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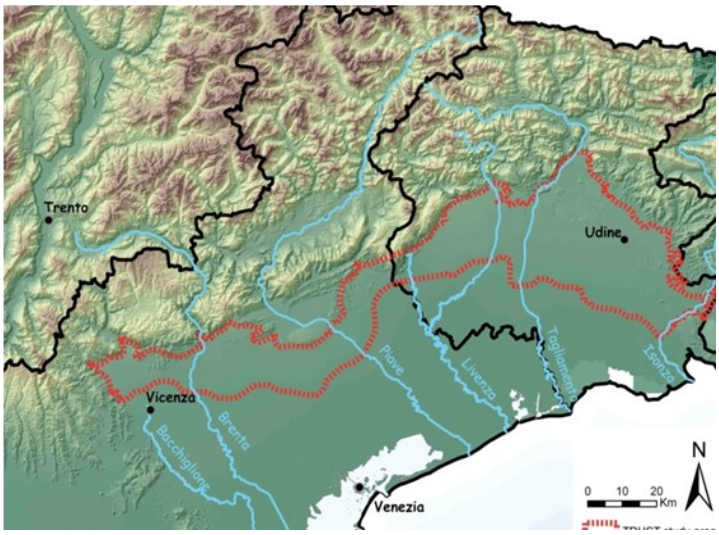
THE TRUST PROJECT

The TRUST project, Tool for Regional scale assessment of groUndwater STorage improvement in adaptation to climate change, co-financed by the European Community's LIFE+ 2007 programme and the Italian Ministry for the Environment, Land and Sea, has addressed the impact of climate change on the future availability of groundwater resources. The project, started in January 2009 and ended in December 2011, was carried out by the Italian Authority of the Northern Adriatic river basins together with the engineering consultant SGI Studio Galli and the Euro-Mediterranean Centre for Climate Change.

The project domain was the aquifer recharge area in the high plains of Veneto and Friuli regions in North Eastern Italy. The area has the Isonzo, Tagliamento, Livenza, Piave and Brenta rivers flowing eastwards, and the far western Bacchiglione river.



The main goal of TRUST was to assess the effects of climate change on the recharge of the study aquifer and on groundwater uses. The predicted climate change scenarios for the 21st century were the boundary condition to quantify the variations on the hydrological balance in the region; the most cost-effective adaptation measures including techniques for Managed Aquifer Recharge and the rationalisation of groundwater abstraction were investigated. A Regional Risk Assessment was conducted to determine the areas affected by the risks of water deficit for irrigation and nitrate pollution of groundwater.

TRUST has contributed to advance the knowledge base of the groundwater mechanisms in the project area and will aid the management and planning of this precious resource in the coming years. The project is aligned with the implementation of the River Basin Management Plans of Directive 2000/60/EC that establish objectives and measures to improve the status of surface and ground waters.

METHODOLOGIES AND RESULTS OF TRUST

A Technical Board was established including the key stakeholders concerned with groundwater management and exploitation. Stakeholders' participation proved fundamental for guaranteeing the consistency of the project activities and achieving the project goals and long term sustainability of the project results. Agreements with stakeholders were signed for the provi-

***FIGURE 1** – Technical Meetings for presenting the TRUST project to the key stakeholders*

sion of data and the implementation of flow monitoring campaigns and Managed Aquifer Recharge demonstrations. The collaboration with stakeholders was maintained for the whole duration of the project and was very successful.

A project Web GIS database was implemented with all the data used and produced in the project. The database is accessible from the project website (www.lifetrust.it) and contains hydrological and hydro-geological information as well as modelling results. Following the end of TRUST, the project coordinating beneficiary and the stakeholders will use the database for the planning and management of water resources of the Veneto and Friuli regions.

