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Wetlands-based solutions for climate
change adaptation, risk prevention
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WETLAND4CHANGE

**Wetlands-based solutions for climate change adaptation, risk
prevention and mitigation
Euro-MED0200309**

**Preliminary study and technical guidance
report for the mapping and assessment of C
sequestration service provided by wetlands:
integration of existing tools/methods and
knowledge**

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Contributions from: all partners

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List of Abbreviations

CH₄ – Methane

CO₂ – Carbon dioxide

LGS.D – Legislative Decree

EUNIS – European Nature Information System

EU – European Union

EVI – Enhanced Vegetation Index

GHG – Greenhouse gases

GIS – Geographic Information System

HTCI – Habitats of community interest in Spanish (Hábitat Tipo Comunitario de Interés)

IUCN – International Union for Conservation of Nature

KML/KMZ – Keyhole Markup Language / Keyhole Markup Language Zipped

LOI – Loss on Ignition

LULUCF – Land use, land-use change, and forestry

MNDWI – Modified Normalized Difference Water Index

NDPI – Normalized Difference Phenology Index

NDVI – Normalized Difference Vegetation Index

NDWI – Normalized Difference Water Index

SCI/SPA – **SCI**: Site of Community Importance / **SPA**: Special Protection Area

OM – Organic Matter

PP – Project Partner

SWOS – Satellite-based Wetland Observation Service (EU project)

Spanish LPHE – Laboratorio de Prospección y Evaluación del Hábitat

TOC – Total Organic Carbon

WFD – EU Water Framework Directive

WP – Work Package

Partners name abbreviated

UF : University of Forestry | Bulgaria

EKBY : Goulandris Natural History Museum/ Greek Biotope - Wetland Centre | Greece

UVEG : University of Valencia | Spain

MEDSEA : Mediterranean Sea and Coast Foundation | Italy

TdV : Tour du Valat | France

ETC-UMA : European Topic Center - University of Malaga | Spain



1. Introduction

Quantifying the benefits of wetlands in terms of carbon sequestration is crucial for acknowledging values of these ecosystems. The effective communication of this ecosystem service to decision-makers aligns with EU adaptation strategy goals, emphasising the importance of environmental assessments, guidance, capacity building, and funding.

Essential for informed decision-making is to have availability of environmental carbon-related data, integrated with comprehensive inventories of wetland typification and ecological status. This involves measuring and modelling carbon flows within wetlands, incorporating baseline rates and evaluating its variation in response to disturbances.

Finally, this will allow us to assess, in terms of the climatic regulation service of the wetland, the effectiveness to implement different management strategies of restoration and/or conservation. These strategies could, for instance, involve the maintenance of natural hydrological regimes, minimise eutrophication, or protect the development of vegetation (Valach et al., 2021; Camacho-Santamans et al., 2024).

Regarding the evaluation of the capacity of wetlands to mitigate warming, there is still a need to reach consensus on methodologies, looking for a common and advanced assessment framework that should align with both national and international agreed-upon standards. Still, this evaluation can be approached with varying degrees of methodological complexity. The chosen level of complexity, which should yield an equivalent level of accuracy, would depend on factors such as data availability, specific requirements, and any constraints present.

This document offers technical instructions for the mapping and assessment of carbon sequestration at the pilot sites of the Wetland4Change project.

2. Foundations

The proposed approach involves delineating the extent and dynamics of main functional compartments within the wetland, namely, flooded surface, unflooded sediment, bare soil, and emergent vegetation. Subsequently, a weighted carbon exchange balance for each of these components should be quantified. The precision of this calculation may vary depending on the methodology employed. This is because the rates of carbon exchange can either be directly measured in the pilot site or approximated from estimates based on available data. Regardless of the approach, the procedure relies on the following foundations.



2.1. Parameterization of carbon exchange

For the proposed method, the assessment of C sequestration is based in the dynamic interchange of greenhouse gases (GHG), carbon dioxide (CO₂) and methane (CH₄), between the wetland compartments (i.e., vegetation, soil, water) and the atmosphere, which is regulated by biological, chemical, and physical processes (Morant et al., 2020a,b). The influx and outflux of carbon can be measured over time to obtain the rates of carbon exchange. Differences in the global warming potential for each molecule CO₂ and CH₄ must be considered, and units for expressing emissions/mitigation will be accordingly adopted (e.g., metric tons of CO₂ equivalent). For instance, whether to consider the variable radiative forcing of greenhouse gases has an effect in the estimate of the benefit of restoration on the climate mitigation effect.

There are several available methods for directly measuring GHG exchange rates, being the closed chambers, extraction of intact cores, or eddy covariance towers (Bastviken et al., 2002; Camacho et al., 2017; Morant et al., 2020a,b). Chambers, both static and dynamic, can be deployed over different compartments of the wetlands (i.e., open waters, vegetation, soils, etc.). The eddy covariance tower technique combines high-frequency measurements of vertical wind speed with gas concentration measurements to estimate carbon fluxes at the ecosystem scale, providing more spatially integrated information compared to the chambers or intact cores approach. Another approach to be adopted will consist in the analysis of seasonal plant growth rates (harvesting method), from which it is possible to assess rates of carbon accumulation.

2.2. Wetland type definition and ranges

Different water body types exhibit distinct hydrological dynamics, vegetation patterns, productivity, mineralization, and nutrient cycling. These factors collectively influence the exchange of carbon with the atmosphere. Accordingly, a typification of wetland will be considered to assess C sequestration. Repositories with the environmental data used as discriminator factors for typification, such as for instance hydroperiod or salinity, will be used too. For the classification in some of the sites, trophic variables could be also used.

2.3. Wetland ecological status

The ecological status of wetlands plays a pivotal role in transitioning them from being net carbon sources to becoming effective carbon sinks. (Morant et al., 2020b). Accordingly, the ecological status assessment, based on the European WFD, can serve as a benchmark for allocating a specific capacity for carbon sequestration, in such a way that healthy wetlands, displaying well-functioning ecological processes, tends to have a higher potential for carbon sequestration. Monitoring procedures and metrics used for each pilot site must be provided.



2.4. Spatial variability, wetland compartmentation

Functional dissimilarities of the main compartments of the wetland are expected to produce different carbon exchange dynamics. Following this approach, a delineation of them into discrete surfaces will be adopted for modelling carbon dynamics. Different remote sensing tools and in situ monitoring data can provide spatially explicit information on the extent and dynamics of these components flooded areas, as well as vegetation coverage, biomass, or type.

In the context of this project, the flooded area can be considered as a highly dynamic component for most wetlands under study, therefore, detailed information on the duration, timing, and extent of surface inundation is desired. The emergent vegetation also represents a dynamic component, but to a lesser extent than the previous one. The analysis of this functional compartment should encompass the dynamics of vegetation cover and type over time, trying to identify contributions of individual species to that.

Other remaining wetland areas must be assessed. This may comprise sites not occupied by emergent vegetation or within the maximum floodable zone but being integrated into the overall wetland area. Examples of this can be bare soils or abandoned for other purposes, such as agriculture, but still exhibiting wetland characteristics.

