

**MODULE A1**  
**Knowledge Sharing from**  
**the Implementation of**  
**Full Water Cycle**  
**Nature-based Solutions**  
**(FWC-NbS)**

Training Manual

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October, 2025

The training programme has been developed within the framework of the NATMed project **“Nature-based Solutions on existing infrastructures for resilient water management in the Mediterranean”** funded by the PRIMA programme.

This manual is a collection of notes for workshop participants and is intended to complement the presentation delivered by the workshop facilitator.

For more detailed information on each module, please refer to the "Further Information" section provided at the end of each module, as well as the project website: **<https://natmed-project.eu>**

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# FWC-NbS TRAINING PROGRAMME



## MODULE A – Lessons learnt from NATMed case studies

**A1:** Knowledge Sharing from the Implementation of FWC-NbS

**A2:** IUCN Global standards for NbS (self-assessment tool)

**A3:** Replicability and Upscaling of FWC-NbS projects

## MODULE B – NATMed tools

**B1:** Implementation Guidelines for FWC-NbS in the Mediterranean

**B2:** Citizen engagement and co-design procedures

**B3:** NATMed decision-making tool for the implementation of FWC-NbS

## MODULE C – Market-based Mechanisms for NbS implementation

**C1:** Financial mechanisms, opportunities and business models for NbS

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# What will you learn?

The experience gained by the partners throughout the entire process of FWC-NbS implementation will be the core of this lesson. Specifically, experts will share with trainees the lessons learnt from the five case studies in terms of site analysis and diagnosis, challenges faced, solutions provided, tendering, data collection, KPIs measured and monitoring. This will also be a valuable tool for fostering the future replication of project results.

## What will you learn?

- ▶ Understand the **full process of FWC-NbS implementation**, from site analysis and diagnosis to monitoring and evaluation.
- ▶ Recognize the **challenges and solutions** identified in the five NATMed case studies.
- ▶ Understand the fundamental principles of **tendering**.
- ▶ Understand why **selecting and monitoring KPIs** is essential for demonstrating NbS effectiveness and resilience benefits.
- ▶ Appreciate the **role of stakeholder engagement and co-design** in successful NbS deployment.

## Guiding questions



What are the key steps and challenges in implementing FWC-NbS?

Why are monitoring and KPIs important for demonstrating NbS impact?

What policy and governance barriers do you need to address?

## Who is this for?



Technical staff of local and regional authorities and water authorities,  
NbS practitioners,  
Local communities,  
Regional and national policy makers,  
Researchers and academics,  
Agricultural businesses, SMEs, entrepreneurs.

# Overview of FWC-NbS and the NATMed Vision



## Project Goal

Support resilient water management in the Mediterranean through Nature-based Solutions (NbS) integrated into existing infrastructure.

## Focus

Entire Full Water Cycle (FWC) — from source to distribution, use, treatment, and return to the environment.

## Full Water Cycle Nature-based Solutions (FWC-NbS)

FWC-NbS refers to integrated combinations of NbS that:

- Address different phases of the water cycle including Supply, Demand, Quality management, Reuse and recycling;
- Are designed to be embedded in existing grey or natural infrastructure;
- Focus on co-benefits (biodiversity protection, recreational value, social inclusion, cost efficiency compared to grey infrastructure etc.).

## Co-design methodology

FWC-NbS are co-designed with local stakeholders to ensure relevance and acceptance. Each NATMed Case Study followed a structured process:

- a. Site diagnosis;
- b. NbS identification;
- c. Roadmap definition;
- d. Risk assessment and mitigation;
- e. Monitoring and adaptation.

## Aim

Optimize water-related and water-dependent ecosystem services while:

- Empowering stakeholders;
- Promoting community engagement;
- Enhancing climate resilience.

## NATMed Vision Pillars

- Integration of grey and green infrastructure;
- Stakeholder empowerment and participatory governance;
- Adaptation to climate change and water scarcity;
- Replication and upscaling of tested FWC-NbS;
- Knowledge sharing via the Mediterranean Community of Practice (MedCoP) and cross-border learning.

## Monitoring and validation

- Performance indicators (technical, environmental, social);
- IUCN validation;
- Feedback loops via MedCoP and participatory workshops.

# NATMed case studies

The NATMed project works with **five case studies** across the Mediterranean region: Spain (CS1), Greece (CS2), Italy (CS3), Türkiye (CS4), and Algeria (CS5).



All case studies face shared Mediterranean challenges, such as water scarcity and climate pressures, but also specific local challenges.

FWC-NbS were **co-designed, developed, and tested** in each case study.

Although site-specific, the solutions have high potential for replication in other regions facing similar challenges and seeking to enhance ecosystem services.



## ★ CS1 – Carrión de los Céspedes, Spain



### 💧 Location:

CS1 is located in a rural agricultural area in southern Spain with a hot-summer Mediterranean climate. CS1 is located in the Experimental Centre for New Water Technologies (CENTA) in Carrion de los Céspedes, in Seville, within the Andalusia region (Spain); it is an experimental centre and Living Lab for the co-creation, experimentation and evaluation of water innovative products, wastewater treatment and circular economy, in addition to its functionality as the municipality's wastewater treatment plant.

### 💧 Challenges:

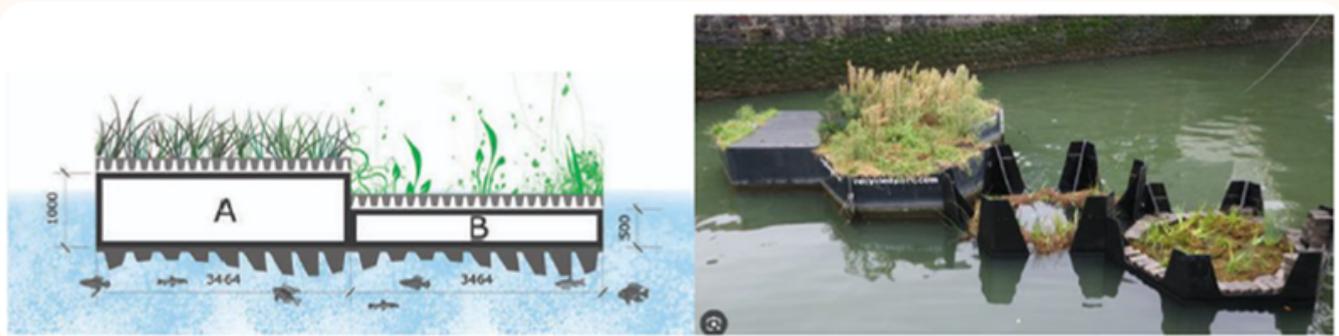
- Recurring droughts and **declining water availability**, intensified by climate change.
- **High evaporation rates**, reducing the efficiency of water storage and reuse systems.
- Strong dependence of **irrigated agriculture** on reliable and safe water supplies.
- **Variable wastewater inflows**, affecting the stability and performance of treatment systems.
- **Water quality pressures** from agricultural runoff.
- **Algae growth in storage systems**, limiting water reuse reliability.
- **Diffuse aquifer pollution** linked to agricultural activities.
- Strong **climate–water–economy interdependencies**, increasing vulnerability of local livelihoods and farming systems.

