FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

European Commission

MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

EIP Water Online Market Place
Matchmaking for water Innovation
MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

Il legame tra acqua, cibo, energia e ambiente: le attività dei progetti di ricerca EU H2020 FREEWAT e FP7 MARSOL e …

WORKSHOP GEO$_2$BASI

Conoscere la composizione chimica dell'acqua per conoscere il nutrimento base della vita: l'esperienza del progetto GEOBASI – TOSCANA

Università degli Studi Firenze DST Dipartimento di Scienze della Terra

Università degli Studi Firenze

Museo di Storia Naturale

Con il Patrocinio di EXPO MILANO 2015 NUTRIRE IL PIANETA ENERGIA PER LA VITA

Rudy Rossetto
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Firenze 24 September 2015

INSTITUTE OF LIFE SCIENCES
Scuola Superiore Sant'Anna

Che legame?

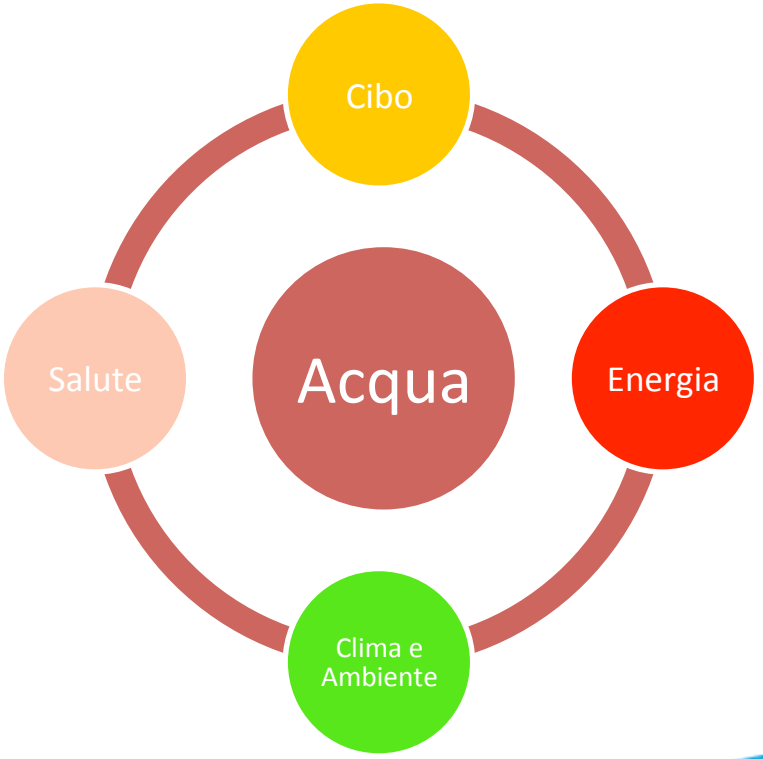
Acqua, produzione di cibo ed energia e ambiente sono intrinsicamente collegati.

Azioni in un settore hanno molto spesso impatti pesanti sugli altri.

Questo legame è sempre stato presente, ma l'aumento della popolazione cui segue:

- Aumento della domanda di cibo
- Aumento della domanda di acqua
- Aumento della domanda di energia

legati al desiderio di ciascuno di migliorare le proprie condizioni di vita comporta nuove sfide nell'affrontare questa relazione.



Una sfida importante

Queste pressioni minano la capacità degli agro-ecosistemi di rispondere a sollecitazioni importanti tornando ad uno stato a queste precedenti e manifestarsi con effetti quali la degradazione dei suoli – scarsità d'acqua e/o carestie.

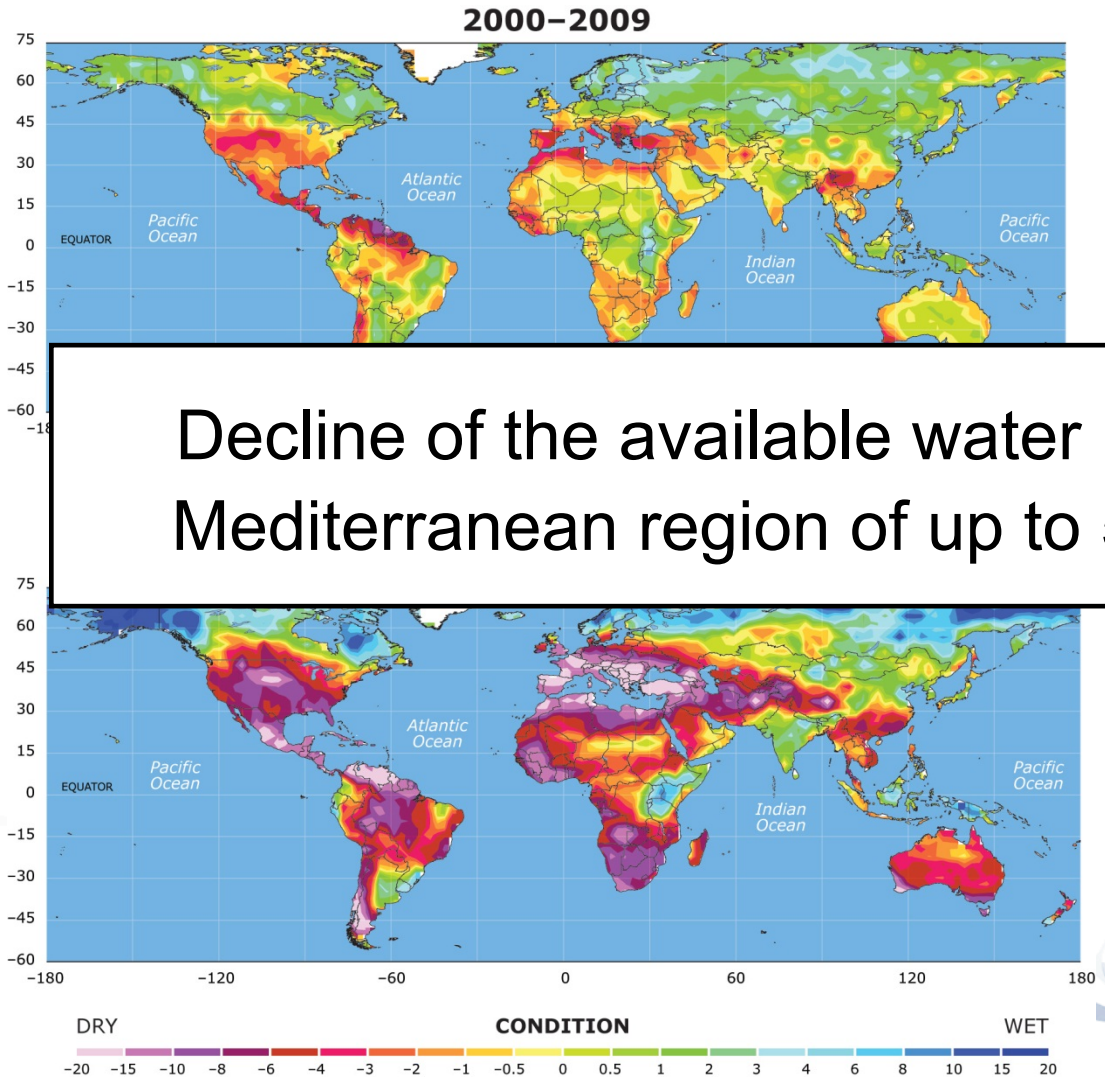
La principale sfida:
riconciliare obiettivi globali e di lungo periodo (mitigazione cambiamento climatico, miglioramento degli agro-ecosistemi e obiettivi di equità nella ripartizione delle risorse)
con l'economia,
con la necessità di assicurare alle popolazioni una serie di diritti umani inalienabili quali accesso all'acqua ed al cibo.

Il ruolo della ricerca

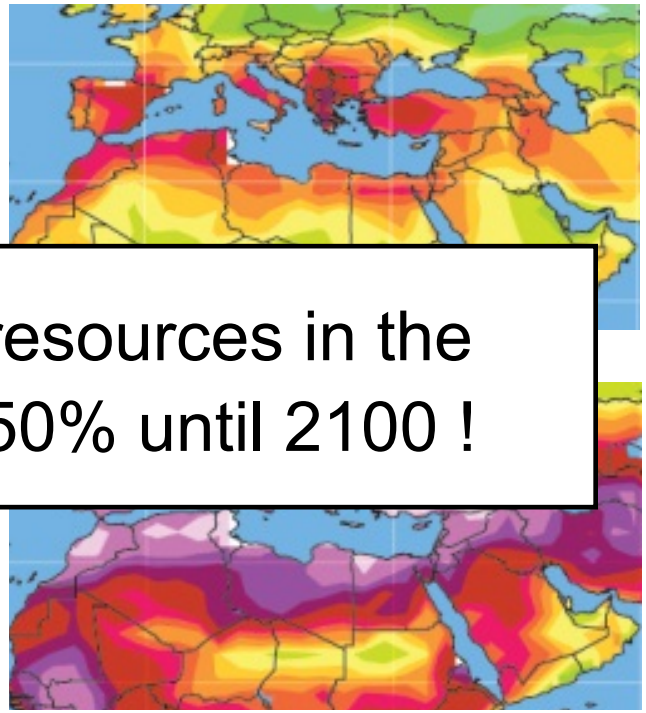
Proporre modelli innovativi e sostenibili
per la gestione delle risorse
lo sviluppo socio-economico
il mantenimento degli agro-ecosistemi

Increasing number and intensity of dry periods (Palmer Drought Severity Index*)

Temporal variation



source: NCAR images, 2010



Decline of the available water resources in the Mediterranean region of up to 50% until 2100 !

* Determines aridity from precipitation and temperature information, especially for long-term prediction

< -4 = extreme drought

Risorse convenzionali vs. non convenzionali

Invasi?

Ricerca di ulteriori livelli acquiferi sfruttabili?

Risorse non convenzionali

Desalinizzazione

Recupero e riutilizzo reflui post-trattamento

Impianti di ricarica degli acquiferi

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Impianti di ricarica degli acquiferi

Ingenti volumi di acqua defluiscono in mare nei periodi di pioggia

Nella stagione estiva gli unici deflussi superficiali osservabili sono generalmente costituiti dagli scarichi della depurazione (es.: 10/15 Mm^3 nelle aree della pianura di Pisa e Grosseto nel periodo Giugno-Settembre)

E' possibile pensare un utilizzo di queste acque ?