2.5. Temporal variability

Temporal variations may occur in the extent and characteristics of the previously mentioned compartments that affect carbon exchange. For instance, within the flooded area, the inundation level affects the form and magnitude of carbon exchange (Gunther et al., 2020; Hassett et al., 2024). The dynamics of this flooded area are very high in shallow Mediterranean wetlands, exhibiting in most cases temporary hydroperiods. Some discriminator environmental factors used to define wetland type, such as salinity, may vary also notably along hydroperiod (Camacho et al., 2017).

3. Levels of methodological complexity

Taking in consideration the previous foundations, the capacity of warming mitigation in wetlands can be assessed adopting different levels of methodological complexity. The level is selected based on the availability of data, requirements, and other constraints. As an initial scheme, three complexity levels (i.e., Tiers) are proposed which are supposed to cover all the scenarios of data accessibility.



- Tier 1: the simplest approach using default values of carbon exchange. Simplest implementation. Applicable across a wide range of scenarios, but with low specificity and accuracy.
- Tier 2: Higher level of specificity, incorporating carbon exchange factors and additional environmental data. The method advances beyond the previous level by considering environmental conditions, ecological status, land uses practices, etc., to adjust carbon exchange factors.
- Tier 3: methods are advanced techniques for carbon dynamics assessment, employing intricate models and. Based on in situ measurements at pilot sites and modelling frameworks. Requires the higher specialised expertise and resources for implementation.

Whatever the tiers adopted, a weighted carbon exchange balance must be obtained for each functional component of the wetland using carbon weighted carbon exchange factors. Specific factors will be obtained adopting the tier 3 approach, which will be done for some of pilot sites in which this was technically possible. For the other sites, carbon exchange factors will be estimated based on scientific literature and data repositories, both internal and open access. Adjustments made on these carbon exchange factors will be done following a top-down approach (adopting tiers 1 or 2 depending on data resolution), making use of the different information gathered, such as wetland type, ecological status and environmental factors.

4. Data required

The assessment of carbon exchange in the wetland requires gathering information on different environmental aspects. The greater the temporal and spatial resolution of this information, the more accurate the estimates of both the contribution of functional components to the wetland carbon balance (all the tier levels) and the top-down approaches (tier levels 1 and 2). In table 1 are compiled the different types of data requested from each pilot site. Data could be directly provided by pilot site coordinators, alternatively, instructions on accessing them should be provided. Following there is a description of the different types of data listed in table 1.

- Metada: Basic description of sites; methods and procedures for assessments (i.e., wetland typification and ecological status evaluation).
- Layer: Geospatial data to represent different aspects of the wetland within a GIS.
- Environmental: Typically, are measurements of environmental parameters. There are several factors affecting the metabolic process of carbon in wetlands (Bastviken et al., 2004). But here are prioritised those used as discriminator factors for typification or ecological status assessments.



- **Assessment:** evaluation or analysis of wetland features, such as typification or ecological status
- **C-exchange:** estimates of carbon fluxes that will be used to obtain exchange factors. Common examples are chamber-based Techniques and eddy covariance towers. Chambers can be placed at different compartments within the wetland to measure carbon fluxes. Static or dynamic chambers can be deployed in wetland soils to measure gas exchanges (Levy et al., 2011). Eddy Covariance towers combine high-frequency measurements of vertical wind speed with gas concentration measurements to estimate carbon fluxes at the ecosystem scale (Shahan et al., 2022), providing spatially integrated information. Another approach is obtaining rates of carbon sequestration by measuring changes (i.e., accumulation) in biomass and carbon content over time in plants (Morant et al., 2020a,b).
- **C-stock:** amount of carbon stored in different pools of the wetland.
- **Biological:** information about living organisms. In this context, that referred particularly to taxonomy and density of vegetation species.

Table 1. Different types of Information and data required for the initial steps of the assessment of carbon sequestration capacity.

Data type	Data	Description/Comments
Metadata	Pilot site name	Currently, a simple name is enough. When feasible, habitats and wetlands to be studied within the site will be included
Metadata	Pilot site location	The same that for the pilot site name but referred to geographical location (KMZ/KML files are fine)
Metadata	Wetland classification criteria	Classification may vary among countries. Specify methodology, discriminator factors (including ranges)
Metadata	Ecological status protocol	Monitoring procedures, metrics used and assessment criteria
Layer	Water body surface	Extent and boundaries of water surface, including temporal dimension when possible
Layer	Vegetation surface	Extent and boundaries of emergent vegetation, including temporal dimension when possible
Layer	Vegetation Indices	e.g., Normalised Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Chlorophyll Fluorescence
Layer	Soil moisture content	Both layers with moisture levels and analyses from field sampling may exist
Layer	CORINE land cover	Standardised classification system for land cover uses. Provide land cover classes and codes, at all levels available



Data type	Data	Description/Comments
Environmental	Salinity in water	Salinity, Conductivity. Wetland type discriminator
Environmental	Water column depth	Wetland type discriminator
Environmental	Chlorophyll-a in water	Ecological status discriminator
Environmental	OM in sediment	Organic matter content in sediments, as typically measured by gravimetry. Helpful to estimate C stock
Environmental	Water temperature	Ideally should include seasonal variation
Environmental	Weather conditions	Data gathered by convectional weather stations as close as possible to the pilot site (i.e., Air temperature, Atmospheric pressure, wind velocity)
Biological	Vegetation species composition	To have a description of community would allow to create more specific C exchange factors
Assessment	Wetland type	National wetland inventories, Ramsar categories, EU wetland habitat type, LULUCF
Assessment	Ecological status	Proxy to assess quality of the structure and functioning of surface water ecosystems based on WFD
C-stock	Belowground carbon	Organic carbon content, including plant roots, etc.,
C-stock	Aboveground Carbon	Carbon stored in the biomass of vegetation
C-stock	Carbon content in sediments	Specify analytical method/carbon form as it could be notably variable (e.g., total/organic, dead organic carbon, belowground carbon including roots, etc.,)
C-exchange	CO ₂ fluxes	Data obtained by standardized and tested methods: static chambers, intact cores, eddy covariance towers
C-exchange	CH ₄ fluxes	Data obtained by standardized and tested methods: static chambers, intact cores, eddy covariance towers
C-exchange	Plants growth	To assess carbon dioxide removed from the atmosphere and stored in plant biomass



5. Pilot sites

5.1. Wetlands of Struma catchment (Bulgaria). Responsible partner UF

5.1.1. Synoptic description of pilot site

The pilot site in Bulgaria covers 197 small and medium sized wetlands of the Struma catchment (Figure 1).

The Struma River rises from the southern slopes of Mount Vitosha, at 2246 m altitude, 250 m south of Cherni vrah peak. The river flows south and leaves the Bulgarian territory near the village of Kulata. The length of the river from the source to the Bulgarian-Greek border is 290 km, which makes it the sixth longest Bulgarian river after Danube, Iskar, Tundzha, Maritsa and Osam. The catchment area amounts to 17300 km², which represents 9.73 % of the country's territory and covers parts of four Balkan countries - the Republic of Bulgaria, the Hellenic Republic, the Republic of North Macedonia and the Republic of Serbia.

One of the wetlands within the Struma catchment, that represent a field of interest for more detailed assessment of its carbon sequestration capacity, is Chokliovo marsh (Ramsar type: Tp - Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season). It is located at 880 m altitude and covers an area of 85.97 ha. It is the biggest peat bog in Bulgaria.

In 1992, Chokliovo marsh (Figure 2) was designated as a protected area (IUCN, IVth category). The purpose of designation is to protect essential sites of rare and endangered birds and terrestrial habitats.