# NATMed case studies



## CS1 – Carrión de los Céspedes, Spain

### Solutions implemented:



This site showcases how NbS enhance water reuse in Mediterranean agriculture. The site upgrades a water treatment facility with ten **constructed wetlands**, working in different configurations. Using plants and gravel, these systems naturally clean wastewater for discharge and safe reuse. The Case study is also testing **floating gardens**, i.e. native plants that grow on structures on the water's surface. These reduce evaporation, enhance biodiversity, and improve water quality. To support this nature-based approach, **ultrasound devices** have been installed in the storage lagoon and tanks. These tools help control algae and bacteria. Frequency adjustments make the system effective and reliable. **Treated water irrigates nearby olive groves**. Farmers report richer soils, better water retention, and more sustainable yields. A meteorological station tracks local climate, while a filtration system is the final stage in the water reclamation train for agricultural irrigation, supporting smarter, sustainable water use.



# NATMed case studies

## CS2 – Chimaditida, Greece



### Location:

CS2 corresponds to the Chimaditida lake complex that consists of four hydrologically connected lakes: Zazari, Chimaditida, Petron, and Vegoritida, linked through artificial canals and ditches. The intervention area includes protected wetlands of high ecological value, designated as part of the Natura 2000 Network. The case study is implemented in cooperation with local and regional authorities and stakeholders in Amyntaio Municipality, within a rural, agriculture-dominated area.

### Challenges:

- **Water scarcity and seasonal droughts**, driven by over-pumping for irrigation.
- **Water pollution and runoff** from urban and industrial wastewater, agro-pastoral activities, and solid waste, affecting water quality.
- **Eutrophication** linked to agricultural pressures.
- **Severe reed overgrowth**, covering up to 70% of the lake surface, limiting plant and animal diversity.
- **Silting and sediment accumulation**, reducing lake depth and ecological function.
- **Groundwater level decline**, caused by past lignite mining activities, drainage works, and aquifer over-extraction for irrigation.
- **Strong dependence on agriculture and livestock**, increasing pressure on water resources.
- **Climate change impacts**, exacerbating droughts, water stress etc.



# NATMed case studies

## CS2 – Chimaditida, Greece

### Solutions implemented:



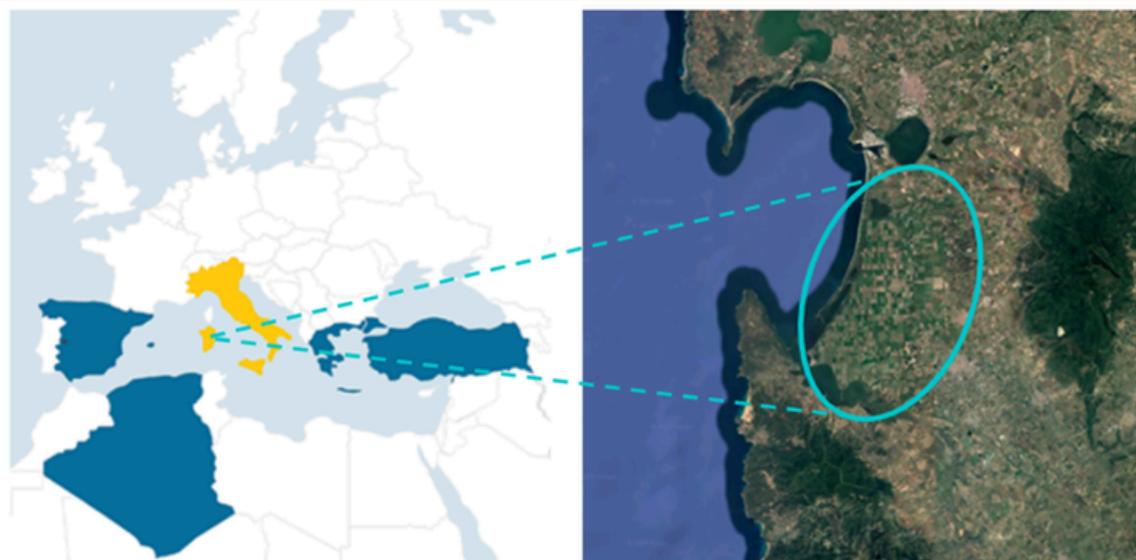
Lake Chimaditida is a unique wetland in Northern Greece, part of the Natura 2000 network due to its exceptional biodiversity. It hosts rare bird species and supports rich aquatic life. In recent years, however, the lake has faced a serious threat: the uncontrolled spread of reed beds, which risks turning the wetland into dry land and disrupting the ecosystem's balance. To restore this balance, NATMed introduced an **innovative yet traditional solution: controlled grazing by Greek buffaloes**. Once native to the area, buffaloes are now reintroduced as a NbS. They graze within movable electric fences and wear GPS collars, allowing scientists to track their movements, collect data, and safeguard the ecosystem through a digital platform. Scientists also use Earth Observation systems to monitor vegetation and water quality.

As buffaloes move and step into the shallow parts of the lake, they open small channels and paths through the reeds, improving water circulation and creating safe passages for fish. This process enhances fish biodiversity and protection and, together with reed control, contributes to the formation of high-quality habitats for endangered bird species such as the Dalmatian pelican and the ferruginous duck.



# NATMed case studies

## CS3 – Arborea, Italy



### Location:

CS3 is located in central western Sardinia, in the Arborea plain, within the province of Oristano (Italy). Arborea is a town and municipality characterised as a highly productive farming district. The case study is implemented in collaboration with local institutions, farmers, and research actors operating in the Arborea agricultural district. The area hosts intensive dairy farming systems and lies partly within a Nitrate Vulnerable Zone (NVZ), requiring close cooperation with agricultural stakeholders, water authorities, and scientific partners working on groundwater protection and sustainable farming practices.

### Challenges:

- **Groundwater nitrate pollution** is the main environmental issue, with nearly 50% of groundwater samples exceeding the 50 mg/L nitrate threshold.
- Nitrate contamination originates mainly from **effluents of intensive dairy cattle farming**, involving more than 200 farms and approximately 30,000 cattle.
- The area is designated as a **Nitrate Vulnerable Zone (NVZ)**, imposing strict regulatory constraints on manure and slurry management.
- Farmers face **increased production costs** due to limits on slurry and manure application, the costs of disposing of excess effluents, and greater reliance on external nitrogen fertilizers



# NATMed case studies

- These regulatory and economic pressures, combined with rising raw material and fuel prices, are **reducing farm incomes and generating social discontent**.
- The region has a semi-arid Mediterranean climate, with warm summers, mild winters, and a strong water deficit from May to September, **increasing stress on water resources**.
- The presence of **ecologically valuable marsh wetlands** and interconnected aquifers adds complexity to water management and environmental protection.