La ricarica intenzionale e controllata di un acquifero (***Managed aquifer recharge - MAR***) è un processo per cui il volume di acqua ordinariamente immagazzinato nel sottosuolo è incrementato ad un tasso superiore alla ricarica naturale.

Viene sfruttata la naturale funzione di serbatoio del sottosuolo e utilizzata l'elevata disponibilità di acqua nei periodi di pioggia oppure derivante da altre fonti.

E' poi possibile utilizzare l'acqua immagazzinata in periodi successivi.

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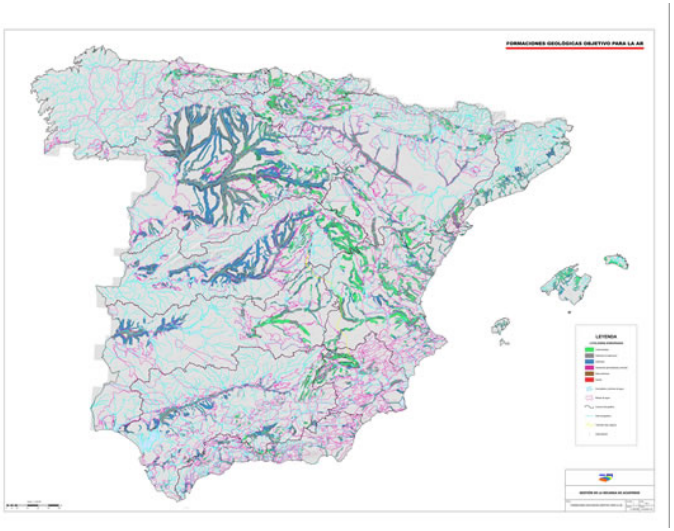
Impianti di ricarica degli acquiferi

Tecnologia non nuova sviluppata a partire dagli anni 50 del secolo scorso.
(Mario Canavari la cita nel suo Manuale di Geologia Tecnica, 1927)

Diffusa in USA, Israele, Australia, Spagna (http://www.dina-mar.es/)



Il fatto che questa ricarica sia "controllata" (*managed*) assicura una adeguata protezione della salute umana e dell'ambiente.

Il controllo la differenzia da impianti in cui la ricarica è cosiddetta "non-gestita" (es.: ricarica di subalveo indotta) o "non-intenzionale" (es.: ricarica derivante da irrigazione in eccesso).

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Impianti di ricarica degli acquiferi

Interventi di geoingegneria ambientale in cui si ricaricano gli acquiferi con aliquote di acqua provenienti da corsi d'acqua, invasi – o acque non convenzionali.

Potenziali utilizzi:

-Immagazzinamento di acqua per utilizzo in periodi di criticità;

-Utilizzo per usi idropotabili, irrigui, industriali

-Contrastare l'abbassamento creato da emungimenti;

-Controllo di fenomeni di subsidenza;

-Contrasto a fenomeni di intrusione salina

-Mantenimento di ecosistemi dipendenti dalle acque sotterranee

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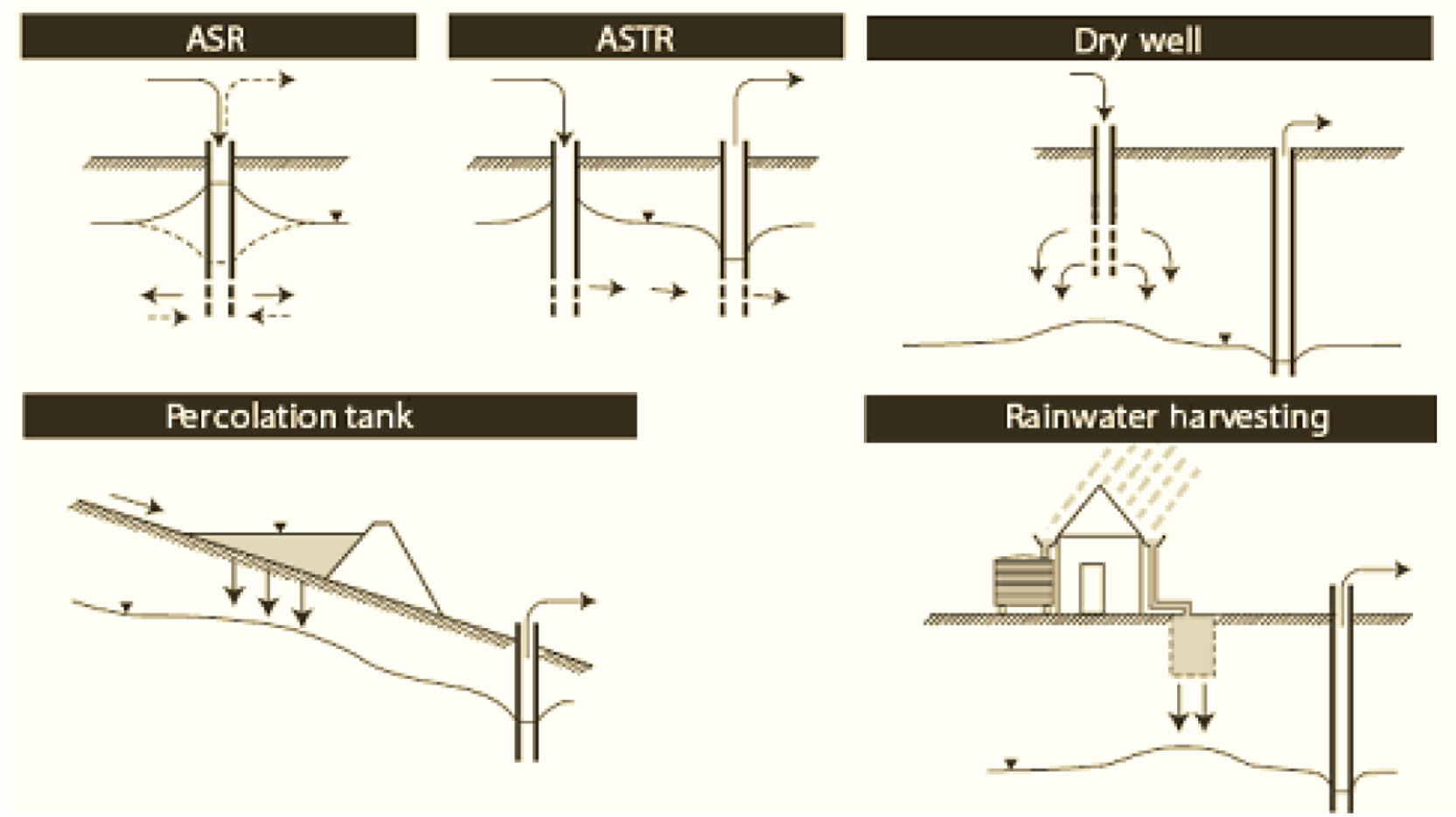
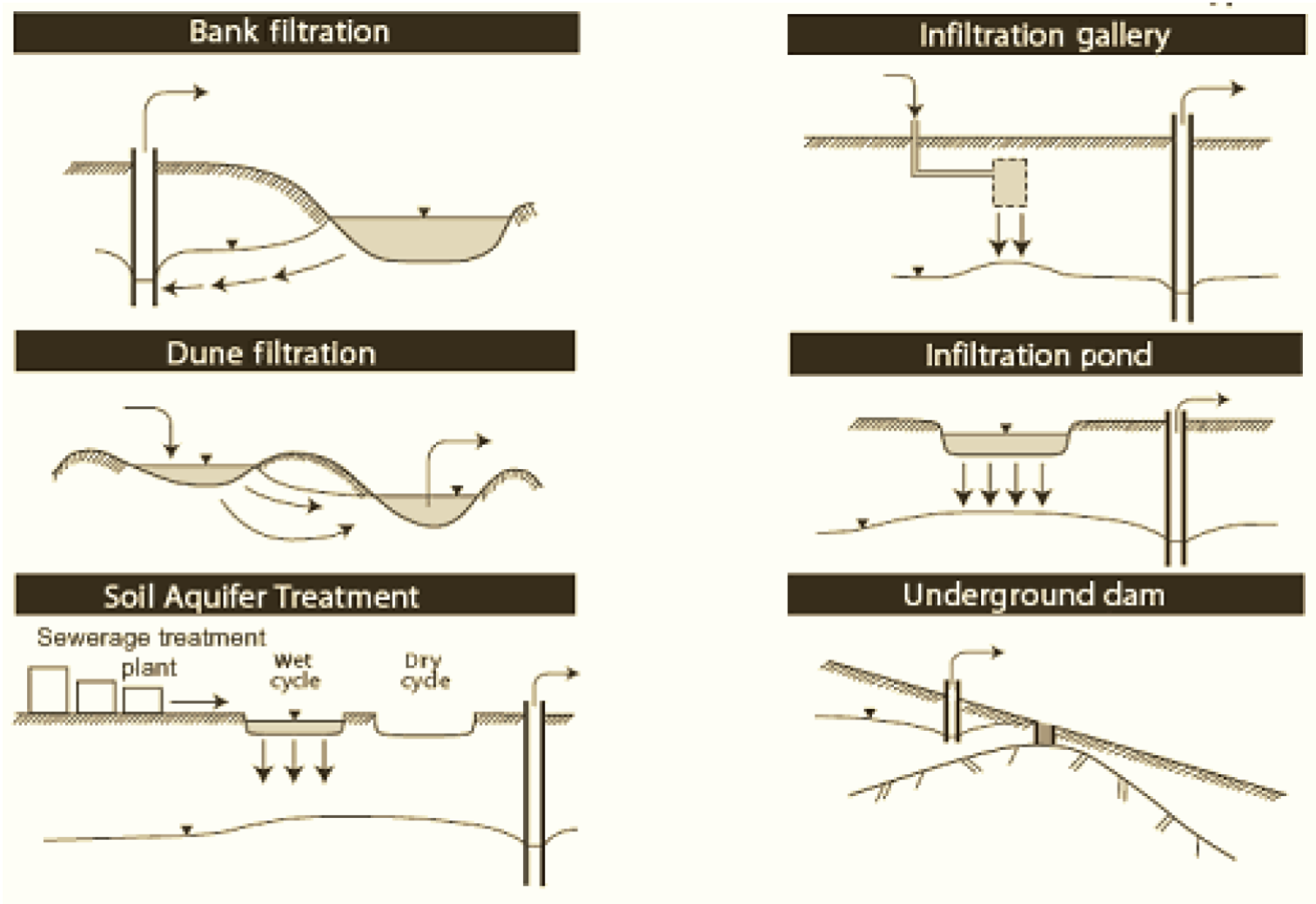
Tipologie di impianti MAR



