maximizes the strengths of NbSs, acknowledges their constraints, and secures coastal community resilience in the face of climate uncertainties.

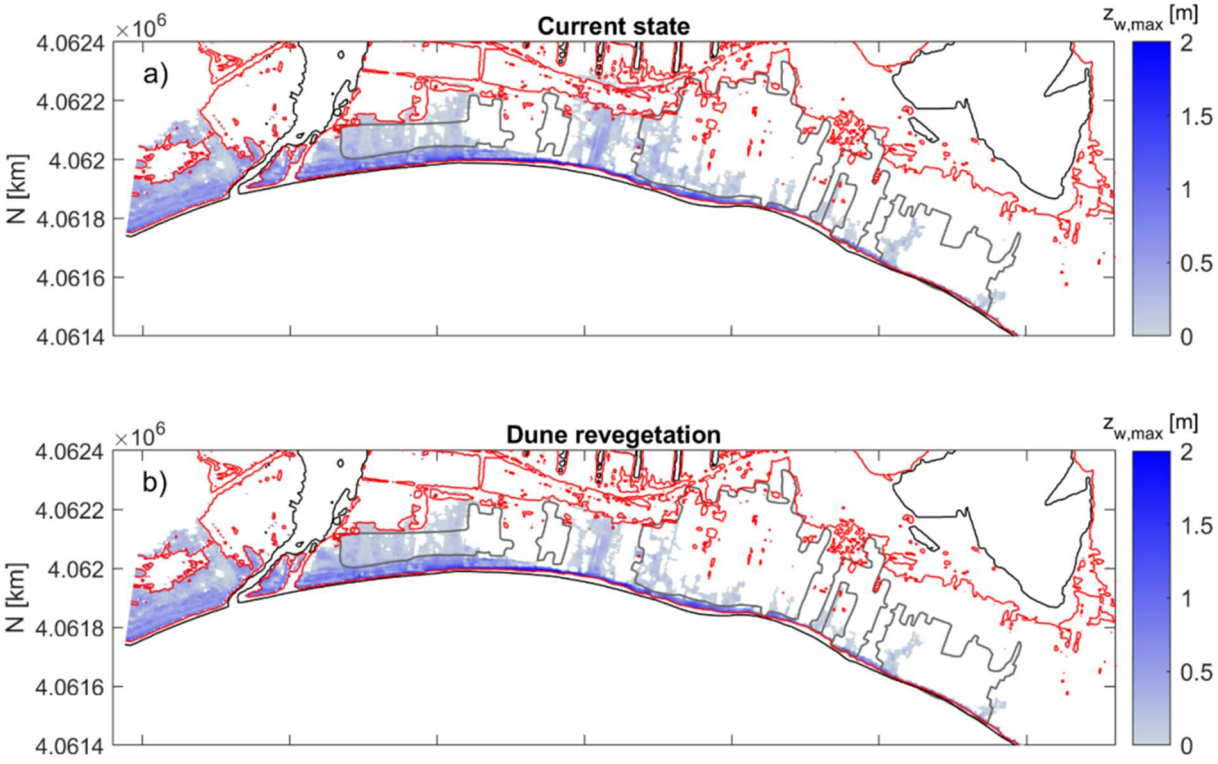

Figure 18: Inundation maps for simulation scenario RCP 4.5 for year 2100, (significant wave height = 7.75 m, sea level rise = 0.369 m): a) current state, b) dune revegetation.

3.2 Building of the CORE-PLAT: the 17 March 2023 stakeholder meeting

In the process of building the CORE-PLAT at the Sicily pilot site, on March 17, 2023, Marianelli served as the venue for the inaugural meeting of REST-COAST stakeholders, courtesy of the Forestry Agency of Syracuse. This event convened esteemed representatives from government bodies, academic institutions, and the private sector to discuss on the advantages of restoration in the region. The agenda highlighted critical obstacles and enablers for effective restoration, with thematic roundtable discussions enhancing the collaborative discussion.

3.3.1 Governance and Climate Change risks thematic table

The Facilitators of this thematic table were Prof. Rosaria Ester Musumeci Dr. Venera Pavone (UC). Prof. Rosaria Ester Musumeci introduced the theme of the table and both the two facilitators explained how the discussion would be conducted (Figure 19). Afterwards, participants were invited to make a brief presentation of themselves. After completing the presentations, the discussion began to focus on the critical issues identified by each participant as well as the strengths of the nature site undergoing environmental restoration. What emerged was a shared perception of several issues, relevant not only to the Longarini and Cuba Marshes nature site, but also to other coastal/lagoon wetlands with similar characteristics. Below are the observations regarding the critical issues and solutions identified.