## Solutions implemented:



Arborea is a fertile district in Sardinia facing a silent crisis, in part due to the groundwater pollution from agriculture. The nitrate levels in groundwater often exceed 50 mg/L, the legal limit under EU water protection laws, so the Arborea plain was declared Nitrate Vulnerable Zone (NVZ) in 2005. A NbS known as **Forested Infiltration Area (FIA)** has been developed to reduce groundwater nitrate pollution in the NVZ. **FIA is a Managed Aquifer Recharge** technique consisting of a series of parallel drainage trenches bordered with trees, specifically poplars and eucalyptus trees. The trees improve water infiltration and creates an 'active layer' in the soil that naturally transforms nitrates into inert nitrogen gas. While waiting for the forest to mature, a **Passive Treatment System of eucalyptus woodchips and inert material** is used as a short-term solution. It adds soluble carbon to the infiltrating water, which is used by the denitrifying bacteria to remove the nitrates before they reach the aquifer. Beyond denitrification, the FIA provides a series of important ecosystem services, for example supports biodiversity, captures carbon, and cools the landscape.

# NATMed case studies

## CS4 – Bozcaada, Türkiye



### Location:

CS4 is located on Bozcaada (Tenedos), a small island in the northern Aegean Sea. The case study is implemented in collaboration with local authorities and stakeholders on Bozcaada, including actors from the tourism, agriculture, and fisheries sectors. The local economy is driven mainly by tourism, winemaking, and fishing, alongside small-scale agricultural production and handicrafts, requiring close cooperation with municipal services and local producers.

### Challenges:

- **Water scarcity and seasonal water stress** (during summer months).
- **Limited freshwater resources**, with no permanent rivers or streams and reliance on a small number of interconnected wells and a single fountain.
- **Over-exploitation of groundwater**, leading to declining water tables and an **increased risk of seawater intrusion**.
- Dependence on **water transfer from the mainland** to meet peak summer demand.
- A **hot-summer Mediterranean climate** that affects water balance.
- **Climate change impacts**, such as altered precipitation patterns.
- Presence of **natural and archaeological protected areas**, adding constraints to land and water management.
- High ecological value, with several **endangered species**, increasing the need for careful resource management.

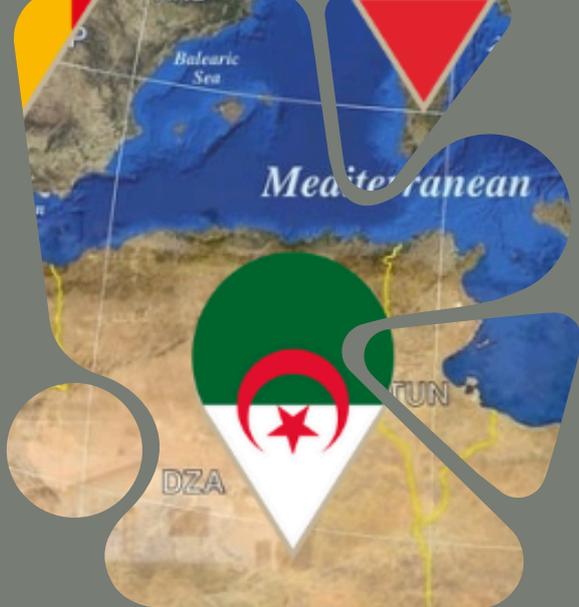


# NATMed case studies

## Solutions implemented:



Bozcaada is a unique island in Türkiye that faces increasing pressure on its water resources due to tourism, agriculture, and climate change. With **24 dedicated monitoring wells and high-frequency CTD-Divers**, NATMed tracks groundwater in real time, every minute. This creates a dynamic database, capturing seasonal and climate-related variations in water levels and quality. The data informs current **reed bed management** and supports long-term water strategies, helping the ecosystem adapt to future climate pressures. Seasonal water samples are analyzed at IZTECH for a full chemistry profile: ions, metals, hardness, and more, giving a comprehensive picture of groundwater quality. On Bozcaada, NATMed pilots Nature-based Solutions like **gradoni terraces, conservation agriculture, MAR, treated wastewater reuse, and smart irrigation** to protect water and strengthen resilience. Sensors measure soil moisture in real time, helping farmers adapt to changing conditions with precision agriculture.



# NATMed case studies

## ★ CS5 – Oued Righ, Algeria

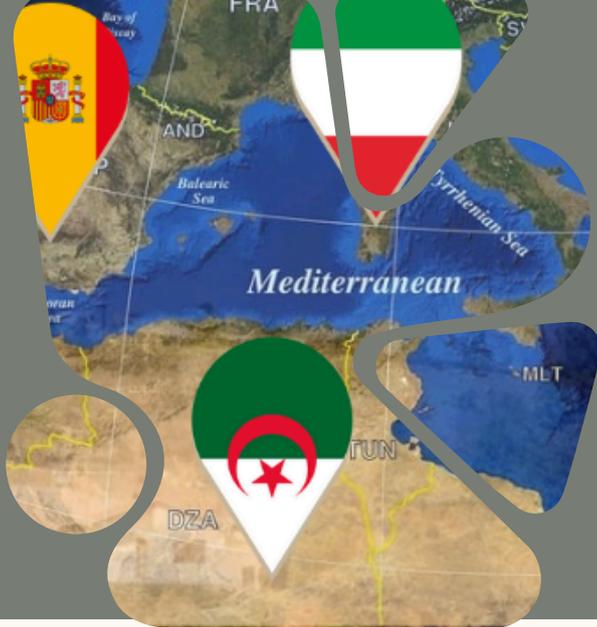


### 💧 Location:

CS5 is located in the Oued Righ Valley, a large lowland area in south-eastern Algeria. The Oued Righ canal, an artificial drainage infrastructure constructed in 1925, crosses 12 municipalities before ending in the Chott Merouane wetland complex and serves as the main collector for irrigation drainage and wastewater. The case study is implemented in collaboration with local authorities and stakeholders in the municipality of Touggourt, within an oasis-based agricultural system. The area is strongly dependent on date palm cultivation and associated agricultural activities, requiring coordination with municipal services, water managers, farmers, and environmental actors responsible for wastewater management, drainage systems, and wetland protection.

### 💧 Challenges:

- An **arid climate**, with extremely hot, dry summers, low precipitation, high evaporation rates, and recurrent droughts.
- Strong dependence of local livelihoods on **oasis agriculture**, increasingly threatened by water quality degradation and salinization.
- **Severe water pollution** in the Oued Righ canal, as only one wastewater treatment plant exists and treats about 20% of Touggourt's wastewater, while the remainder is discharged untreated into the canal.
- Combined impacts of urban wastewater discharges and agricultural drainage, leading to **eutrophication and ecosystem degradation**.



