

Coastal adaptation for climate resilience

Prof. A Sanchez-Arcilla **et al**

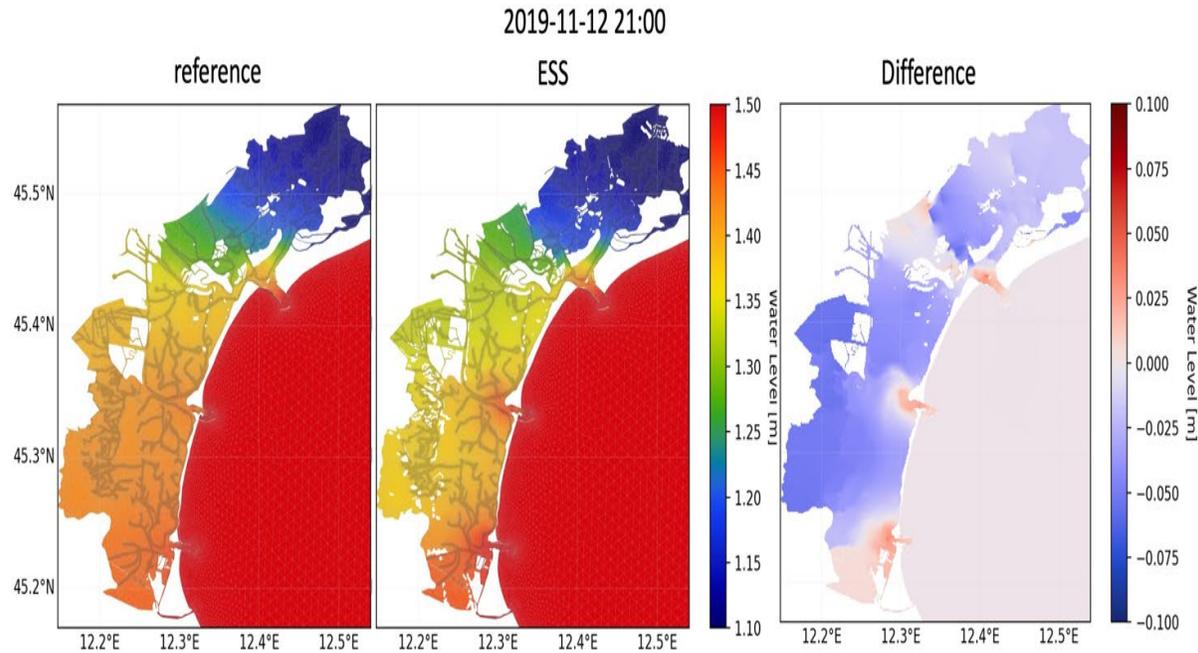


CONTENTS

- 1) Knowledge-based decisions: Short to long term warnings
- 2) Advances: synergies and tradeoffs for systemic restoration
- 3) Coordinated science: adaptation-through-restoration plans
- 4) Next future: rethinking coastal scapes for resilience

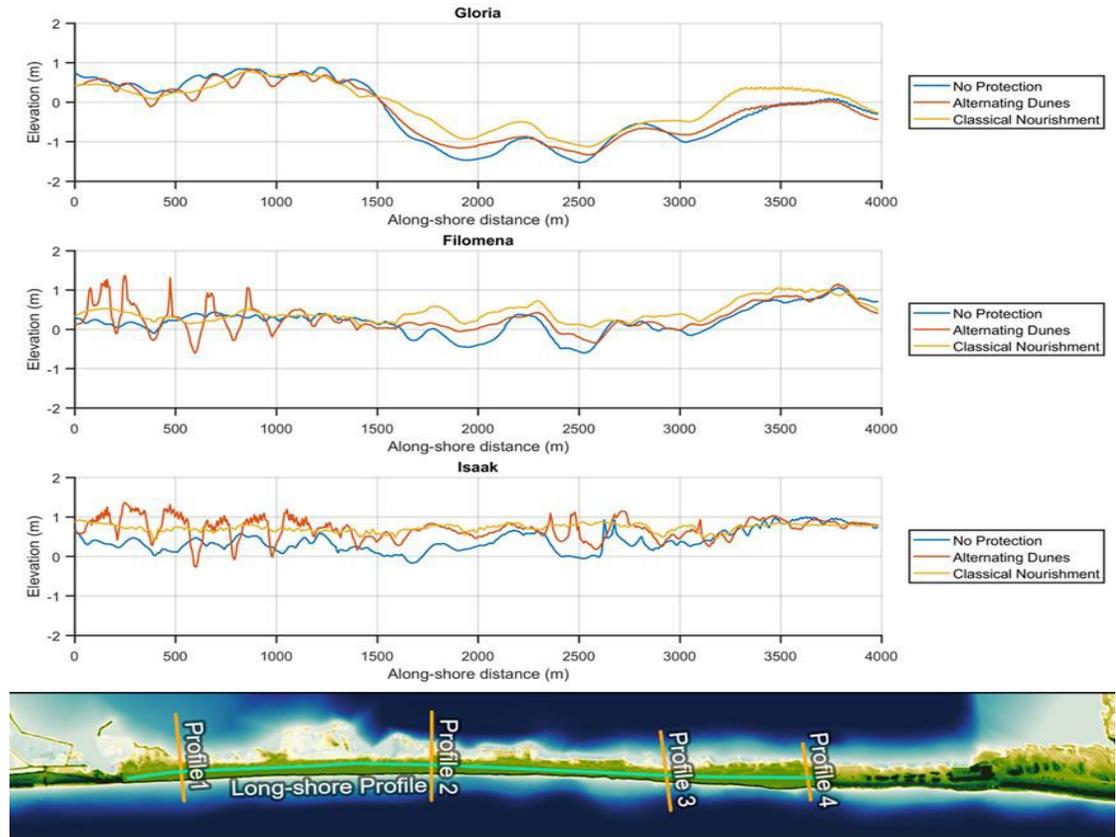
HOW TO ADAPT WITH EWS (SUPPORTING RESTORATION)

Knowledge based short-term decisions



Simulated storm water levels for **Venice lagoon**: present (reference) vs transplanted seagrass (ESS) & differences (**hydrodynamic risks ↓**)

ADD INFO: *Furlan, E., Derepasko, D., Torresan, S. et al. (2022). ESS at risk from coastal inundation, Int. Env. Ass. & Manag. 18(6)*