In 2020, Chokliovo marsh was designated as Natura 2000 site under the Habitats Directive.

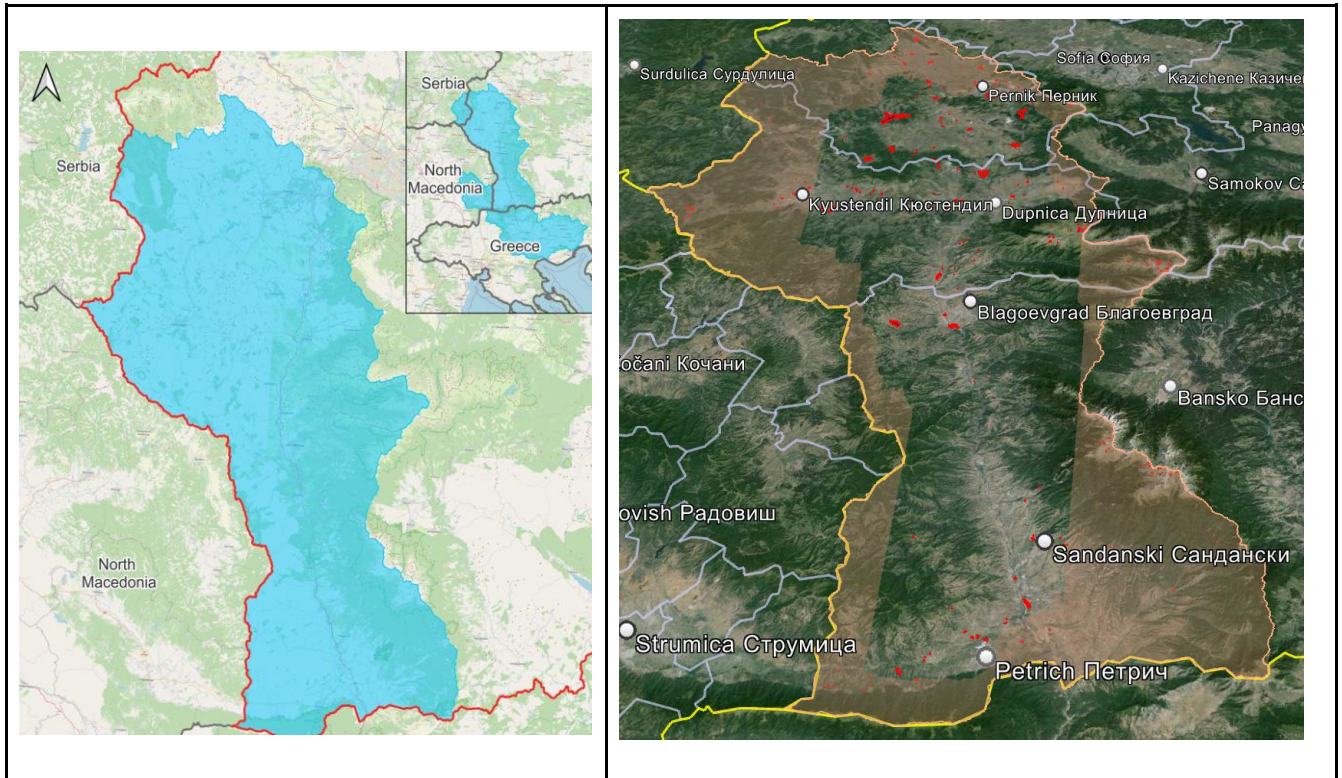


Figure 1. Map of Struma catchment. Wetlands within Struma catchment



Figure 2. Aerial and landscape pictures of Chokliovo Marsh, planned for Tier-2 methodology

5.1.2. Level of methodological complexity to be followed

We are considering to follow Tier-2 methodology for Chokliovo marsh and Yazovir Izvor (70.10 ha) (Figure 3), Ramsar type 6 (Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8 ha).



For the other 195 small and medium wetlands of the Struma catchment, we aim to follow Tier-1, as the simplest approach using default values of carbon exchange, as detailed data are not yet available for these wetlands.



Figure 3. Yazovir Izvor, planned for Tier-2 methodology

5.1.3. Data availability & sampling strategy

The following Table 2 provides the list of available datasets that have been collected for the Bulgarian pilot site, following the guidelines of the WP Leader.



Table 2. Data provided for the pilot case of Struma catchment for the initial steps of the assessment of carbon sequestration capacity.

Data type	Data	Description/Comments
Metadata	Pilot site name	Struma catchment
Metadata	Pilot site location	Catchment_Area_Struma_BG_only.shp and kml. Wetlands_Struma.shp and kml
Metadata	Wetland classification criteria	Annex I habitat types of Struma catchment Biodiversity State at landscape level for Struma catchment (excellent, adequate, average, inadequate, bad, not natural) based on Biodiversity attributes monitored under the EU Nature Directives (Art. 17, Art. 12, N2K) Nature Dominance at landscape level for Struma catchment (all natural, mostly natural, natural-agricultural, natural-developed, natural-agricultural-developed, not dominated by natural) "Spatial analysis: based on the degree of landscape heterogeneity (Landscape Mosaic) is assessed by applying a tripolar classification model at pixel level that estimates the presence (10%), dominance (60%) or uniqueness (100%) of: (i) Natural and semi-natural areas, (ii) Crops and (iii) Urban areas" Ecosystem condition at landscape level for Struma catchment (no natural potential, very low, low, medium, high, very high natural potential) For each wetland if located in or out Natura 2000 sites For each wetland if located in protected area or not For each wetland connectivity with Natura 2000 sites: yes / no
Metadata	Ecological status protocol	Ecological status of Chokliovo marsh and Yazovir Izvor according to WFD
Layer	Water body surface	For wetlands over 8 ha (permanent water, seasonally flooded, intermittently flooded areas). For wetlands over 8 ha: NDWI (Normalized Difference Water Index) & MNDWI (Modified Normalized Difference Water Index) (summer 2017-spring 2020) from Sentinel2 images stored in the web portal: https://extrema.space/WetMainAreas/dashboard.html
Layer	Vegetation surface	For 2 selected wetlands that will be digitalized after the visit in the field.



Data type	Data	Description/Comments
Layer	Vegetation Indices	For wetlands over 8 ha: NDVI (Normalized Difference Vegetation Index) & NDPI (Normalized Difference Phenology Index (summer 2017-spring 2020) from Sentinel2 images stored in the web portal: https://extrema.space/WetMainAreas/dashboard.html
Layer	Soil moisture content	Data from the Balkan-Mediterranean Wetlands Geoportal (available on the following link: http://185.17.146.157/). The data present average soil moisture from 1958 to 2019.
Layer	CORINE land cover	CORINE Land Cover 2018 (CLC18_BG_Stuma.shp)
Environmental	Salinity in water	For Chokliovo blato and Yazovir Izvor - WFD sampling
Environmental	Water column depth	Basin Authority
Environmental	Chlorophyll-a in water	Basin Authority
Environmental	OM in sediment	Basin Authority
Environmental	Water temperature	for the 2 selected wetlands - WFD samplings, Basin Authority
Environmental	Weather conditions	Data from the Balkan-Mediterranean Wetlands Geoportal (available on the following link: http://185.17.146.157/). The data includes wind speed average, min average temperature, max average temperature, precipitation, standardised precipitation index.
Biological	Vegetation species composition	for Chokliovo marsh -and Yazovir Izvor that will be visited on the field
Assessment	Wetland type	Ramsar type of wetlands of Struma catchment
Assessment	Ecological status	Ecological status in accordance with the WFD, 2016-2021; 2022-2027
C-stock	Belowground carbon	-
C-stock	Aboveground Carbon	-
C-stock	Carbon content in sediments	-
C-exchange	CO ₂ fluxes	-
C-exchange	CH ₄ fluxes	-
C-exchange	Plants growth	-



5.1.4. Potentials and weaknesses

The proposed two wetlands - Chokliovo marsh and Yazovir Izvor fall under the EU Water Framework Directive, ensuring that robust ecological data is already available. Our study will build on this existing information, assessing the effectiveness of these wetlands for carbon sequestration. This approach can serve as a reference model for future studies and amplify the impact of our efforts.