Da: AUSTRALIAN GUIDELINES FOR WATER RECYCLING: MANAGING HEALTH AND ENVIRONMENTAL RISKS (PHASE 2)
Managed Aquifer Recharge
(Natural Resource Management Ministerial Council + Environment Protection and Heritage Council +National Health and Medical Research Council 2009)

Tipologie di impianti MAR



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Vantaggi impianti MAR rispetto a invasi (intorno immagazzinamento 1-5 Mm^3)

- Bassi costi di investimento

  (la più economica tra le metodologie per fornire acqua – circa 1/1.5 €/m^3 contro 5/6 €/m^3 degli invasi);

- Maggior facilità per identificazione siti idonei;

- Nessuna (o minima) perdita di terreno;

- Potenziale utilizzo di acquiferi salinizzati (*salinised groundwater displacement*)

- Non si ha evaporazione, formazione di alghe o proliferazione di insetti;

- Minori immissioni di gas climalteranti in atmosfera

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EU FP7 MARSOL:

Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought

Principali obiettivi:

- Dimostrare attraverso 8 siti sperimentali che le tecniche MAR costituiscono un sistema innovativo, sicuro e sostenibile per incrementare la disponibilità di risorsa idrica nel bacino Mediterraneo ed in altre aree soggette a scarsità

- Migliorare lo stato dell'arte delle applicazioni MAR per portarle ad un alto livello di efficienza/bassi costi di realizzazione in modo da creare opportunità di mercato per l'industria europea ed in particolare SME (***MAR to market***)

- Promuovere i vantaggi delle tecniche MAR attraverso la realizzazione di appositi programmi di formazione e disseminazione anche al fine di permettere ed accellerarne la penetrazione nel mercato.

MANAGED AQUIFER RECHARGE SOLUTIONS

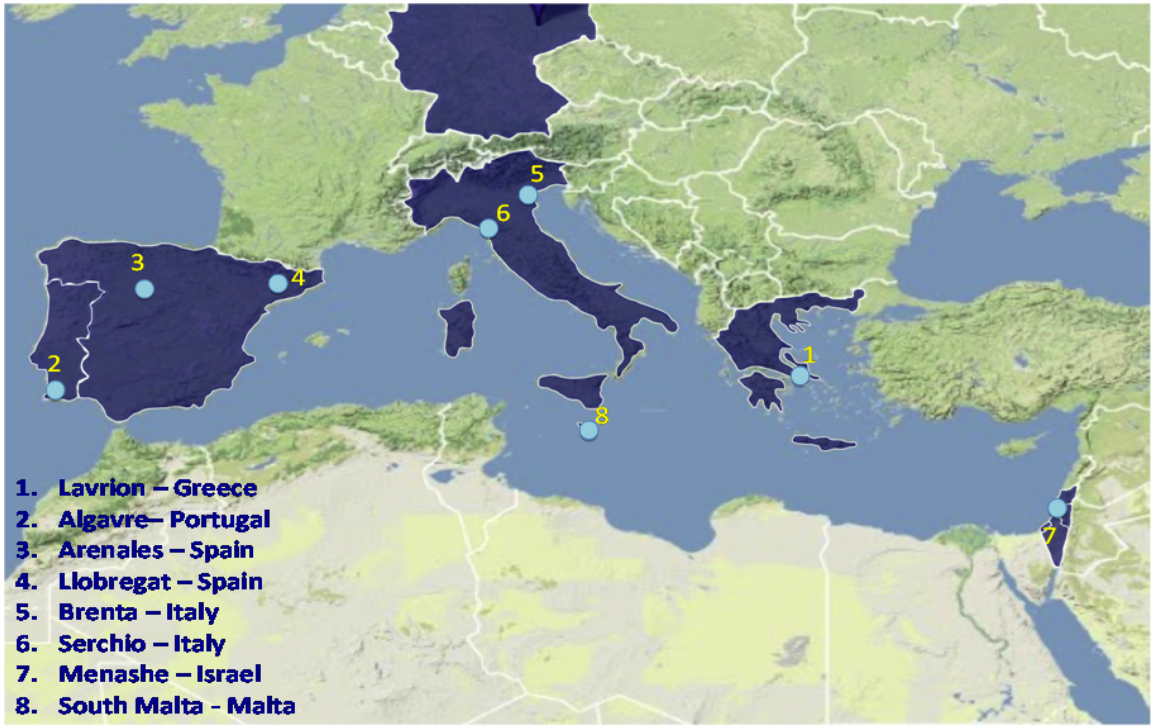
MARSOL

Demonstrating Managed Aquifer Recharge as a Solution to Water Scarcity and Drought

(FPVII-ENV-Water Inno Demo)

- **21 Partners**

- **starting date: 12/2013**
- **duration: 36 months,**



MARSOL Consortium

MAR SOL MANAGED AQUIFER RECHARGE SOLUTIONS

21 partners **7 countries** **8 field sites**

Public (Research) Institutions (5)

- LNEC – Laboratório Nacional de Engenharia Civil
- MRA – Malta Resources Authority
- Helmholtz Zentrum für Umweltforschung UFZ
- Autorità di Bacino
- Provincia di Lucca

Universities (6)

- Technische Universität Darmstadt
- UPC
- Scuola Superiore Sant'Anna di Studi Universitari e di Perfezionamento
- ICCS
- UAlg Universidade do Algarve

Industry (4)

- Tragsa – TragsaGroup, Partners in excellence
- Mekorot Development & Enterprise Ltd.
- ΕΥΔΑΠ
- 20 Years Water Services Corporation 1992 - 2012

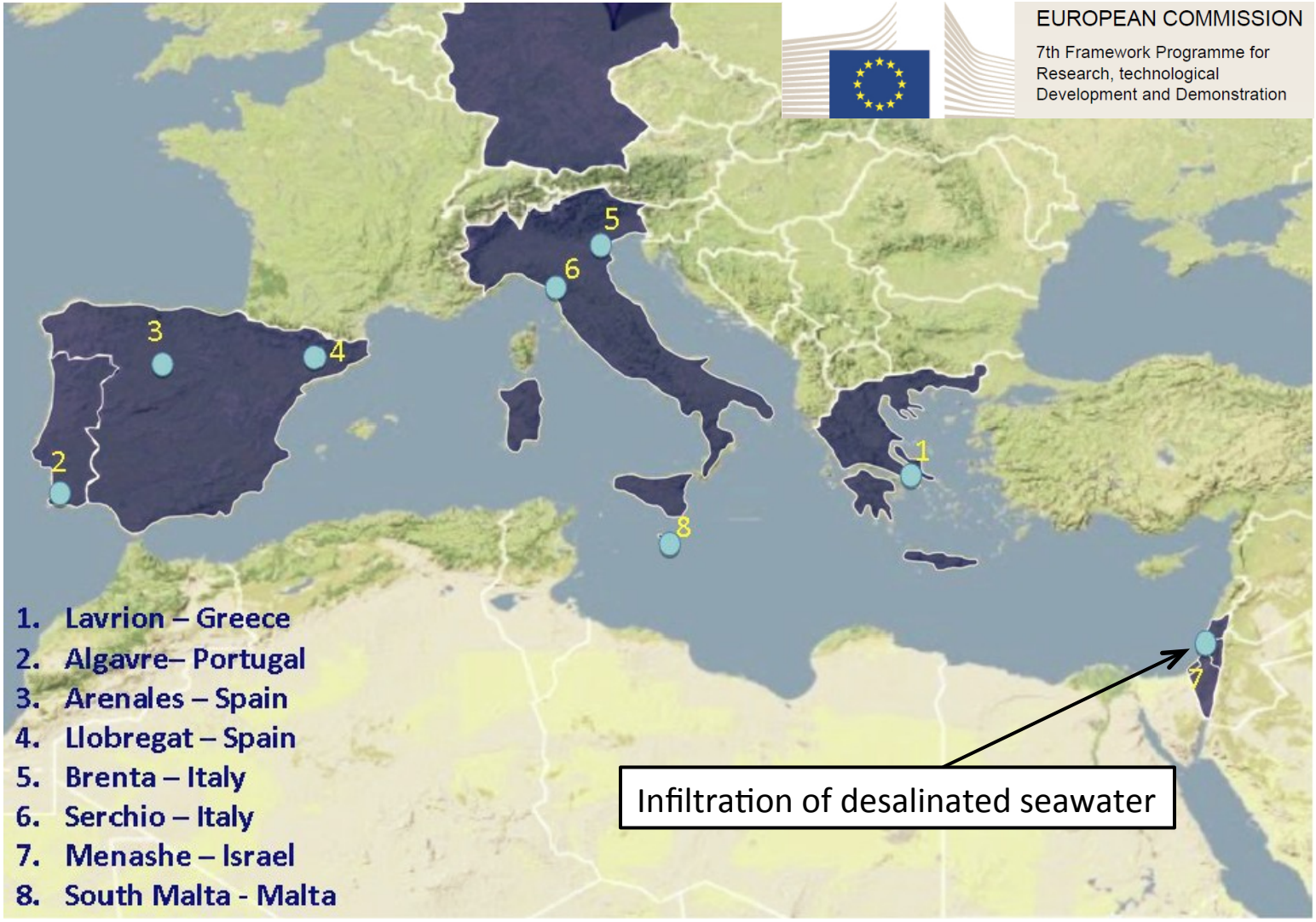
SMEs (6)

- Τεχνολογικό Πολιτιστικό Πάρκο Λαυρίου
- SGI – life, first
- IWW
- TARH
- TEASISTEMI – Energy and Environment Technologies
- PARAGON Europe

Scientific Advisory Board

MARSOL Field sites

Various water sources and qualities - various technologies - various objectives



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Desalinated sea water – Israel (Daniel Kurtzman, Yossi Guttman et al.)