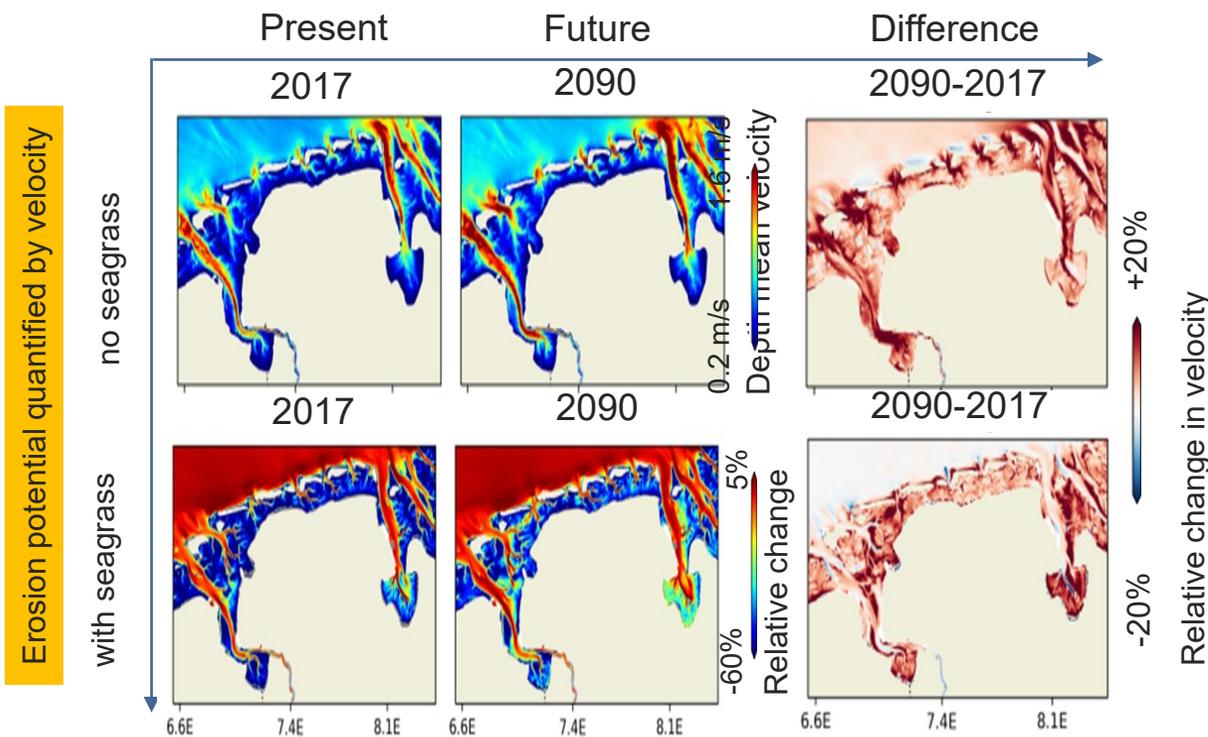


Breach simulations (**Ebro Δ**) under storms: embryo dunes vs classic nourishment (**breaching ↓**)

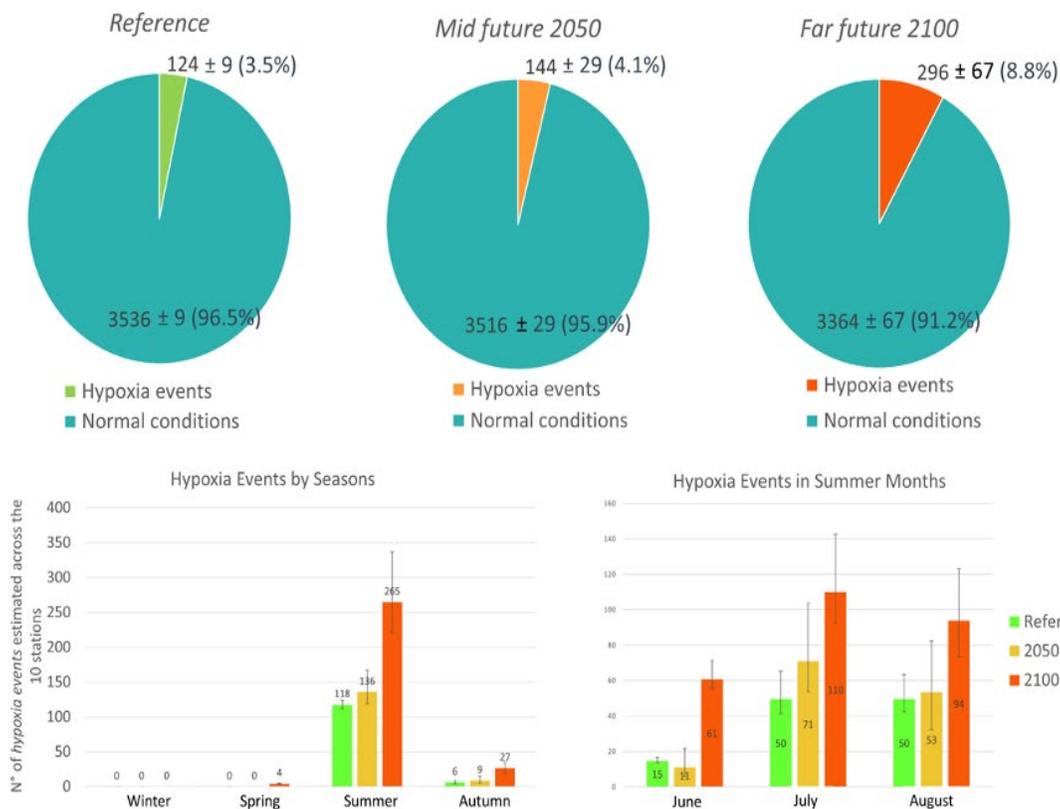
ADD INFO: *Sanchez-Artus, X., Subbiah, B., Gracia, V....and Sánchez-Arcilla, A (2024). Evaluating barrier beach protection. Coastal Eng. 191*

HOW TO ADAPT WITH CWS (SUPPORTING RESTORATION)