Analysis of critical issues

- Domenico Solegreco pointed out that the Ciane/Saline Reserve in the province of Syracuse suffers summer fires and winter flooding.
- Gieseppe Rannisi pointed out coastal retreat, also influenced by dams and solid transport retention. He also mentioned fruition problems, such as the entry of motocross into protected areas and the cleaning of beaches with mechanical means that damage turtle nests.
- Antonino De Marco highlighted the issue of conflicting interests among different users and stressed the importance of managing conflicts and promoting cultural development focused on protecting these areas. He also mentioned the involvement of municipalities as a crucial element.
- Antonello Colombo pointed to the risk associated with Vendicari being surrounded by parties with other interests.
- Giancarlo Perrotta expressed concern about use and mobility in the area, which are often thought of only as a tourist destination and not a naturalistic one.
- Agata Di Stefano pointed out the discrepancy between the existing studies and the real needs of the area, highlighting the importance of making the results of research (which she stressed, are there) usable.
- Stefano Marina highlighted the importance of communicating research results outside academic circles, such as by involving the scientific councils of the provinces.
- Prof. Giuseppe Iuvara emphasized the importance of Posidonia and proposed engaging in the dissemination of the effects.
- Alessandra Trigilia, on hydrogeological risk and erosion, stressed the need to monitor floods and regulate canals.
- Carlo Lo Re raised the issue of weaknesses related to restoration efforts, and that more data and guidelines are needed in addition to what is established in the National Climate Change Adaptation Plan.
- Luca Cavallaro pointed out that the land is constantly changing and stressed the importance of restoring with climate change in mind.
- Carlo Capuzzello and Antonino De Marco pointed out the complications of involving farmers and ranchers, stressing that it is not easy to ask them to change practices that have been established for decades.

Possible solutions and proposals

- Alfredo Petralia suggested reflecting on the composition of the participants at the next meeting and considering whether to involve breeders and farmers as well. He also asked whether we should start from scratch in the debate, or start from a point established in previous meetings.
- Antonino De Marco stressed the importance of the presence of municipalities and provinces to address the issues at hand.
- Santacroce of the superintendency suggested encouraging the dissemination of marine climate and rainfall studies to foster greater understanding and awareness of the phenomena at hand.
- Lo Re pointed out the conflict of objectives between natural land users and farmers, indicating the need to address this issue in a balanced way.
- Capuzzello opposed the direct involvement of farmers and citizens, stressing that they need to understand the impact of their actions in wetlands. He suggested more boldness and less diplomacy in making decisions, even if unpopular.
- Salvatore Santacroce proposed awareness-raising efforts aimed at mayors, suggesting, for example, holding a lectio magistralis to raise awareness of environmental issues.
- Prof. Iuvara emphasized the importance of making the territory understand the importance of the issues discussed, fostering awareness.
- Rosaria Musumeci requested help from the actors present in organizing meetings with the administrations to foster greater cooperation and sharing of issues and possible solutions.

List of participants: Giancarlo Perrotta (Regione Sicilia – Servizio 16), Antonino Colombo (Regione Sicilia – Servizio 16), Ante Ivcevic (Vrije Universiteit Brussel), Vittoria Brullo (Dipartimento Sviluppo Rurale), Enrico Foti (UC), Stefano Marina (Legambiente Ispica), Luca Cavallaro (UC), Agata Di Stefano (UC), Sebastiano Leone (Regione Sicilia), Carlo Lo Re (ISPRA), Salvatore Santacroce (Soprintendenza RG), Massimiliano Marino (UC), Giorgio Spadola (Sikelion Legambiente), Domenico Solegreco (Provincia SR), Giuseppe Vario (WWF Sicilia), Alfredo Petralia (Ente Fauna Siciliana), Giuseppe Rannisi (LIPU), Carlo Capuzzello (Stiftung Pro Artenvielfalt), G. Loreto (Environmentalist), Alessandra Trigilia (Legambiente), Bianca Corrado (Ente Fauna Siciliana), Salvatore Brunetti (UC), Giuseppe Iuvara (WWF Sicilia).

Figure 19: Governance and Climate Change risk thematic table and all the participants.

