Baixo Vouga Lagunar (BVL) bocage landscape, Portugal

Year of issue

2025

Summary

This is a traditional practice in the Baixo Vouga Lagunar Area (Aveiro District, Vouga River Estuary, Portugal), since 19th century in order to protect BVL from the tidal floods. Baixo Vouga Lagunar represents a man-shaped landscape working in a dependent relationship between agricultural activities, wildlife and water regulation. BVL includes three main landscape units: bocage (smallholdings bounded by living-hedges and water ditches supplying water for crop and livestock production and also assure the drainage when there is water in excess in the fields), wetlands and open-fields.

In recent years, BVL has become a living lab for climate adaptation and resilience strategies, studied through projects such as ADAPT-MED and Man and Nature in the BVL. Local stakeholders recognize the protective role of tidal defense structures, though awareness of climate impacts remains limited. Efforts continue to promote synergies between nature conservation, agriculture and water management. The area is part of the Ria de Aveiro Natura 2000 site and hosts over 170 bird species, reinforcing its ecological value within a multifunctional landscape.

Photo Gallery



Location

40.7099019, -8.5986756

Project

NWRM

National ID

Portugal_03

Sector

Agriculture

Implementation status

Ongoing

Contact

Marta Rodríguez (IMDEA Water) on the basis of information kindly provided by Ana Lillebø (Universidade de Aveiro) and Ruth Pereira (Universidade do Porto), whose valuable contribution is acknowledged and very much appreciated

Overview

Location of the project

The project is located in the Baixo Vouga Lagunar area, in the Vouga River estuary, within the municipality of Estarreja, Aveiro District, Portugal.

Country

Portugal

NUTS2 Code

Centro (PT)

Sponge measures implemented in the case study

Buffer strips and hedges

Floodplain restoration and management

Objectives

Restore and preserve the traditional bocage landscape : Maintain the system of living hedges, drainage ditches, and small agricultural plots that support water regulation and biodiversity.
Enhance flood protection : Protect the area from tidal and fluvial flooding.
Promote multifunctional land use.
Improve biodiversity status : Conserve habitats within the Ria de Aveiro Natura 2000 site, which supports over 170 bird species.

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility

Research institute / University	CESAM – University of Aveiro	Monitoring	CESAM – University of Aveiro	Supporting
Research institute / University	—	Monitoring	Coordinates field research and ecological monitoring in the region, particularly in BVL.	Supporting
Local water authority	Municipality of Estarreja	Initiation of the measure	Territorial authority concerned with land use, water management, and local development in BVL. Involved in EU adaptation projects and public awareness campaigns.	Responsible
National water authority	ICNF (Instituto da Conservação da Natureza e das Florestas)	Monitoring	National agency managing Natura 2000 sites in Portugal, including Ria de Aveiro	Supporting
NGO	Associação Portuguesa de Educação Ambiental (ASPEA)	Other	Participated in awareness and community-based activities within BVL during past EU-funded initiatives	Supporting

Site Information

Climate Zone

Warm temperate dry

Precipitation

960.60 mm

Temperature (°C)

14.40 °C

Elevation range

3

Vegetation class

The trees are intended to serve as a subdivision of farmland and environmental mitigation (creation of shade, reducing the temperature and increasing humidity). The shrubby vegetation have essentially the function of defense of field crops against the winds.
Forming the living hedges we can fine trees, shrubs and herbaceous vegetation (http://www.biorede.pt/)
The tree community, part of the living hedges, is characterized by alder (Alnus glutinosa), willows (Atrocinerea salix), oak (Quercus robur), silver or white poplar (Populus alba) and laurel (Laurus nobilis).
The shrub layer is represented by hawthorn (Crataegus monogyna), the butcher's broom (Ruscus aculeatus), elderberry (Sambucus nigra), buckthorn (Frangula alnus), roses (Rosa pouzini, Rosa sempervirens) elmleaf blackberry (Rubus ulmifolius).
Regarding the herbaceous community there are standing out climbing plants such as honeysuckle (Lonicera periclymenum), the Bryonia dioica, Morning Glory (Calystegia sepium), and Senecio mikanioides, among others.
Vegetation influences the rate and efficiency of storm-water infiltration and filtration.

WFD Ecological status

Poor

WFD Chemical status

Good

Design and Implementation

Project scale

Meso

Project scale specifications

The project targets a regional landscape - the Baixo Vouga Lagunar area. The interventions and research span multiple land parcels and ecosystems within the estuarine zone but do not cover an entire large river basin or national territory. Hence, it exceeds micro-scale, but remains within a sub-basin/regional planning scope.

Project area

1285

Financing

Total cost information

No quantitative data available (note that some of these infrastructures were built in the 19th century).

Costs investment information

No quantitative data available (note that some of these infrastructures were built in the 19th century).

Costs land acquisition unit

€/ha

Financing authorities

Authority name	Type of funding	Comments	Financing share
European Union	EU-funds: Rural development funds	Multiple projects have received EU funding through: ADAPT-MED: funded by MED Programme (EU Regional Development Fund), previous initiatives have been supported via LIFE, INTERREG, or FP7/H2020.	unknown

Compensations

No

Policy and Governance

Policy description

Need for a tidal flood protection in the region.

