PROMOTING THE APPLICATION OF ICT TOOLS BY MEANS OF AN INNOVATIVE PARTICIPATORY APPRACH FOR WATER RESOURCE MANAGEMENT

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KEY POINTS

- *ICT tools are valuable candidates for dealing with water resource management*
- *The H2020 FREEWAT project aims at promoting the application of ICT tools for water management*
- *The FREEWAT platform integrates modelling tools within the QGIS GIS desktop.*
- *FREEWAT has been applied to several water management issues at EU and non-EU case studies*
- *FREEWAT capabilities have been applied within an innovative participatory approach*

1 INTRODUCTION

Although being a topic widely treated in recent decades, Water Resource Management (WRM) is still today poorly addressed via scientific means and underrated at political and decision-maker level. Because of this, possible impacts and effectiveness of measures envisaged in River Basin Management Plans (RBMPs) aimed at improving of the quantitative/qualitative status of groundwater bodies are not properly assessed.

Advanced ICT (Information and Communication Technology) tools are valid candidates for dealing with issues related to WRM. Among these, the integration of modeling tools in the GIS (Geographic Information System) environment is an effective methodology to represent hydrological systems and their response to anthropogenic stresses and climate change, as well as the spatial dimension of the processes explored, thus supporting proper management of groundwater resources.

Within the EU H2020 FREEWAT project (FREE and open source software tools for WATer resource management; www.freewat.eu; *Rossetto et al.*, 2015; *De Filippis et al.*, 2017), the application of ICT tools has been combined with an innovative participatory approach and capacity building activities. The FREEWAT project aims at simplifying the application of European water-related directives, through the application of a free and open source simulation platform, integrated in GIS, for WRM.

The FREEWAT platform was applied to 14 case studies in EU and non-EU Countries, to demonstrate the usefulness of ICT tools for evaluating the effectiveness of measures envisaged in RBMPs. Modeling activities were carried out involving local stakeholders during all the technical phases of characterization and modeling of the hydrological systems, in order to develop shared solutions for WRM. The adoption of a participatory approach aimed at combining the scientific approach and decision-making, in view of creating

a common environment among stakeholders, providing practical and robust results for the implementation of management and planning policies.

In this contribution, the most relevant results of the FREEWAT project are presented and the results of some of these "modeling experiments" are reported.

2 THE FREEWAT PLATFORM

The FREEWAT platform (Figure 1) is conceived as a composite plugin integrated in the QGIS GIS desktop (*QGIS Development Team*, 2009), which integrates several spatially-distributed and physically-based modeling codes, mostly developed by the USGS (e.g., MODFLOW and some MODFLOW-related programs) for the simulation of different hydrological processes (e.g., groundwater flow, solute transport, conjunctive use of ground- and surface-water, sensitivity analysis and parameters estimation). FREEWAT integrates also specific pre-processing tools for the analysis of hydrochemical and hydrogeological data (akvaGIS) and time-series data (OAT – Observation Analysis Tool). As such, the FREEWAT platform results in a unique environment, where pre-processing data, setting and running the model and analyzing results, taking advantage of GIS tools to manage and visualize large spatial datasets.

Data management is based on SpatiaLite (*SpatiaLite Development Team*, 2011), and integration between GIS and modeling codes is performed using the Python programming language (www.python.org) and the FloPy library (*Flopy*, 2016).

