FREEWAT: FREE and open source software tools for WATer resource management

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ABSTRACT

FREEWAT is an HORIZON 2020 project financed by the EU Commission under the call WATER INNOVATION: BOOSTING ITS VALUE FOR EUROPE. FREEWAT main result will be an open source and public domain GIS integrated modelling environment for the simulation of water quantity and quality in surface water and groundwater with an integrated water management and planning module. FREEWAT aims at promoting water resource management by simplifying the application of the Water Framework Directive and other EU water related Directives. Specific objectives of the FREEWAT project are: to coordinate previous EU and national funded research to integrate existing software modules for water management in a single environment into the GIS based FREEWAT; to support the FREEWAT application in an innovative participatory approach gathering technical staff and relevant stakeholders (*in primis* policy and decision makers) in designing scenarios for the proper application of water policies.

The open source characteristics of the platform allow to consider this an initiative "ad includendum" (looking for inclusion of other entities), as further research institutions, private developers etc. may contribute to the platform development.

Through creating a common environment among water research/professionals, policy makers and implementers, FREEWAT main impact will be on enhancing science- and participatory approach and evidence-based decision making in water resource management, hence producing relevant and appropriate outcomes for policy implementation. The Consortium is constituted by partners from various water sectors from 10 EU countries, plus Turkey and Ukraine. Synergies with the UNESCO HOPE initiative on free and open source software in water management greatly boost the value of the project. Large stakeholders involvement is thought to guarantee results dissemination and exploitation.

KEY WORDS: GIS integrated water management modeling, Implementation of EU water related policies, Open source and public domain software, Participatory approach, Water Resource Management.

INTRODUCTION

Decisions on water management and planning, taken to practically apply the Water Framework Directive (WFD) and water related directives requirements, are often made on geographically lumped 20/30 years average water budgets. These do not consider both the spatial variability of the various hydrological factors and the time variability of the hydrological variables within the year. Moreover, they do not allow the solutions of localised problems, such as aquifer overdraft or exploitation, as they are not able to provide local and time-based solutions. Consequently, results are highly qualitative (semi-quantitative) and not really useful for water management and planning.

The Water Framework Directive 2000/60/CE required an increase of monitoring activities on water quantity and quality; this in turn led to the availability of time series that allow the implementation of more efficient water management tools. Up to now the information content of such data is not properly exploited, because they are often analysed with very simple algorithms providing limited insight into the dynamic of the systems. The availability of ICT-tools performing spatially and temporally based analysis will greatly help to exploit the information content of such data and to get a better insight on water bodies behaviour.

Although the use of GIS in water management is nowadays widespread (as demonstrated also by the results to the questionnaire distributed among the partners of the proposal) and well standardised (see CIS Guidelines 9 and 22), many water authorities still rely on professionals (geologists, geographers, biologists, engineers, etc.) with limited capabilities on the use of new technologies especially dedicated to water management, such as modelling. The same often applies for water utilities or private companies. This constitutes a limit to the challenges and problems posed by water management.

The value of using advanced technologies (often referred as "complex" in WFD related documents) in water management is often diminished by the fact that only well-trained practitioners and professionals are involved in the study and present the results to stakeholders. The latter are not actively involved in the model development and have to rely and trust who performed the analysis (Refsgaard et al., 2010). In this sense, the lack of participatory approach in using advanced ICT tools for evidence-based decisions in water management constitutes a limit to the application of the water related Directives.

From a technical and social point of view, this results in poor coordination among technical and scientific personnel,

policy and decision makers, and the various stakeholders involved in the monitoring and management of the water resource.

To overcome this purely technical approach in dealing with very complex water related issues with a large variety of stakeholders involved, it is necessary to introduce the participatory approach. The non-technical aspects of water resource systems (such as societal, political and legal concerns) are recognized as having a great, if not fundamental, importance to reaching an agreed-upon decision; these are therefore to be integrated into the more technical and mathematical issues (Soncini-Sessa, Weber & Castelletti, 2007).

THE FREEWAT PROJECT

FREEWAT is an HORIZON 2020 project financed by the EU Commission under the call WATER INNOVATION: BOOSTING ITS VALUE FOR EUROPE and coordinated by Scuola Superiore Sant`Anna, Pisa, Italy (Grant Agreement 62224) that will start on April 1st 2015. The FREEWAT project general objective is to promote water management and planning by simplifying the application of the WFD, Groundwater Directive (GWD), Nitrate Directive (NiD) and other water related Directives. The simplification is achieved through the FREEWAT platform and its participatory approach. FREEWAT main result will be an open source and public domain GIS integrated modelling environment for the simulation of water quantity and quality in surface water and groundwater with an integrated water management and planning module.

