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BLUE RECHARGE

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„Blue credits for water aquifers recharge and sustainability"

Bologna, 14th May 2026

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INTRODUCTION:

The BLUE RECHARGE project aims to preserve groundwater by introducing innovative aquifer replenishment and conservation systems. It seeks to reverse current trends of groundwater overexploitation by increasing managed aquifer recharge (MAR) and promoting sustainable water use.

The project develops a transnational mechanism called Blue Credits, which financially rewards public and private entities for contributing to aquifer recharge. It combines technical innovation, economic modelling, and policy harmonisation across Croatia and Italy.

The overall objective is to achieve and maintain good chemical and quantitative status of groundwater, in line with the EU Water Framework Directive and the European Green Deal.

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Partners:

1. City of Vodnjan-Dignano (Lead partner - CRO)
2. Venetian Cluster – ITA
3. ART-ER Joint Stock Consortium Company- ITA
4. EXO Consortium Company - ITA
5. Emiliano Romagnolo Canal Reclamation & Irrigation Board- ITA
6. University of Rijeka, Faculty of Economics and Business- CRO
7. University of Rijeka- CRO
8. IWS – Istrian Water Protection System- CRO

Associated organisations:

1. Global Network of Water Museums- ITA
2. Region of Emilia-Romagna - ITA
3. Istrian County - CRO
4. Pula–Labin Water Utility- CRO

Program: Interreg VI-A Italy-Croatia 2021.-2027.

Total Value of the Project: 1.989.798,43 EUR

ERDF amount allocated: 1.591.838,74 EUR - (80%)

Project Duration: 01.02.2024. – 31.07.2026

Technical and Strategic Motivation for the Project

Groundwater is a strategic resource across the Adriatic region, supporting ecosystems and all major economic sectors. Aquifers supply a substantial share of essential water needs, including:

- 65% of drinking water and
- 25% of agricultural demand.

Karst formations dominate the eastern Adriatic region, particularly in Croatia and parts of Italy, forming highly permeable aquifer systems that are especially vulnerable to contamination and over-abstraction.

The high permeability and limited natural filtration of these carbonate aquifers result in exceptional groundwater vulnerability to contamination and over-abstraction. Climate change further worsens the already fragile situation.

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Project Structure and Key Phases

THREE WORK PACKAGES:

WP1: Knowledge harmonisation, modelling and governing the blue credits' market

Activities:

A1.1. Comparison of Italian and Croatian regulations on aquifer recharge management

A1.2. Definition of EU-level best practices for aquifer recharge management

A1.3. Feasibility of the Blue Stewardship mechanism

A1.4. Supportive technology for the economic model of blue credits
(Blockchain system for smart transactions)

A1.5. Development of a communication strategy

- ✓ Deliverable: Report on national regulations
- ✓ Deliverable: Video of best practices / lessons learnt
- ✓ Deliverable: Transnational Committee + Feasibility report
- ✓ Deliverable: First survey on the blockchain market
- ✓ Deliverable: Informative materials, project newsletter

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Project Structure and Key Phases

WP 2: Integrated case studies

A2.1. Case study in Italy

Assessment of the feasibility of implementing blue credits for groundwater recharge in a watershed managed by the Canale Emiliano-Romagnolo (CER).

✓ Deliverable: Report – Case study, Italy

A2.2. Case study in Croatia

Assessment of groundwater quality and compliance risks in Southern Istria as a basis for blue credits implementation.

✓ Deliverable: Report – Case study, Croatia

A2.3. Analysis of results in the pilot cases

Synthesis and comparison of results from the pilot case studies.

✓ Deliverable: Handbook on case study results; Interregional Conference on pilot cases

A2.4. Environmental impact of the case studies

Evaluation of the environmental impacts of Managed Aquifer Recharge (MAR), including groundwater level fluctuations and quality changes.