The remaining 195 small and medium wetlands of the Struma catchment are not covered by the EU Water Framework Directive making it more challenging to gather available data and information on them and the requested parameters. But, this is an indication for the need for future studies and research activities.

5.2. Kerkini Lake and the wider catchment of Strymon River (Greece). Responsible partner EKBY

5.2.1. Synoptic description of pilot site

The pilot site in Greece is the Kerkini Artificial Lake (Figure 5) and 87 small and medium sized wetlands of the Strymon catchment.

Kerkini is a large, artificial freshwater lake located at the place of a former wetland complex of small lakes and marshes, since ancient times. It is fed by River Strymon flowing in Greece from Bulgaria, which forms an inland delta, at the mouth of the lake. It was created in 1932, with the construction of a dam at Lithotopos village and of two embankments, on the east and one the northwest river banks to protect nearby villages. It was created for flood control and irrigation purposes. The construction of the dam on a previously wetland area, the bird migration corridor along the valley, and the shallow depth made it one of the most important wetlands in Greece.

In 1977, Lake Kerkini was designated as a Wetland of International Importance (Ramsar). Later, it was included in the Natura 2000 Network and became the core of the Kerkini National Park. The catchment of Strymon river includes 13 Natura 2000 sites (7 SCI, 5 SPA, 1 SCI/SPA), 32 Wildlife Refugees, an Aesthetic Forest -Dasi Amygdaleona Kavalas, a Controlled hunting area of Serres and a Game breeding station - Chrysopigi Oreinon Serron.

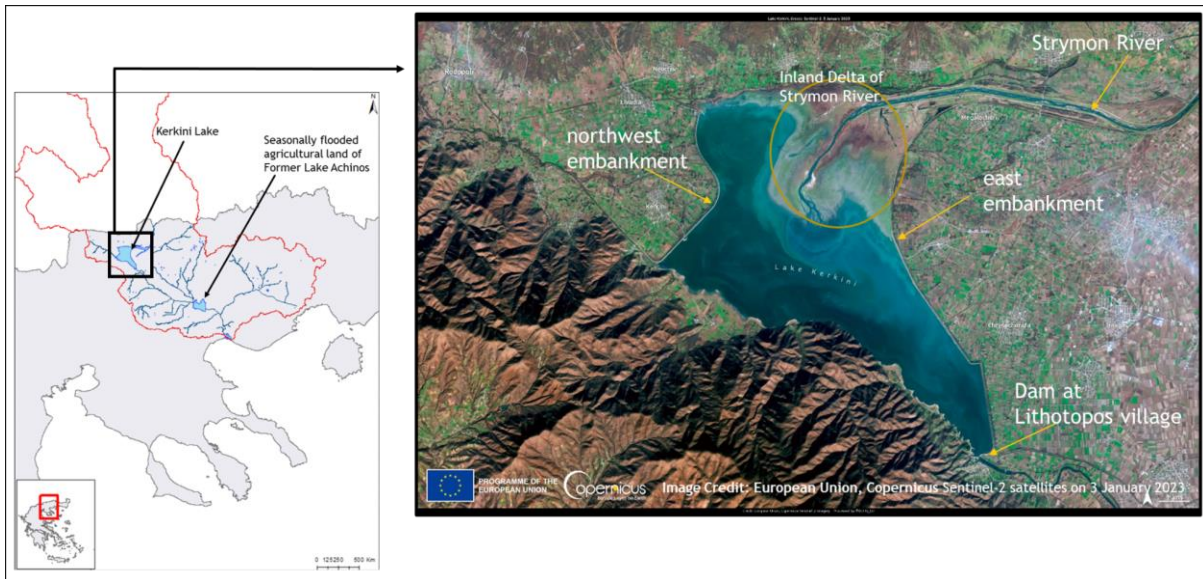


Figure 5. Map of Strymon catchment in the Greek pilot, with wetlands and hydrographic network within its boundaries. Satellite image of Artificial Lake Kerkini, an important Ramsar site and a central wetland for our pilot case.

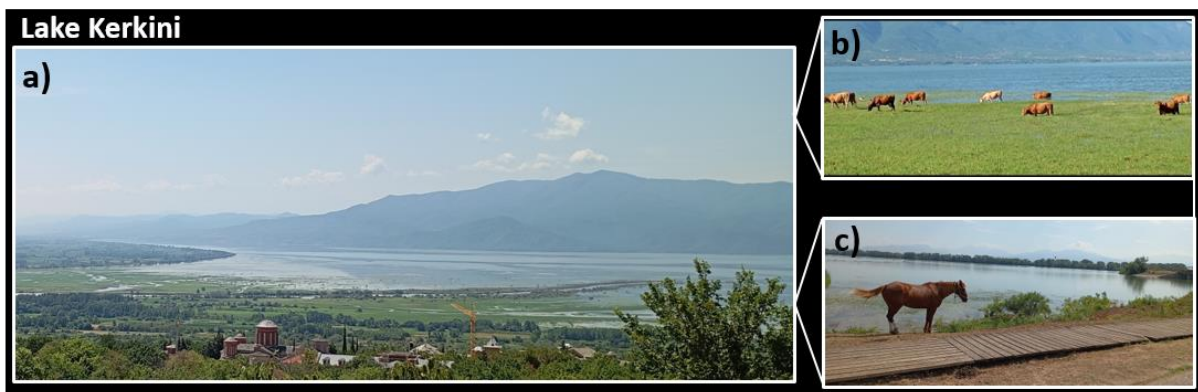


Figure 6. Photos of the Lake Kerkini landscape. a) View of the lake from the north-west side, depicting the input of Strymon inside the Lake Kerkini. b) Cattle grazing in Kerkini Lake. c) Horses wandering and grazing around Lake Kerkini close to Lithotopos dam.

5.2.2. Level of methodological complexity to be followed

For Kerkini lake we aim to follow Tier-3 and implement sampling protocols providing the project with available data by 2025. We aim to produce in situ measurements of greenhouse gases (GHG) and carbon stock. Supplementary, we aim to also follow Tier-2, as there is available information to proceed, and be able to compare both results.



For the other 87 small and medium wetlands of the Strymon catchment, we aim to follow Tier-1, as the simplest approach using default values of carbon exchange, as detailed data are not yet available for these wetlands.

5.2.3. Data availability & sampling strategy

The table 3 provides the list of available datasets that have been collected for the Greek pilot site, following the guidelines of the WP Leader. For data that are not yet available, there is a description of their planned collection through in-situ samplings or modelling approaches.