3 desalination plants currently operating, by 2015 two more will start operation

- Desalination plants built under build-operate-transfer (BOT) contracts
- Less dry periods during the last years

→ **Production of an increasing amount of excess water.**

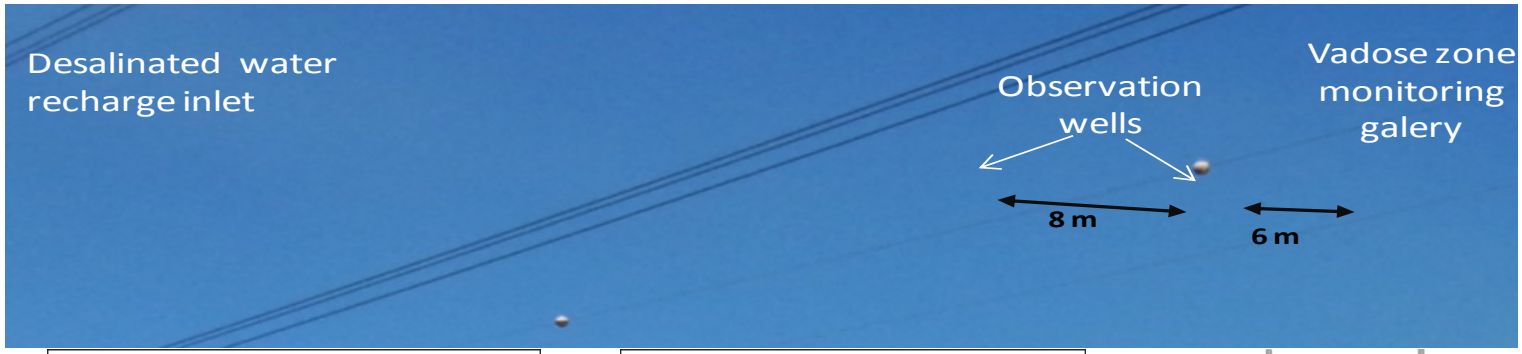
Water authorities aim at seasonal storage as well as aquifer storage of large volumes of these surpluses in

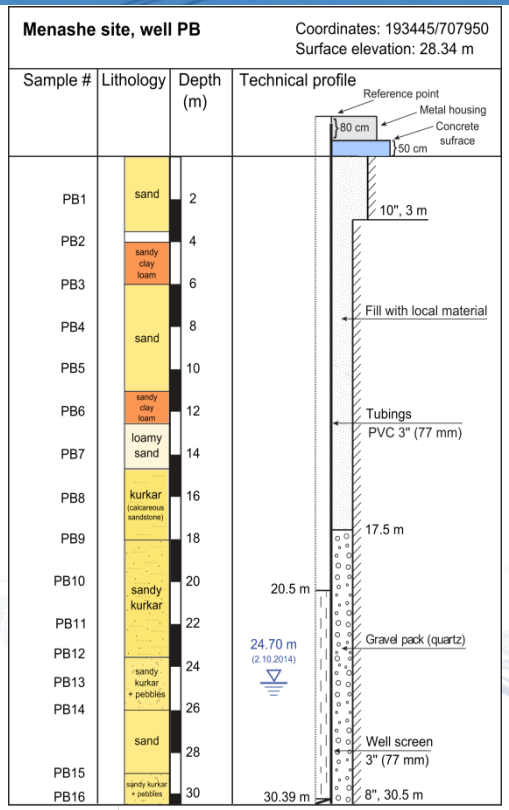
the adjacent coastal aquifer

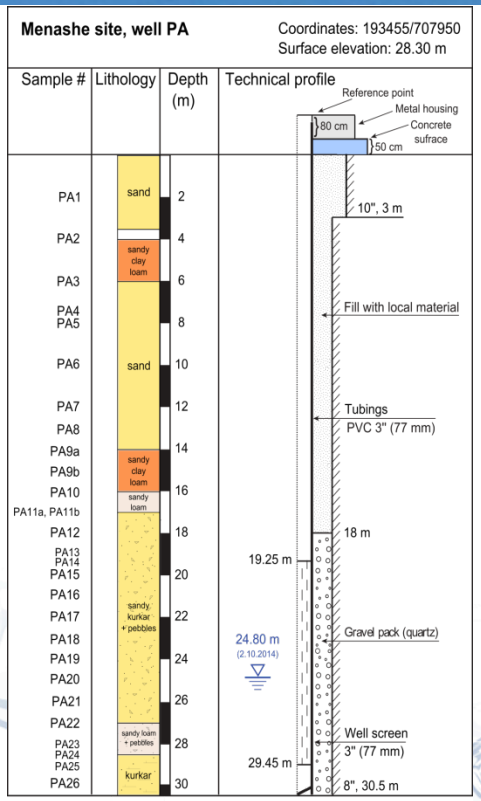
via artificial recharge.

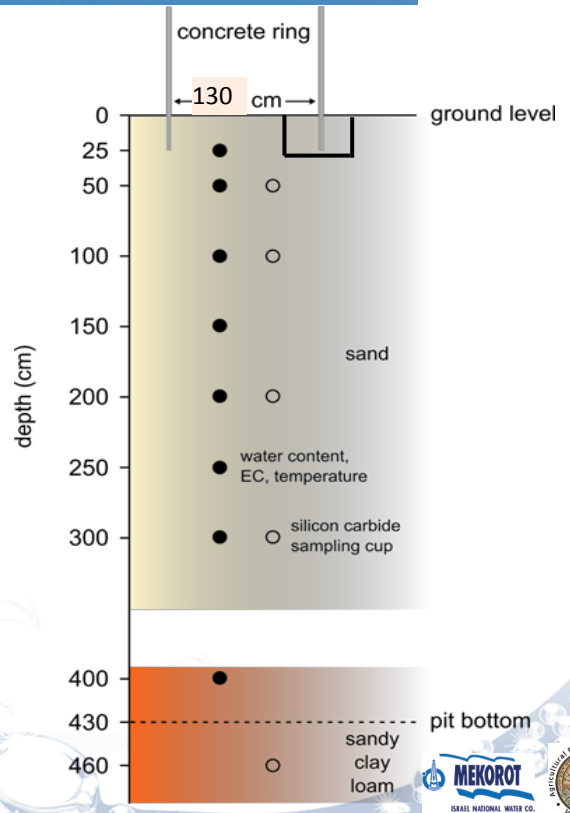
Techniques include infiltration ponds and injection wells