# NATMed case studies

- **Sedimentation and declining groundwater levels**, partly caused by drainage operations and historical mining activities.
- **Soil degradation**, characterised by low organic matter and strong influence of fluctuating water tables.
- **Biodiversity loss**, despite the presence of wetlands that host rich fauna and flora.
- **Inefficient wastewater management systems**, limiting water reuse and increasing environmental and health risks.
- **Climate change impacts**, further intensifying water stress, ecological degradation, and risks to human well-being.

## Solutions implemented:



The case study in Algeria tackles the deterioration and pollution of the Oued Righ canal due to the discharge of untreated raw wastewater from urban sources, as well as the erosion and degradation of the canal banks. This situation has led to water and soil pollution, threatening ecosystems and public health. To address these challenges, NATMed has adopted two NbS. The first is a **pilot scale of constructed wetland (French vertical flow CWs)**, and the second is the **restoration of a section of the Oued Righ canal**. This strategy relies on proven methods based on natural and biological principles, minimizing energy consumption and avoiding maintenance costs. The first solution consists of five treatment basins with impermeable linings, tanks, and supports designed to enhance the biological treatment of incoming water by using natural processes to filter wastewater, reduce pollution, and enable the reuse of treated water in various sectors, particularly agricultural irrigation. The second solution involves restoring a section of the Oued Righ canal using local materials to reduce bank erosion.

# Diagnosis and Site Analysis: Lessons from Case Studies

## Purpose of Site Diagnosis

- Ensure FWC-NbS are tailored to local hydrological, ecological, and socio-economic contexts.
- Identify site-specific risks, stakeholder needs, and infrastructural constraints.
- Guide the co-design and implementation of appropriate NbS interventions.

## General Methodology for Diagnosis

- Multi-criteria assessment combining:
  - Hydrological and climate vulnerability analysis;
  - Ecosystem Services (ES) mapping;
  - Infrastructure and land use review;
  - Stakeholder mapping and engagement.
- Diagnostic phase involved:
  - On-site visits and remote sensing;
  - Interviews and surveys with local stakeholders;
  - Risk assessments and identification of enabling conditions.

## Case Study Insights (Extracted Lessons)



### CS1 Spain (Carrión de los Céspedes):

- Issue: Seasonal algae blooms and water quality degradation in the area.
- Diagnosis: High temperature, high water evaporation, sediment accumulation, low dissolved oxygen.
- Lesson: Need for floating gardens and constructed wetlands and algae treatment (ultrasound).



### CS2 Greece (Chimaditida):

- Issue: Water scarcity and inefficient irrigation in peri-urban and agricultural zones.
- Diagnosis: Overuse of boreholes, fragmented infrastructure, low rainwater retention.
- Lesson: Integration of constructed wetlands, rainwater harvesting, and MAR systems needed.

# Diagnosis and Site Analysis: Lessons from Case Studies

## Case Study Insights (Extracted Lessons)



### CS3 Italy (Arborea):

- Issue: groundwater quality, social impact of EU nitrate directive, ecosystem degradation.
- Diagnosis: Nitrate and pollution, increase of costs for production, biodiversity loss.
- Lesson: NbS can provide the solution for solving environmental and social problem, provided participatory approach and co-design are used during implementation.



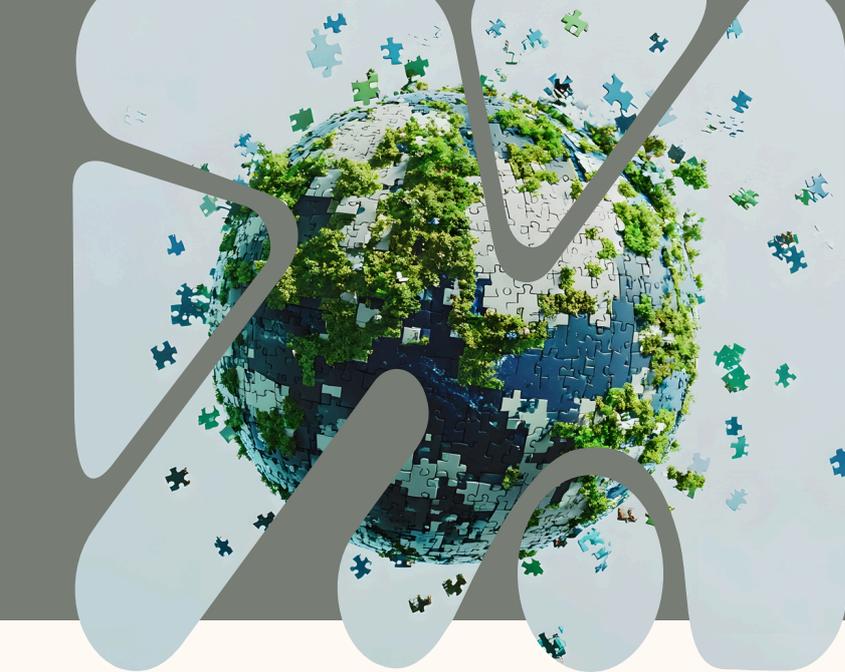
### CS4 Türkiye (Bozcaada):

- Issue: Aquifer overexploitation and lack of wastewater reuse.
- Diagnosis: Polluted discharge, urban expansion pressures.
- Lesson: Combined grey-green solutions essential; Living Labs play a key role.



### CS5 Algeria (Oued Righ):

- Issue: Water scarcity, deterioration and pollution of the Oued Righ canal and lack of access to treated water.
- Diagnosis: Low awareness, lack of community involvement, infrastructure deficits.
- Lesson: Success depends on strong community engagement and low-cost NbS.



# Diagnosis and Site Analysis: Lessons from Case Studies

## Diagnosis Tools Used

- GIS mapping & remote sensing (e.g., slope, land use);
- Soil and water quality tests;
- Community and technical surveys (see D3.1 Appendix B);
- Ecosystem Services matrix (based on Russi et al., WWAP, and IUCN guidance).

## Key Lessons from Diagnosis

- Local environmental and social context must drive NbS selection.
- Early stakeholder involvement leads to better adoption and co-benefit alignment.
- Diagnosis phase is foundational for later risk mitigation and monitoring design.
- Similar water cycle challenges exist across all sites, but NbS solutions differ.



# Tendering processes for FWC-NbS



The phases below are common to all case studies and can serve as a replicable process. However, the specific steps within each phase may vary, as certain elements may be omitted depending on the country and case study.