The FREEWAT project aims at improving Water Resource Management (WRM) by achieving the following specific objectives:

(i) to coordinate previous EU and national funded research to integrate existing software modules for water management in a single environment: the GIS based FREEWAT platform;

(ii) to support the FREEWAT application in an innovative participatory approach gathering technical staff, and relevant stakeholders (*in primis* policy and decision makers) in scenario creation and simulations to apply and develop appropriate water policies. This will provide EU Governing Bodies, Authorities and Water Utilities and environmental companies/water professionals with innovative, free and open source software tools having high accuracy level and friendly usability;

(iii) the open source characteristics of the codes and platform allow to consider this an initiative "*ad includendum*" (looking for inclusion of other entities), allowing further research institutions, private developers etc., not only within the EU, to contribute to the platform development and uptake. Moreover, an important collaboration with the UNESCO-IHP HOPE-Initiative (http://www.hope-initiative.net/) further boosts the project potentialities;

(iv) to build knowledge and capacity in the use of scientific software technologies, by improving the professional level of technical and managerial personnel involved in WRM issues in public institutions and private companies;

(v) applying these innovative software instruments to 10 case studies within the EU, 2 case studies in neighboring countries (Turkey and Ukraine) and to a large trans-boundary aquifer in Africa;

(vi) optimising the use of water resource monitoring data, by obtaining trough simulations results distributed in space and time, useful to the solutions of issues such as: water availability and quality, groundwater pollution monitoring and remediation, and coping with seawater intrusion;

(vii) providing MSc and PhD students, researchers and professors of a free and open source software to be applied on various issues related to water management;

(viii) involving relevant stakeholders in the application of the FREEWAT platform by means of regular focus group meetings to enable a participatory process;

(ix) building a web based community of users and developers of the free and open source FREEWAT platform;

(x) contributing to the creation of innovative companies and work places that will exploit and continue the integration, development and training on the FREEWAT platform.

All this will include a strong capacity building plan that will target an expected number of about 1000 individuals from about at least 180 different stakeholder communities. A dedicated dissemination and exploitation plan will further widen the audience (non-technical one also) reaching up to about minimum 10000 individuals worldwide.

The FREEWAT Consortium is constituted by 17 partners from 10 European countries (Italy, Germany, Spain, France, Greece, Estonia, Romania, Malta, Czech Republic, Slovenia) plus Turkey and Ukraine. UNESCO international organization is also member of the partnership. The consortium is composed of a broad spectrum of research, private companies and authority institutions, including 6 SMEs, 2 authorities, 5 universities, 2 research institutes, 1 not-for-profit research and International training centre and 1 International organisation.

The main motivations underpinning the FREEWAT project proposal are related to the following needs of:
1. ICT tools and technologies, and in particular models, to boost the application of the WFD and water related Directives;
2. creating coordination and synergies among ICT tools produced for the application of water related Directives and establishing a common set up in their application (i.e. as far as calibration and validation);
3. free and open source tools, numerically based, GIS integrated, and capable to perform analysis on water quantity and quality issues;
4. ICT tools for the analysis of the conjunctive use of surface water and ground water, the impacts related to land use and urban sprawling and of climate change on water resource;
5. changing the approach from lumped-yearly averaged water balances as base of decision making to water balances which are spatially distributed, time-series driven and yearly-variation based;
6. effectively using data provided by the extensive monitoring required by the WFD;

7. capacity building within the EU water sector;
8. including participatory approach not only in the phase of result discussion, to step forward from solely technical approaches to deal with very complex water related issues involving a large variety of stakeholders;
9. supporting adequately scientific research results to foster their real scale application and replication and uptake by policy makers and water authorities.

The overall structure of the FREEWAT project (Fig. 1) is based on: i) coordinating previous national and EU funded research to create the FREEWAT platform; ii) supporting capacity building around the FREEWAT platform by means of dedicated training and case studies implementation, in partner's country and at the international level; iii) supporting the FREEWAT application in an innovative participatory approach, that gathers technical staff, and relevant stakeholders in the development and simulation of scenarios for the application of appropriate water policies; iv) promoting dissemination and exploitation, and communication on the FREEWAT activities and results at international level in order to foster its wide application at EU scale and beyond. These four elements guide the project workflow and are coordinated within the project management.

The project development and management is lead by Scuola Superiore di Studi Universitari di Perfezionamento Sant'Anna, project coordinator. In WP2 "Software integration" (lead by TEA SISTEMI SPA, Italy) the integration of already existing codes, developed in previous national, EU and non-EU funded research, in the unique GIS integrated modelling and data analysis FREEWAT platform for water quality issues, calibration and sensitivity analysis, agriculture and water management and planning will take place. The FREEWAT platform will implement several capabilities: their integration will be guaranteed by a modular structure (modules can be activated and/or de-selected to run different model scenarios) as well as by the approach selected for managing input/output data within the GIS desktop. The FREEWAT Consortium agrees that any module produced within the FREEWAT Project should not depend on third party non-open source software.

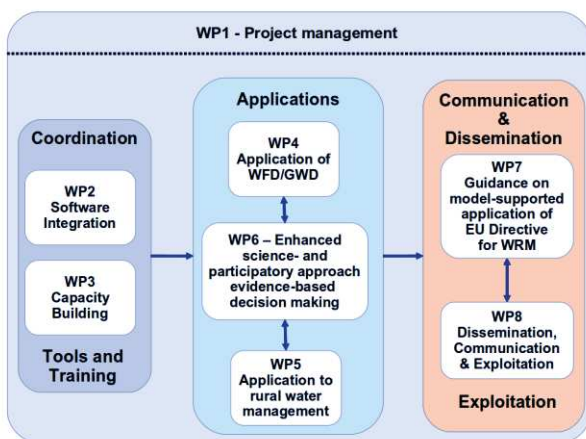An accurate integration of different process inputs can be achieved by applying GIS-embedded tools (i.e. geostatistics tools), also allowing the use of outputs from one module as input to another process (for instance groundwater balance as input for the water management tool).