Setup of the field site

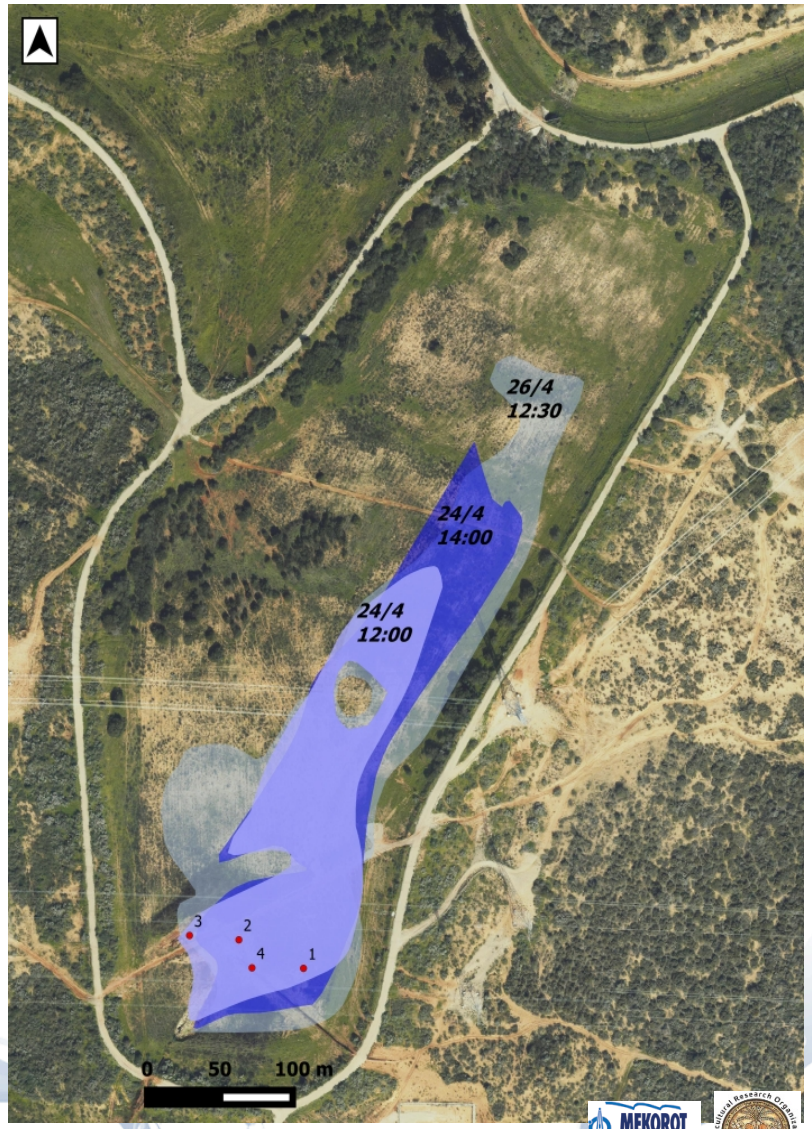








Monitoring an operational MAR event



Water chemistry

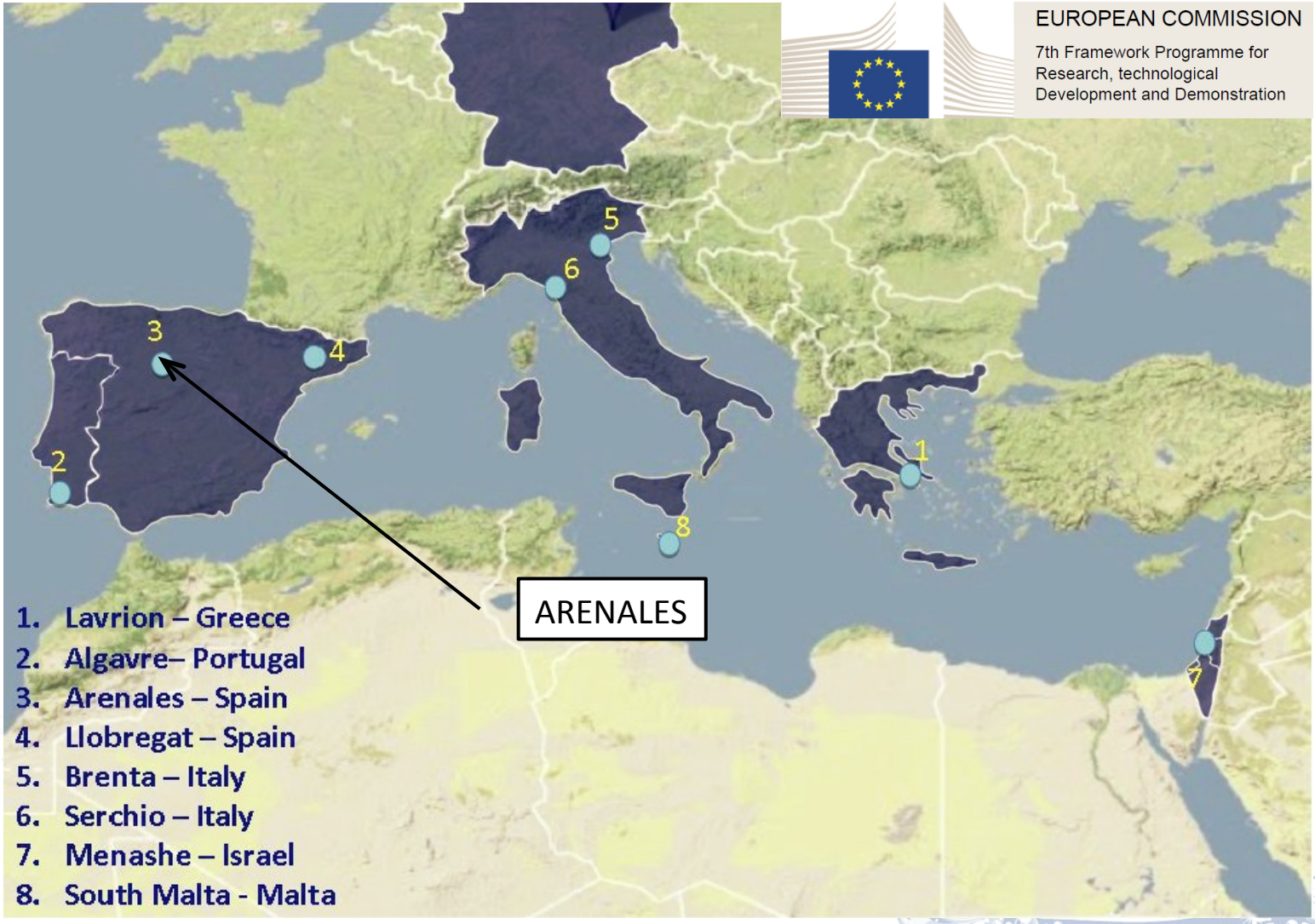
Sampling	Water type and source	Cl	Na	K	Ca	Mg	HCO3	SO4	NO3	B
01/06/14	Groundwater production well H7	79	42	2.0	85	11.1	205	27	19	0.03
01/06/14	Groundwater production well M24	54	25	1.0	60	11.7	186	22	23	0.01
01/06/14	Groundwater production well M6	74	36	1.6	100	11.9	267	35	37	0.03
01/06/14	Groundwater production well M9	70	33	1.4	93	9.7	253	34	23	0.03
01/06/14	Groundwater production well M21	61	40	1.8	99	11.2	254	32	24	0.03
01/06/14	Groundwater production well M22	80	34	1.1	81	13.4	230	29	25	0.02
01/06/14	Groundwater production well M26	67	33	1.6	88	14.4	246	28	28	0.02
01/06/14	Groundwater production well M27	86	43	2.0	96	16.7	249	25	31	0.02
01/06/14	Desalinated (Reservoir)	10	11	0.5	40	0.1	107	8	<0.3	0.24
24/02/14	Desalinated (MAR event)	20	19	0.5	27	<1	97	17	<0.3	
05/10/14	Shallow groundwater below pond PA	15	23	0.8	48	3.6	202	16	0.5	
02/10/14	Shallow groundwater below pond PB	13	24	0.8	51	3.7	215	16	0.8	

$$CaCO_{3(s)} + CO_2 + H_2O \leftrightarrow Ca^{2+} + 2HCO_3^-$$

Assuming remineralization through MAR will lead to concentrations similar to the production wells and an operational cost of 0.03 EUR/m^3 for discharging and pumping, we can get remineralization at 0.01 EUR/m^3 and get a little Mg^{2+} as a bonus.

MARSOL Field sites

Various water sources and qualities - various technologies - various objectives



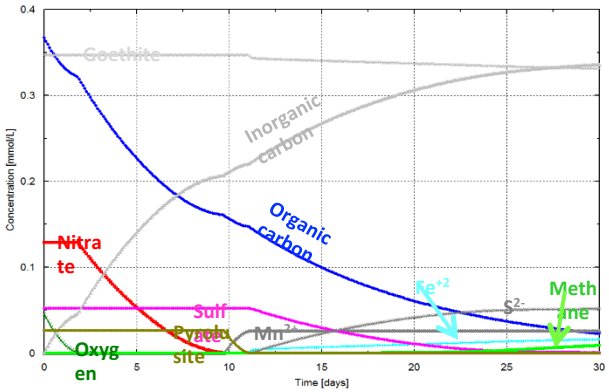
MARSOL

MAR for FARM– Spain (E. Escalante et al.)

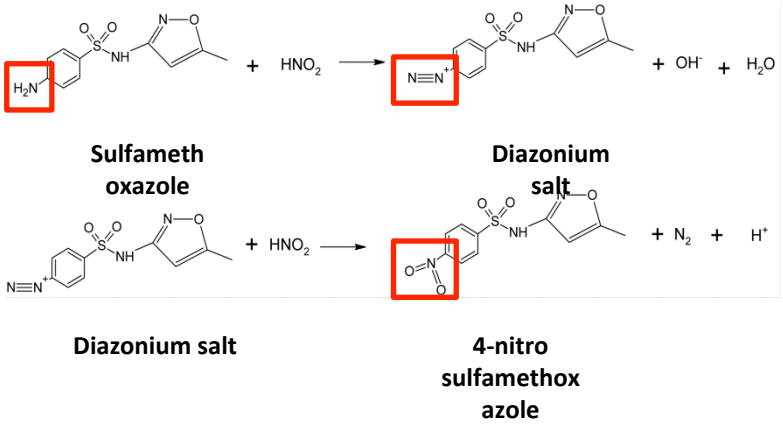
to bring the results of research projects to a rural area where the feeling is of being "forgotten", the range of dissemination of results of research projects has been expanded to the "general population", while this activity tends usually to be directed at scientists, technicians and professionals..

Pollutant degradation

- How to enhance natural attenuation of emerging pollutants in MAR applying engineering injection-extraction→ Montecarlo simulations.
- Understanding degradation mechanism of antibiotics: sulfamethoxazole and diclofenac.
- Evaluating change of hydraulic properties in different materials of reactive layers in MAR (Univ. Barcelona, WADISMAR).



Modeling organic matter degradation of reactive layer during MAR



Mechanism degradation of SMX under denitrifying conditions

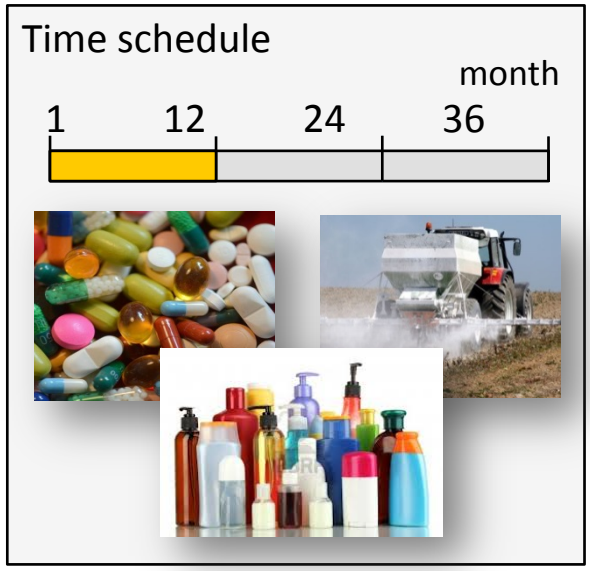
Water quality (Axel Bergmann, Christine Kübeck)

- Water constituents (Task 14.1, IWW)
  - Identification of anthropogenic substances in the infiltrated waters and percolates at the DEMO sites

➢ Create a consistent data base

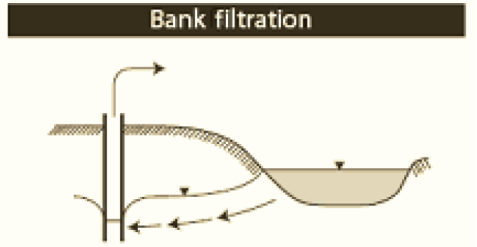
- Human pharmaceuticals (Diclofenac, Ibuprofen…)
- Antibiotics (Doxycycline, Sulfamethazole…)
- Beta blocker (Bisoprolol, Satalol…)
- X-ray contrast agents (Iomeprole…)
- Surfactants
- Complexing agents (EDTA)
- Sweetener (Acesulfam…)
- Nonylphenole
- Xenobiotics (Atracine, DET…)

- Inorganic parameter (tww: COD, BOD etc.)