3.3.2 Biodiversity thematic table

The Facilitators of this thematic table were Prof. Saverio Sciandrello and Dr. Laura Borzì (UC). After a quick round of presentations, participants started the discussion focusing on what each participant considered to be weaknesses and strengths of the REST-COAST restoration sites (Figure 20). Many points were raised by the participants, which can be summarized as follows:

Analysis of critical issues

- Shortage of scientific personnel within the government departments. All the participants conveyed the idea that public administration should make efforts to improve technical and scientific personnel backgrounds;
- Lack of effective control over the territory to limit illegal hunting and minidumps creation;
- Lack of scientific- and technical-based tools, e.g. a potential vegetation map, to support the decision-making process for the wetlands area management;
- The need for regular monitoring of water quality parameters to assess the hydrological status of the lagoons;
- Lack of a scientific and technical data-sharing system;
- Lack of planning and management of the regimentation interventions of the waterways that pertain to the Marshes;
- Lack of an integrated approach to coastal management.

Strengths

- The good level of biodiversity of the pilot site posed the basis for the ongoing restoration interventions;
- Active involvement and cooperation by part of the farmers whose properties bordered the wetlands;
- Private management of the site is a major strength because it reduces the timing and logistics of interventions that are carried out within the site;
- After the discussion, participants proposed some possible actions that could be implemented to mitigate or solve the weaknesses listed above and whose technical and economic feasibility is considered realistic.

Possible interventions and solutions

- Effective communication with the local population regarding the actions and interventions to be implemented;
- Promote responsible management of water resources to restore the sediment supply to the beach to limit the coastal erosion process;
- Promote incentives to encourage local farmers for a better management of crops.

List of Participants: Adriana Alagna (ISPRA), Giuseppe Mammino (Prov. Siracusa), Antonio Alicata (Dip. Regionale Ambiente), UC, Egle Gambino (Stiftung pro Artenvielfalt), Paolo Galasso (Stiftung pro Artenvielfalt), Tullio Serges (Dip. Svil. Rurale Serv. 15 – RG), Valeria Restuccia (DSRT)

Figure 20 - Biodiversity thematic table and all the participants.

4 Demonstration value and replication

This demonstration served not merely as a showcase of applied research and practical interventions in the Sicily Lagoon pilot site but also as an instrument to enhance collaborative opportunities with local managers and authorities. Such initiatives are paramount in expanding the scope and scale of coastal restoration efforts within REST-COAST, catalysing stewardship across the Mediterranean basin and beyond.
The demonstration activities favour replication potential of effective and sustainable Nature-based practices, to ensure that the positive impacts of the project transcend the immediate pilot site and inspire similar undertakings on a larger scale and at other similar sites (Figure 21). This is testified by the birth of relevant collaborations between University of Catania and local site managers and stakeholders to guarantee long-term sustainability and commitment towards these solutions, which include:

- The development and installation of an advanced monitoring network at the Vendicari Nature Reserve, which mirrors the sensor and weather station network implemented at Sicily Lagoon. This allow the progressive building of an integrate monitoring network for understudied Sicilian coastal wetland areas.
- The signature of a formal agreement with the Fiume Ciane and Saline di Siracusa Natural Reserve and the Saline di Priolo Natural Reserve, which secures a commitment to upscaling and shared objectives and resource-sharing for future restoration and conservation initiatives.
- A partnership between REST-COAST and Stiftung Pro Artenvielfalt, which will be formalized by agreement of understanding. The collaboration goes beyond the REST-COAST pilot site of Cuba-Longarini lagoons, focusing also on the ecological restoration of the Baronello Lagoon, recently purchased by Stiftung. This collaboration is an exemplary model of upscaling, where successful methodologies are applied to new sites, thereby expanding the impact and scope of restoration actions.
- The initiation of proactive restoration measures including the replantation of native flora, lagoon environmental rehabilitation efforts marked by the removal of accumulated waste, and the dismantling of infrastructures detrimental to the lagoon's ecological balance, such as greenhouses.

Beyond the direct collaborations, the demonstration has acted as a booster for broader project initiatives, in collaboration with partners external to REST-COAST. Among these emerging projects are:

- A new Interreg Italia-Malta proposal, ambitiously aiming to elevate the restoration of coastal wetlands to a transboundary level, encompassing both Sicily and Malta. This project is set to expand to new pilot sites, such as Stagnone di Marsala, and extend to critical wetland and lagoon areas in Malta, fostering a trans-regional approach to ecosystem management.
- A new Interreg Italia-Tunisia proposal, which mirrors the goals of its Malta counterpart, aiming to scale up coastal wetland restoration efforts, marking a significant step towards a cooperative Mediterranean strategy against environmental degradation.

Additionally, the international recognition of the project was underscored during the EU Mission's "Restore our Oceans and Waters" annual event. At this forum, which included diverse collaboration initiatives such as the network matchmakings, presentations and speeches to the EU Parliament, Prof. Rosaria Musumeci communicated the REST-COAST project milestones and the challenges faced at the Sicily pilot site (Figure 21).

