



Project WARBO

Water re-born - artificial recharge: innovative technologies for the sustainable management of water resources

ground water

water saving

PROJECT DESCRIPTION

Depletion and pollution of surface and underground water resources are becoming increasingly widespread phenomena. The causes are mainly due to the increase in water consumption and quality deterioration of the water resources, phenomena linked to factors such as changes in the agricultural practices, population growth and climate change. In this context, managing and governing the water resource and its use is one of the main challenges to be faced worldwide. With reference to the Mediterranean areas, which show anomalies of higher average temperatures compared to the climatological values recorded on a global scale, effective and immediate compensation measures are necessary in order to reduce the phenomenon of qualitative and quantitative water degradation.



OBJECTIVES

In this scenario the WARBO project was designed to meet the need to **safeguard, protect and enhance water resources and terrestrial ecosystems, through the regulation of the artificial recharge (AR) of groundwater and the analysis of different application methodologies (ARM "Artificial Recharge Methodologies")**. The project had the aim to define methodologies of Artificial Recharge, related problems and main objectives of its application, as well as some concrete examples of application. In addition the procedures that precede the recharge were presented with particular attention to the identification of underground aquifers by using seismic reflection and geoelectric data, as well as the purification processes of wastewater intended for the Artificial Recharge. Another objective was to identify recovery and cleaning measures for the so-called "gray waters".

WARBO considers **AR the only effective method in the short and long term to combat water scarcity and drought**. In fact, it makes it possible – containing the competitive use's dynamics - to reduce the imbalance between water demand and availability of the resources for domestic and agricultural uses, as well as for industrial and craft activities that require fresh water. Moreover, AR is considered the best method to rebalance the water cycle's equilibrium, in harmony with the territory's structure; and it is also used for the construction of hydraulic barriers to contrast saltwater intrusion in coastal areas to avoid the risk of salinization of aquifers with consequent destruction of agricultural crops.

Demonstrative project actions have been implemented in areas representative of the qualitative-quantitative degradation of water resources in different climatic regions of Central and South Europe, where fast-acting interventions are needed in order to prevent water scarcity.

PROJECT PHASES

The project has applied different methodologies of artificial recharge in three test areas to facilitate the storage in the subsoil of



part of the rainfalls that flow into the main waterways to the sea. The project has used methodological and technological **innovations in the field of remote sensing, applied geophysics, hydrogeology, geochemistry and environmental economics (applied through an integrated multidisciplinary approach)**. Monitoring and analysis have been carried out to evaluate and demonstrate the advantages/ disadvantages of the different methodologies, to identify the quality indicators necessary for their correct application and to verify the qualitative and quantitative repercussions of the artificial recharge in the short, medium and long term.

The main project activities (described in detail in the [Final Report](#)) were:

- **Database and implementation of the GIS** - Definition of the sites' characteristics for the application of the aquifers' AR method with particular attention to the methodology for monitoring and defining the reference indicators.
- **Technical-scientific and procedural support (from the Regional Environmental Protection Agency) to the feasibility of the various project phases; and evaluation** of geological, chemical, biological and environmental data **within the DPSIR** (Driving Forces, Pressures, State, Impact, Responses) **logical schemes;**
- **Application of integrated methodologies for defining the artificial recharge's efficiency** in the Friuli flood plain and in the lower Po Valley;
- **Development of mathematical models for the recharge management;**
- **Artificial recharge of complex alluvial aquifers with different salinization and/ or pollution levels:** application to a test area in the territory of Copparo;
- **Integrated geophysical, hydrogeological, geochemical and biological methodologies for the management of artificial recharge of complex multi-aquifer systems (Directive 2000/60/CE, Leg. Decree no. 152/06);**
- **TGRA** (Integrated thermometric detection for artificial recharge): innovative system for continuous monitoring of the infiltration's efficiency and of the water quality;
- **Application of innovative technologies for the implementation and management of recharge wells;**
- **Hydrogeological support activities** to improve knowledge on local hydrogeology;
- **Environmental and socio-economic analysis** of the artificial recharge;
- **Dissemination** of news, skills and knowledge to create a solid technical-scientific culture enhancing the functionality of the Artificial Recharge of protecting and conserving water resource.

PROJECT RESULTS

The results achieved by WARBO make it possible to provide Bodies (Region, Province, Municipality, reclamation consortia, etc.), professionals and researchers of the sector with tools to assess the risk of degradation of water resources and the proposals of artificial recharge essential for a correct balance of the economic and environmental impacts of water availability.