PHARM SWAP – MED (ITALIA – ISRAELE) 2016-2018

Managed induced riverbank filtration (IRBF) at the Serchio River well field



Obiettivi:

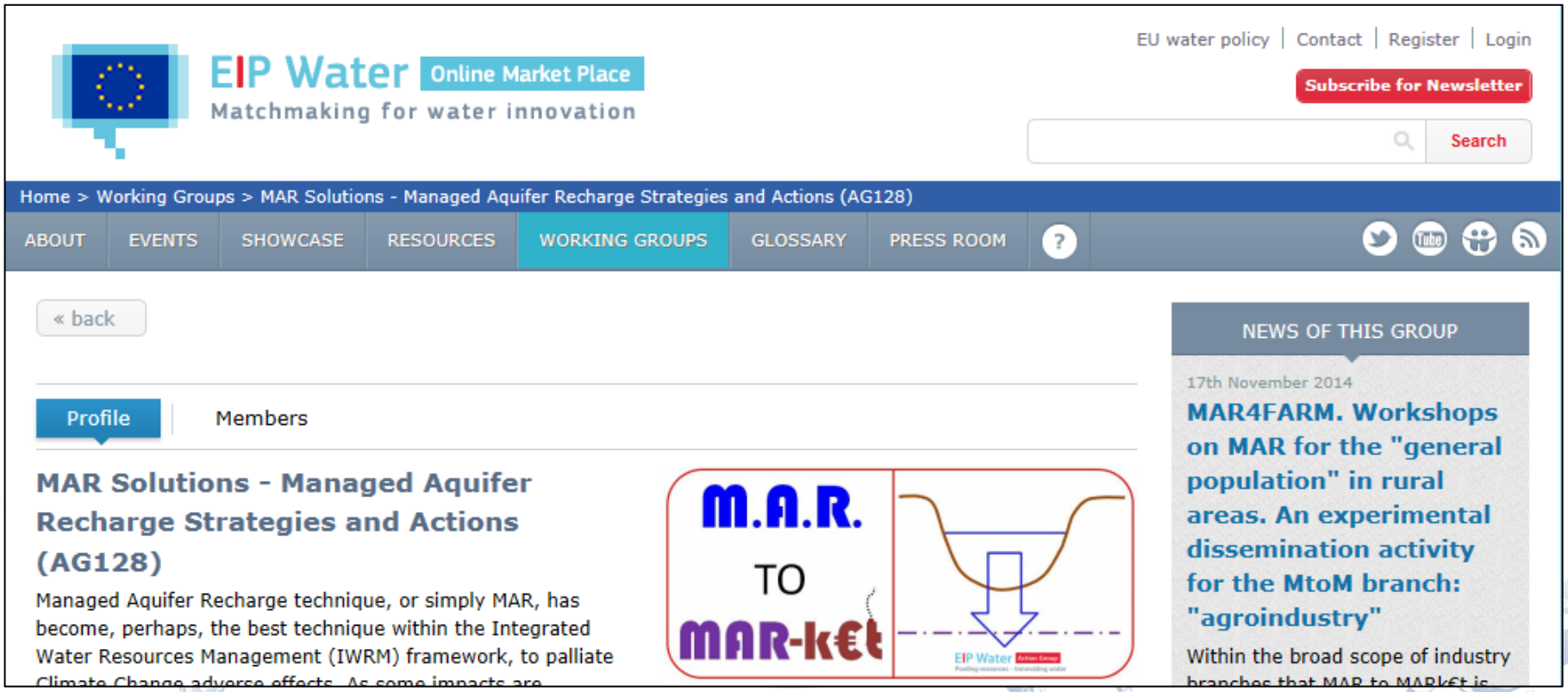
1. Portare l'attuale modalità di prelievo ai campi pozzi che emungono la falda di subalveo da ricarica non-controllata a una sicura tecnica MAR;
2. Sviluppare una piattaforma tecnologica di controllo dove i dati sono acquisiti in continuo attraverso sensori dedicati, trasmessi a database, elaborati in automatico in modelli numerici calibrati per la gestione delle operazioni ai campi pozzi;
3. Verificare le potenzialità di penetrazione di mercato della piattaforma tecnologica sviluppata

MAR to MARKET

Action Group, European Innovation Partnership (EIP)

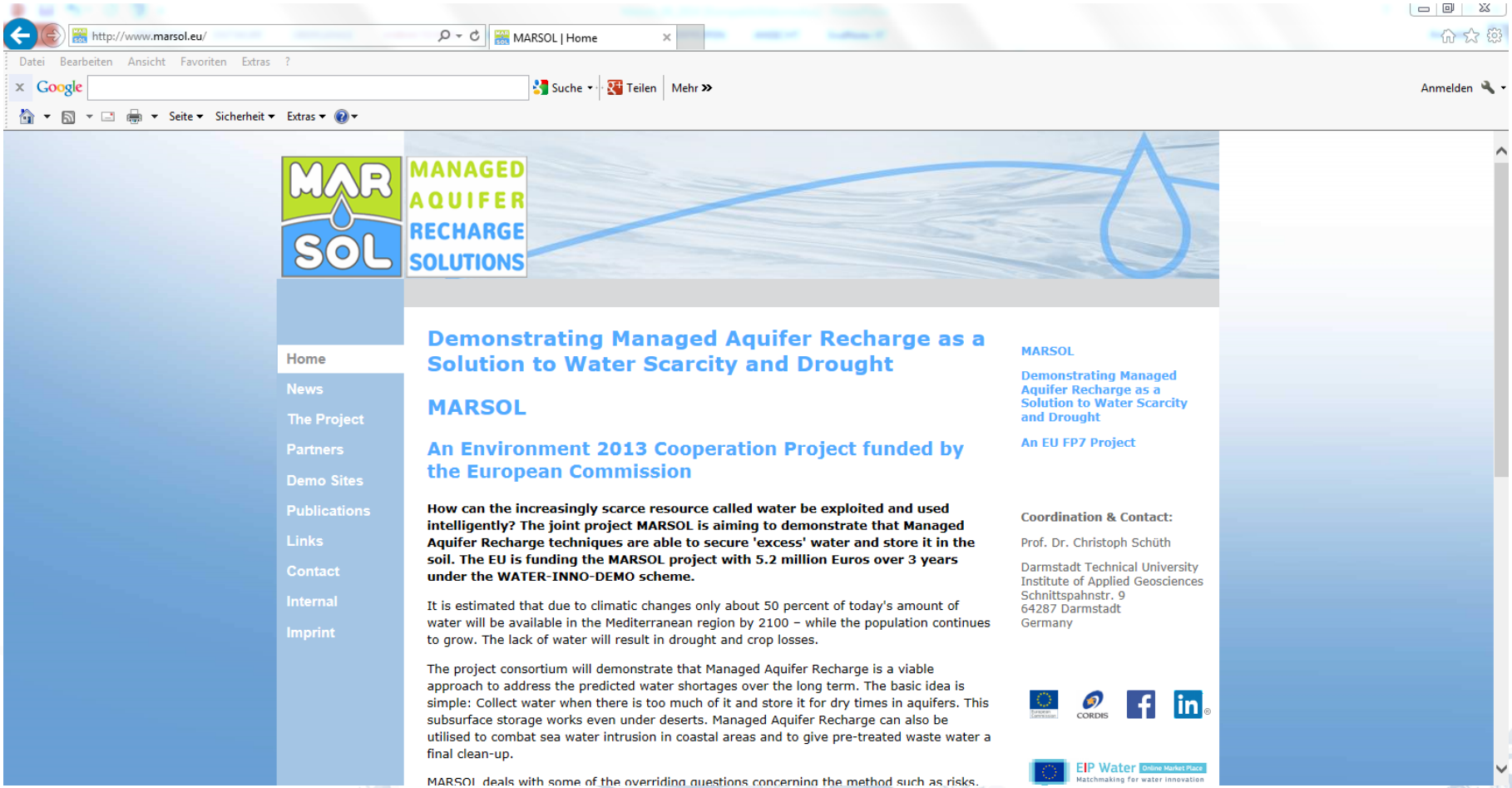
The aim is to speed up innovations that contribute to solving societal challenges, enhance Europe's competitiveness and contribute to job creation and economic growth. EIPs help to pool expertise and resources by bringing together public and private actors at EU, national and regional level, combining supply- and demand-side measures.

Coordinated by LNEC, 36 Partners



MARSOL Webpage

www.marsol.eu



www.freewat.eu

FREEWAT is an ICT project for improving Water Resource Management (WRM)

MAIN EXPECTED RESULT

Open source and public domain GIS integrated modelling platform for promoting WRM by simplifying and strengthening the application of WFD, GWD and other water related Directives.

FREEWAT expected main impact →

help producing scientifically and technically sounding decision and policy making based on:

- data and innovative data analysis tools and
- including participatory approach not only in the final stage of discussion but also during the phase of scenario generation.

A shared vision

ground water

Issue Paper/

Groundwater Modeling in Integrated Water Resources Management—Visions for 2020

by Jens Christian Refsgaard[1], Anker Lajer Højberg[2], Ingelise Møller[3], Martin Hansen[2], and Verner Søndergaard[3]

Abstract

Groundwater modeling is undergoing a change from traditional stand-alone studies toward being an integrated part of holistic water resources management procedures. This is illustrated by the development in Denmark, where comprehensive national databases for geologic borehole data, groundwater-related geophysical data, geologic models, as well as a national groundwater-surface water model have been established and integrated to support

FREEWAT
Concept and Motivations/1

1. ICT tools to boost the application of the WFD and water related Directives;

2. free and open source tools, numerically based, GIS integrated to perform spatial and temporal analysis on water quantity and quality issues;

3. training technical staff at authorities and private companies on the use of state-of-the-art innovative software for water management;

4. readily available ICT tools to analyse conjunctive use of surface- and ground-water, the impacts of land use and urban sprawling and of climate change on water resource;

FREEWAT
Concept and Motivations/2

5. use effectively data provided by the extensive monitoring required by the WFD;

6. including participatory approach earlier than only result discussion;

7. capacity building within the EU water sector;

8. supporting scientific research results to foster their real scale application and uptake by policy makers and water authorities.

Open source characteristics of the project→

initiative "*ad includendum*" - further research institutions, private developers etc. may contribute to the project development.

WHY PUSHING WITH SIMULATIONS?