In summary, the abovementioned activities elucidate the implications of the Sicily Lagoon demonstration, not only as an embodiment of local restoration success but as a beacon for replication of coastal resilience efforts beyond the pilot site.

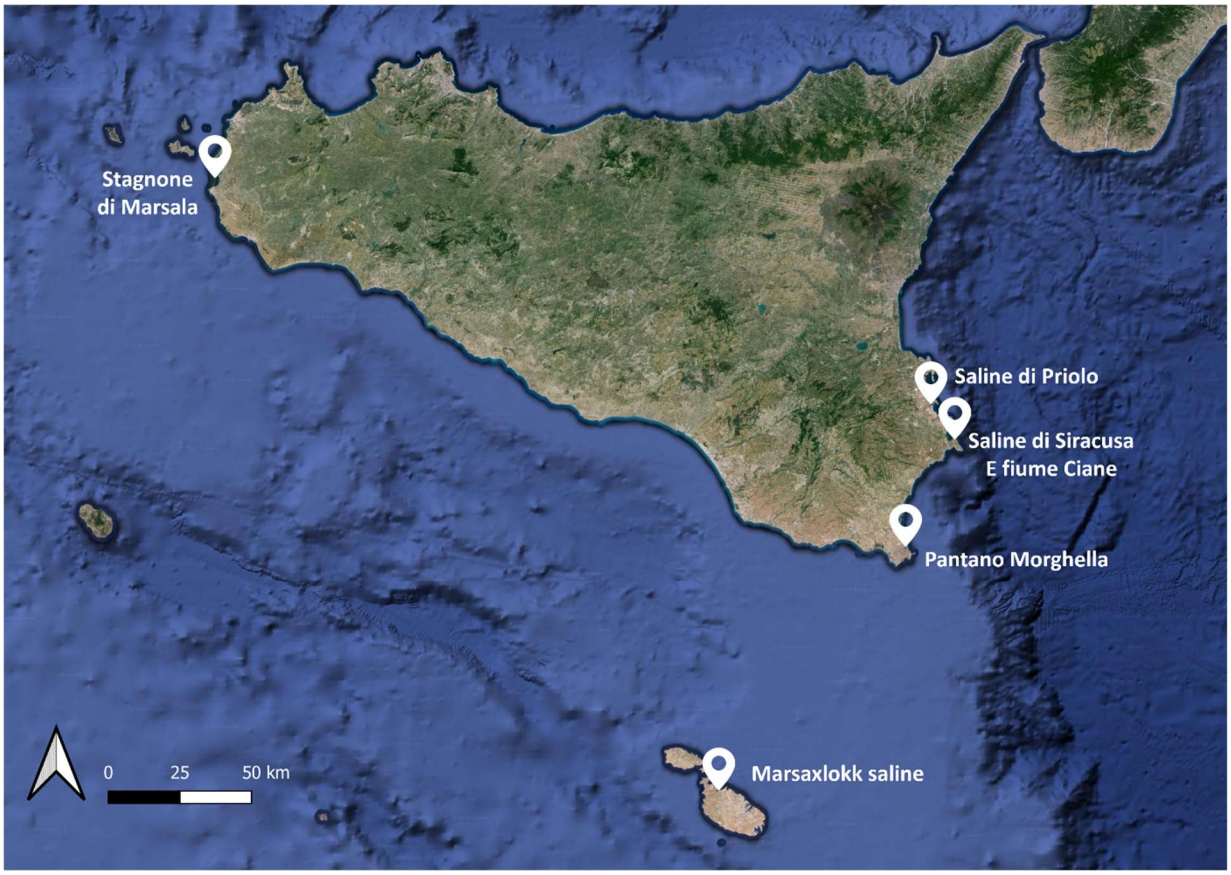

Figure 21 – Opportunities for upscaling and replicate REST-COAST Sicily lagoon pilot site experience

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6 Acknowledgements

The authors wish to thank the:

- Giancarlo Perrotta, Valeria Restuccia, and Antonio Colombo of the *Dipartimento dello Sviluppo Rurale e Territoriale* of the Sicilian Regioa for actively cooperating with the REST-COAST project and for kindly allowing the use of the Center of conservation of vegetal germoplasm of Marianelli for the organization of meetings with stakeholders and for supporting field trip visits to the Natural Oriented Reserve *Oasi Faunistica di Vendicari* in cooperation with the projects;
- Carlo Cappuzzello, Egle Gambino, and Paolo Galasso of Stiftung pro Artenvielfalt Foundation for active collaboration with the REST-COAST UC team, through data sharing, access to the area for field measurement campaigns, availability to kindly allow the installation of the REST-COAST monitoring network at their premises, support in the instrument management.