✓ Deliverable: Report – Environmental impact of the case studies

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Project Structure and Key Phases

WP 3- Cross-border policies for the replicability of the blue credits' market

A3.1. Mechanism of Blue Stewardship as an integrated management measure for climate change mitigation (Italy and Croatia)

✓ Deliverable: Handbook – Blue Credit Market for Climate Change Adaptation

A3.2. Definition of EU-level replication guidelines

✓ Deliverables: EU-level Replication Guidelines; Communication campaign

A3.3. Workshop for technicians and policymakers

✓ Deliverable: Training tools for technicians and policymakers

A3.4. Building consensus and civil society engagement

✓ Deliverable: Blue Recharge communication and educational materials

2. PILOT ACTION RESULTS: FIELD IMPLEMENTATION

Structure of Project Implementation in the Southern Istria Pilot Area:

- City of Vodnjan – Lead Partner: Responsible for implementing the Stormwater Management Study, developing the Integrated Water Resources Master Plan, and carrying out infrastructure improvements.
- Istrian Water Protection System: Responsible for research on groundwater level fluctuations and water quality dynamics, including the assessment of possibilities for managed aquifer recharge.
- Faculty of Physics, University of Rijeka: Responsible for research on water exchange dynamics using stable isotope analysis.
- Faculty of Economics, University of Rijeka: Responsible for research on the economic components of water use and water resource replenishment.
- Pula–Labin Water Utility: monitors water quality.

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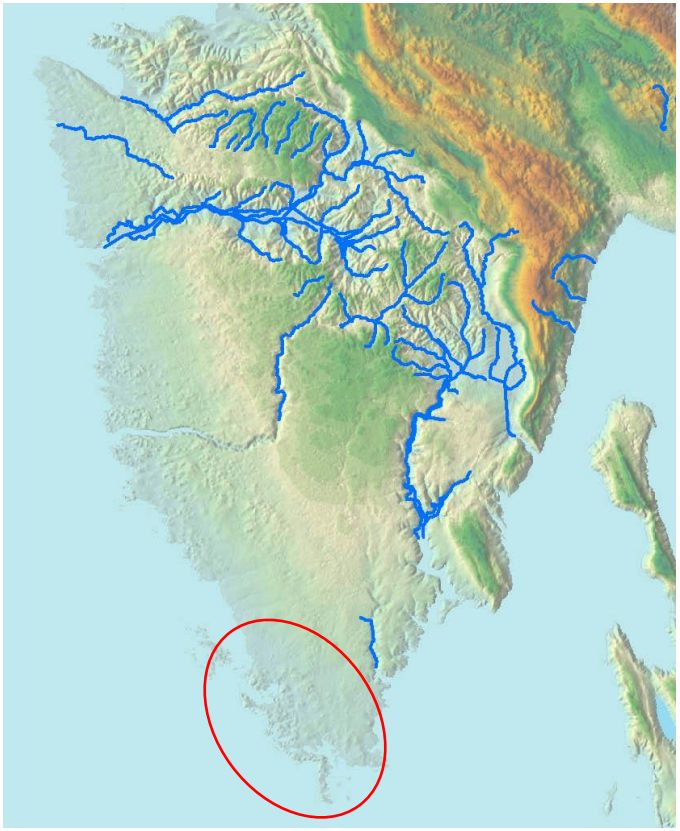

Southern Istria has no permanent surface watercourses due to its karst geology. Water resources are stored in a karst aquifer with low porosity, which limits its capacity to accumulate water seasonally.