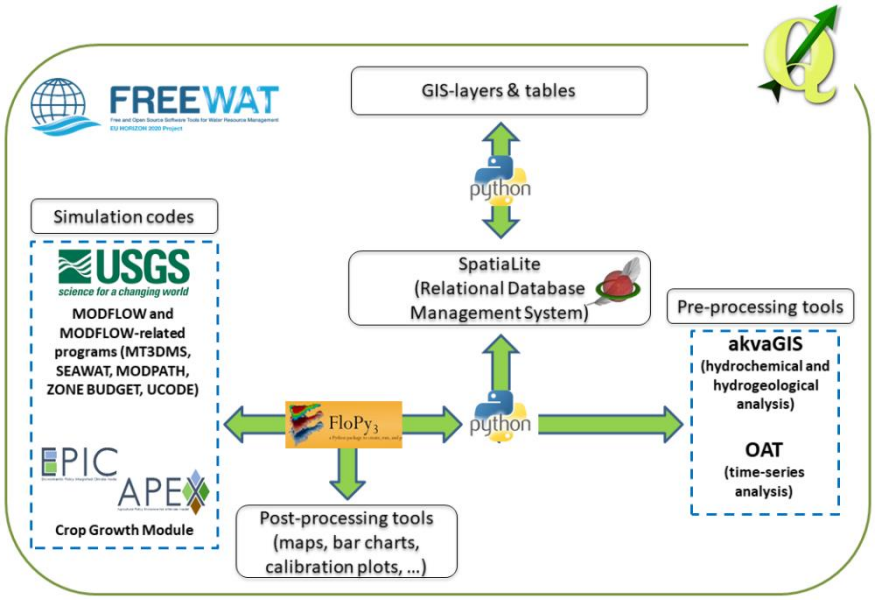

Figure 1. Simplified scheme of the FREEWAT architecture (*De Filippis et al.*, 2017).

3 FREEWAT APPLICATION AND PARTICIPATORY APPROACH

FREEWAT capabilities have been tested on several case studies in EU and non-EU Countries (Figure 2) within the context of the H2020 FREEWAT project and other EU-funded projects (e.g., FP7 MARSOL - demonstrating Managed Aquifer Recharge as a SOLution to water scarcity and drought, www.marsol.eu - and LIFE REWAT - sustainable WATER management in the lower Cornia valley through demand REduction, aquifer Recharge and river Restoration, www.liferewat.eu).

Within the H2020 FREEWAT project, the FREEWAT platform was applied to 14 case studies:

- nine of these (8 in EU Countries and one in Switzerland) focus on the implementation of the Water Framework Directive and other European water-related directives and aim at testing the feasibility of measures foreseen in RBMPs to achieve a good quantitative/qualitative status of groundwater bodies;

- five case studies (2 in EU Countries, one in Ukraine, one in Turkey and one in Africa) are dedicated to groundwater management in rural areas and focus on recommendations by EU and national regulations.

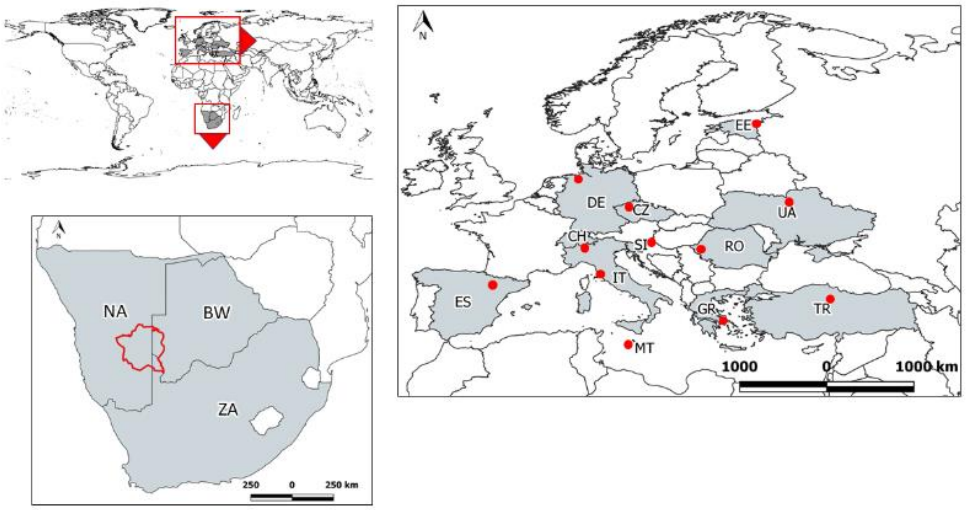

Figure 2. Case studies where the FREEWAT platform have been applied within the framework of EU-funded projects

The FREEWAT platform has been tested on a wide range of topics, including: saltwater intrusion, management of transboundary aquifers, conjunctive use of ground- and surface-water in rural environments, nitrate pollution of groundwater.