Land ownership

Mostly private (bocage farms), some protected/public areas. Ownership is fragmented, reinforcing the need for coordination among multiple stakeholders.

Policy targets

Runoff control

Peak-flow reduction

Oher Societal Benefits

Oher Societal Benefits

Groundwater Recharge

Requirement directive remarks

- Water Policy - WFD.
- Water Policy - Floods Directive.

Policy challenges requirements

- Environmental Policy: Biodiversity Strategy (incl. Green Infrastructure Policy), NATURA 2000, Habitats Directive, LIFE, Soil Strategy.
- Climate change adaptation policy.
- Regional Policy: Cohesion Funds, ERDF
- Agricultural Policy: CAP, EAFRD

Part of a wider plan

No

Public consultation

No

Has contractual arrangements

No

Impacts and Monitoring

Monitoring System

Monitoring parameters

Biodiversity : Avifauna. Species diversity and abundance - over 170 bird species mentioned.
Hydrological conditions : Seasonal flooding in bocage fields, Water levels affecting wetlands and ditches.
Stakeholder perception / adaptation readiness : Awareness and perception of climate risk, evaluation of the effectiveness of tidal defense infrastructure.

Maintenance

Maintenance requirements

The bocage network of ditches and hedges requires ongoing local maintenance.

Impact Assessment Methodology

Performance impact assessment method

Unknown

Socio-economic Impacts

Direct benefits

- Cultivated crops, namely Rice, maize and permanent pastures.
- Reared animals and their outputs , namely Marinhoa cattle for meat; other cattle breeds for meat (Charolais, Limousine, crossbreed); Holstein Friesian cattle for dairy products like milk.

Ancillary benefits information

The Marinhoa is an endemic species and is a certified cattle breed for Aveiro region, having an added market value.
The area has a high intrinsic value due to its biodiversity and also due to its representativeness of a sustainable land use type and water management and it could be explored in the future for ecotourism.

Biophysical impacts: Hydrology

Information on retained water

Two management operations—dredging and extension of a flood bank in 2018–2019—had unintended negative impacts. Hydrodynamics: increased tidal prism and water velocity altered turbidity and flow patterns, affecting seagrass and saltmarsh communities. Coastal squeeze: downstream saltmarshes experienced excessively long submersion periods to which they are not well adapted. As part of the AQUACROSS/Ecosystem-Based Management (EBM) planning, participatory modelling identified the need to compensate such impacts by preserving traditional bocage, freshwater channels, and estuarine subtidal channels that provide critical ecosystem services.

The traditional bocage network (hedges + drainage ditches) functions as a water retention and drainage system, reducing flood propagation across ~1,200 ha of farmland.Dike and ditch interventions, including flood bank extension, are intended to prevent tidal and saline intrusion, though they have also generated altered submersion regimes for wetlands.

Information on peak flow reduction

Yes, but not quantified

Information on increased infiltration

Yes, but not quantified

Biophysical impacts: Biodiversity

Improved biodiversity

Yes

Information on improved biodiversity

Yes, BVL is recognized as model of biodiversity and balance between man activities and wildlife.
The Baixo Vouga Lagunar is integrated in Ria de Aveiro Special Protection Area (SPA – with the Natura 2000 code PTZPE0004). This SPA regularly supports over 1 % of the population of the pied avocet (Recurvirostra avosetta) and 60 % of the population of the purple heron (Ardea purpurea).
Baixo Vouga Lagunar is an important for 173 species of birds, such as the fish-hawk (Pandion haliaetus), the purple heron (Ardea purpurea), the black kite (Milvus migrans), the mallard duck (Anas platyrhynchos) and the white stork (Ciconia ciconia). It is also an important habitat for mammals like the least weasel (Mustela nivalis), the hedgehog (Erinaceus europaeus) and the European otter (Lutra lutra), for amphibians like the common toad (Bufo bufo), the tree frog (Hyla arborea), the fire salamander (Salamandra salamandra), the marbled newt (Triturus marmoratus) and the Iberian Painted Frog (Discoglossus galganoi), for reptiles, namely the Iberian emerald lizard (Lacerta schreiberi) and the viperine water snake (Natrix maura), and for several fish species including the eel (Petromyzon marinus) and the lamprey (Lampetra planeri). According to the EU Directive 92/43/EEC some of these species are classified as "strictly protected" (e.g. the otter and the tree frog). Also for IUCN (International Union for Conservation of Nature), the otter is in the “red list”, classified as “Near Threatened” as well as the Iberian Emerald Lizar

Biophysical impacts: Water & Soil Quality

Water quality overall improvements

N/A info

Information on water quality overall

No quantitative data available (note that some of these infrastructures were built in the 19th century). One can infer that living hedges will enhance the retention of SPM (suspended particulate matter) and associated/adsorbed pollutants, therefore contri

Soil quality overall improvements

N/A info

Information on soil quality overall improvements

A 2025 study on paddy soil quality in the BVL assessed pH, organic matter, conductivity, and potentially toxic elements (PTEs):
Soils ranged from moderately to strongly acidic (pH 4.4–5.8), with organic matter up to 34%.
Arsenic (As), Lead (Pb), Uranium (U) in some sites exceeded Portuguese thresholds for agricultural soils.
Cultivated fields had similar copper (Cu) levels; abandoned fields showed elevated As, Pb, U - possibly due to saline intrusion or geogenic sources.
However, porewater and irrigation water carried low PTE concentrations, and rice grains (white, brown, wild) showed PTE levels well below EU food-safety limits.

