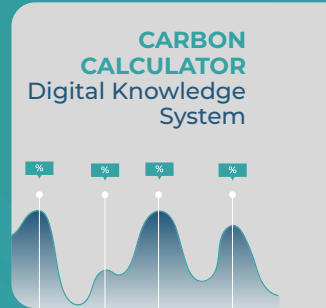


Integrating climate change mitigation via decarbonization and coastal ecosystems restoration



BIOFUEL FOR MARITIME TOURISM
GHG EMISSIONS



SEAGRASS RESTORATION WITH CITIZEN SCIENCE
CARBON STORAGE AND SEQUESTRATION
GHG EMISSIONS



CO₂ DECARBONIZATION OF PORT ACTIVITIES
GHG EMISSIONS



One interface, multiple pathways to EBM – Ecosystems-based management



Key Message

- Climate mitigation in coastal areas requires integrating emissions reduction with ecosystem restoration.
- Shared data and decision-support tools enable coordinated climate action across ports, ecosystems, and stakeholders.

Policy Relevance

- European Green Deal
- EU Climate Law (Regulation (EU) 2021/1119)
- EU Nature Restoration Regulation (Regulation (EU) 2024/1991)
- Portuguese National Energy and Climate Plan (NECP 2030)



The Benefits the solution produces

This solution generates multi-dimensional benefits that extend beyond climate mitigation, embedding itself in a socio-ecological systems perspective and aligned with Ecosystem-Based Management (EBM) principles:

- **Climate Change Mitigation:** By reducing greenhouse gas (GHG) emissions through the decarbonisation of maritime logistics and recreational boating, and by enhancing carbon sequestration through blue carbon ecosystems, the solution addresses both emission sources and natural carbon sinks.
- **Biodiversity and Ecosystem Health:** The restoration of seagrass meadows and salt marshes strengthens ecosystem functioning, improves water quality, and supports nursery habitats for marine species, contributing to ecological resilience in coastal and estuarine systems.
- **Socio Economic Co Benefits:** Engagement of local communities and economic sectors fosters shared responsibility, supports the development of green jobs, and promotes more sustainable forms of tourism, aligning economic activities with environmental stewardship.
- **Public Awareness and Behavioural Change:** Citizen science initiatives and participatory restoration activities enhance ocean literacy, while the use of scenario based carbon emission tools enables individuals to explore the consequences of different choices, supporting longer term behavioural change towards sustainability.
- **Policy and Governance Integration:** The solution operationalises EBM by supporting coordination across sectors within a shared governance framework, reducing fragmented approaches and enabling more adaptive and coherent management.
- **Knowledge Co Production:** Through participatory processes and interactive visualisation tools, stakeholders jointly produce knowledge, explore trade-offs, and identify potential win-win pathways, contributing to decisions that are both socially acceptable and ecologically sound.



CO₂Emissions Calculator - LEVEL 1

Análise de Veículo ou Equipamento portuário (Vehicle or Port Equipment analysis)

Selecione um modo de transporte (Please select a transport mode)

Calcular (Calculate)



How developed is the solution

The solution is at an advanced stage of readiness, combining fully validated core activities with an integrative digital interface currently under testing. Key components, including the maritime carbon footprint calculator, biofuel testing in recreational boating, and seagrass restoration protocols, have been implemented and validated in real-world conditions. These activities are now being brought together through an interactive interface that integrates emissions data, fuel substitution options, and blue carbon restoration metrics, enabling joint exploration of impacts and trade-offs. The interface is undergoing functional and usability testing within participatory settings and will be embedded in the A-AAGORA Digital Knowledge System, allowing iterative improvement, interoperability, and scalability across regions.



Co-funded by
the European Union



UK Research
and Innovation

Where could also be applied to?

The solution is highly transferable to other European coastal and estuarine regions, as its modular components can be deployed independently or combined as a complete package. By embedding Ecosystem-Based Management principles, it supports integrated consideration of ecological, social, and economic dimensions across diverse contexts. The digital interface acts as a shared visualization and engagement space, enabling stakeholders and citizens to explore scenarios, understand trade-offs, and co-design actions in a transparent and participatory way. This flexibility supports replication and scaling, while fostering cross-sector dialogue and alignment with EU missions and strategies.