○ Knowledge based long-term adaptation



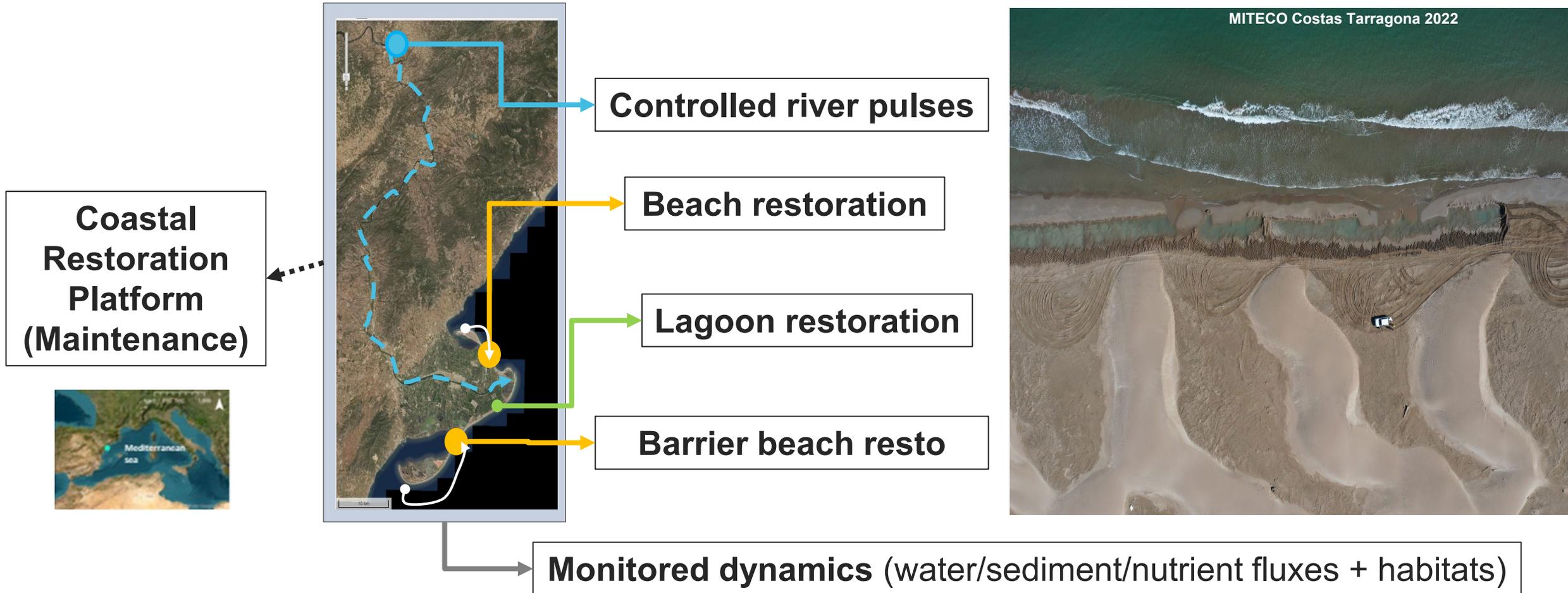
Present/future/difference in simulated water velocities (**Wadden Sea**) with/out seagrass beds: optimal **buffers** (erosion ↓) in **high Hs** areas



Present (reference), mid-future (2050) & long-future (2100) **hypoxia events**, simulated for Venice Ig.: seasons (l), summer (r) + **errors**

NEW SYSTEMIC RESTORATION: River-Coast Synergies/Tradeoffs

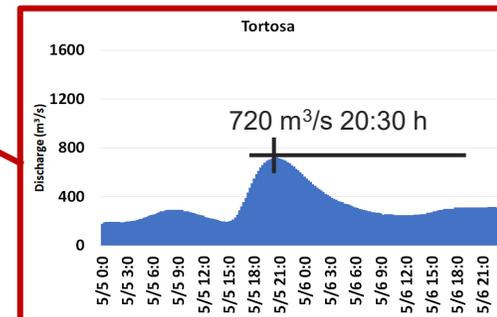
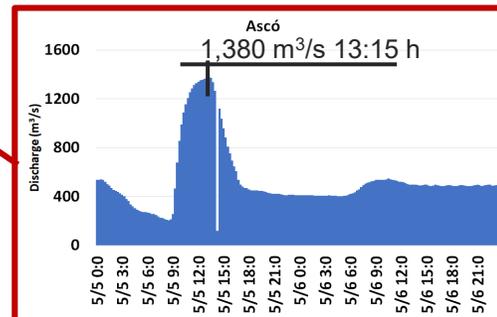
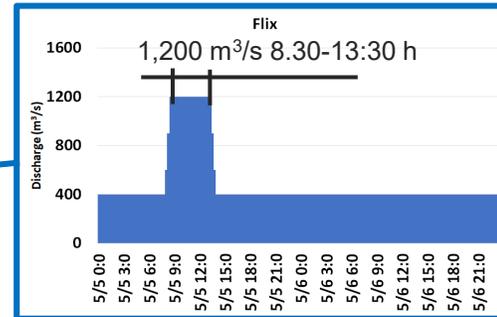
- Maintained connectivity + dynamics (coastal roughness): Ebro system



ADD INFO: *Sánchez-Arcilla, A., Garrote, L., Gracia, V., ... & Iglesias, A. (2025). Trade-offs and synergies in river-coastal restoration for the Ebro delta. Nature Conservation, 59, 101-137. <https://doi.org/10.3897/natureconservation.59.142061>*

SYSTEMIC RESTORATION: River pulses for solid transport (Ebro Δ)

- Connectivity with synergies/tradeoffs in water/sed/nutrients (**problem origin**)



River controlled pulses

- Discharge released from **Flix**
- Peak **flow downstream**
- **Flood wave** travel times (58 km \rightarrow 8 km/h)
- Peak **attenuation** in downstream travel

Monitoring

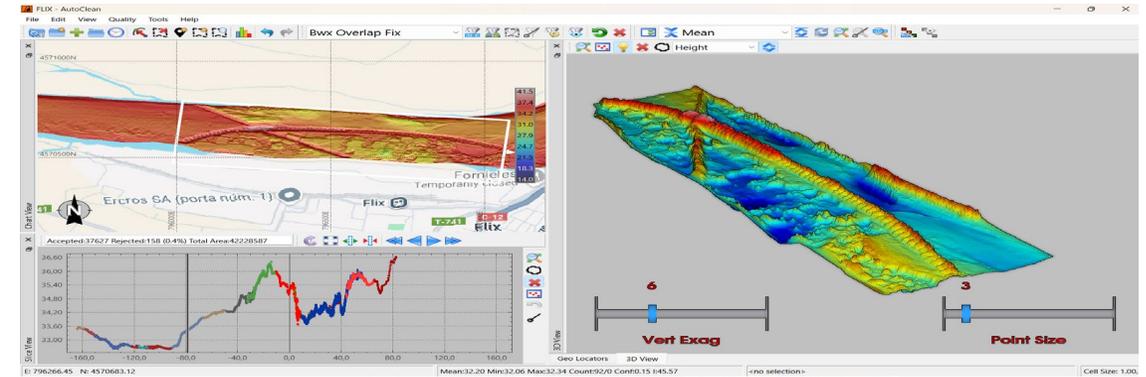
- **Permanent** observation networks
- Doppler **v profiles** 2 sections
- **SSC** 7 sections in bridges along Ebro River
- **Images** from drones + Sentinel 2