The core of the FREEWAT platform will be the SID&GRID framework in its version ported to the QGIS desktop. SID&GRID (GIS integrated physically-based distributed numerical hydrological model based on a modified version of MODFLOW 2005; Rossetto et al. 2013; Borsi et al. 2013) is an open source and public domain modelling platform firstly developed within the EU-POR FSE 2007-2013 Regione Toscana – Italy and then ported to the QGIS desktop through a dedicated fund by Regione Toscana. SID&GRID will be complemented by June 2015 with solute transport (also density dependent) capabilities in aquifers within the MARSOL (2014) FPVII project.

Activities will be mainly carried out on two levels: (i) integration of modules, so that the software will fit the end-users requirements, including tools for better producing feasibility and management plans; (ii) a set of activities devoted to fix bugs and to provide a well-integrated interface for the different tools implemented. Further capabilities to be integrated are:

- a dedicated module for water management and planning that will help to manage and aggregate all the distributed data coming from the simulation scenarios;
- a whole module for calibration, uncertainty and sensitivity analysis;
- a module for solute transport in the unsaturated zone;
- a module for crop growth and water requirements in agriculture;
- tools for dealing with groundwater quality issues;
- tools for the analysis, interpretation and visualization of hydrogeological data.

Project partners will be required to start capacity building (WP3, lead by Agencia Estatal Consejo Superior de Investigaciones Cientificas, Spain) on the FREEWAT platform as soon as the earliest version will be ready. By month 10 a beta version of the FREEWAT platform and related User Manual and a set of tutorials for end-user partners will be available to demonstrate the platform capabilities. One week training will be delivered at the premises of each case study partner ("*training the trainers*") by the FREEWAT core team to demonstrate all the platform capabilities. Feedbacks are expected to improve the platform; the courses will serve as a testing phase as functionalities implementation is expected to be completed. This will lead to FREEWAT v.0.1. All the trained partners will then give a one week applied workshop in their own country to demonstrate the FREEWAT capabilities to relevant stakeholders. The training materials produced will be distributed through the world wide web and user groups will be created to build a community of users and developers of further tools.

In WP4 (lead by NTUA/AMDC, Greece) and WP5 (lead by UNESCO-IHP), the FREEWAT platform will be applied to selected case studies. These were accurately selected by each participant in these WP's and each of them aims at addressing a specific water management issue. Two WP's were defined to divide the case studies in appropriate classes:

Fig. 1 – Overall structure of the FREEWAT project.

- eight case studies from EU partners (WP4: Application to WFD, GWD and other water related Directives) are specifically referred to the application of the WFD, GWD and other water related Directives;

- five case studies (WP5) are related to the application of the FREEWAT platform in rural management (including the application of the NiD and of the greening aspects of the Common Agricultural Policy).

For all the case studies, initial clear statements on the problems to solve, the objectives to reach and the water policy to target will be made. Further case studies may be implemented on voluntary basis by other Institutions, as already shown by some of the letters of interest.

Within the FREEWAT platform application, one of the innovations that the project wants to bring is the involvement of stakeholders not only to discuss modelling results, but also during the whole phase of model implementation and scenarios building. Main aim of the WP6 (lead by METCENAS,) is securing the uptake of scientific/technical knowledge throughout the policy cycle (namely, from policy design to implementation, monitoring and review) by:

a. introducing the participatory approach during the technical analysis;

b. ensuring that project outcomes will reach policy implementation, by transfer of scientific and technical achievements of the project to stakeholders and in particular to policy makers and authorities.

Support to widening the FREEWAT platform application will be guarantee through extensive applications and through the involvement of relevant stakeholders in the participatory approach. The latter constitutes a focal point of the whole project as test cases will be run in an innovative participatory way, involving technical staff and relevant stakeholders. Stakeholders will be involved from model implementation and scenarios building, to discussion of model results by means of Focus Groups (FGs). The FGs will include discussions on socio economic and environmental consequences of the scenarios analysed. This approach will increase credibility in data and model results used for policies application and further help the spreading of the FREEWAT platform. Policy briefs will be relevant outcomes from these activities to ensure evidence-based decision making.

WP 7 (lead by Technischen Universität Darmstadt, Germany) will see the compilation of all the experiences drawn from the previous WP's, and especially WP3, WP4, WP5 and WP6, to draft the *Guidance on water quantity and quality model-supported application of EU water related Directives* volume. This is intended to serve as a technical reference for technicians and water managers.

Finally, WP8 (Dissemination and Exploitation and Communication) will aim at disseminating the results of the project, promoting the FREEWAT concept, increasing the visibility of the project and supporting the exploitation of the results achieved.

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