At each case study, a Focus Group (FG) consisting of local, technical and non-technical stakeholders was set up (including, e.g., basin authorities, municipalities, research institutions, environmental protection agencies, environmental associations, etc.). At each case study, seven meetings were organized (Figure 3), for a total of 96 FG sessions and more than 1000 participants.

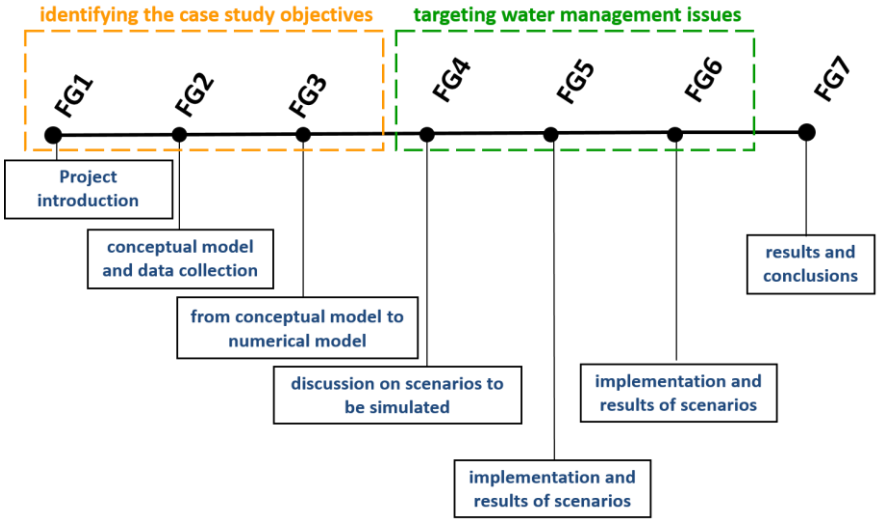

Figure 3. The different phases of the adopted participatory approach.

The objectives of the case studies were defined during the first three FGs. During the first meeting, participants' perception on the use of ICT tools for WRM was discussed. Subsequently, data availability for a characterization of the hydrological system under investigation and for the identification of the main

hydrological processes was discussed. On the basis of the available data, the conceptual model was defined and the methodology to be adopted to represent the identified hydrological processes was discussed.

Once the model was implemented in the basic conditions, in a second phase the FG took part in the discussion on the scenarios to be simulated to test the feasibility of measures envisaged in RBMPs. For this purpose, a SWOT (Strenghts Weaknesses Opportunities and Threats) analysis was adopted in some cases, in order to identify the pros and cons of testing the effectiveness of the aforementioned management measures.

In this contribution, some of these "modeling experiments" are presented.

The FREEWAT platform was used to develop a groundwater flow model to manage an induced riverbank filtration MAR scheme at Vrbansky plato (Slovenia), an alluvial plain near the city of Maribor. The local water supply company intends to use the model to monitor the effects of pollution from the city of Maribor.

A groundwater flow model was developed to test the effects of sea level rise and the reduction of the meteoric recharge up to 2100 at Bremerhaven (Germany). The local water authority was involved to implement an adaptation strategy to climate change.

The FREEWAT model developed at Scarlino-Follonica (Italy) will be used by the regional authority to manage various groundwater remediation projects in a large contaminated industrial site.

The density-dependent flow model developed for the aquifer system on the Gozo island (Malta) allowed assessing the qualitative status of groundwater, classified as "poor" within the Water Framework Directive.

Within the Bakumivka river basin (Ukraine), three groundwater management scenarios were simulated in rural areas, in order to compare different spatial patterns of land use and use of groundwater resources.

4 CONCLUSIONS

Within the H2020 FREEWAT project, the application of ICT tools has been combined with an innovative participatory approach and capacity building activities. Local stakeholders were involved during the technical phase of application of the FREEWAT platform at 14 case studies in EU and non-EU Countries. During periodic meetings organized, the importance of using ICT tools for WRM was discussed.

Following the approach adopted, public authorities have the opportunity to build an accurate and dynamic representation of the hydrological systems under consideration, which is also shared at political and decision-meking level.

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