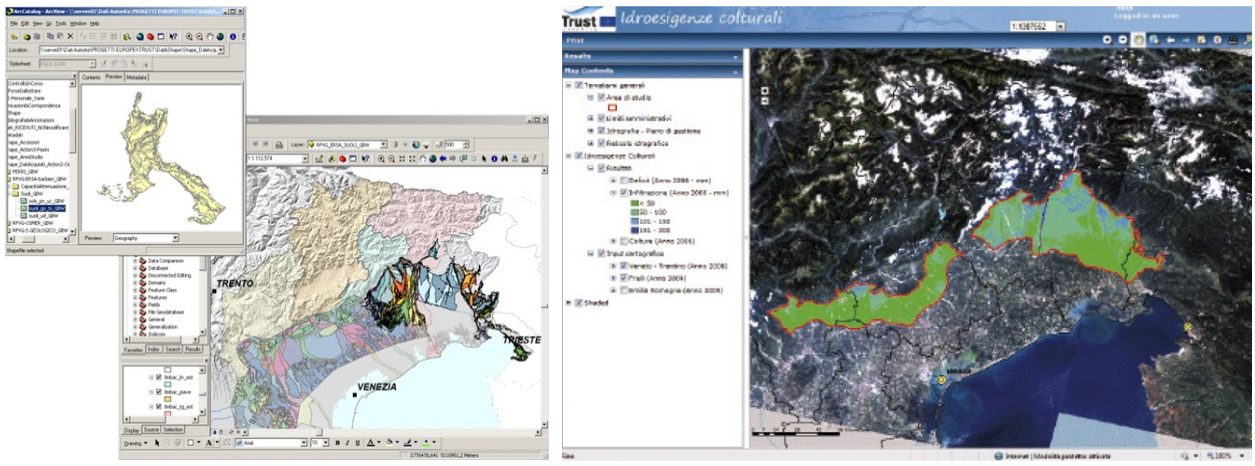


***FIGURE 2** – Views of the TRUST Web-GIS database*

The simulations of the A2 and A1B scenarios of the IPCC (Intergovernmental Panel on Climate Change) were performed with the CMCC climate models and indicated that the whole Euro-Mediterranean region is likely to be affected by a temperature rise in the late 21st century. In the study area, the heating on land could be approximately 5°C , especially during the summer season; a reduction in precipitation (about ~ 0.5 mm / day towards the end of the century) also characterizes the region.

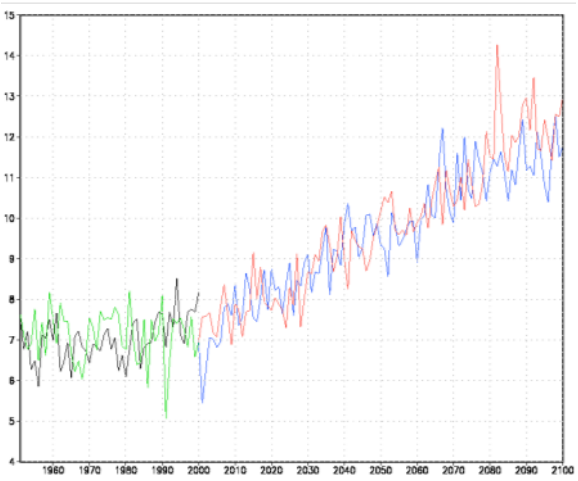
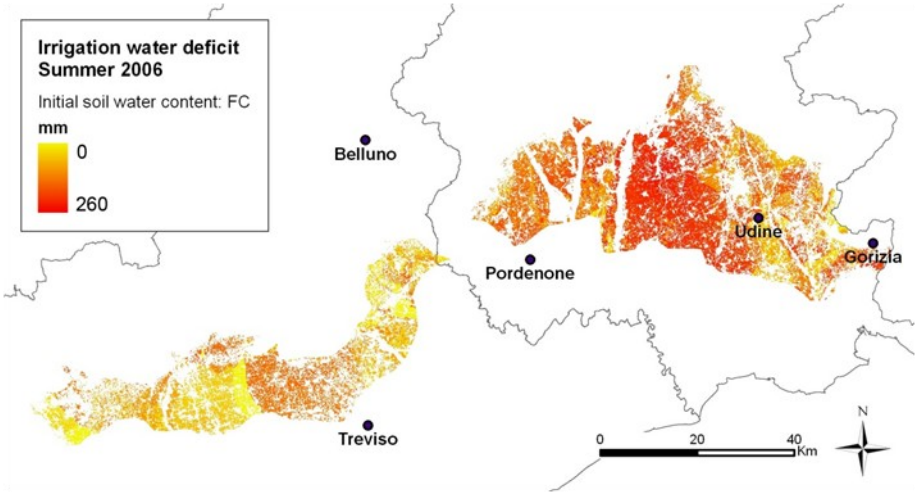


***FIGURE 3** – Temporal series of average temperatures at 2 meters over the TRUST area: The observed data are from the Climatic Research Unit (Mitchell e Jones, 2005). The temperature units (y axis) are in °C, the time (x – axis) is expressed in years*

The forecasted climate change scenarios were used to quantify the water deficits for irrigation of summer crops based on remote sensing and GIS-based modelling techniques; the forecasted water deficit was projected until the end of 21st century.