SYSTEMIC RESTORATION: River pulses for Q_{solid} (ACA, Ebro Δ)

○ Potential solid transport: subsidence & coastal erosion (**problem origin**)

Surface sediment samples & cores (Flix reservoir)

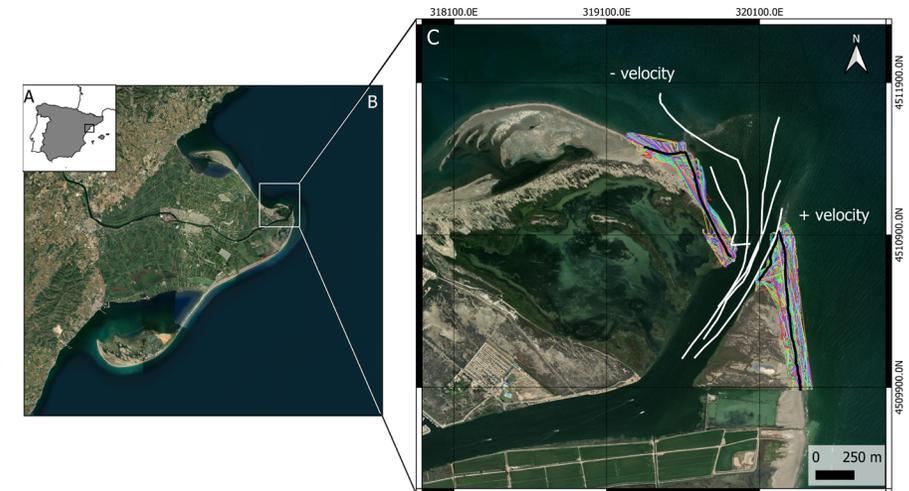


Suspended sediment samples downstream of reservoirs during controlled floods (May 2025)



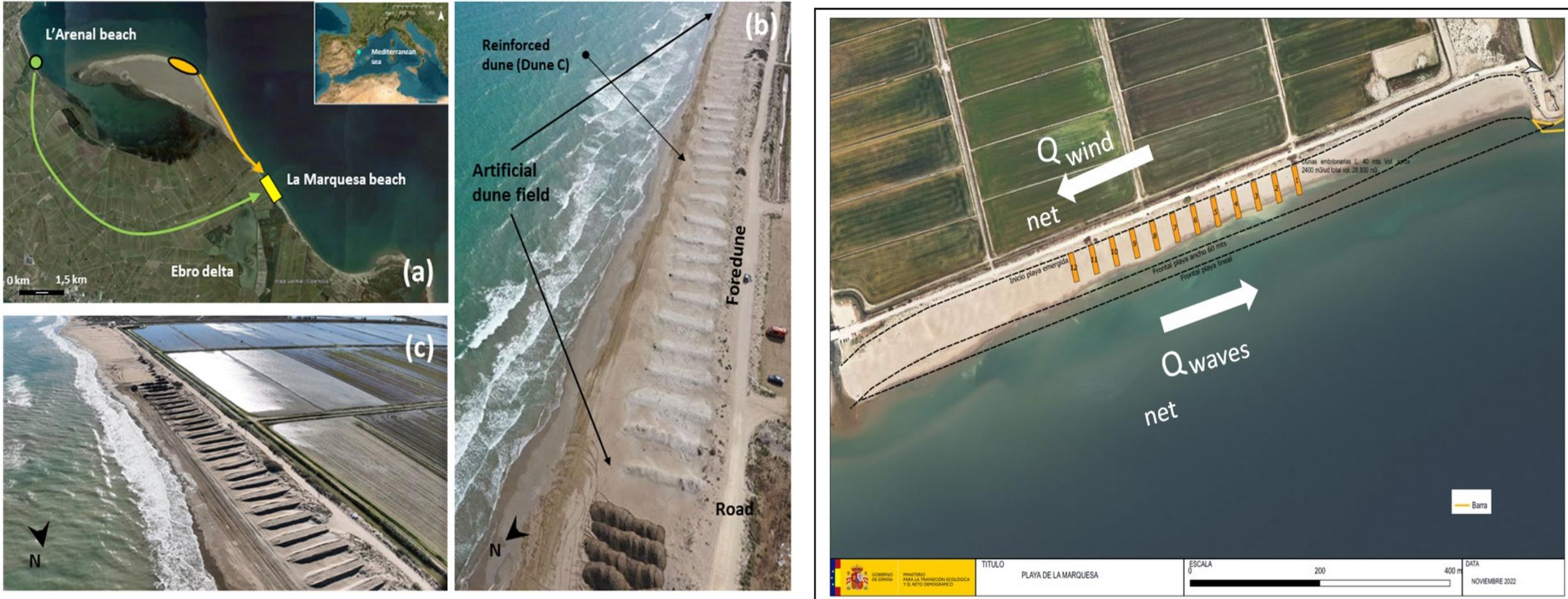
Digital Terrain Model for Δ bathymetry (2007-2025) in Flix: **loss of 0.01 hm³/year**, with visible dredged area

Satellite + UAV
- Bathymetry
- Trajectories (river mouth/est.)