Table 3. Data provided for the pilot case of PP02 *Kerkini Lake and the wider catchment of Strymon River* for the initial steps of the assessment of carbon sequestration capacity.

Data type	Data	Datasets organized
Metadata	Pilot site name	Kerkini Lake and Strymon catchment
Metadata	Pilot site location	Catchment_Area_Strymon_GRonly.shp Wetlands_v13_noMarine_GR_Strymon.shp
Metadata	Wetland classification criteria	Annex I habitat types of Kerkini Lake Biodiversity State at landscape level for Strymon catchment (excellent, adequate, average, inadequate, bad, not natural) Nature Dominance at landscape level for Strymon catchment (all natural, mostly natural, natural-agricultural, natural-developed, natural-agricultural-developed, not dominated by natural) Ecosystem condition at landscape level for Strymon catchment (no natural potential, very low, low, medium, high, very high natural potential) For each wetland if located in or out Natura 2000 sites For each wetland if located in protected area or not For each wetland connectivity with Natura 2000 sites: yes / no
Metadata	Ecological status protocol	Ecological status of Kerkini Lake according to WFD
Layer	Water body surface	For Kerkini Lake: extent of permanent and seasonal water surface extracted from SWOS ecosystem mapping (Water surface extent_Kerkini Lake.shp) For Kerkini Lake and wetlands over 8 ha (permanent water, seasonally flooded, intermittently flooded areas).



Data type	Data	Datasets organized
		For Kerkini Lake and wetlands over 8 ha: NDWI (Normalized Difference Water Index) & MNDWI (Modified Normalized Difference Water Index) (summer 2017-spring 2020) from Sentinel2 images stored in the web portal: https://extrema.space/WetMainAreas/dashboard.html
Layer	Vegetation surface	For Kerkini Lake based on Habitat type mapping layer (HabitatTypes_GR_Strymon.shp) & for selected wetlands that will be digitized after the visit in the field.
Layer	Vegetation Indices	For Kerkini Lake and wetlands over 8 ha: NDVI (Normalized Difference Vegetation Index) & NDPI (Normalized Difference Phenology Index) (summer 2017-spring 2020) from Sentinel2 images stored in the web portal: https://extrema.space/WetMainAreas/dashboard.html
Layer	Soil moisture content	For the Strymon catchment: Data from the Balkan-Mediterranean Wetlands Geoportal (available on the following link: http://185.17.146.157/). The data present average soil moisture from 1958 to 2019.
Layer	CORINE land cover	For the Strymon catchment: CORINE Land Cover 2018 (CLC18_GR_Strymon.shp)
Environmental	Salinity in water	For Kerkini Lake, 2012-2021 (WFD samplings - 1 point), seasonal samplings
Environmental	Water column depth	For Kerkini lake, to be produced by 2025.
Environmental	Chlorophyll-a in water	For Kerkini lake, measurements since 2013 during June-August
Environmental	OM in sediment	For Kerkini lake. We aim to implement samplings on OM in sediment by 2025 and provide the project with the available data.
Environmental	Water temperature	For Kerkini Lake, 2012-2021 (WFD samplings - 1 point), seasonal samplings, depth-dependent measurements per m
Environmental	Weather conditions	For the Strymon catchment: Data from the Balkan-Mediterranean Wetlands Geoportal (available on the following link: http://185.17.146.157/). The data includes wind speed average, min average temperature, max average temperature, precipitation, standardized precipitation index.



Data type	Data	Datasets organized
Biological	Vegetation species composition	For Kerkini Lake based on Habitat type mapping layer (HabitatTypes_GR_Strymon.shp) & for selected wetlands that will be visited in the field. We aim to implement vegetation-sampling protocols for Kerkini Lake during 2024 and 2025.
Assessment	Wetland type	Ramsar type of wetlands of Strymon catchment (kerkini Lake and other 80 small and medium size wetlands)
Assessment	Ecological status	Lake_Ecological_Status_2012-2015.shp & Lake_Ecological_Status_2016-2021.shp)
C-stock	Belowground carbon	For Kerkini lake. Possibly, but not sure whether we would be able to provide measurements. Additional guidelines are required for common testing.
C-stock	Aboveground Carbon	For Kerkini lake. We aim to implement sampling protocols for Kerkini Lake and provide the project with available data by 2025. Sampling strategy under development.
C-stock	Carbon content in sediments	For Kerkini lake. We aim to implement sampling protocols for Kerkini Lake and provide the project with available data by 2025. Sampling strategy under development.
C-exchange	CO ₂ fluxes	For Kerkini lake. We aim to implement sampling protocols for Kerkini Lake at a seasonal pattern, at multiple points and different depths in 2025. Sampling strategy under development.
C-exchange	CH ₄ fluxes	For Kerkini lake. We aim to implement sampling protocols for Kerkini Lake at a seasonal pattern, at multiple points and different depths in 2025. Sampling strategy under development.
C-exchange	Plants growth	For Kerkini lake. Sampling strategy under development.

Pilot site metadata on site name, location and spatial extent are available for Lake Kerkini and the 87 wetlands of the Strymon catchment. Only for the Lake Kerkini, Annex I habitat types are available and its ecological status according to Water Framework Directive protocol (Table 2).

As regards other wetland classification criteria, for all wetlands of the pilot site, there are available mapping products for the entire catchment of Strymon River that were produced during the WetMainAreas project of the INTERREG BalkanMed program. These are: the Biodiversity State, Nature Dominance, Ecosystem Condition and Connectivity. Methodological details for these are provided by Hatzioradanou et al.,



2019 and within the Technical Publication of the WetMainAreas project (Fitoka et al. 2020). It is noted that the same datasets are available for the Bulgarian pilot site, Struma catchment, to be used as common basis for the transboundary assessment.

Geospatial information (layers) is available for the water surface extent (permanent water, seasonally flooded and intermittently flooded areas) of both Kerkini Lake and 11 wetlands over 8ha of the Strymon catchment. Layers are derived from mapping products produced during the EU HORIZON SWOS project and from the NDWI (Normalized Difference Water Index) & MNDWI (Modified Normalized Difference Water Index) indices based on Sentinel 2 images (summer 2017 - spring 2020), which are available via the WetMainAreas satellite web portal. In addition, via the same portal, for the same period, there are available mapping products of NDVI (Normalized Difference Vegetation Index) & NDPI (Normalized Difference Phenology Index). A spatial delineation of the habitat types is also available for Kerkini Lake according to the Habitats Directive. As regards the land cover/uses of the Strymon catchment, the CORINE land cover has been integrated (v. 2018). Finally, soil moisture content derived from a long time series (1958 – 2019) is also available via the Balkan-Mediterranean Wetlands Geoportal (Table 2).

Information on the environmental conditions are available only for Kerkini Lake, derived from the national monitoring program of water bodies under the Water Framework Directive (Table 2). For instance, salinity and water temperature data are available and refer to seasonal samplings from a single point in the lake, with water temperature having also depth-dependent measurements per meter. For the two variables, there are measurements over a long time series during 2012 – 2021. Chlorophyll-a in water measurements are available also for the Kerkini Lake since 2013, taken yearly during summer months (Table 2).