## Phase 1: Prepare the Regulatory and Institutional Framework Early

- **Map all regulatory constraints** before launching the tender, including Natura 2000 obligations, water protection rules, land-use planning requirements, and permitting procedures.
- Ensure that **technical specifications explicitly reflect these constraints** to avoid legal challenges and delays during implementation.
- Where possible, **align NbS tenders with broader regional or territorial instruments** (e.g. Integrated Spatial Investment Plans) to benefit from smoother procurement pathways and policy coherence.
- Use the tendering process as a learning opportunity to **introduce ecological performance metrics, co-benefit accounting, and long-term climate resilience thinking** within public administrations.

## Phase 2 Strengthen Planning and Design Before Tender Launch

- Carry out robust **preliminary site investigations** (geology, hydrogeology, geochemistry) to inform realistic and site-specific specifications.
- Define **clear environmental and technical objectives**, avoiding vague or overly prescriptive requirements.
- Prefer **modular or phased design approaches**, allowing risk management, iterative learning, and adaptation during implementation.
- Ensure **early collaboration between procurement officers and technical teams** when drafting tender documents to prevent misinterpretation and administrative delays.
- Encourage **innovation in NbS design and technology**, including hybrid or intensified solutions where appropriate, and prioritize local, non-invasive plant species.
- Design tenders in ways that **enable participation of local SMEs, ecological engineers, landscapers, and cooperatives**, strengthening local economies and skills.



# Tendering processes for FWC-NbS



## Phase 3: Apply Transparent and Quality-Focused Contractor Selection

- Clearly communicate **evaluation criteria** in the tender documents to improve bid quality and ensure fairness.
- Prioritize:
  - Proven **technical and ecological expertise**;
  - Understanding of **local environmental and socio-institutional contexts**;
  - Experience with NbS **implementation and maintenance**.
- **Avoid over-reliance on lowest-price criteria**, as insufficient experience often leads to implementation errors, delays, and higher long-term costs.
- Use contractor selection as a lever to **build local capacity and support green job creation** through knowledge transfer.

## Phase 4: Integrate Operation, Maintenance, and Long-Term Sustainability

- Require **operation and maintenance (O&M) plans** from the outset, with clear allocation of long-term responsibilities and resources.
- Design contracts to allow **flexibility for minor adjustments** (e.g. vegetation, materials, layout) without triggering full legal revisions.
- Anticipate that NbS may evolve over time and ensure that contracts can **adapt to ecological behavior, climate variability, and stakeholder feedback**.
- Embed **circular economy principles**, such as water reuse, biomass valorization, composting, or energy recovery, where relevant.

## Phase 5: Manage Timeframes Realistically

- Define **realistic timelines** that account for NbS-specific processes, such as plant establishment, growth periods, and pilot phases.
- **Avoid applying conventional “grey infrastructure” schedules** that are incompatible with ecological dynamics.
- **Optimize implementation and monitoring** through remote sensing, sensors, and digital tools, where feasible.

# Tendering processes for FWC-NbS



## Phase 6: Ensure Social Participation and Institutional Coordination

- **Engage local communities, water users, and relevant authorities** early in the process to reduce conflicts, ease permitting, and improve acceptance.
- Coordinate across institutions from the beginning to ensure that tender documents reflect **multi-agency requirements**.
- Include **capacity-building and awareness-raising actions** as part of NbS procurement to improve long-term performance.
- Use tendering strategically to **mainstream NbS principles**, embedding nature-based criteria into standard procurement practices.
- Promote **data transparency and good governance**, building trust and improving the quality of future tenders.

## Phase 7: Build in Flexibility and Adaptability

- Accept that NbS require adaptive management and may need **adjustments in design** or species selection over time.
- Encourage the use of **digital monitoring systems** that allow real-time observation, learning, and corrective actions.
- Treat **adaptability** as a strength of NbS rather than a risk, and reflect this in contractual arrangements.

## Phase 8: Ensure Robust Documentation and Knowledge Management

- Maintain **clear and consistent records** of implementation progress, design changes, and environmental performance.
- Use **digital tools and indicator tracking systems** to support reporting, accountability, and learning.
- **Capitalize on documentation** to improve future tenders, refine specifications, and support institutional memory.

### Key Methodological Principles

These are guiding strategies that overlay the phases above:

- Use of performance-based specifications.
- Flexibility for adaptation, allowing nature-responsive design.
- Co-design and participation, upstreamed into tender drafting.
- Inclusion of environmental and social KPIs.
- Focus on replicability, ensuring process is usable by other local governments.

# Tendering processes for FWC-NbS



## Tendering procedure in the 5 case studies

### CS1 – Carrión de los Céspedes, Spain

#### Tendered NbS:

- Floating Gardens;
- Ultrasound system for algae and E. coli reduction.

#### Contract Types:

- Ultrasounds: Minor contract (<€15,000), services and supplies;
- Floating Gardens: Direct award.

#### Challenges:

- No issues in planning, preparation, tendering, or awarding.
- Medium difficulty in execution:
  - For ultrasounds: issues with removing previous systems delayed implementation.
  - For gardens: plant species did not adapt well to extreme heat; replanted in autumn.

### CS2 – Chimaditida, Greece

#### Tendered NbS:

- Buffalo grazing to manage reedbeds (Livestock management);
- Water 4.0: Smart monitoring for lake water quality.

#### Contract Types:

- Livestock: Open procedure under Regional Operational Programme;
- Water 4.0: Minor contract (<€30,000) for consumables & sensors; direct award.

#### Challenges:

- Livestock NbS faced high difficulty in all stages:
  - Bureaucratic hurdles due to Natura 2000 area designation;
  - Needed additional authorizations from Public Real Estate Company;
  - Open procedure was time-consuming;
  - Execution affected by climate (e.g., dry lakebed in 2024).
- Water 4.0: Medium difficulty in preparation and execution due to technical placement needs and equipment fragility .

# Tendering processes for FWC-NbS



## Tendering procedure in the 5 case studies

### CS3 – Arborea, Italy

**Tendered NbS:** None. All infrastructures already implemented under previous projects (MENAWARA-ENI CBC MED). Monitoring instruments for NATMed will be directly purchased without public tendering

### CS4 – Bozcaada, Türkiye

#### **Tendered NbS:**

- Natural Infiltration Techniques;
- Groundwater Storage System;
- Water 4.0 smart irrigation.

#### **Contract Types:**

Negotiated Tendering for all NbS (<2,076,108 TL) under Turkish Public Procurement Law No. 4734.

#### **Challenges:**

- Natural infiltration & groundwater systems: low difficulty in execution.
- Water 4.0: High difficulty in planning, preparation, and tendering due to:
  - Technical complexity;
  - Bureaucratic hurdles;
  - Scarcity of suitable contractors.

### CS5 – Oued Righ, Algeria

#### **Tendered NbS:**

- Constructed Wetlands;
- Canal banks restoration;

#### **Contract Types:**

- Consultation procedure for contracts under 12,000,000 DZD (works & equipment) and 6,000,000 DZD (services);
- Simplified procedures used for lower-value contracts.