***FIGURE 4** – Cumulative irrigation summer deficit estimated for year 2006. The deficit mapping was obtained by 5 days cumulative data for the modeling iterations.*



A innovative hydrological model was developed to estimate the flows of the rivers that feed the aquifer in the study area. The model described processes in a continuous and distributed fashion based on information derived from digital terrain maps and the geo-statistical interpolation of meteorological data and land use maps. The modelling study forecasted the variations of river flows induced by future climate scenarios: they will increase in the winter whilst decreasing in the summer, spring and autumn seasons.

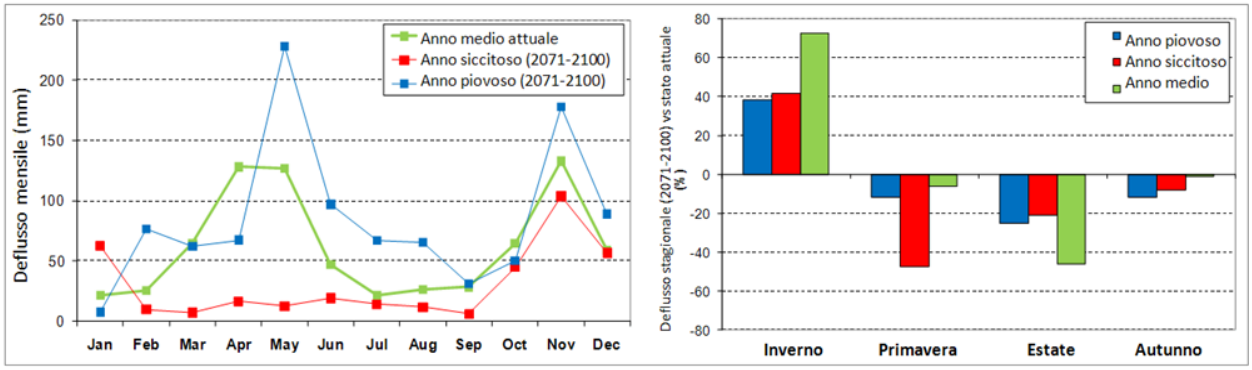


FIGURE 4 *- Monthly discharge and variations of the cumulative seasonal discharge in the the average, dry and wet years (green, red and blue) in the period 2071-2100 , Astico river.*

A groundwater model was developed to analyse the variations in the hydrogeological balance. The rivers and groundwater dynamics were modelled with the Danish Hydraulic Institute's Mike 11 and Mike SHE software. The model was calibrated using water table measurements from 200 stations for the period between years 2000 and 2008.

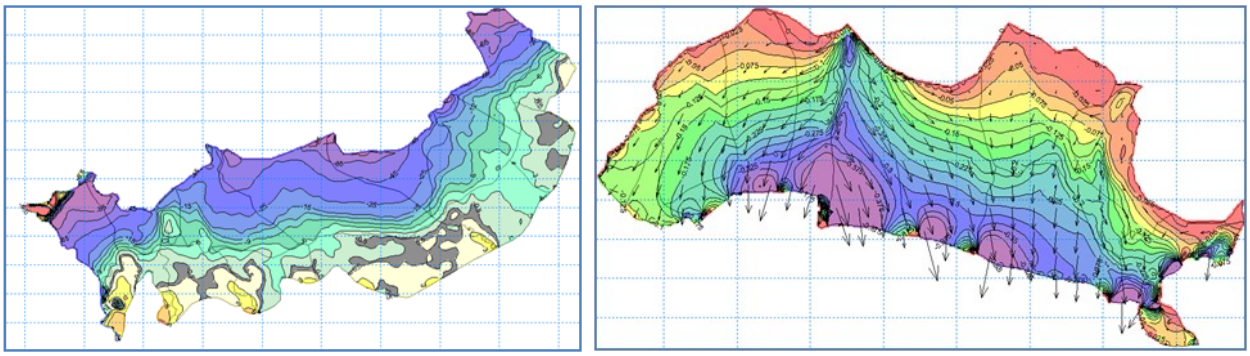


FIGURE 5 *– Water table depths in Veneto area and map of groundwater flow derived from the groundwater model of Friuli region (Mike SHE, DHI).*

The modelling activity was supported with field measurements that quantified the seepage to the aquifer from the beds of the rivers Astico, Brenta, Piave, Tagliamento and Torre, and its main tributary Natisone.