Potential application areas include:

| Area characteristics | Intention for applying this solution |
|---|---|
| Regions with intermodal transport hubs | Support hub managers (ports and related infrastructures) in reducing GHG emissions and improving operational sustainability through integrated data and scenario analysis. |
| Areas with tourism focused boating activities | Promote the adoption of low carbon fuels in recreational and tourism boating, reducing emissions while raising climate awareness among operators and visitors. |
| Areas with coastal habitats with blue carbon potential | Restore seagrass meadows or salt marshes to enhance carbon sequestration, biodiversity, and ecosystem services, ideally through participatory and citizen science approaches. |
| Areas requiring stronger community and stakeholder engagement | Engage stakeholders and citizens in the co design and implementation of actions, fostering awareness, shared responsibility, and social acceptance of climate interventions. |



Who is this relevant to?

- Regional and local governments (implementation of national and EU regulations)
- National regulatory and sectoral authorities
- Port authorities and public administrations
- Maritime transport and logistics operators
- Tourism and small-scale maritime operators
- Environmental agencies and ecosystem managers
- Citizens, civil society, and interest groups

What do you need to have in place:

- **Stakeholder Commitment:** Port authorities, energy companies, tourism operators, municipalities, and citizens for co-design and implementation.
- **Engagement Framework:** Mechanisms for participatory workshops, UX testing, and citizen science initiatives.
- **Technical Infrastructure:** Access to the A-AAGORA Digital Knowledge System (DKS), data-sharing protocols, and capacity to integrate calculators and models.
- **Operational Readiness:** Ability to adapt port protocols, implement biofuel trials, and execute restoration activities.
- **Coastal Ecosystems:** with high blue carbon potential (e.g., seagrass meadows, salt marshes).



Key components of implementation:

Each component is supported by operational guidance, alignment with relevant EU policy frameworks, and user centred design principles.

Stakeholder Engagement Framework:

Co creation workshops, participatory sessions, and citizen science activities to ensure inclusiveness, shared ownership, and social legitimacy of actions.

Carbon Footprint Calculator:

A tool for estimating greenhouse gas emissions from multimodal transport and port related activities, supporting scenario exploration and emissions awareness.

Biofuel Integration Protocol:

Guidance for the partial replacement of fossil fuels with waste based biofuels in tourism related boating activities, supporting emissions reduction in operational contexts.

Seagrass restoration protocol:

A scalable approach for seagrass restoration that combines technical implementation with citizen involvement and environmental monitoring.

Integrative Interface:

A shared environment for visualising and exploring emissions data, fuel substitution options, and blue carbon sequestration, enabling integrated analysis and dialogue across sectors.

UX and usability testing:

Iterative testing with stakeholders to incorporate feedback, ensuring accessibility, transparency, and adaptability to different user needs.



Monitoring your success

Monitoring and adapting solution activities over time is critical for maximising impact. Monitoring focuses on technical performance, climate outcomes, governance effects, and user engagement, recognising the digital interface as the core enabler of integration and co creation. Key indicators include:

UX and Engagement Metrics

- **Usability performance:** Task completion rate, error rate, and time on task during interface testing.
- **User satisfaction:** System Usability Scale (SUS) and Net Promoter Score (NPS) collected from stakeholders.
- **Engagement levels:** Number of active users, frequency of use, and diversity of stakeholder participation (e.g. ports, energy actors, NGOs, citizens).
- **Inclusiveness:** Representation of different sectors and citizen groups in co creation and participatory activities.
- **Behavioural change:** Pre and post engagement surveys assessing willingness to adopt low carbon practices and participate in restoration actions.

Climate and Restoration Indicators

- **GHG Reduction:** Estimated emission reductions from port operations and boating activities, based on calculator outputs.
- **Carbon Sequestration:** Verified increases in blue carbon storage in restored coastal habitats
- **Biodiversity Metrics:** Habitat condition and species presence in restored areas

Governance and Knowledge Co-Production

- **Stakeholder collaboration:** Number and diversity of joint actions, agreements, or initiatives supported through the platform.
- **Policy Uptake:** Evidence of integration of outputs into local, regional, or sectoral climate and biodiversity strategies.
- **Data transparency and trust:** Clarity of assumptions, traceability of data sources, and stakeholder confidence in platform outputs.
- **Replication:** Interest, adoption, or adaptation of solution components in other regions or contexts.