#### **Challenges:**

- Constructed Wetlands:
  - Medium difficulty in planning and preparation.
  - Delay due to recommended change to French-style wetlands system.
  - Tendering and implementation delayed by lack of experience and complex documentation.
  - CWs execution are currently completed.
  - Reed did not growth well in CWs units due the high temperature of summer; replanted in autumn.
- Canal banks restoration:
  - High difficulty in planning due to harsh environmental conditions (high salinity, pollution).
  - Tendering and execution are currently completed.



# Challenges in FWC-NbS implementation

## CS1 – Carrión de los Céspedes, Spain

### Main challenges

- High variability in wastewater inflow quality and volume, affecting system stability and performance.
- Uncontrolled discharges and flooding events disrupting wetland biocenosis.
- Technical limitations of single treatment units, requiring performance optimisation.
- Public acceptance issues linked to odours, mosquitoes, and negative perceptions of wastewater.
- Floating Gardens exposed to extreme temperatures, leading to plant stress, reduced growth, and mortality.
- Structural degradation of Floating Gardens, increasing maintenance needs.
- Limited efficiency of ultrasound treatment due to high suspended solids and algal blooms in summer.
- Operational complexity due to the combination of multiple NbS solutions within one system.
- Absence of formal risk management and grievance mechanisms for reclaimed water use, affecting regulatory approval and stakeholder confidence.
- Lack of a formal NbS strategy based on a clear Theory of Change, limiting the structuring of KPIs and long-term monitoring.
- Difficulty in capturing biodiversity and non-financial impacts (e.g. ecosystem services and social perception), beyond technical performance indicators.



# Challenges in FWC-NbS implementation

## CS1 – Carrión de los Céspedes, Spain

### Key lessons learnt

- Hybridisation and intensification of Constructed Wetlands significantly improve contaminant and pathogen removal while reducing land requirements.
- Combining different CW configurations (vertical, horizontal, surface flow, aerated units) increases system resilience.
- Social acceptance improves when training and co-design activities are implemented with local stakeholders.
- NbS design must account for climate stressors, especially extreme temperatures, to ensure plant survival.
- Floating Gardens require optimised design, robust materials, and thermal resilience to reduce maintenance costs.
- Ultrasound treatment is more effective when combined with complementary low-impact measures for algae control.
- Clear operation and maintenance plans are essential for long-term performance and scalability.
- Continuous monitoring supports adaptive management and timely corrective actions.
- Training of local operation and maintenance staff strengthens sustainability and local ownership.
- All phases, from design to monitoring and stakeholder engagement, are critical for durable NbS outcomes.
- Beyond technical performance, governance arrangements, monitoring frameworks, and stakeholder confidence are critical for scaling up FWC-NbS.



# Challenges in FWC-NbS implementation

## CS2 – Chimaditida, Greece

### Main challenges

- Economic decline linked to the post-lignite transition, with high unemployment and socio-economic stress.
- Legacy environmental degradation and pollution from past mining activities, affecting ecosystems and public health.
- Lack of systematic socio-economic data (e.g. agro-tourism, financial indicators) to support decision-making.
- Complex regulatory procedures due to Natura 2000 designation, slowing authorisations.
- Risk of imbalance between economic viability of buffalo farming and the ecological carrying capacity of the lake.
- Severe reed overgrowth affecting up to 70% of the lake, requiring continuous management.
- Limited formal mechanisms for stakeholder grievances and feedback.
- NbS not yet fully embedded in regional policy instruments (e.g. Water Management Plans).

### Key lessons learnt

- NbS can act as a direct driver of rural revitalisation, supporting a just transition through new livelihoods.
- Integrated solutions (buffalo grazing) can simultaneously solve ecological and socio-economic problems.
- Early acquisition of environmental permits significantly reduces project risk.
- Embedded safeguards (rotational grazing, carrying capacity studies) are essential to manage ecological trade-offs.
- Adaptive management, supported by a Theory of Change and monitoring framework, strengthens resilience.
- Strong stakeholder engagement through co-design and the MedCoP increases acceptance and quality.
- Using existing ecological baseline data enables clear KPIs and evidence-based monitoring.
- Targeted dissemination improves policy uptake and stakeholder awareness.



# Challenges in FWC-NbS implementation

## CS3 – Arborea, Italy

### Main challenges

- High regulatory pressure due to EU infringement procedures on nitrate pollution.
- Groundwater contamination from intensive dairy farming, with many samples exceeding nitrate thresholds.
- Economic strain on farmers caused by fertilizer restrictions and manure management requirements.
- Technical limitations identified during implementation, especially limited phosphate removal by the initial system.
- Need to demonstrate NbS value beyond short-term financial returns.

### Key lessons learnt

- The NbS demonstrated high technical effectiveness, achieving major nitrate reduction.
- Local economic benefits (use of local labour, materials, biomass valorisation) improve acceptance.
- Comprehensive economic evaluation including co-benefits is critical to justify NbS investments.
- Continuous monitoring enables early identification of technical issues and corrective action.
- Adaptive management allows improvement of solutions based on field and laboratory results.
- Interdisciplinary collaboration strengthens problem-solving capacity.
- Institutional agreements support mainstreaming of NbS into regional policy structures.
- Early and continuous stakeholder engagement supports scalable and replicable solutions.

# Challenges in FWC-NbS implementation

## CS4 – Bozcaada, Türkiye

### Main challenges

- Increasing water scarcity driven by climate change and island-specific constraints.
- Stress on NbS implementation due to high temperatures, aridity, and wind erosion.
- Tension between tourism-related water demand and limited natural resources.
- Absence of a formal grievance and feedback mechanism.
- Limited economic valuation of NbS benefits.
- Lack of direct biodiversity monitoring indicators.

### Key lessons learnt

- Simple, low-cost NbS measures can significantly reduce erosion and runoff.
- NbS can deliver indirect habitat and biodiversity benefits, even if not explicitly monitored.
- Integration of ICT and smart irrigation improves water efficiency and resilience.
- Strong municipal leadership enhances alignment between local needs and NbS design.
- Linking NbS to human wellbeing outcomes improves relevance and monitoring clarity.
- Early policy uptake by local authorities supports mainstreaming.
- Farmer feedback and site-level data are valuable inputs for adaptive management.
- Structured dissemination through academic and practitioner networks strengthens impact.





# Challenges in FWC-NbS implementation

## CS5 – Oued Righ, Algeria

### Main challenges

- Severe degradation of the Oued Righ canal (pollution, sedimentation, erosion, pests).
- Groundwater contamination caused by untreated wastewater and poor drainage.
- Agricultural losses due to rising polluted water tables and palm tree mortality.
- Ecosystem disruption from high-temperature groundwater extraction.
- Limited public awareness of NbS and constructed wetlands.
- Reliance on informal grievance mechanisms with untested effectiveness.
- Resource constraints affecting the ability to manage ecological trade-offs.
- Risk of unintentional human interference with NbS structures.