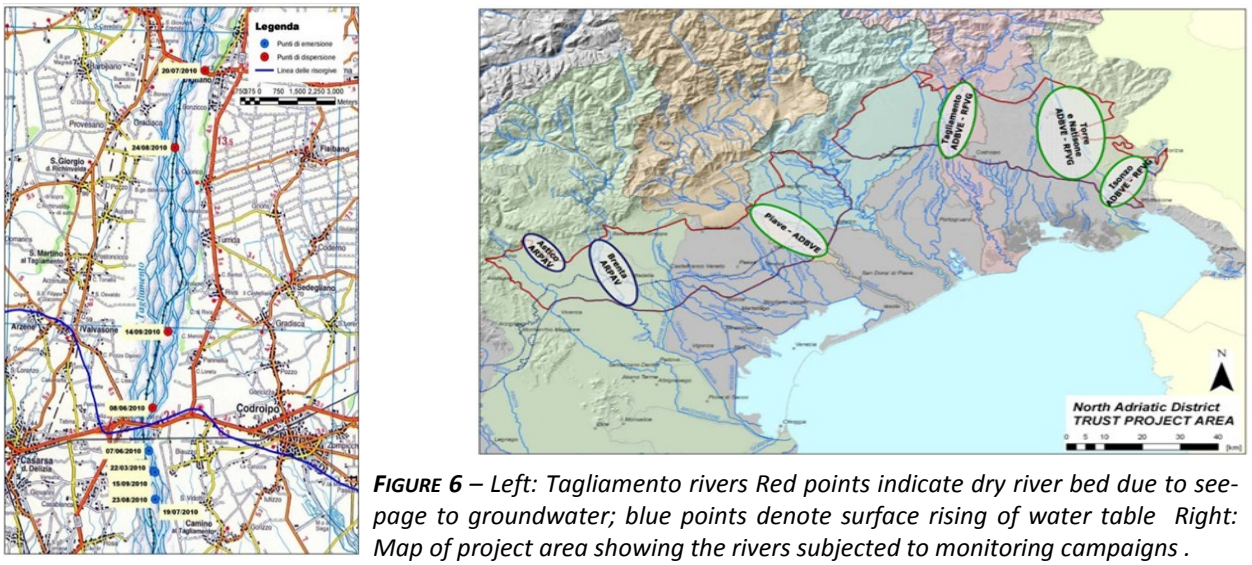


FIGURE 6 *– Left: Tagliamento rivers Red points indicate dry river bed due to seepage to groundwater; blue points denote surface rising of water table Right: Map of project area showing the rivers subjected to monitoring campaigns .*

Additionally the effectiveness of Managed Aquifer Recharge techniques was tested at three demonstration sites to verify the effect of different land cover, lithology and irrigation techniques. The testing sites were adequately equipped to recharge aquifers thanks to involvement of three stakeholders: the Irrigation Consortia of the Brenta, Piave and Ledra-Tagliamento rivers.