NEW ADAPTATION-THROUGH-RESTORATION PLANS

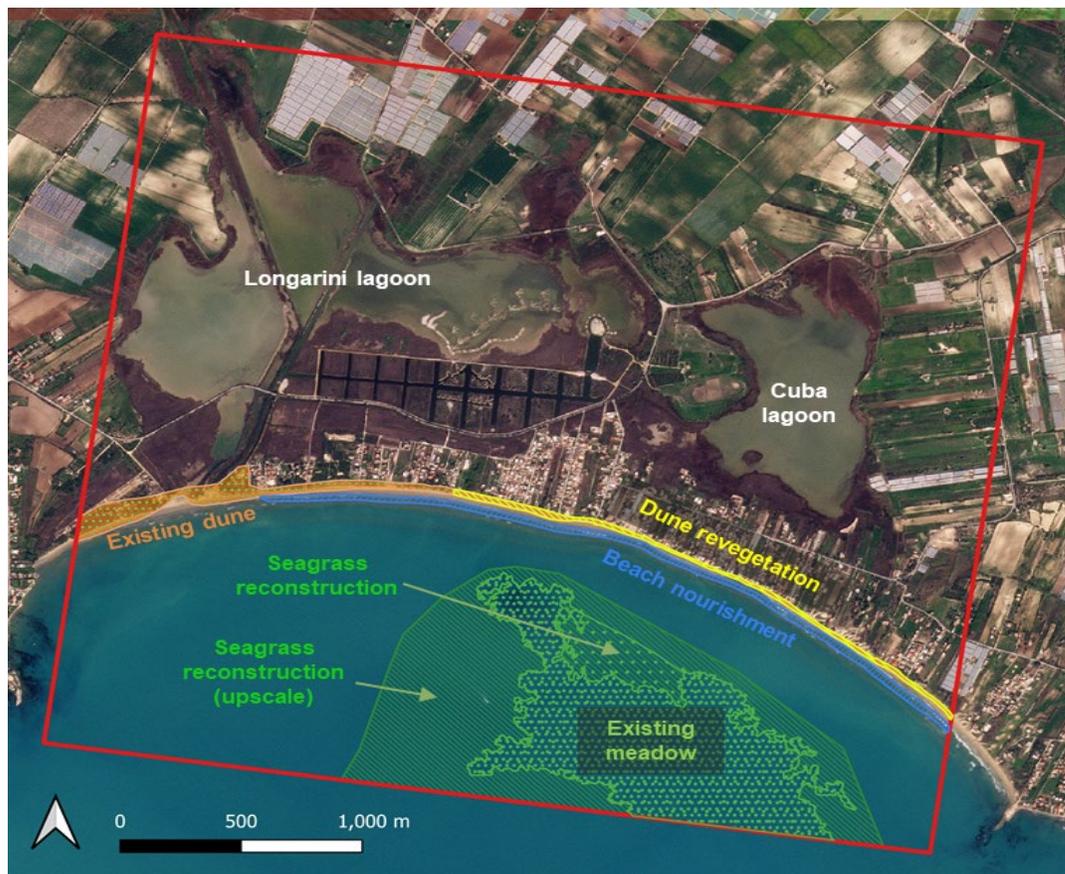
○ Embryo dunes + ridge/runnel + natural sand recycling (NbS)



ADD INFO: **Sánchez-Arcilla, A., Garrote, L., Gracia, V., ... & Iglesias, A. (2025). Trade-offs and synergies in river-coastal restoration for the Ebro delta. Nature Conservation, 59, 101-137. <https://doi.org/10.3897/natureconservation.59.142061>**

NEW ADAPTATION-TH-RESTORATION PLANS: NbS building blocks

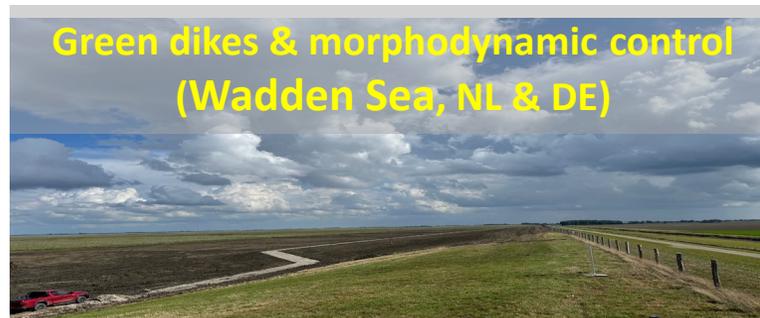
- Constructed seagrass beds + marshes + bird island (Sicily lagoons)



ADD INFO: Marino, M., Baptist, M.J., Alkharoubi, A.I.K. et al. Nature-based Solutions as Building Blocks for coastal flood risk reduction: model-based ecosystem service assessment. *Sci Rep* 15, 12070 (2025). <https://doi.org/10.1038/s41598-025-95230-4>

COORDINATED SCIENCE: ADAPTATION-TH-RESTORATION

REST COAST provides demos of hands-on restoration for ESS & BDV



ADD INFO: Sánchez-Arcilla, A., Cáceres, I., Le Roux, X., Hinkel, J., Schuerch, M., ... & Torresan, S. (2022). Barriers and enablers for upscaling coastal restoration. *Nature-Based Solutions*, 2, 100032. <https://doi.org/10.1016/j.nbsj.2022.100032>

COORDINATED SCIENCE: ADAPTATION-TH-RESTORATION

Climate coastal hotspots: supporting EU Nature Restoration Law & Green Deal

Nature restoration: Parliament adopts law to restore 20% of EU's land and sea

Press Releases [PLENARY SESSION](#) [ENVI](#) Yesterday



- EU countries must restore at least 30% of habitats in poor condition by 2030, 60% by 2040, and 90% by 2050
- Provisions for agricultural ecosystems can be temporarily suspended under exceptional circumstances
- Over 80% of European habitats are in poor shape



Photo caption: Parliament has adopted the first EU law to restore degraded ecosystems across the EU © Arnau / Adobe Stock

4 twinned GD projects

Joint river-coast production:

- resto techniques/data
- business plans/markets
- governance shift
- engagement tools

Joint Policy Brief (2025)

SUPPORTING NATIONAL RESTORATION PLAN DEVELOPMENT
with insights, learnings and recommendations from 4 European-scale restoration projects



SAVE THE DATE, AGENDA & REGISTRATION

Monday, 10th March 2025 (invitation only)
Venue: EC building - Covent Garden (Place Rogier 16, 1000 Brussels)
11:00-16:00 CET (registration 10:30)

[REGISTER HERE](#)

According to the [Nature Restoration Regulation \(NRR\)](#), [draft National Restoration Plans \(NRPs\)](#) need to be developed by each Member State by **1st September 2026**, and build on the latest technical progress and scientific evidence on how to create the best possible restoration impact.

Supporting Member States in this development, four European-scale restoration projects offer to **share their insights, learnings and recommendations across diverse landscape types (coastal areas, wetlands, rivers/floodplains and forests) and settings** in a professionally moderated & interactive event in Brussels.