The **three selected test areas** are: the Po delta area (in the province of Ferrara), the Friulian Upper Plain (in the province of Udine) and an area of the Friuli-Venezia Giulia Region's resurgences (in the province of Pordenone) where various methods of artificial recharge have been applied:

- **Innovative experimental artificial recharge facility of Mereto di Tomba (UD).**
- **Phytodepuration plant of the Ponte Rosso-ZIPR Industrial Area in San Vito al Tagliamento (PN).**
- **Quarry lake in Ponte San Pietro Copparo (FE).**

The project has assessed the role that recharging can have in counteracting the diffuse pollution by nitrates (in the Friuli plains) and by salinization (in the Po Valley). Furthermore, it was verified that recharging is integrated into the flood management plans, defining phytodepuration strategies to be put in operation in the water derivation channels with the aim to ensure quality. WARBO has analyzed how to connect the reservoirs of the quarry with the river network and consequently strengthen the ecological corridor of the waterway axis. Finally, the project introduced innovative methodologies for the characterization of sites in order to promote essential knowledge for correct management plans. The addressed problems are common to many climatically sensible areas that face the Mediterranean; the **managing bodies of the facilities (Consortium Leda Tagliamento and the Municipality of Copparo) have included the recharging activities in their management plans, therefore they will give continuity to the project.**

It is to be mentioned that the analysis of various artificial recharging methods reveal that the applicability of ARM is characterized by a strong geographical variability, and that at basin level the response may be different based on orographic, geological and biological factors, for which this response at local level has to be assessed in the context of its application. For the purposes of a correct understanding of the achieved results, monitoring was essential in all phases of ARM, in order to assess eventual direct



effects in the vadose zone and subsequently in the aquifer.

An innovative factor and strong point of this project was its **interdisciplinarity and the multidisciplinary of the applied scientific methodologies** and not just; before the presentation, a series of experimental methodologies (geophysical, geochemical, interferometric) have been tested with excellent results. These methods, applied for the first time in an ARM study, have allowed to obtain a lot of data necessary for the evaluation of the fundamental parameters that allow to make a water balance (porosity, fracturing, soil texture, etc.) and to obtain more reliable and accurate models, based on real, updated and non-theoretical experimental data. This methodological tool can be applied as support for updating the legislation, aimed at achieving the objectives of the enhancement and protection programs envisaged by the water-related directives.

Outputs, related to the single actions, can be downloaded in the [deliverables](#) sector of the project's website. These outputs, in addition to providing more details on the activities carried out and the results achieved, are also useful for the replicability of the initiative, in particular for the following aspects:

- [Hydrogeological protocols](#) for selection of the intervention areas, monitoring methods and evaluation of the artificial recharge's effectiveness;
- [Definitive integrated WARBO](#) model. The report describes the entire experience acquired during the project in the field of hydrological modeling to support the study of aquifers' recharge, as well as the best instrumentation and methodologies for the subsoil system's characterization and monitoring of the aquifers' dynamics;
- [Report on the WARBO multidisciplinary protocol](#). The data on chemical, hydrogeological, chemical-physical and biological monitoring of the surface and underground water bodies in the test areas allowed to describe seasonal dynamics, identify the causes of resource depletion and describe the system's response to natural and artificial recharge. The synthesis of these dynamics was obtained by the elaboration of all the data with hydraulic, hydrogeological and geochemical models useful to describe the dynamics of exchange between surface waters and groundwater, defining the qualitative and quantitative impacts of the artificial recharge on the resources stored in the subsoil. The results of these activities allowed the drafting of **multidisciplinary analysis protocols supporting the recharge procedures and methodologies that are developed and drafted on the basis of the EU regulatory framework**, proposing - with the WARBO project - methods, experiences and operational tools for the implementation of and coordination between the Floods Directive 2007/60/EC and the Water Framework Directive 2000/60/EC, in the knowledge that compatible management of recharge facilities has to deal with hydraulic and hydrogeological safety questions as well as with integrated management of irrigation water resources;
- Report on [Application of the DPSIR methodologies in the Friuli area](#) and assessment of the potential of wastewater reuse in the recharging with AFI system;
- [Multidisciplinary WARBO protocol and assessment of the protocol's transferability](#) to other European contexts. The Report provides a summary of the technical and scientific work carried out within the WARBO project in application of the Water Framework Directive through the use of artificial recharge of aquifers in flood plain areas affected by serious qualitative and quantitative water losses. The project has used both conventional and innovative methods aimed at site characterization, artificial recharge monitoring and data processing. Methodological innovations are also reported in the document.
- [Parameters and descriptive indicators of environmental and socio-economic aspects of AR](#), a document containing an inventory of impacts of the aquifers' recharge;
- Report on the [TGRA](#) system's design and acquisition of lithostratigraphic data necessary for the system's calibration.
- Report on [Monitoring results of the efficiency of new type wells designed to optimize AR](#) with the multidisciplinary WARBO protocol.

A key aspect of the project is represented by its **replicability** in contexts with problems similar to those of the pilot sites. The main elements that make the project replicable are:



- **approach to the water resource context**, which allows all employees in the sector to adopt a broader perspective offering effective and achievable innovation opportunities;
- **project structure** (which combines an analysis of the context and of the innovation opportunities available to deal with sustainability and water resource issues).
- **Follow-up of issues relevant at national and international levels and having important implications at local level; reduction of the encountered negative environmental impacts and improvement of the problem solving effectiveness;**
- **direct involvement of managing authorities, stakeholders, businesses, consumers, etc;**
- **development of concrete innovative solutions for the competent authorities and their dissemination to all the bodies responsible for the territory's management.**



Acronym
WARBO

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Reference Programme
LIFE

Beneficiary Coordinator
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale)

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860.887,00

Call Year
2010

Start Year
2012

End Year
2014

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Region
Friuli-Venezia Giulia

Description

Friuli Venezia Giulia, Emilia-Romagna.