As regards the Organic Matter (OM) in sediment, we plan to implement samplings following the procedure of Morant et al., 2020, which uses the Protocol of Environmental Protection Agency (2002) on the methods for the determination of total organic carbon (TOC) in soils and sediments. Based on this, we would have to collect sediment samples from selected sites of the pilot and subsequently estimate the total organic carbon concentration with elemental analyzers equipped with a stable isotope mass spectrometer.

Weather conditions are available for the whole Strymon catchment, including measurements on wind speed average, min average temperature, max average temperature, precipitation, standardized precipitation index. A vegetation species composition is available based on the habitat type mapping layer, however sampling protocols will also take place for the years 2024 and 2025, so we would be able to enrich and update our dataset on the vegetation synthesis and abundance in the lake. There



are not yet available data on the water column depth and we plan to produce a bathymetry map of Lake Kerkini by 2025.

On the assessment criteria of the wetlands, the ecological status of the Lake is available for years 2012-2015 and 2016-2021, as mentioned above, as well as the wetland types of the Strymon catchment according to Ramsar typology (Table 2).

On what concerns the C-stock data of our pilot site, we aim to implement sampling protocols for Kerkini Lake and provide the project with available data on aboveground carbon and carbon content in sediments by 2025 (Table 2). However, for below-ground carbon data we are not sure whether we would be able to provide in-situ measurements, and might we need to rely on model estimations of the ratio of belowground to aboveground biomass that is established for many plant species (Bansal et al., 2023). For the aboveground carbon, which would be represented by the carbon biomass stored in plants, we plan to apply an extensive sampling of the most representative sampling points covering the sum of the vegetation synthesis of the emergent and the submerged vegetation, wet meadows and riparian forests surrounding the lake, across their environmental gradients (Bansal et al., 2023). For the vegetation biomass estimation methods, we will rely either on harvesting or on using allometric equations (Bansal et al., 2023). For riparian forests, we would probably use allometric equations in order to estimate their carbon sink. By conducting representative samplings for the rest of the vegetation types, we aim to be able to calculate total C content of aboveground biomass and scale it by vegetation cover to the total representative area. Also, samplings for carbon content in sediment will aim to cover the spatial variability within the pilot site, with overlapping results with the OM in sediments (see previous section on environmental conditions). For estimating soil carbon sink, it is required that we estimate the dry bulk density of our samples.

Finally, we aim to acquire C-exchange data on CO₂ and CH₄ fluxes, implementing sampling protocols for Kerkini Lake at a seasonal pattern, at multiple points and different depths in 2025 (Table 2). The strategy of samplings is under development. In particular, we aim to sample for fluxes in the appointed by the WPI leaders site-categories of: vegetation, bare soil, water and flooded land. In water, we aim to perform flux measurements with a constructed floating chamber, and in the soil with static chambers. Samples will be transported to the laboratory, where they will be further processed by a gas chromatograph in order to measure GHG concentration, as indicated by (Camacho et al., 2017). Planning of the sampling strategy would take under consideration different hydrology and vegetation zones, as well as zones of higher concentration of organic matter in the lake and human pressures (e.g. grazing of cattle) that could possibly influence GHG measurements. In sampling for GHG of emergent vegetation, we will have to ensure that we take separate measurements for vegetation and not emissions from both vegetation and water pollution in the lake and flooded water by also taking measurements in shallower depths of Lake Kerkini, where



ebullition is much more possible to happen (Sturm et al., 2016). Seasonal measurements will ensure that we capture the variability of temperature, precipitation and vegetation patterns during the year.

5.2.4. Potentials and weaknesses

As far as we acknowledge, this is the first effort to estimate the carbon balance of a wetland in Greece based on high-quality in situ measurements and this represents a great potential of our study case. Lake Kerkini represents a very well-studied lake in Greece, with high research interest historically and thus, stands as a very valuable case study. It is a Natura 2000 site and it belongs to the lakes that are being monitored under the Water Framework Directive, which will provide us with the required time series for data. Lake Kerkini represents as it is a wetland hosting conditions with great spatial and temporal variability, with seasonally flooded lands and demand of water for irrigation purposes. Therefore, planning of our sampling would have to cover quite a lot of conditions, however this would set the ground for future potential samplings in other lakes, too. Use of Tier-3 methodology will grant the provision of detailed data. Weaknesses of our pilot site case is that, unfortunately, we do not have available information of the other small and medium sized wetlands of the Strymon catchment, in order to proceed with the estimation of their carbon balance. For them, we will have to follow Tier-1. Furthermore, although Lake Kerkini represents a well-monitored lake, there are certain variables for which we do not have available information, namely for most of the C-stock and C-exchange data. Planning of the sampling strategy will be performed for the first time and this entails some level of uncertainty for the course of our pilot site case.

5.3. Albufera of Valencia (Spain). Responsible partner UVEG

5.3.1. Synoptic description of pilot site

The Albufera of Valencia is a coastal wetland representative of the Mediterranean region, located about 10 km from the city of Valencia (Figure 7). This geomorphological system consists of a sandbar and a lagoon with minimal connection to the sea. Its origin and development date back to the last Holocene interglacial period, which spans the last 10,000 years. The current configuration of the Albufera was outlined approximately 2,000 years ago. This area is surrounded by extensive rice fields, highlighting its agricultural significance in addition to its ecological value.

The Albufera of Valencia has undergone significant changes over time. These changes include a) decrease in depth and aquatic perimeter: The lagoon has experienced a reduction in its depth and aquatic perimeter due to the accumulation of sediments; b) Substitution of sea water by fresh water: Sea water has been replaced by fresh water from various sources, altering the lagoon's ecosystem; c) Sandbar increase, formation



of dunes, and an extensive beach: The sandbar has increased in size, leading to the formation of dunes and an extensive beach along the seashore. These transformations have played a crucial role in shaping the current state of the Albufera, affecting its ecological balance and its interaction with surrounding agricultural areas.

The Albufera of Valencia features a range of distinct habitats that contribute to its ecological diversity:

- a) Lagoon: This permanent body of open water has a depth of 0.5-1 meters depth and covers approximately 2,400 hectares. The water is fresh but has become eutrophic over decades due to nutrient accumulation.
- b) Marshland habitats: Surrounding the lagoon are various marshland areas that play a critical role in supporting the local biodiversity.
- c) Perimeter vegetation: Vegetation around the perimeter of the lagoon provides habitat and protection for many species.
- d) Depressed areas (Tancats): These low-lying areas within the wetland are crucial for water management and habitat diversity.
- e) Small islands within the lagoon (Matas): Scattered throughout the lagoon, these islands offer important nesting and resting sites for birds and other wildlife.
- f) Interdune depressions (Malladas): These areas, characterised by silty soils, can become flooded and are integral to the dynamic hydrological system of the Albufera.
- g) Rice fields: Rice cultivation is prominent in the perimeter areas of the Albufera lagoon. The landscape features numerous channels and irrigation ditches that, along with pool floodgates, regulate crop flooding cycles. The area is a vital habitat for waterfowl, supporting breeding and feeding activities.



Figure 7. Aerial and landscape pictures of Albufera Natural Park, showing the close relationship between its hydrology and the surrounding rice fields.

5.3.2. Level of methodological complexity to be followed

For Albufera Park we aim to follow Tier-3 and implement sampling protocols providing the project with available data, which is compiled in table 4. We already have available in situ measurements of greenhouse gases (GHG) and carbon stock and expect to provide more during the implementation of the project.