With endorsement by the European Commission and the European Research Executive Agency (REA), and the support of the [Green Deal Projects Support Office](#), the four EU funded Green Deal Ecosystem Restoration Upscaling Projects: [MERLIN](#), [REST-COAST](#), [SUPERB](#) and [WaterLANDS](#) invite you to **this high level meeting** aimed at national and EU competent authorities for the development of NRPs and key restoration stakeholders.

The four ongoing projects **lever practical experience and multi-disciplinary knowledge from a total of 71 restoration and knowledge sites across Europe** with 149 partner organisations and supported by large networks of stakeholders at regional and international levels.

At the event, we will present NRR-relevant experiences and findings and **discuss with you how these can be concretely applied for the development of the National Restoration Plans**. The projects equally look forward to receiving your feedback for aligning their final products with your needs.

Main topics covered include

- Impactful scaling up of restoration, supported by effective restoration methods
- Feasible financing options for restoration, supported by adequate monitoring & evaluation

Additionally, we will address the onboarding of local and regional stakeholders through engagement and targeted communication - as also required for the NRPs.

Please register at your earliest convenience given the limited number of places available.

We look forward to seeing you in Brussels!

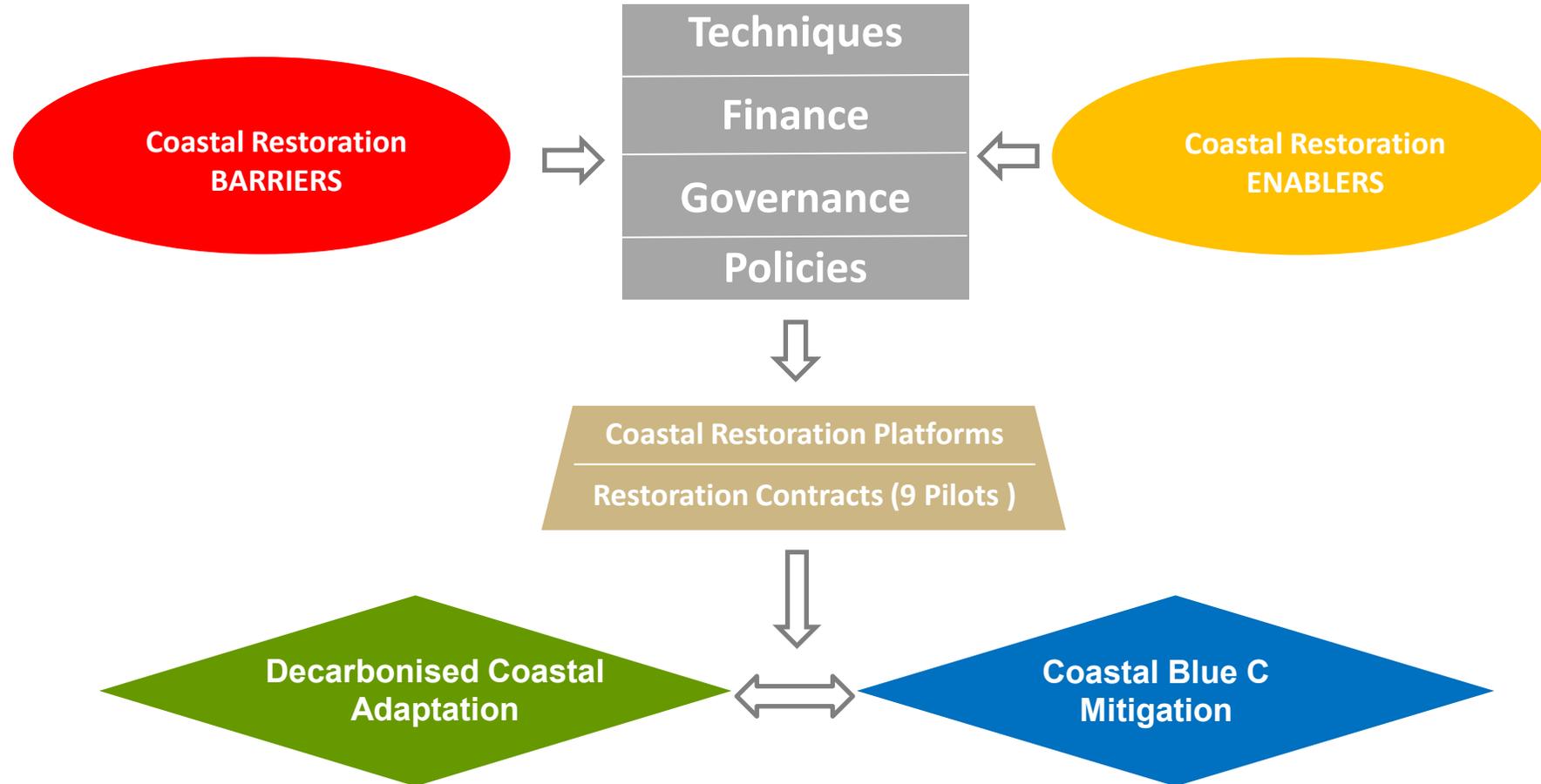


These projects have received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreements No 101036337, 101037097, 101036849 and 10103648.