Information on soil quality, overall soil carbon

Positive impact-SQ improvement

Biophysical impacts: Others

Ecosystem impact climate regulation

No information available

Information on ecosystem impact climate regulation

Living hedges will enhance the 1) GHGs storage, including soil carbon; 4) increased permanent biomass. The canopy also enhances the surface area for the settlement of atmospheric PM (particulate matter). In this specific example ‘Bocage’ as green infrastructure reduces the visual impact and the smell from a pulp mill industry

Lessons Learned

Key lessons

Bocage requires high maintenance as it gathers not only a living-hedges network but also a hydraulic grid of ditches, channels, floodgates, banks and other water barriers. Some of these infrastructures were built in the 19th century in order to protect BVL from the tidal floods and its lack of maintenance is leading to draining issues and to the increase of salinity. So, these infrastructures are not only a cultural part of the landscape but also functions as a part of an integrate management system. With the increase of the surface salinity intrusion, more tolerant species appear, like bulrushes, rushes and reeds

Infrastructure interventions can have unintended ecological impacts : Engineering works like floodbank extensions and dredging (2018–2019) altered tidal flow regimes, leading to negative impacts on saltmarshes and estuarine habitats. These interventions, while aiming at flood protection, created hydrological imbalances and stress for sensitive biodiversity (e.g. over-submersion of marshes). Even well-intentioned interventions require thorough ecosystem-based impact assessments to avoid degrading key habitats and ecosystem functions.

Awareness and engagement of local stakeholders remain limited : Surveys (ADAPT-MED) show that only 39% of stakeholders felt aware of climate change impacts. There is still low social appropriation of adaptation planning, and many local actors do not perceive visible changes despite ecological data showing otherwise. Long-term adaptation success depends not only on technical solutions but also on social learning, trust-building, and participatory planning.

Multiscale coordination is needed for coherent outcomes : The BVL lies within a Natura 2000 site, under local, regional, and EU-level environmental regulations. Fragmented land ownership and jurisdictional overlap challenge coherent implementation of measures. Aligning local actions with regional and EU-level objectives is key to achieving durable outcomes, especially in multifunctional landscapes.

Barriers

Barrier type	Barrier role	Comments
Lacking financing sources	Main barrier	This is a barrier for the maintenance of the infrastructure (specific maintenance needs and aging of local population are expected to become a challenge). Note that some of these infrastructures were built in the 19th century.
Lacking coordination between authorities	Secondary barrier	This is a barrier for the maintenance of the infrastructure (specific maintenance needs and aging of local population are expected to become a challenge). Note that some of these infrastructures were built in the 19th century.

Barrier type	Barrier role	Comments
Specific financing rules	Secondary barrier	This is a barrier for the maintenance of the infrastructure (specific maintenance needs and aging of local population are expected to become a challenge). Note that some of these infrastructures were built in the 19th century.
Missing regulatory support	Secondary barrier	This is a barrier for the maintenance of the infrastructure (specific maintenance needs and aging of local population are expected to become a challenge). Note that some of these infrastructures were built in the 19th century.

Drivers

Driver type	Driver role
Past flooding events	Main driver

Success factors

Success factor type	Success factor role	Comments
Attitude of decision makers	Main factor	This is a success factor for the maintenance of the infrastructure. Note that some of these infrastructures were built in the 19th century.
Public participation	Main factor	This is a success factor for the maintenance of the infrastructure. Note that some of these infrastructures were built in the 19th century.
Communication activities	Secondary factor	This is a success factor for the maintenance of the infrastructure. Note that some of these infrastructures were built in the 19th century.

Transferability

The BVL bocage system is transferable to lowland estuarine or flood-prone areas where multifunctional land use is viable. Success depends on maintaining traditional structures (hedges, ditches), stakeholder engagement, and careful hydrological balance. Attention must be paid to unintended impacts from infrastructure works and to aligning local practices with conservation goals.

Sources

Sources

Spatial and temporal variation of trace elements in paddy soils and rice from a lowland bocage floodplain (Baixo Vouga Lagunar, Portugal)

O Baixo Vouga Lagunar: Estão as atuais tomadas de decisão adaptadas para internalizar a adaptação na elaboração de políticas

Mitigating Negative Unintended Impacts on Biodiversity in the Natura 2000 Vouga Estuary (Ria de Aveiro, Portugal)

Man and Nature in the Baixo Vouga Lagunar: Promote synergies and resilience in a global change scenario

À descoberta do Bocage do Baixo Vouga Lagunar

Encontro d'Águas: Segredos da Ria e do Baixo Vouga Lagunar