5.3.3. Data availability & sampling strategy

The next table 3 provides the list of available datasets that have been collected for the Albufera Park, following the guidelines of the WP Leader. For data that are not yet available, there is a description of their planned collection through in-situ samplings or modelling approaches.



Table 4. Data provided for the pilot case of PP02 *Kerkini Lake and the wider catchment of Strymon River* for the initial steps of the assessment of carbon sequestration capacity.

Data type	Data	Datasets organized
Metadata	Pilot site name	Albufera de València
Metadata	Pilot site location	ALBU_ws.shp Albufera_Valencia.shp
Metadata	Wetland classification criteria	HTCI in the Valencian region Ramsar Natura 2000 Catàleg Valencià d'Aiguamolls Inventario Español de Zonas Húmedas
Metadata	Ecological status protocol	
Layer	Water body surface	Layer of waterbodies and their classification in the Xúquer/Júcar Basin Authority
Layer	Vegetation surface	La_Albufera.shp
Layer	Vegetation Indices	Monitoring water quality and hydrological patterns of wetlands using recent techniques in remote sensing. PhD Thesis Carolina Doña. https://producciocientifica.uv.es/documentos/5eb09cee29995276411220ac?lang=en
Layer	Soil moisture content	Extensive data is available by gravimetric method.
Layer	CORINE land cover	ALBU_CLC.shp
Environmental	Salinity in water	Reports from the Xúquer/Júcar Basin Authority.
Environmental	Water column depth	Reports from the Xúquer/Júcar Basin Authority
Environmental	Chlorophyll-a in water	Reports from the Xúquer/Júcar Basin Authority
Environmental	OM in sediment	Extensive data is available by the Loss on Ignition (LOI) method, and part of it has been calibrated with carbon content.
Environmental	Water temperature	Reports from the Xúquer/Júcar Basin Authority



Data type	Data	Datasets organized
Environmental	Weather conditions	Data from AVAMET Associació Valenciana de Meteorologia, and AEMET Asociación Española de Meteorología
Biological	Vegetation species composition	Data obtained from the layer on vegetation, plus other sources and inventories from public administration
Assessment	Wetland type	Classification in Ramsar, EUNIS, HTCI, Spanish LPHE, Waterbody lake type and Ecosystem classification
Assessment	Ecological status	Reports from the Xúquer/Júcar Basin Authority
C-stock	Belowground carbon	Extensive data is available by the Loss on Ignition (LOI) method, and part of it has been calibrated with carbon content.
C-stock	Aboveground Carbon	Seasonal data available for main helophytes species and some submerged macrophytes
C-stock	Carbon content in sediments	Seasonal data available for the different habitats of the pilot site
C-exchange	CO ₂ fluxes	Seasonal data available for some of the habitats of the pilot site
C-exchange	CH ₄ fluxes	Seasonal data available for some of the habitats of the pilot site
C-exchange	Plants growth	Seasonal data available for main helophytes species and some submerged macrophytes

5.3.4. Potentials and weaknesses

One of the primary strengths of the carbon sequestration assessment in the Albufera of Valencia lies in the substantial body of research already conducted on this lagoon. This wealth of knowledge is reinforced by the significant interest from both public sectors and private stakeholders, including the local agricultural and fishing communities that manage and depend on the site. The UVEG team has been assessing the carbon sequestration capacity in different habitats of the Albufera by measuring carbon fluxes, biomass production, and carbon stock, providing a robust foundation for the development of the project. Already acquired data from analogous wetland systems in the region will enhance our understanding of carbon exchange processes. These data can be used to refine carbon exchange factors, which will assist in estimating carbon fluxes in diverse vegetation communities and functional



compartments, thereby improving the accuracy of calculations. By incorporating this comprehensive dataset, we can develop more precise carbon exchange factors.

5.4. Marceddì and San Giovanni Ponds (Italy). Responsible partner MEDSEA

5.4.1. Synoptic description of pilot site

The coastal area of Oristano (Sardinia, Italy) is a complex and high-density system of rivers, lagoons, and salt marshes (Figure 8). Most of the wetlands are shallow eutrophic water bodies (approximately 0.5-2 m depth), around 7,700 hectares of which (over 60% of Sardinia's wetlands) are protected by the Ramsar convention and the Natura 2000 network. The Gulf of Oristano is characterised by the tight integration between the existing settlement structure and the environment characterised by the system of coastal wetlands. It is a low-density area, characterised by small concentrated urban zones, most of them located in the inland areas, and sprawl urbanisation related to fishing cooperatives, agricultural and livestock farms and small touristic villages located along the coast (Satta, 2014).

The southern wetlands of the Gulf are the Marceddì-San Giovanni lagoon compendium (Figure 9), which appears as a deep marine inlet artificially separated from the sea by a fishpond bridge (Figure 10) and divided into two different wetlands: the Marceddì lagoon (900 ha), closer to the sea with brackish water, and the internal pond of San Giovanni (700 ha), characterised by freshwater inputs from the rivers Rio Mogoro, Rio Mannu, Rio Sitzzerri, and from some artificial canals.

The surrounding territory is dominated by the agricultural plain of Arborea on the north-east side, an expanse of regular fields bordered by the reclamation infrastructure (canals and roads), while to the west it is surrounded by the mountainous complex of Monte Arcuentu. The fishing activities in the Marceddì-San Giovanni lagoon are managed by the Consortium Coop. Riunite della pesca di Marceddì. Covering an area of 2610 ha, the fishing operations involve around 140 operators.



Figure 8. Map of the wetlands' system of Marceddì, San Giovanni and Corru S'ittiri in the Gulf of Oristano

Hydraulic interventions carried out in recent decades have significantly altered the original structure of the entire wetland system. These modifications have disrupted the natural water exchange conditions between marine and freshwater environments, leading to changes in the ecological conditions of the area due to sediment discharge into the water and impacting on the ongoing fishing activities.



Figure 9. Landscape of the wetland of Marceddì



Figure 10. Fishpond bridge that separates Marceddì wetland from the sea (on the left). Extreme flooding event in the area (on the right).

5.4.2. Level of methodological complexity to be followed

For Marceddì and San Giovanni Ponds we are considering the possibility to follow Tier-3 and implement sampling protocols providing the project with available data. We aim to produce in situ measurements of greenhouse gases (GHG) and carbon stock.

If it is not possible, we will follow Tier-2 for this wetland. We plan to follow Tier-2 also for 1 more wetlands – Corru Sittiri e Corru Mannu (1.08 ha), included in the Ramsar site.



5.4.3. Data available & sampling strategy

The next table 5 provides the list of available datasets that have been collected for the Marceddì and San Giovanni compendium, following the guidelines of the WP Leader. For data that are not yet available, there is a description of their planned collection through in-situ samplings or modelling approaches.

Table 5. Data provided for the pilot case of PP04, *Marceddì and San Giovanni Ponds* for the initial steps of the assessment of carbon sequestration capacity.