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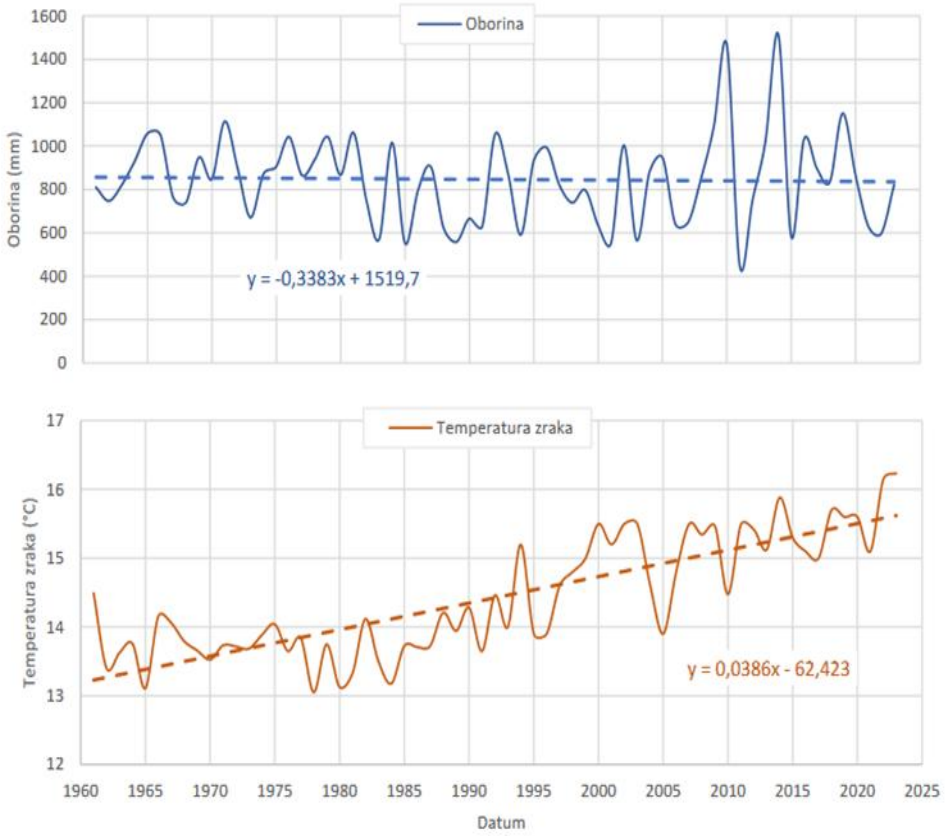

Annual trends of average air temperature and precipitation at the Pula meteorological station (1961–2023)

Climate Conditions

- There is a very pronounced trend of rising air temperatures, while no clear trend is observed in precipitation.
- However, greater variability is present, with increasingly pronounced wet and dry periods.
- This poses challenges for water management, as it increases the risk of water shortages for various uses and also brings risks of periodic flooding.
- The negative impact of climate change is evident.

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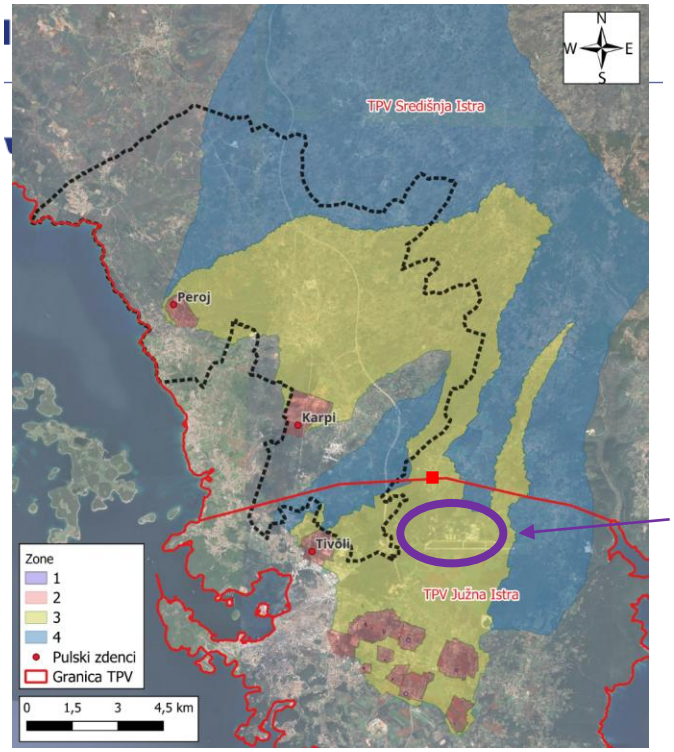
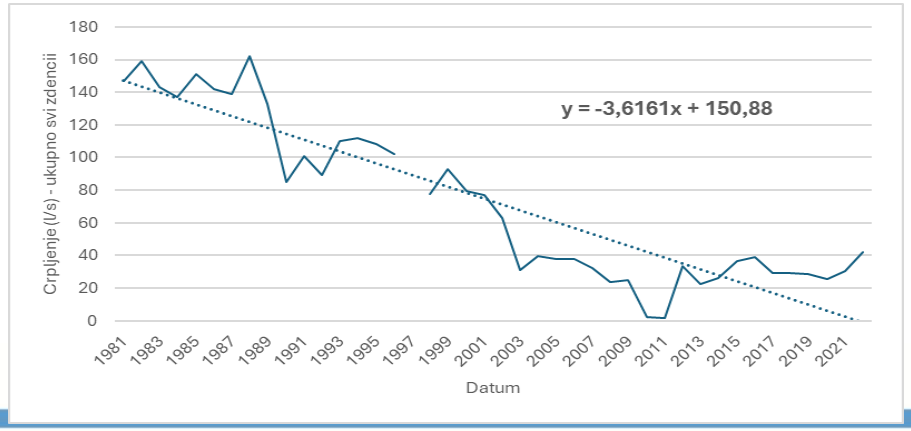
The only significant coastal water source in Southern Istria is the Karolina spring in Pula, dating back to Roman times. However, it was abandoned in the last century due to contamination and the inability to ensure protection in a highly urbanized environment.



