



KNOWLEDGE INVENTORY FOR
HYDROGEOLOGY RESEARCH

MAKING GROUNDWATER VISIBLE, ACCESSIBLE AND TREASURED

KINDRA PROJECT FINAL CONFERENCE - Brussels, 27 th February 2018



A word from Vitor Correira

President of the European Federation of Geologists



In a world dealing with climate change and a growing population, access to clean water will become the primary key challenge to humanity in this century. In this context groundwater, the hidden part of the water cycle, is paramount, and geoscientists who investigate and map the subsurface, evaluating groundwater geochemistry and modelling water flow offer a fundamental contribution to manage water quality and supply.

Kindra is the first step to advance sustainable management practices for groundwater. Joint international research and better coordination are fundamental to cope with water scarcity in many regions of Europe. The results of the project show that geoscientists are ready to work cooperatively, and I trust all stakeholders will come along.



Kindra consortium in 2015 Kick off Meeting in La Palma, Spain.



Joint Panel of Experts Meeting in 2017 in La Palma, Spain.

A word from Marco Petitta

Project Coordinator

It was an exciting experience to coordinate the KINDRA project, thanks to the active collaboration of the project partners, of the Joint Panel of Experts and of the EC staff. During last three years, I realized that groundwater is not only a relevant research topic and a fundamental resource for humans and environment, but also that its relationships with modern societal challenges and EC policies are so important and need to be reinforced, more than I suspected at the beginning of the project.

I hope that KINDRA realized some steps forward in pushing groundwater issues on the European context. All of us did our best during the project, but additional efforts are required for the future. We are ready to do it.

About KINDRA

Hydrogeology related research activities cover a wide spectrum of research areas at EU and national levels. The European knowledge base on this important topic is widespread and fragmented into broader programmes generally related to water resources, environment and ecology.

To achieve a comprehensive understanding on the groundwater theme, **the KINDRA project - Knowledge Inventory for Hydrogeology Research has carried out an accurate assessment of the state of the art in groundwater knowledge and created a critical mass for scientific exchange of information, to ensure wide accessibility and applicability of research results, including support of innovation and development, and to reduce unnecessary duplication efforts.**

Work under KINDRA (besides project management and project communication & dissemination) is divided into the following three core work packages:

WP1 – METHODOLOGY FRAMEWORK DEVELOPMENT

This WP created a harmonised classification system (HRC-SYS) for reporting groundwater research and knowledge in Europe (coming from programmes, papers, projects, results, reports, etc.). This classification, based on a 3D visualization related to three main categories, is supported by a web-service repository of metadata- the European Inventory of Groundwater Research (EIGR).

WP2 – DATA COLLECTION AND PROCESSING

This WP facilitated the EU-wide assessment of existing practical and scientific knowledge on hydrogeology research and innovation in Europe. The assessment has been carried out with the help of the national member associations of EFG, namely Linked Third Parties (LTPs), using the developed classification system/data sources identified in WP1. The LTPs and the KINDRA partners have uploaded into the EIGR the metadata related to groundwater research and knowledge, following the classification criteria. At the end of the project, more than 2000 records have been validated and published on the EIGR.