### Key lessons learnt

- NbS can provide integrated water, environmental, and economic benefits.
- Constructed wetlands support wastewater treatment, water reuse, and groundwater protection.
- Improving canal health is directly linked to agricultural recovery and farmer livelihoods.
- Defining human wellbeing outcomes strengthens local relevance and acceptance.
- Alignment with national strategies supports NbS mainstreaming and sustainability.
- Collaboration with academia and civil society enhances knowledge and awareness.
- Participatory design ensures local challenges and priorities are addressed.
- Demonstrating tangible benefits is key to encouraging behaviour change and protection of NbS.
- Regular stakeholder engagement and capacity building improve long-term cooperation.

# Monitoring, Evaluation and Key Performance Indicators (KPIs)



**Monitoring** == data collection

**Evaluation** == analyzing results against KPIs

**KPIs** == the bridge between monitoring and evaluation

## Why Monitoring Matters

Monitoring ensures that NbS deliver measurable impacts on water, climate, and society. The monitoring framework is directly linked to project evaluation, replication, and validation with IUCN Global Standards.

## Defining the Right KPIs

A core set of 49 KPIs was established in NATMed project, addressing provisioning, regulating, supporting, and cultural ecosystem services.

Examples of KPIs:

- Environmental: reduction in water use for irrigation; soil erosion rate; nutrient removal by wetlands.
- Social: number of educational activities; citizen involvement in NbS design.
- Economic: jobs created; number of new economic activities.

## What is Evaluation?

Evaluation is the process of analyzing monitoring data to understand whether NbS are achieving their intended impacts.

It involves:

- Comparing baseline vs. post-intervention data.
- Assessing progress against KPIs.
- Looking at both successes and challenges.
- Providing feedback for future improvements.

Evaluation in NATMed was applied to both environmental outcomes (e.g., water quality, biodiversity) and co-benefits (e.g. social awareness, local jobs).

# Monitoring, Evaluation and Key Performance Indicators (KPIs)



## Building a Monitoring Framework

Each KPI in NATMed was matched with parameters and standard measurement methods (e.g., flow meters, rain gauges, soil sensors, biodiversity surveys). This guarantees comparability across all case studies and ensures data is scientifically robust.

## Establishing the Baseline

Before implementation, baseline data was collected on climate, soil, water quality, biodiversity, and socio-economic indicators. This created the “before” scenario necessary to measure NbS impact.

## Applying Monitoring in NATMed Case Studies

- **Spain:** Water reuse supported olive grove irrigation, improved water quality via constructed wetlands and floating gardens.
- **Greece:** Riparian buffers and irrigation plans reduced runoff and improved soil management.
- **Italy:** Forested infiltration area with the Passive Treatment system increased groundwater recharge and reduced nitrates without significant production of harmful by-product of the denitrification process (e.g. nitrite, ammonia, greenhouse gas).
- **Türkiye:** Conservation agriculture improved soil organic matter and reduced erosion.
- **Algeria:** Constructed wetlands and canal banks restoration improved wastewater treatment and biodiversity.



# Monitoring, Evaluation and Key Performance Indicators (KPIs)



## **Looking at the Full Water Cycle**

Monitoring included upstream and downstream areas, capturing the wider ripple effects of NbS interventions on the whole water cycle.

## **Including Social and Economic Benefits**

KPIs also captured co-benefits such as jobs created, new economic activities, stakeholder involvement, education, awareness, and SDG coverage.

## **Keeping it Flexible and Adaptive**

The KPI list was not fixed. Indicators were reviewed during implementation and could be added or removed as needed to ensure relevance and accuracy.



# Monitoring, Evaluation and Key Performance Indicators (KPIs)



## Recommendations

- Start small: **select 5–10 KPIs** that reflect your main priorities (e.g., water quality, biodiversity, jobs created).
- Always **build a baseline dataset** (even with simple tools like surveys, photos, or citizen science) before implementing NbS.
- Use standard methods where possible but **adapt to local resources** (e.g., manual water testing if labs are unavailable).
- Monitor both **environmental and social impacts**, showing how communities benefit builds political and citizen support.
- **Extend monitoring to upstream and downstream areas** to understand the broader system impacts.
- Keep the framework flexible; **revise KPIs as new challenges or opportunities arise**.
- **Share your results with citizens and decision-makers** to demonstrate NbS value and secure long-term support.

## Note

- As part of our evaluation methods, NATMed also applied the **IUCN Global Standard for NbS**. This helped assess the quality of NbS implementation beyond technical indicators. For more details, see Module A2.
- Monitoring and evaluation in NATMed were closely linked to **stakeholder engagement**. Through participatory approaches and the **MedCoP (Mediterranean Community of Practice)**, local actors contributed to defining priorities, validating KPIs, and interpreting results. These processes strengthened ownership and ensured that NbS implementation was context-sensitive. A full overview of NATMed's stakeholder engagement strategies and MedCoP insights is provided in Module B2.



# Addressing Policy and Governance Barriers

## General Barriers across Mediterranean contexts

**Fragmented governance structures:** Water, agriculture, and environment are often managed by different authorities, making coordination difficult.

**Regulatory misalignment:** Existing laws sometimes favor grey infrastructure over NbS, slowing approval and funding.

**Permitting challenges:** NbS often lack clear regulatory pathways for construction, monitoring, and operation.

**Limited stakeholder integration:** Farmers, municipalities, water agencies, and citizens are not always equally involved in decision-making.

**Financial and institutional inertia:** Traditional funding schemes and administrative routines tend to prioritize conventional solutions.

**Knowledge and capacity gaps:** Lack of technical guidelines and limited training for local authorities reduce confidence in NbS adoption.

## Case-Specific Barriers

- ★ **CS 1 – Carrión de los Céspedes, Spain**
  - Excessive bureaucracy causes delays.
  - Existing wastewater treatment regulations designed for conventional systems, not wetlands or floating gardens.

- ★ **CS 2 – Chimaditida, Greece**
    - Fragmented land ownership and unclear water-use rights complicate implementation.
    - Lack of integration between agricultural policies and wetland conservation measures.
- 



# Addressing Policy and Governance Barriers

## Case-Specific Barriers



### CS 3 – Arborea, Italy

- Regional water legislation does not include clear rules for the application of the managed aquifer recharge. There is not specific legislation for the NbS.
- Multiple local agencies involved in surface water and groundwater management act with limited coordination.



### CS 4 – Bozcaada, Türkiye

- Weak enforcement of land-use and water protection rules on the island.
- Limited institutional capacity to integrate conservation agriculture into existing agricultural policy frameworks.



### CS 5 – Oued Righ, Algeria

- Strong reliance on centralized water management makes local NbS adoption more difficult.
- Absence of specific guidelines for NbS in wastewater treatment and canal management.