The exploitation of the Peroj and Karpi wells, as well as several other wells in the Pula area, gradually decreased due to nitrate contamination (caused by agriculture and uncontrolled urban development). Pumping eventually stopped in the 1990s, when the Butoniga reservoir—constructed in the Mirna River valley in Northern Istria—was integrated into the water supply system.

However, the severe droughts of 2012 and 2022 prompted new groundwater exploration, resulting in the development of eight deep wells located further inland, away from the coast and outside highly urbanized areas east of Vodnjan. The Loborika wastewater treatment plant is also situated nearby.

Although the Peroj and Karpi wells are no longer used, large sanitary protection zones remain. These zones will need to be revised, and the water redirected to other purposes – primarily agricultural use.



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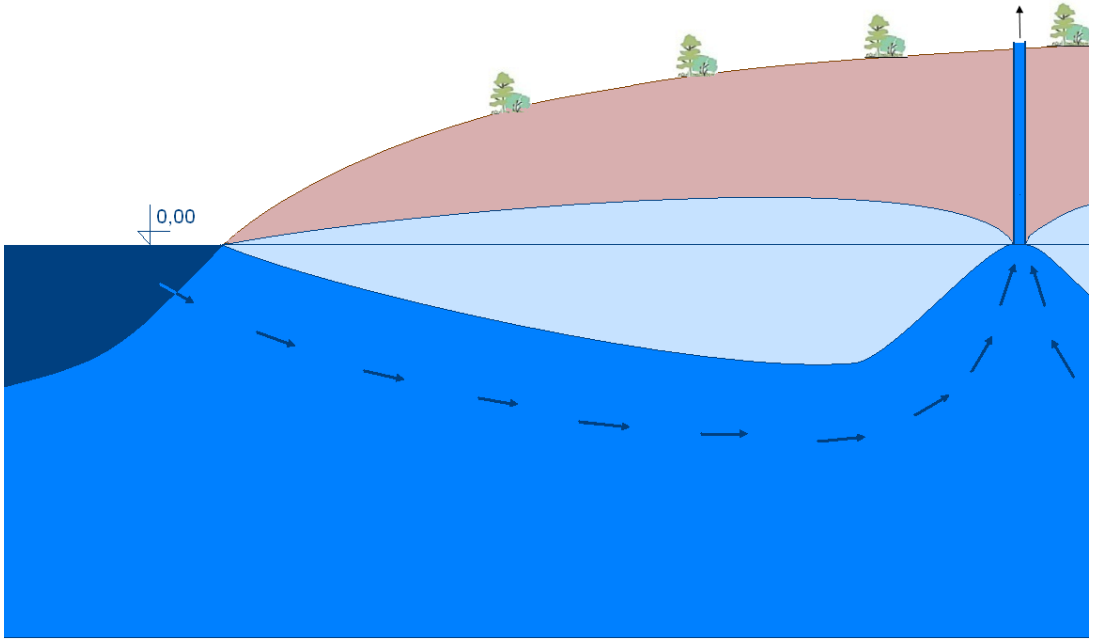
The ongoing construction of the new Peroj Wastewater Treatment Plant further enhances the potential for implementing MAR in this area. Once operational, the facility will provide a continuous and reliable source of treated wastewater, with a design capacity of 48,000 Population Equivalent (PE), increasing to 58,000 PE when fully completed.

The plant is expected to treat more than 1 million m^3 of water annually, with peak summer flows of around 50 L/s.

In this way, the new treatment infrastructure creates an important opportunity to develop a sustainable MAR scheme that strengthens regional water security.