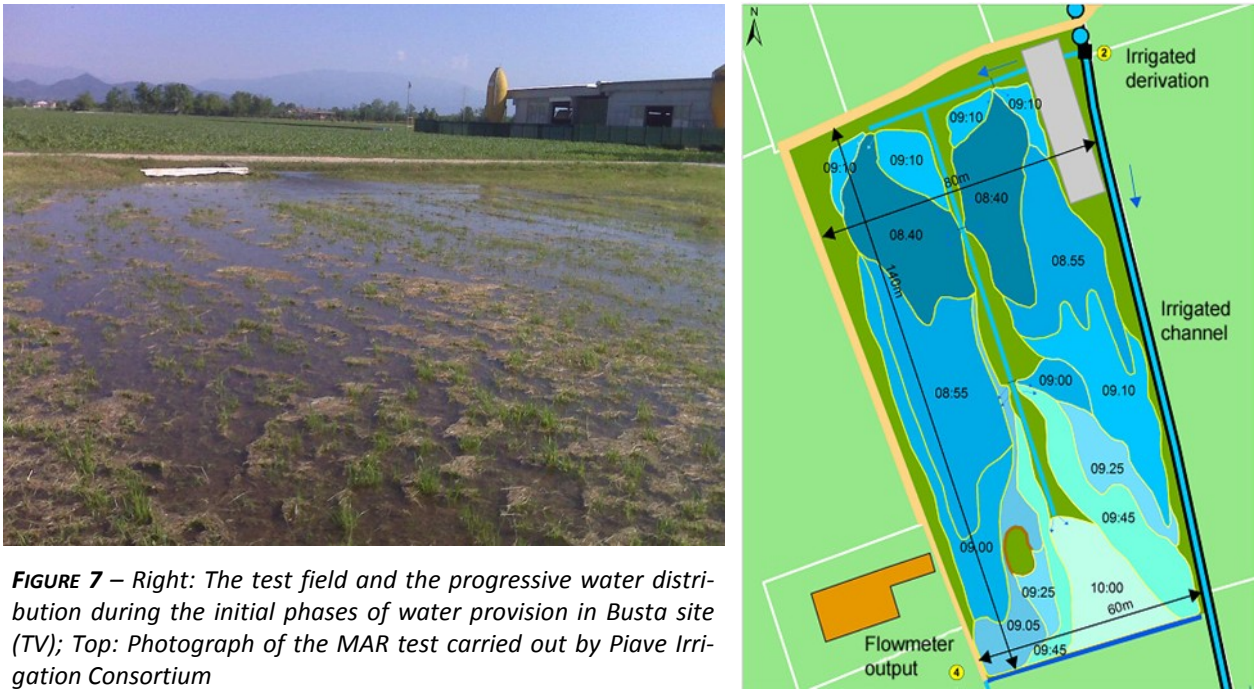


***FIGURE 7** – Right: The test field and the progressive water distribution during the initial phases of water provision in Busta site (TV); Top: Photograph of the MAR test carried out by Piave Irrigation Consortium*

Assessment of the benefit and impact

TRUST contributed to advance the knowledge of groundwater processes in the project area through the development of modelling tools and Managed Aquifer Recharge techniques to restore the aquifer. The project will support public administrations in the management and planning of water resources in compliance with the European Water Framework Directive (2000/60/EC) and the Groundwater Directive (2006/118/EC).

The modelling simulations showed that by the end of the 21st century the annual aquifer recharge in Veneto could lower by 7% and by 11% in Friuli region. In the Veneto study area, the available annual groundwater volume was reduced by 175 Million m^3, whilst in the Friuli study region the reduction was of 335 Million m^3. The impact of climate changes on groundwater was evaluated in terms of resource availability for irrigation: the reduction was estimated in 10 - 15% in Veneto and Friuli regions.

Additionally the model evaluated that MAR techniques could restore groundwater by 25% and 70% of the groundwater deficit induced by climate changes in Veneto and Friuli regions respectively. Regulated groundwater domestic well abstraction from the artesian aquifer could substantially help to lower the groundwater deficit, particularly in Veneto region.