The **EU Water Framework Directive** recognizes as relevant modelling activities for:

- testing hypothesis on conceptual models;
- validating scenarios to be included in River Basin Management Plans;
- water resource evaluation and forecasting;
- large engineering works impact assessment;
- evaluation of effectiveness of proposed contaminated water remediation activities.

FREEWAT Consortium

DURATION: 30 months – started April 1st 2015 – to September 2017

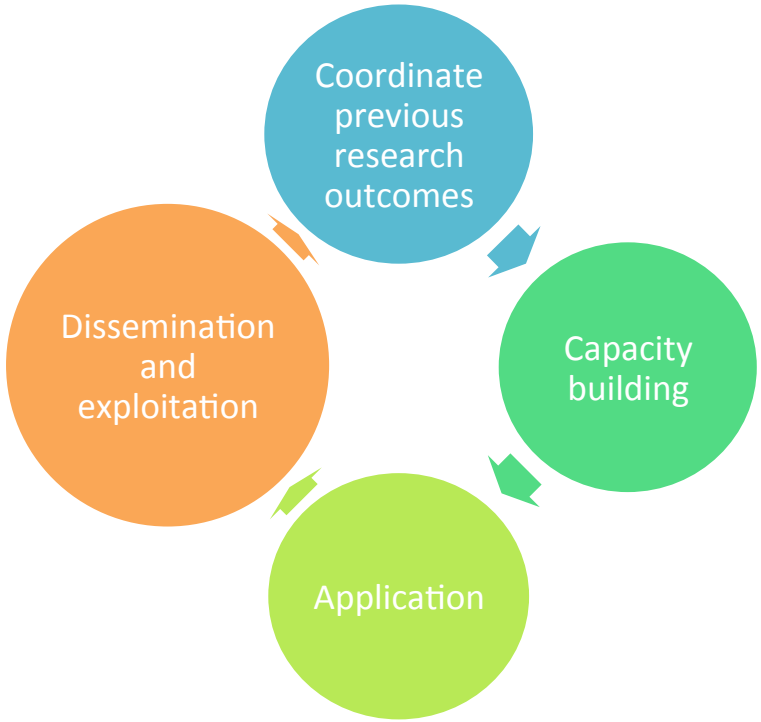
FREEWAT circular economy

SOFTWARE DEVELOPMENT AND CAPACITY BUILDING

- Building the software platform (WP2)
- Training the trainers (WP3)
- Spreading the word of using FREEWAT throughout Consortium countries and beyond (WP3)

APPLY THE FREEWAT PLATFORM (WP4/5/6)

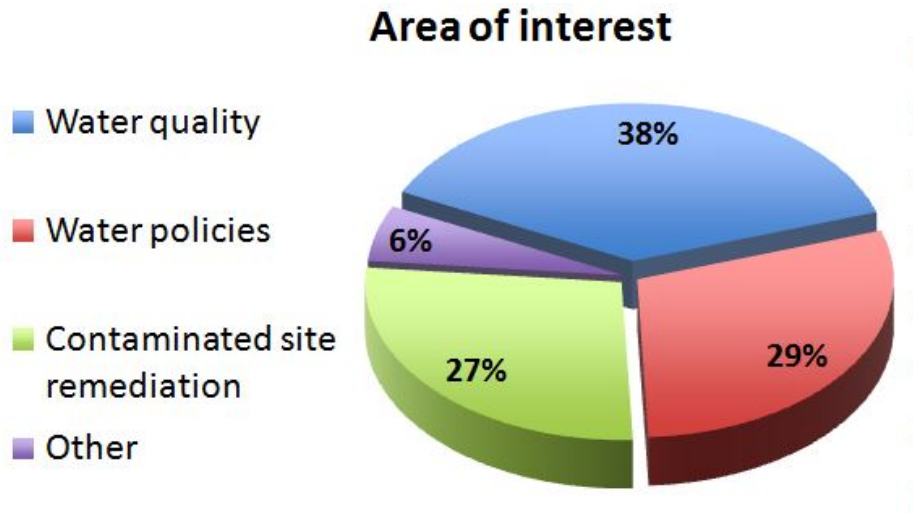
- **Postulate the problem you have to solve**;
- Gather the data;
- Discuss the data with relevant stakeholders;
- Start the model implementation;
- Involve the stakeholders during model implementation and calibration;
- Apply the model for solving your problem;
- Producing policies!

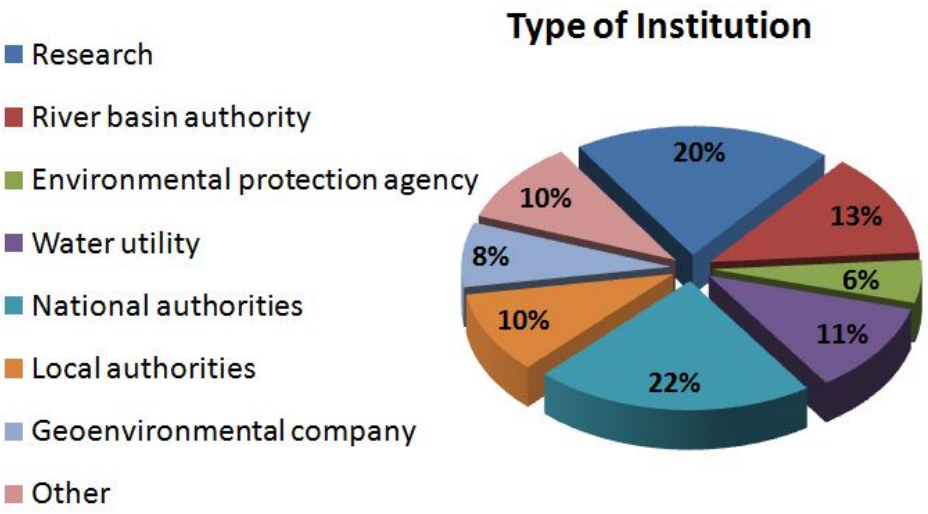


FREEWAT CAPACITY BUILDING

- Large stakeholders involvement (more than 200 stakes going to be involved)
- Web social and professional networks

(linkedin group launched 5 days ago yet about 170 followers)

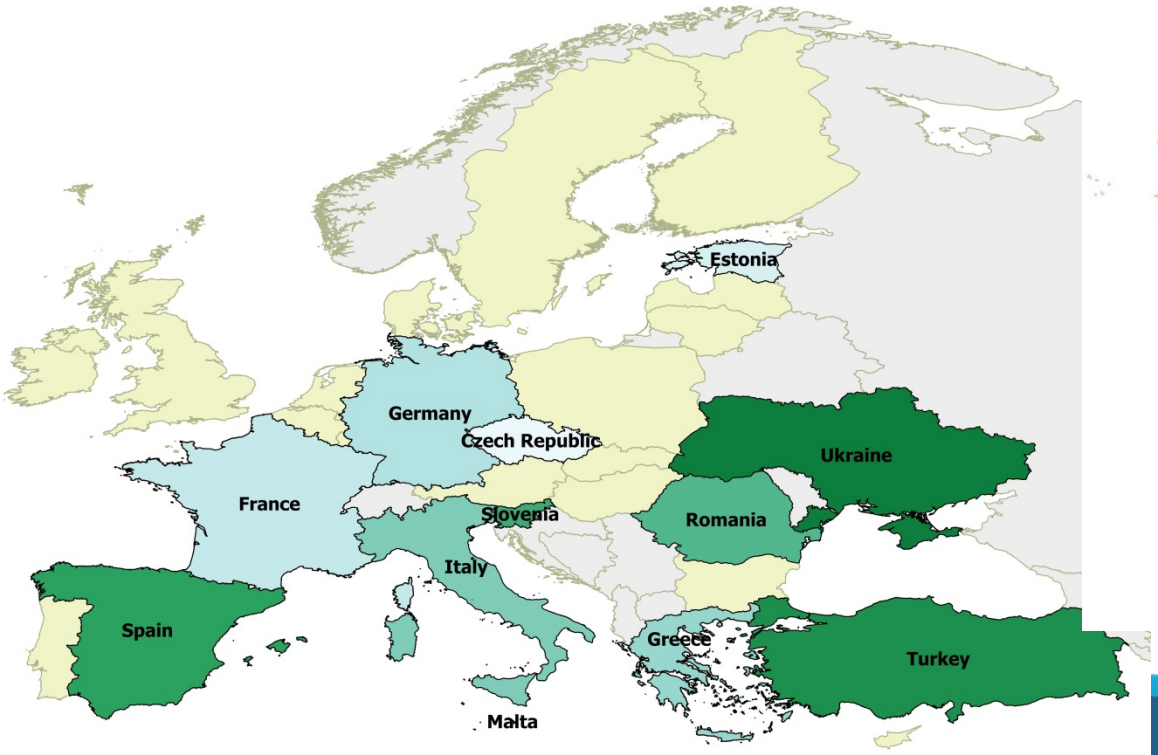




FREEWAT case studies

14 case studies:

- 8 for the application of WFD, GWD and others (EU countries) plus 1 case study in Switzerland (SUPSI, collaborating Institute)
- 5 devoted to rural water management: 2 EUs, Turkey, Ukraine, and Africa (through UNESCO involvement)