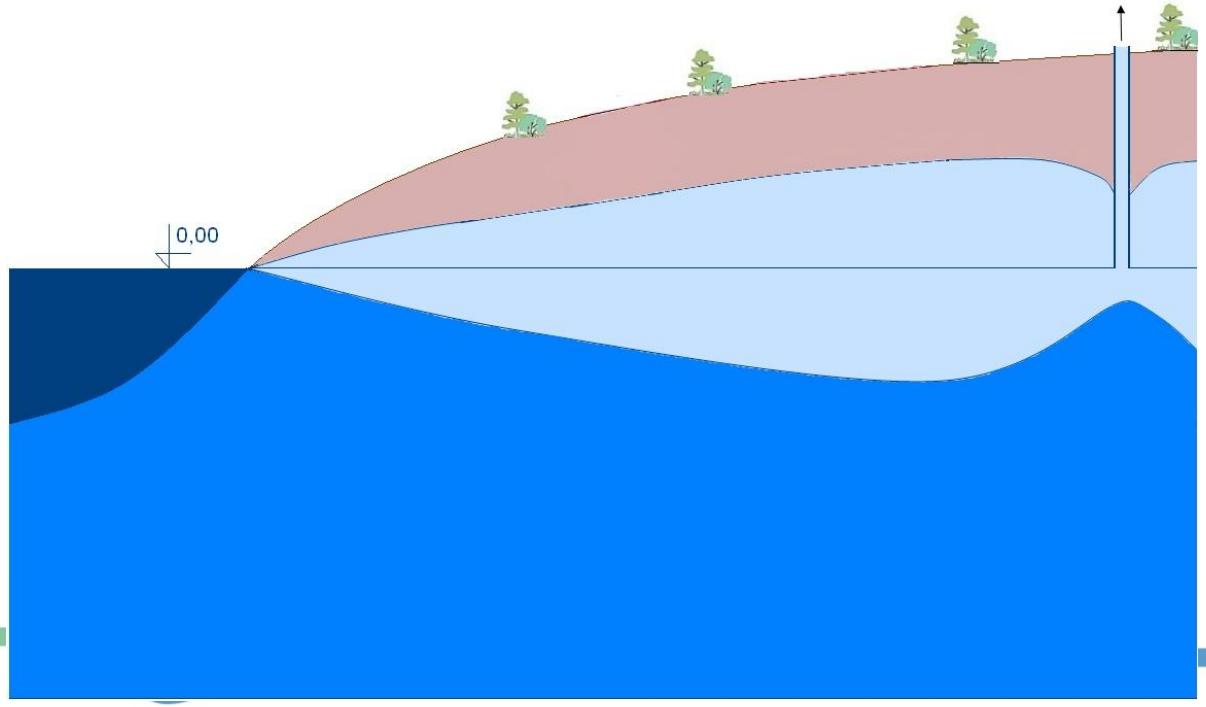
Current state: over-extraction of the aquifer with saltwater intrusion



This illustration shows the problem of coastal aquifer over-extraction.
When pumping exceeds natural recharge, the freshwater level drops and seawater (dark blue) begins to intrude inland.

Brackish water (blue) then mixes with the freshwater layer (light blue), eventually causing wells to produce brackish instead of fresh water.

Planned state – infiltration of treated wastewater into the aquifer through infiltration wells and fields



The solution shown here is the infiltration of treated wastewater into the subsurface through recharge wells or infiltration fields.

This increases the thickness of the freshwater layer in the coastal zone, enables greater abstraction from production wells, and prevents saltwater intrusion

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Development of a Master Plan for Integrated Water Resource Management

- To address the growing local needs for water and the protection of water resources, as well as future challenges, the project includes the development of a “Master Plan for Integrated Water Resource Management” for the City of Vodnjan.
- Although the plan will cover all segments of water management, the focus is on activities under the direct responsibility of the local community, particularly: stormwater management, protection of aquatic water resources (groundwater and surface water bodies such as ponds, as no other surface resources exist),securing water for irrigation from existing sources, and under improved conditions through the application of MAR (Managed Aquifer Recharge) procedures.
- The plan will also include segments related to public water supply systems, drainage, and municipal wastewater treatment, which fall under the competence of specialized institutions such as Croatian Waters (national water management agency) and municipal utilities.
- An important foundation for the Master Plan is the implementation of research results related to water dynamics and exchange in Southern Istria, as well as the discharge of treated wastewater at the Loborika WWTP, carried out by project partners IVS and the University of Rijeka.