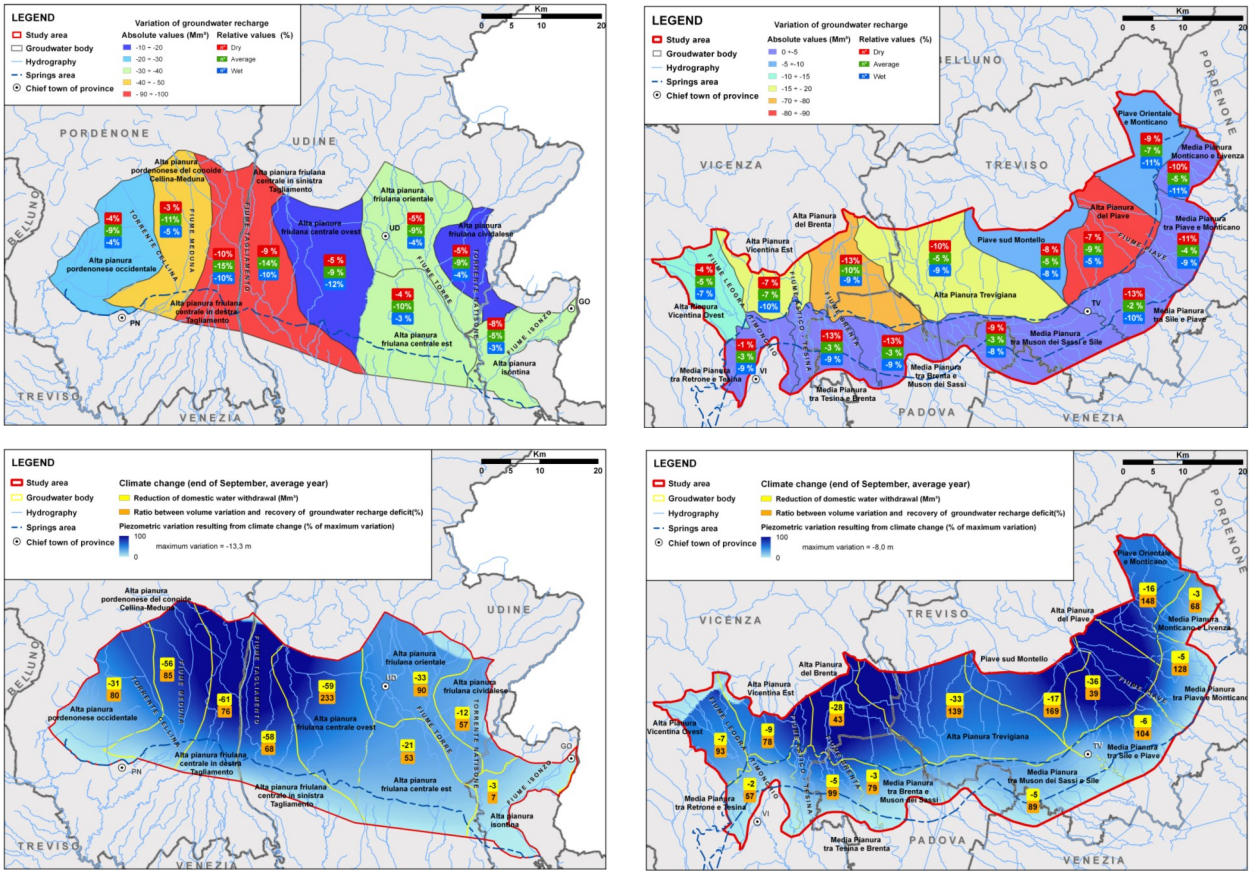


FIGURE 8 *– Top: Variations in groundwater recharge in Friuli (left) and Veneto (right) regions; Bottom: Piezometric variations induced by climate change at the end of September of the average year in Friuli (left) and Veneto (right) regions.*

The Regional Risk Assessment showed that the impact in water availability for irrigation was significant: 50% of the agricultural areas at risk fell into the High to Very High risk, mainly concentrated in the Friuli region. The impacts of climate change on the infiltration of nitrates in groundwater highlighted that the risk exposure is limited to a few water bodies in the Friuli area with Very Low to Medium levels. The medium risk was located in a very small area of the Upper Plain near Pordenone.

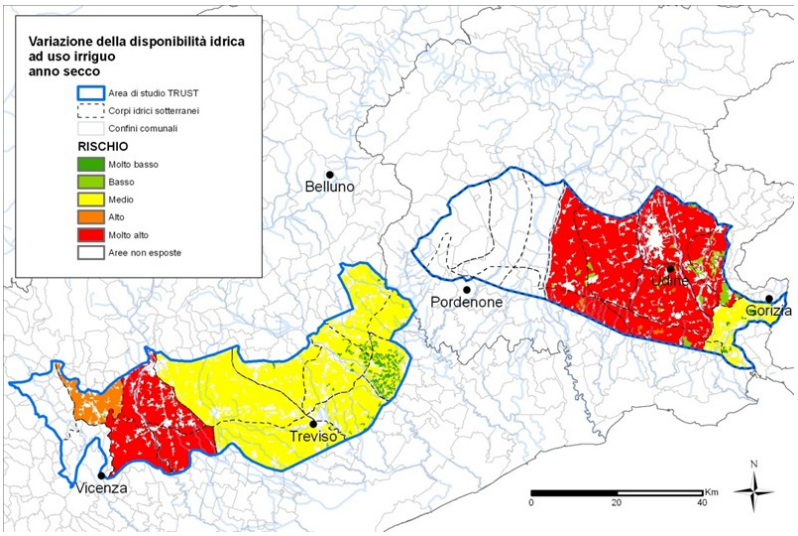


FIGURE 9 *– Relative risk map of the water availability for irrigation of summer crops (from June to August) in the dry year*