Data type	Data	Description/Comments
Metadata	Pilot site name	"Marceddì and San Giovanni Ponds"
Metadata	Pilot site location	<i>Marceddi.kmz</i>
Metadata	Wetland classification criteria	<ul style="list-style-type: none"> - Coastal brackish / saline lagoons according to Ramsar convention - Natura 2000 - Special Protected Area according to Birds Directive (ITB034004) - Natura 2000 - Special Area of Conservation according to Habitat Directive (ITB030032) - National Inventories of Coastal wetlands (According to Dlg. 42/2004)
Metadata	Ecological status protocol	<p>Ecological status of the Ponds of Marceddì and San Giovanni according to WFD.</p> <ul style="list-style-type: none"> - Ecological status of the entire pond: <i>v_acque_transizione.shp</i> - Values in the 9 sampling points: <i>v_staz_mon_at_eco_pdg2021.shp</i>
Layer	Water body surface	Extension and boundaries of permanent water surface



Data type	Data	Description/Comments
		Marceddi_water_surface.shp
Layer	Vegetation surface	The Habitat map from the Wetland Management Plan (2018). Detailed digitalization of emergent vegetations will be produced during the project <i>habitat_type_Marceddi.shp</i>
Layer	Vegetation Indices	Normalised Difference Vegetation Index 2020-present (raster 300 m), global, 10-daily – version 2 from Copernicus Normalised Difference Vegetation Index 2016-present (raster 10 m), from Copernicus
Layer	Soil moisture content	To be collected through in-situ sampling or modelling approaches during the project.
Layer	CORINE land cover	<i>marceddi_CLC_WGS84.shp</i>
Environmental	Salinity in water	Trimestral data (WFD samplings – 5 points in Marceddi and 4 points in San Giovanni) From September 2024 we will have also daily data from 2 stations that will be installed in San Giovanni Pond and Marceddi
Environmental	Water column depth	Trimestral data (WFD samplings – 5 points in Marceddi and 4 points in San Giovanni) From September 2024 we will have also daily data from 2 stations that will be installed in San Giovanni Pond and Marceddi



Data type	Data	Description/Comments
Environmental	Chlorophyll-a in water	Trimestral data (WFD samplings – 5 points in Marceddì and 4 points in San Giovanni)
Environmental	OM in sediment	To be collected through in-situ sampling or modelling approaches during the project.
Environmental	Water temperature	Trimestral data (WFD samplings – 5 points in Marceddì and 4 points in San Giovanni) From September 2024 we will have also daily data from 2 stations that will be installed in San Giovanni Pond and Marceddì
Environmental	Weather conditions	Data will be collected starting from September 2024 through 1 weather station that will be installed in the bridge of the Marceddì Lagoon. Data includes (Humidity, Wind speed, Wind direction, Rainfall intensity, Rainfall height, Temperature)
Biological	Vegetation species composition	The Habitat map from the Wetland Management Plan (2018).
Assessment	Wetland type	National wetland inventories, Ramsar categories, Natura 2000 site, EUNIS, habitat types according to the Management Plan of the site
Assessment	Ecological status	Ecological status in accordance with the WFD (2000/60/CE) and D.LGS. 152/2006



Data type	Data	Description/Comments
C-stock	Belowground carbon	To be collected through in-situ sampling or modelling approaches during the project.
C-stock	Aboveground Carbon	To be collected through in-situ sampling or modelling approaches during the project.
C-stock	Carbon content in sediments	To be collected through in-situ sampling or modelling approaches during the project.
C-exchange	CO ₂ fluxes	To be collected through in-situ sampling or modelling approaches during the project.
C-exchange	CH ₄ fluxes	To be collected through in-situ sampling or modelling approaches during the project.
C-exchange	Plants growth	To be collected through in-situ sampling or modelling approaches during the project.

5.4.4. Potentials and weaknesses

One of the primary strengths of the carbon sequestration assessment in the San Giovanni and Marceddì wetland system is the extensive research already conducted on this lagoon, coupled with high interest from public sectors and private stakeholders, particularly the local fishing cooperative managing the lagoon. The growing community awareness of the lagoon's ecosystem services, including flood risk protection for adjacent agricultural lands and inhabited areas, further supports the study. Additionally, this project will shed light on the contribution of wetlands engaged in economic activities like aquaculture to carbon offsetting and GHG emission reductions. It will also help identify low-carbon maintenance and management practices for both natural components and business operations.

However, this wetland system has faced significant anthropogenic alterations over the decades. A new restoration project will start within a few months to restore natural



hydrodynamic and sedimentary processes and improve internal water circulation, enhancing the wetland's resilience to climate change. Despite these efforts, the dredging activities might result in the partial release of carbon from sediments to the atmosphere as CO₂, posing a significant consideration for evaluating the overall effectiveness of carbon sequestration in these restored wetland conditions.

5.5. Camargue (France). Responsible partner TdV

5.5.1. Synoptic description of the pilot site

The Camargue wetland, located in the Rhone Delta, southern France, is one of the largest wetlands in Western Europe, characterized by a mosaic of lagoons, marshes, grasslands, and agricultural lands. It plays a key role in hydrological regulation, biodiversity conservation, and carbon sequestration. The region has been shaped by coastal dynamics, riverine sedimentation, and anthropogenic influences, including agricultural expansion and water management infrastructure.

Camargue is designated as a Ramsar site, Natura 2000 area, and a Regional Natural Park, ensuring its protection under national and European environmental policies. The wetland supports diverse wildlife, including migratory birds and salt-tolerant vegetation, making it a hotspot for conservation. However, the area faces pressures from water management practices, land-use changes, and climate variability, all of which affect its ability to function as a carbon sink.

5.5.2. Level of methodological complexity to be followed

For the Camargue pilot site, a Tier 2 methodology will be implemented, focusing on site-specific data collection and modeling. Chamber-based techniques will be used to measure CO₂ and CH₄ fluxes, allowing for a detailed assessment of carbon sequestration processes. GIS and remote sensing will be applied to track land cover changes, vegetation dynamics, and hydrological conditions. Additional environmental data, such as water salinity, soil moisture, and climatic variables, will refine carbon sequestration estimates. In areas where continuous monitoring is not available, Tier 1 methodologies will be used to supplement the dataset with default carbon exchange values.

5.5.3. Data availability & sampling strategy

A structured data collection approach has been implemented to support carbon sequestration assessments. Available metadata includes wetland classification, land-use data from Corine Land Cover, and hydrological boundaries. GIS layers provide spatial information on water flow, vegetation distribution, and soil types. Environmental



datasets cover water quality parameters, salinity levels, and meteorological conditions relevant to wetland carbon fluxes.

Carbon flux data will be collected using chamber-based techniques to measure CO₂ and CH₄ exchanges in different wetland compartments, while carbon stock estimates will focus on soil organic carbon and vegetation biomass. Biological data includes wetland plant species composition and primary productivity, which are crucial for evaluating seasonal changes in carbon cycling.

5.5.4. Potentials and Weaknesses

The Camargue wetland benefits from a long history of scientific monitoring and conservation initiatives, providing a solid foundation for carbon sequestration studies. The presence of controlled hydrological infrastructure allows for experimental testing of water level management strategies to enhance carbon storage.

However, human intervention in water regulation introduces variability in natural carbon flux processes, making it difficult to isolate anthropogenic impacts. Some areas lack high-resolution continuous monitoring, requiring the use of Tier 1 estimates to fill data gaps. Land-use changes, particularly conversion of wetland areas for agriculture, further impact the long-term carbon sequestration potential of the ecosystem.

By addressing these challenges, the Camargue pilot site will contribute valuable data to the Wetland4Change project, improving our understanding of carbon sequestration dynamics in Mediterranean wetlands.



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