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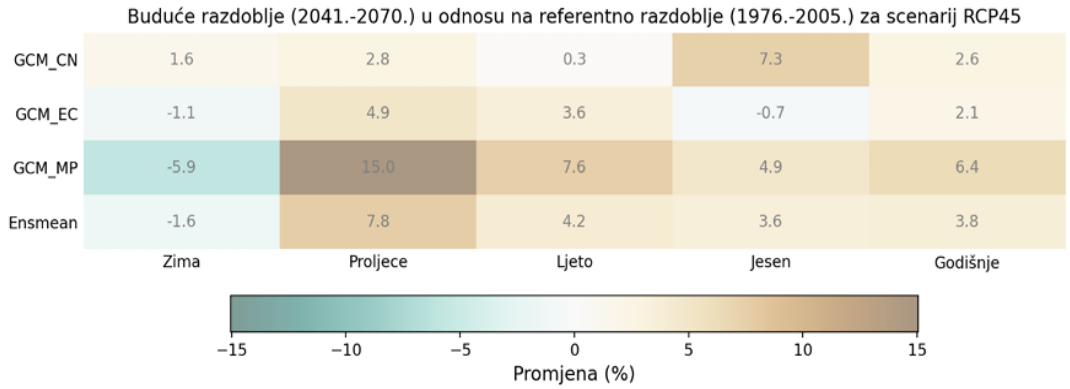

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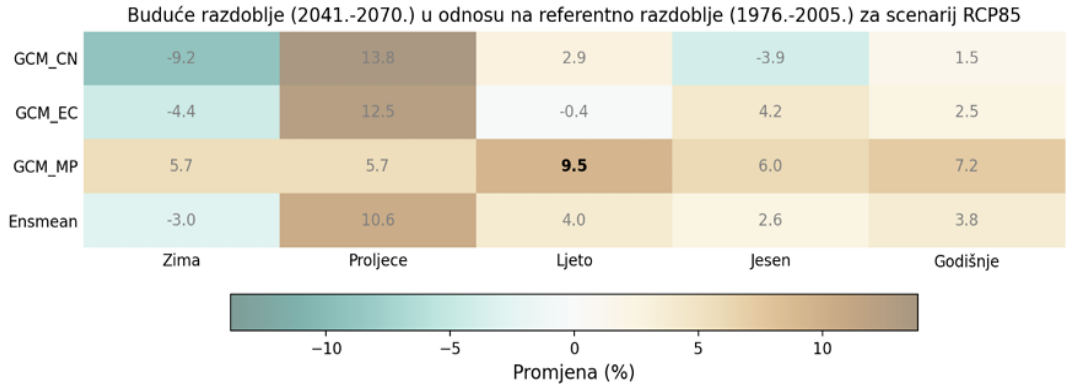

To ensure long-term resilience of water resources, the Master Plan must also account for future climate conditions.

Precipitation analysis was based on historical data and projections for the period 2041–2070, compared to the reference period 1976–2005, using two greenhouse gas emission scenarios (RCP 4.5 and RCP 8.5).

Projections were made with the regional climate model (RegCM), driven by three global models (CNRM-CM5, EC Earth, MPI-ESM) and an ensemble average (Ensmean).

Results show an increase in the number of dry days, while intense daily precipitation shows the opposite trend – expected to rise by up to 20% (RCP 4.5) and 30% (RCP 8.5). This suggests future climate conditions will bring longer dry spells combined with more frequent short, high-intensity rainfall events.

Conclusions – current stage of implementation

I. The project has so far produced research studies and technical documents aimed at improving water management within the scope of the local community.

II. The ongoing implementation of the BLUE RECHARGE project in the pilot area of Southern Istria, with a particular focus on the City of Vodnjan, is establishing the initial foundations for enabling the artificial recharge of coastal karst aquifers with treated wastewater — as a strategic response to increasing water demand and the growing impacts of climate change.

III. As part of the project, an economic model has been proposed to support future MAR development, which is expected to have relevance beyond the pilot area. Together with the preparatory work carried out so far, these elements contribute to creating the conditions for protecting and optimising regional water reserves under changing climate conditions.

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