Economic and Environmental benefits

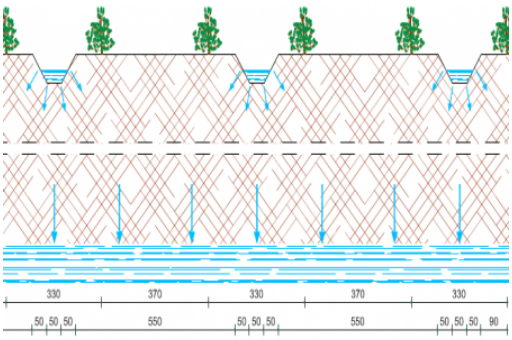
The MAR demonstrations showed a spinoff opportunity to implement "ecosystem services", a sector that is gaining increasing interest in Europe. They provide "a unifying concept in the evaluation of the relationship between environmental resources, economic systems and governance".

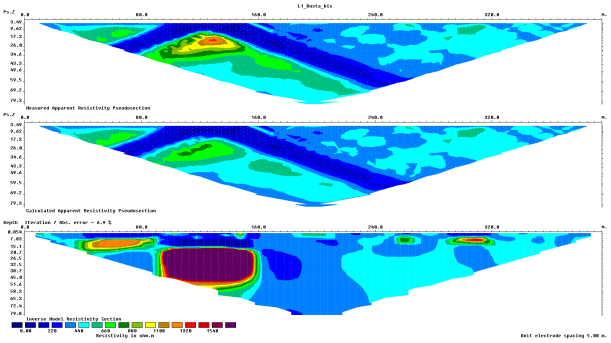
The application of MAR on an area of 100 hectares could recharge the aquifer with approximately 50 million cubic meters of water and, simultaneously, provide 60,000 Euro from the sale of fast growing plants cultivated in the MAR sites. This experience highlighted the possibility to explore the potential for PES (Payment for Ecosystem Services).

***FIGURE 10** – Photograph of the fast growing trees in the MAR test site of Brenta Irrigation Consortium (Source: Consorzio di Bonifica Brenta)*

TRUST built a solid basis for enhancing the management of groundwater resources in the plains of Veneto and Friuli regions. The project evidenced the need to consider the following aspects in future groundwater management:

- the contribution of natural streams in recharging the aquifers should their courses not be derived;
- sustainability of the current use of water resources in view of the forecasted climate change;
- the possibility that the agricultural sector considers ecosystem services within their production cycles.





Transferability of project results

Signs of the depletion of groundwater resources are commonplace not only in Europe but worldwide. TRUST has demonstrated that modelling and risk assessment tools can aid the sustainable planning and management of groundwater resources in compliance with the European Water legislative framework (2000/60/EC and 2006/118/EC). The effectiveness of Managed Aquifer Recharge for restoring the aquifer has been demonstrated as well as the spinoff possibility to combine MAR with environmental services. The knowledge and experience gained can be replicated to great effect for integrating climate change in the sustainable planning of groundwater resources in Italy and worldwide.

The project results were widely diffused. Audiovisual communication tools were used to learn how the different users and decision makers interpret the measures for adapting and mitigating impacts of climate change on groundwater resources. Project beneficiaries intend to continue the work implemented in TRUST and diffuse the project results among Italian and European stakeholders.

Trust
LifePlus

Tool for regional scale assessment of groundwater Storage Improvement in adaptation to climate Change

www.lifetrust.it

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The TRUST Project

The general principles of the European Water Framework Directive (2000/60/EC) summon up the need to protect groundwater, both in relation to quantity and quality. The Directive also calls to contextualize the planning of water resources in regard of the potential impacts of climate change. The TRUST project has focused on these complex and difficult issues that concern environmental, technical and economic aspects.