Costs and timeframes

| Activity | Approximate cost | Cost range* | Approximate timeframe | Timeframe range |
|-------------------------------|------------------|-------------------------------|-----------------------|-----------------|
| Piloting the change | Medium–High | CAPEXintensive at start | 1–2 years | Short term |
| Facilitating collaboration | Medium | OPEXdominated | 1–2 years | Short term |
| Teaching through nature | Low–Medium | Mainly engagement costs | 1–2 years | Short term |
| Making restoration investible | Medium–High | High upfront, delayed returns | ~10 years | Medium term |
| Mapping the future | Medium | Long term monitoring costs | ~25 years | Long term |

**Cost ranges are relative to each other within this blueprint document, and have been developed by looking at the demonstration sites the activities were undertaken in. Please contact the authors for more information on how they could translate in your region.*

Costs and timeframes

| Activity | Type of cost | Cost level | Approximate timeframe |
|-------------------------------|--|-------------|-----------------------|
| Piloting the change | Infrastructure adaptation; digital tool development; habitat restoration; R&D | High | 1–2 years |
| Facilitating collaboration | Incentives for fleet retrofitting and low carbon fuels; stakeholder engagement | Medium | 1–2 years |
| Teaching through nature | Citizen engagement, education, and awareness raising | Low–Medium | 1–2 years |
| Making restoration investible | Financial structuring, MRV systems, aggregation of restoration actions | Medium–High | ~10 years |
| Mapping the future | Skilled personnel for monitoring, modelling, and maintenance | Medium | ~25 years |



The challenges you may encounter

| Activity | Challenge 1 | Challenge 2 |
|-------------------------------|--|---|
| Piloting the change | Adoption of low carbon operational practices (biofuels, port procedures) | Licensing, permitting, and regulatory approval |
| Facilitating collaboration | Sustained stakeholder engagement and commitment | Alignment of interests across sectors with different incentives |
| Teaching through nature | Effective communication across diverse audiences | Limited or uneven citizen participation |
| Making restoration investible | High upfront costs and uncertainty in carbon revenues | Long return periods and investor risk perception |
| Mapping the future | Uncertainty linked to climate, markets, and policy evolution | Long term institutional commitment beyond political cycles |

Key Contact who to talk to about your application idea

- **One interface, multiple pathways for EBM:** University of Aveiro (Ana Lillebø | lillebo@ua.pt)
- **Carbon footprint calculator:** Port of Aveiro (Maria Manuel Cruz | mariammanuel.cruz@portodeaveiro.pt)
- **Decarbonization of touristic boating:** PRIO Energy (Cristina Correia | cristina.correia@prio.pt)
- **Large-scale restoration:** University of Aveiro (Ana Sousa | anaisousa@ua.pt; Pedro Coelho | jpcoelho@ua.pt)
- **Integrative software:** Politehnica University of Bucharest (Florin Nemtanu | florin.nemtanu@upb.ro)

Further information (reading/resources box)

- Barbosa, S., Cruz, M.M., Coelho, M.C. (2025). Green Mobility for Small-Medium Size Ports: A GHG Emissions Web Calculator. In: McNally, C., Carroll, P., Martinez-Pastor, B., Ghosh, B., Efthymiou, M., Valantasis-Kanellos, N. (eds) Transport Transitions: Advancing Sustainable and Inclusive Mobility. TRAconference 2024. Lecture Notes in Mobility. Springer, Cham. https://doi.org/10.1007/978-3-031-89444-2_69
- Costa, V., Flindt, M.R., Lopes, M., Coelho, J.P., Costa, A.F., Lillebø, A.I., Sousa, A.I. (2022) Enhancing the resilience of *Zostera noltei* seagrass meadows against *Arenicola* spp. bio-invasion: a decision-making approach. Journal of Environmental Management, 302, (113969). <https://doi.org/10.1016/j.jenvman.2021.113969>
- Lillebø A.I., Teixeira H., Morgado M., Martinez-Lopez J., Marhubi A., Delacamara G., Strosser P., Nogueira A.J.A. (2019) Ecosystem-based management planning across aquatic realms at the Ria de Aveiro Natura 2000 territory. Science of the Total Environment, 650, 1898-1912 (Open access) <https://doi.org/10.1016/j.scitotenv.2018.09.317>







Blueprint

Integrating climate change mitigation via decarbonization and coastal ecosystems restoration

a-aagora.eu



Co-funded by
the European Union



UK Research
and Innovation