### KEY MESSAGE

Policy and governance barriers are not just technical problems, they reflect institutional fragmentation, outdated regulation, and lack of capacity. Addressing them requires cross-sector coordination, legal recognition of NbS, capacity building and stronger involvement of local communities.



# Achieving Climate Resilience through FWC-NbS



## Benefits of FWC-NbS

- **Secure water resources** – Reduce evaporation, reuse treated water, and recharge groundwater.
- **Buffer climate extremes** – Use wetlands, buffers, and soils to regulate floods and retain moisture in droughts.
- **Improve water quality** – Apply natural filtration and wetlands to remove pollutants, ensuring safe supplies under stress.
- **Enhance soil health** – Increase soil organic matter and retention capacity to protect crops during extremes.
- **Restore ecosystems & biodiversity** – Reconnect habitats, strengthen ecosystems, and use biodiversity as a resilience indicator.
- **Support socio-economic resilience** – Create jobs, stimulate local economies, and raise awareness through NbS co-design.
- **Adopt adaptive monitoring** – Track KPIs (e.g. precipitation, evapotranspiration, groundwater, soil health) and adjust strategies.

## CS 1 – Carrión de los Céspedes, Spain

- **NbS:** Constructed wetlands, floating gardens, ultrasound treatment in water storage, reuse of treated water for irrigation.
- **Climate resilience benefits:** Reduced evaporation losses, increased water reuse for agriculture, and stabilized water availability during dry seasons.

# Achieving Climate Resilience through FWC-NbS



-  **CS 2 – Chimaditida, Greece**
  - **NbS:** Livestock grazing management, riparian buffer zones, irrigation planning, and wastewater treatment.
  - **Climate resilience benefits:** Protection of water resources, reduced nutrient runoff and soil erosion, and more efficient irrigation, strengthening the system against drought risk.
  
-  **CS 3 – Arborea, Italy**
  - **NbS:** Forested infiltration areas for aquifer recharge and mitigation of groundwater pollution.
  - **Climate resilience benefits:** Improved groundwater recharge, reduced nitrate concentrations, buffering against seasonal droughts, cooling of the environment.
  
-  **CS 4 – Bozcaada, Türkiye**
  - **NbS:** Natural infiltration, groundwater storage systems, natural barriers, conservation agriculture, and Water 4.0 (smart irrigation).
  - **Climate resilience benefits:** Enhanced soil water retention, erosion control, and increased irrigation efficiency, supporting adaptation to hotter and drier conditions.
  
-  **CS 5 – Oued Righ, Algeria**
  - **NbS:** Constructed wetlands and canal banks restoration
  - **Climate resilience benefits:** Improved water purification, reduction of pollution loads, reuse of treated wastewater, and ecosystem restoration along canals, increasing resilience to water scarcity.



# Tools and guidance supporting implementation

## **NATMed Full Water-Cycle Nature-based Solutions (FWC-NbS):**

- Technical specifications (D2.2) and implementation/assessment reports (D2.3, D3.3).
- Framework for integrating NbS into existing infrastructures, following IUCN Global Standards.

**Mediterranean Community of Practice (MedCoP):** A participatory framework for stakeholder engagement, knowledge sharing, and co-design.

**FWC-NbS Catalogue (D4.1):** Self-assessment results (based on IUCN Standard), challenges, good practices, lessons learned.

**FWC-NbS Guidelines (D4.2):** Practical recommendations for NbS design, implementation, governance, and replication across different contexts .

**Decision-Making Tool (D4.3) [dss.natmed-project.eu](https://dss.natmed-project.eu):** An interactive, user-friendly platform to help authorities and stakeholders choose and plan NbS. Provides structured, evidence-based support tailored to ecological, social, and economic needs .

**Replication Plan (D5.1):** Strategies for scaling and transferring NATMed approaches to other regions.

**Demonstration Sites (Case Studies):** Five pilot sites serving as living demonstration areas for cities to visit, learn from, and replicate approaches.

# Further Information



For more in-depth information on the NATMed concept, project vision, and definition of FWC-NbS, refer to the following public deliverables available on zenodo and the project website:

- D1.1 – Diagnosis of Sites
- D1.3 – Roadmap for Implementation
- D2.1 – Report of the Local Stakeholders
- D2.2 – 5 FWC-NbS Technical Specification
- D2.3 – Guidelines to the Tendering Process of the 5 Case Studies
- D3.1 – Monitoring Programme and Assessment Framework
- D3.2 – Baseline
- D3.3 – Case Study assessment
- DSS [dss.natmed-project.eu](https://dss.natmed-project.eu)

**1. Why is understanding local context important when implementing NbS, as shown in the NATMed case studies?**

- A) Because all NbS require the same technical design
- B) Because climate, governance, and socio-economic conditions influence effectiveness
- C) Because NbS eliminate the need for monitoring
- D) Because local stakeholders should not be involved

**2. Why is it important to include operation and maintenance plans in an NbS tender from the beginning?**

- A) To reduce the number of bidders
- B) To ensure the NbS can function and adapt over time
- C) To speed up the construction phase
- D) To avoid involving local stakeholders

**3. Why is baseline data important in a monitoring programme?**

- A) It provides evidence of conditions before interventions
- B) It replaces the need for KPIs
- C) It only measures financial costs
- D) It is optional for evaluation

**4. Why do NbS often face challenges in policy and governance frameworks?**

- A) They are more expensive than grey infrastructure
- B) Regulations are usually designed for conventional/grey solutions
- C) They are not supported by citizens
- D) They do not require monitoring

**5. Which of the following is a Key Performance Indicator (KPI)?**

- A) "Water is important for life"
- B) "Communities like nature"
- C) "We plan to implement a wetland"
- D) "Soil organic matter increased by 10%"

**6. Centralized water management can sometimes limit the adoption of NbS at the local level. TRUE or FALSE?**

# Glossary



- CS** Case Study
- CTD** Conductivity, Temperature, and Depth
- CW** Constructed Wetland
- D** Deliverable
- DZD** Algerian Dinar
- ES** Ecosystem Services
- FIA** Forested Infiltration Area
- FWC-NbS** Full water Cycle Nature-based Solutions
- ICT** Information and Communications Technology
- IUCN** International Union for Conservation of Nature
- IZTECH** İzmir Institute of Technology
- KPI** Key Performance Indicator
- MAR** Managed Aquifer Recharge
- MedCoP** Mediterranean Community of Practice
- NATMed** Nature-based Solutions on existing infrastructures for resilient Water Management in the Mediterranean
- NbS** Nature-based Solutions
- NVZ** Nitrate Vulnerable Zone
- O&M** Operation and Maintenance
- SDG** Sustainable Development Goals
- TL** Turkish Lira
- WWAP** World Water Assessment Programme

NATMed

Nature-based Solutions on existing  
infrastructures for resilient Water  
Management in the Mediterranean



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