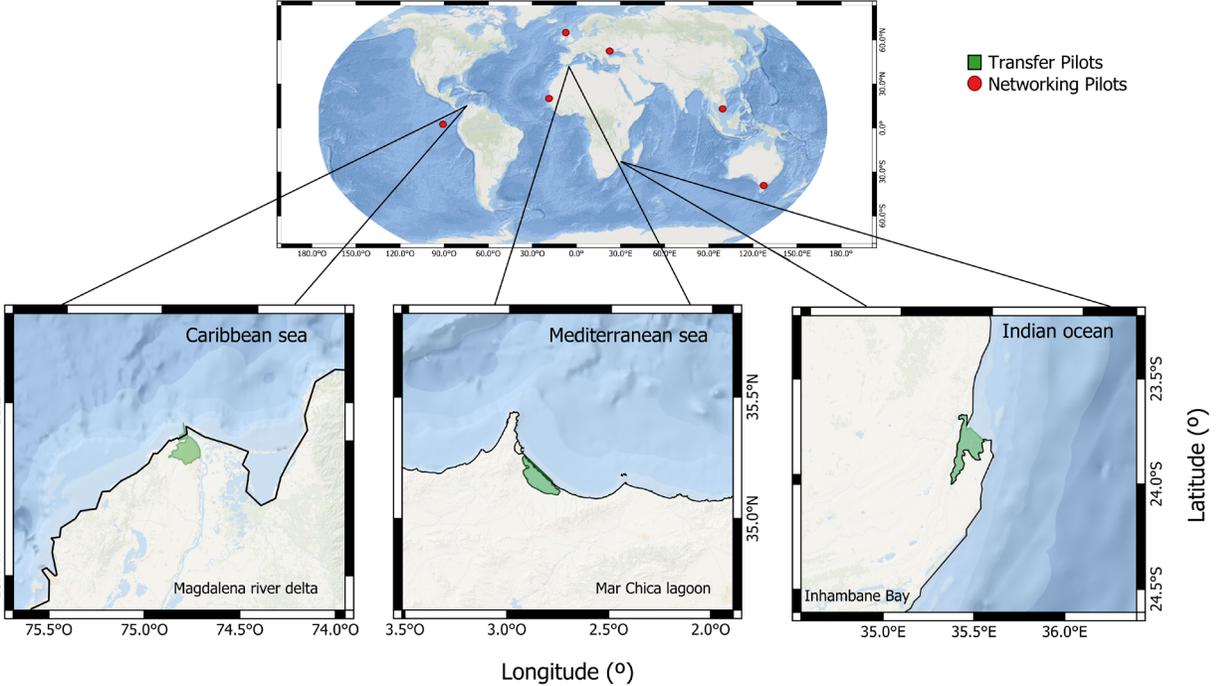
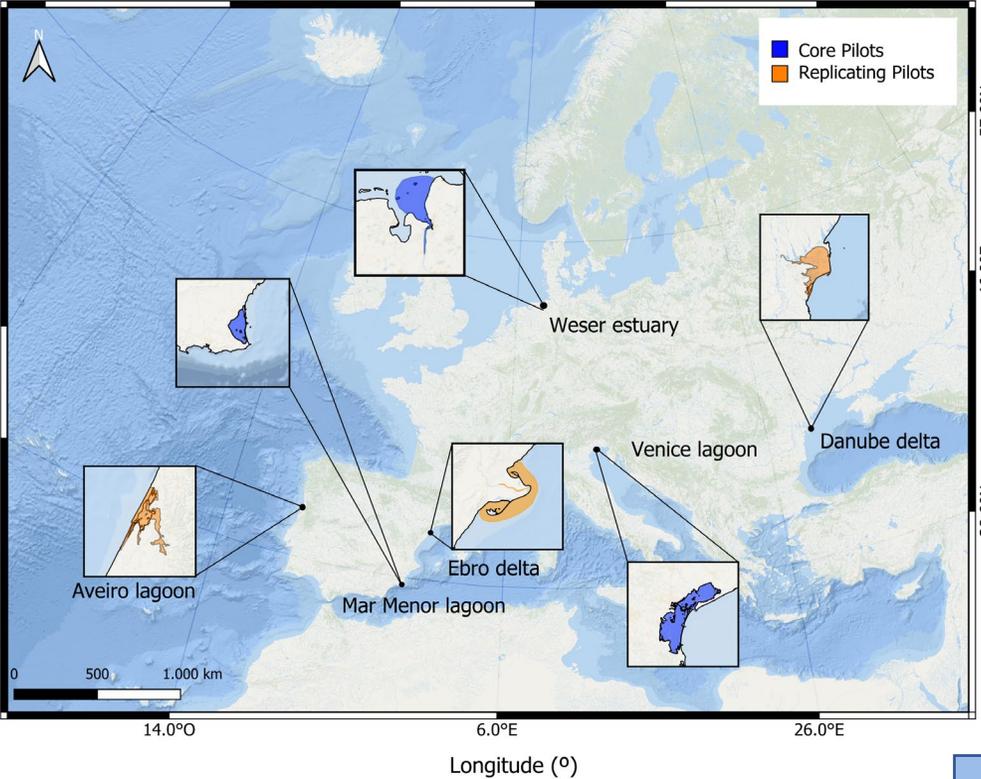
ADD INFO: E. Hart, A. Sánchez-Arcilla, C. Richards, C. Bullock, D. Hering, E. Schatzdorfer, F. Ferrara, G. ...P. Noukas, L. Palomo, C. Warin, V. Beaz (2025). Supporting National Restoration Plans: Insights from EU Green Deal Projects

COORDINATED SCIENCE : ADAPTATION-TH-RESTORATION

Adaptation-through-restoration plans to curb implementation deficit



NEXT FUTURE: RETHINKING COASTAL SCAPES FOR RESILIENCE



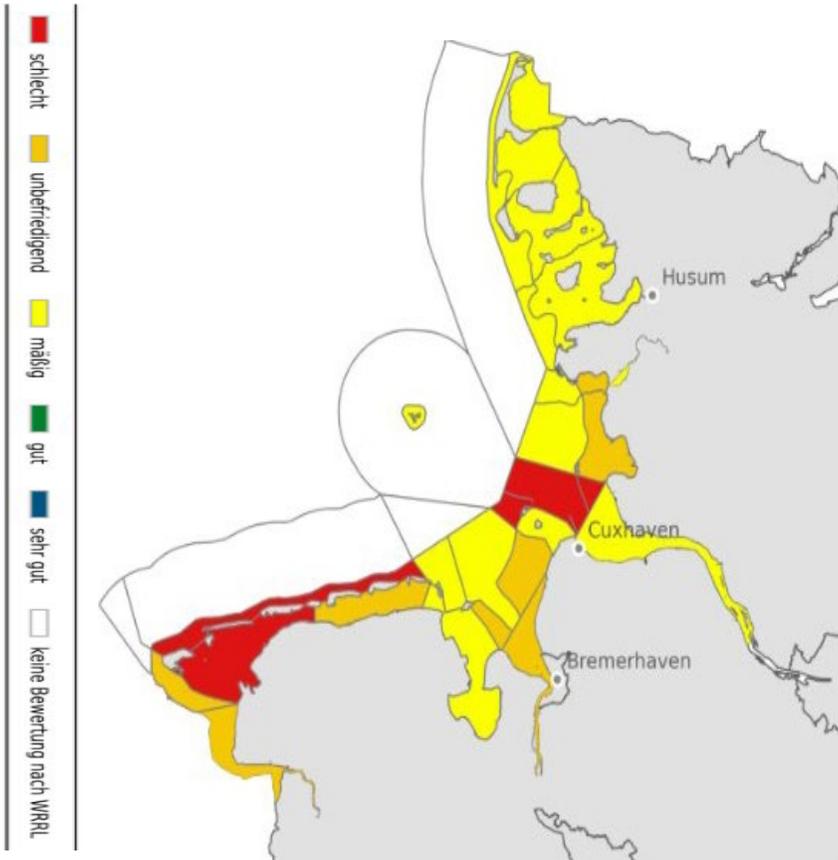
- Triad system (CP – RP – TP)
- 6 Network Pilots