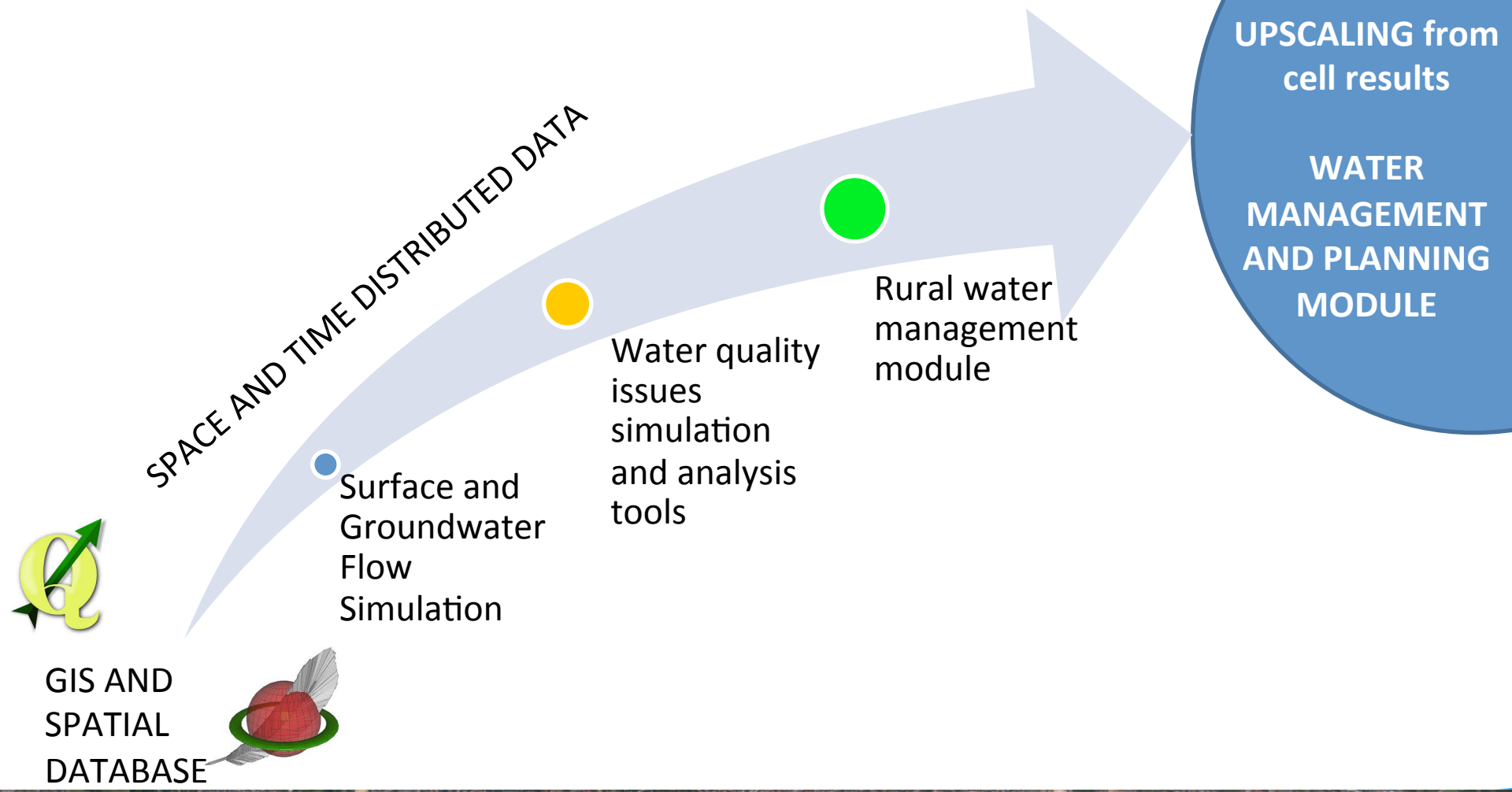
Which EU and national previous efforts are integrated in FREEWAT?

- **SID&GRID** (Regione Toscana): Surface water and groundwater flow and unsaturated zone processes in gvSIG GIS (*superseeded*)
- **MARSOL** (EU, FP7): solute transport in groundwater
- **QUIMET** (Catalan Water Agency): GIS based hydrogeochemical analysis tools
- **REGIONE TOSCANA**: porting of SID&GRID into QGIS
- … plus not only EU-made codes

And potentially:

- **NITRATOS** (EU, LIFE)
- **FEDER12** (France): 3D databases, namely **PostGIS 3D**, to be able to store and manipulate 3D objects and 3D meshes
- …

FREEWAT architecture



FREEWAT NEW MODULES → (development ongoing)/1

MODULES FOR SPECIFIC WATER CYCLE ISSUE ANALYSIS

1. Solute transport in the unsaturated zone (UFZ-MT3DMS? SWAP? Hydrus 1D)
2. Observations Analysis Tools (TSPROC-like module)
3. Calibration, uncertainty & sensitivity analysis (UCODE_2014)
4. Aquifer-lake interaction (LAK package)
5. Tools for dealing with groundwater quality issues
6. Tools for the interpretation and visualization of hydrogeological data

For more technical info tomorrow at 11.45
S8.9 Advances in public domain groundwater flow and transport modelling

FREEWAT NEW MODULES → (development ongoing)/2

UPSCALING CELL BY CELL RESULTS

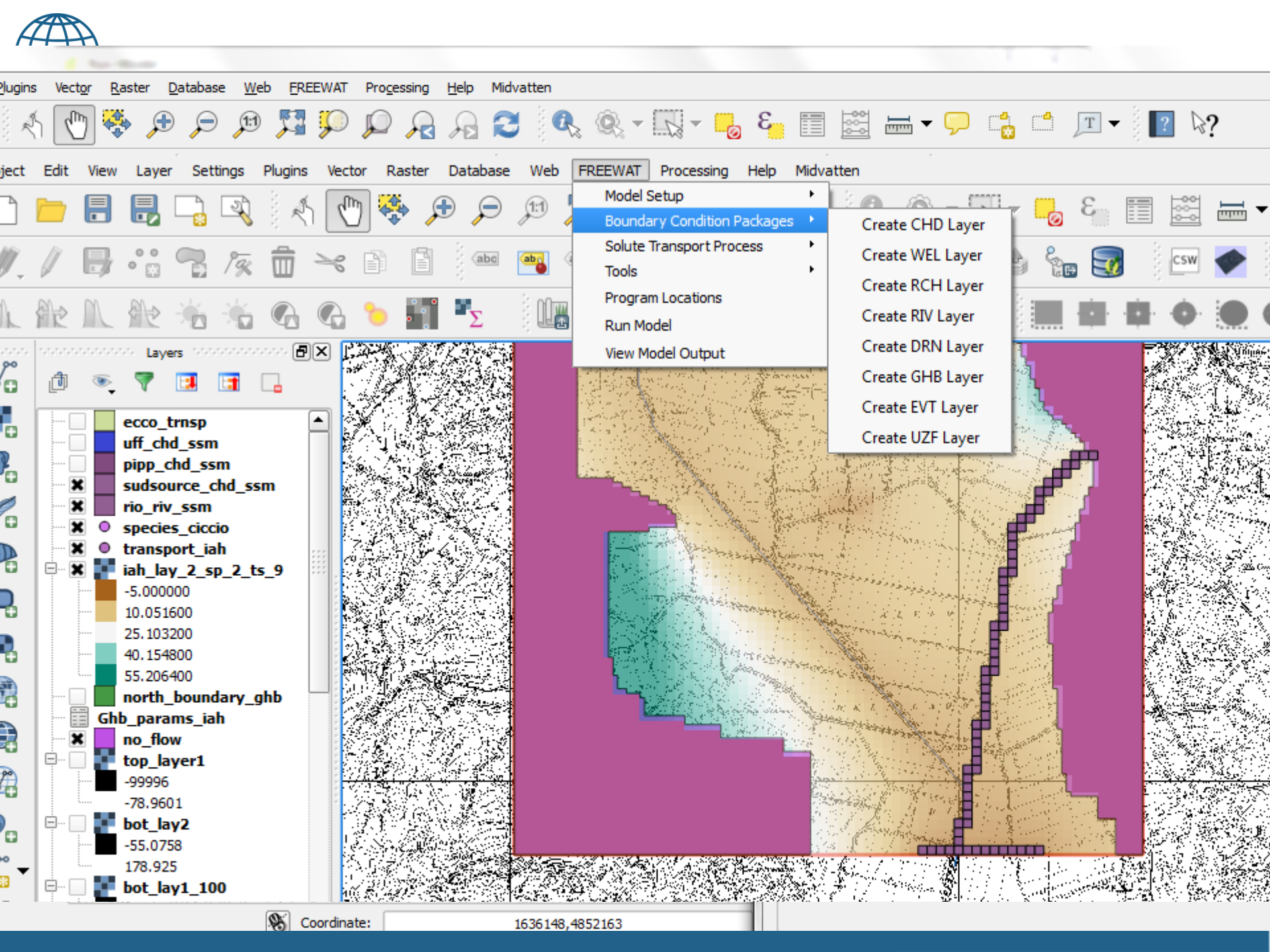
1. Management of water in agriculture (Farm Process &EPIC-like mod.)
2. Water management and planning module (GWM? WEAP-like module?)

These two modules will be the heart of a DSS for water resource managers.

Will take steps from simulation scenarios

Mainly devoted to groundwater resource management

Will allow spatial and time-dependant analysis on water allocation re-allocation and infrastructure planning


Plugins Vector Raster Database Web FREEWAT Processing Help Midvatten
Project Edit View Layer Settings Plugins Vector Raster Database Web FREEWAT Processing Help Midvatten
Model Setup
Boundary Condition Packages
Solute Transport Process
Tools
Program Locations
Run Model
View Model Output
Create CHD Layer
Create WEL Layer
Create RCH Layer
Create RIV Layer
Create DRN Layer
Create GHB Layer
Create EVT Layer
Create UZF Layer
Layers
ecco_trnsp
uff_chd_ssm
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sudsource_chd_ssm
rio_riv_ssm
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178.925
bot_lay1_100
Coordinate:
1636148,4852163

FREEWAT PLATFORM ADVANTAGES vs. commercial simulation platform

- Unite the power of GIS geo-processing and post-processing tools in spatial data analysis to that of simulation software
- The chance for public authorities to build a high informative and dynamically growing representation of a hydrologic system (i.e. river basin) where perfoming data storage and planning analysis
- WRM modules thought for decision-making and policy applications
- No cost for licences (money can be moved to development of client tailored applications)

FREEWAT NEW MODULES → (development ongoing)/2

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EU LIFE REWAT 2015 -2019

sustainable WATer management in the lower Cornia valley through demand REduction, aquifer REcharge and river REstoration

Coordinatore:
Consorzio di Bonifica 5 Toscana Costa

Partners:

Regione TOSCANA

Scuola Superiore Sant'Anna – Istituto di Scienze della Vita

ASA spa

FREEWAT

Free and Open Source Software Tools for Water Resource Management

EU HORIZON 2020 Project

ict4water.eu

Thank you for your attention!

FREEWAT - Free and Open Source Software Tools for Water Resource Management

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