RETHINKING COASTAL SCAPES: WESSER Est (C) → AVEIRO Lg (R)

Nutrients, eutrophication, missed WFD status, complex S-E interactions, climate pressures

Stand: 29.03.2022
Bearbeitung: Umweltbundesamt, Bund/Länder-Arbeitsgemeinschaft Wasser (LAWA)



RESILIENCE FROM RESTORATION

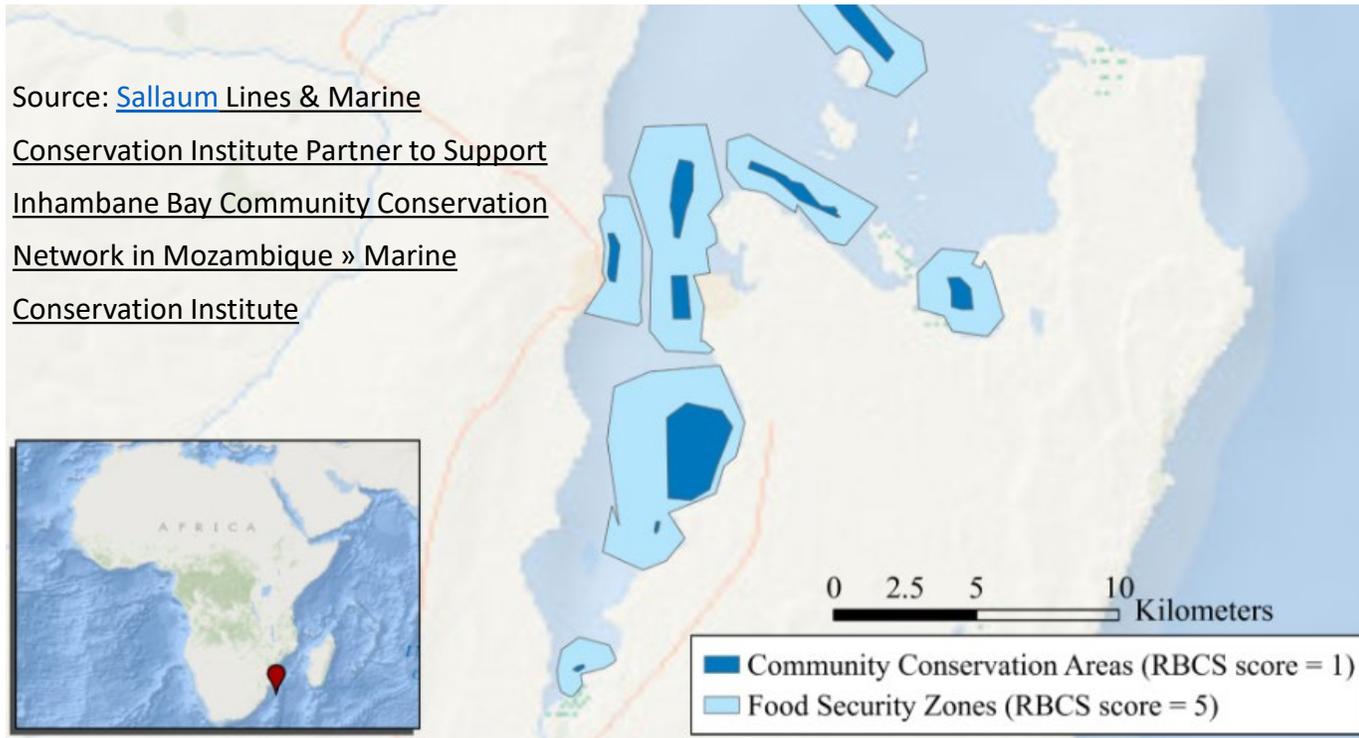
- Complex governance
- Interacting systems
- Overlapping programs
- Different plans/aims

SOURCE: *Genua-Olmedo, A., Verutes, G. M., Teixeira, H., Sousa, A. I., & Lillebø, A. I. (2023). A spatial vulnerability assessment for a coastal socio-ecological N 2000 site. Front. in Marine Sc. 10, 1086135. <https://doi.org/10.3389/fmars.2023.1086135>*

RETHINKING COASTAL SCAPES: INHAMBANE Bay (Mozambique, T)

Source: [Sallaum Lines & Marine](#)

[Conservation Institute Partner to Support Inhambane Bay Community Conservation Network in Mozambique](#) » Marine Conservation Institute

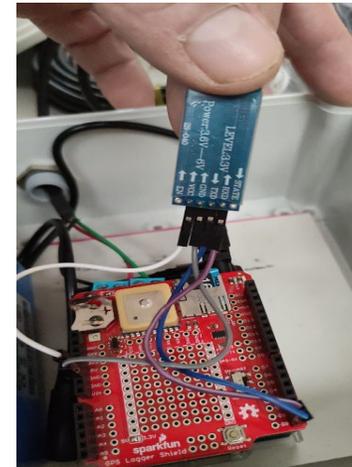


Critically important seagrass & mangroves

Inhambane Bay Community Conservtn. Network

SOURCE: Gota, P., & Ekblom, A. (2025). *Locally protected forests: status, character and challenges (Inhambane P., S Mozambique. Biodiversity and Conservation, 34(9))*

DIY observations
Transferable equipment



Arduino shield



Echosounder



Tilt current meter

NEXT FUTURE: Restoration Agreements (Rest-Coast legacy)

○ From CO-RE-PLATs + project outcomes (tailored for the 9 Pilots)

- Aims (present and target states)
- Participating stakeholders
- Adaptation-through-restoration plans
- Co-designed solutions
- Funding & Business plans
- Monitoring + maintenance (EWS + CWS + metrics)
- Governance & policies for upscaling (briefs)



SOURCE: *Dietrich, M., Sánchez-Arcilla Jr, A., Sánchez-Artús, X., Gracia, V., Caiola, N., Dabalà, C., ... & Sánchez-Arcilla Sr, A. (2025). Coastal Restoration Agreements Under Climate Change: Barriers/Enablers. Water, 17(21), 3154. <https://doi.org/10.3390/w17213154>*



@RESTCOAST_H2020



rest-coast.eu



REST-COAST project

Thank you!

Constructing local geodiversity
(Ebro delta, MITECO Costas Tarragona)