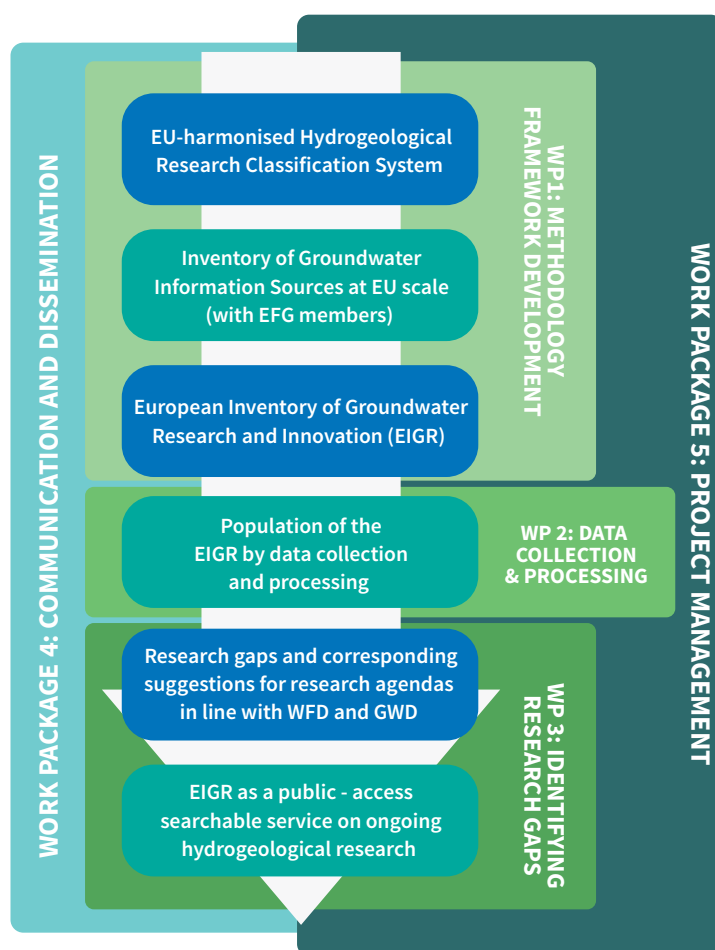
WP3 – RESEARCH GAPS AND RECOMMENDATIONS

This WP identified research gaps and trends in hydrogeology research, by analysing collected metadata from the EIGR and from scientific databases (as SCOPUS). In addition, the EIGR can be used as a public-access searchable service, which will be available for uploading and extracting information also after the end of the project.

Obtained results are intended to be used for the implementation of the Water Framework Directives (WFD and GWD) including a sound understanding of groundwater-surface water interactions and climate change impact and adaptation.

KINDRA gives you many reasons for being actively involved in the water community!

- ✓ KINDRA and its on-line inventory (EIGR) are the only tools exclusively dedicated to groundwater research & knowledge
- ✓ KINDRA combines research and knowledge, merging academic and practitioner communities
- ✓ A dedicated classification system allows you to classify your products, papers, projects, reports, databases, etc. for facilitating future searches and analyses
- ✓ The EIGR promotes networking and enlarges the community of hydrogeologists and “groundwater-people”
- ✓ The EIGR represents an international access point to national knowledge sources
- ✓ The database analysis has been used for EU policy support and implementation of water directives



Groundwater Classification

For developing the common terminology and classification, keywords characterizing research on groundwater have been identified following two approaches: (1) from the most important EU directive documents, and (2) from groundwater related scientific literature, which has been fundamental for identifying relationships and intersections between topics, themes and activities. To assess the importance and pertinence of the keywords, these have been ranked by performing searches via the Web of Science and Scopus search engines. The complete merged list of keywords consisting of about 240 terms have been organized in a tree hierarchy, identifying three main categories: Societal Challenges (SC), Operational Actions (OA) and Research Topics (RT). In each of these three categories, 5 overarching groups have been defined for easy overview of main research areas, representing level 1 (Fig. 1). All identified keywords have been categorized into one of these overarching group in up to three levels. The classification system previews the interaction among the three main categories through a 3D approach (Fig. 2), where along each axis the 5 overarching groups are indicated.

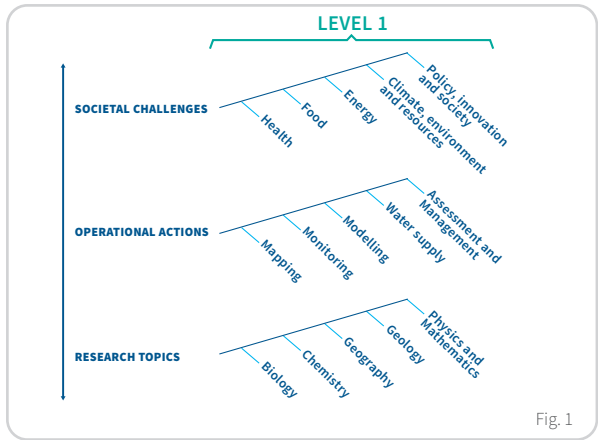


Fig. 1

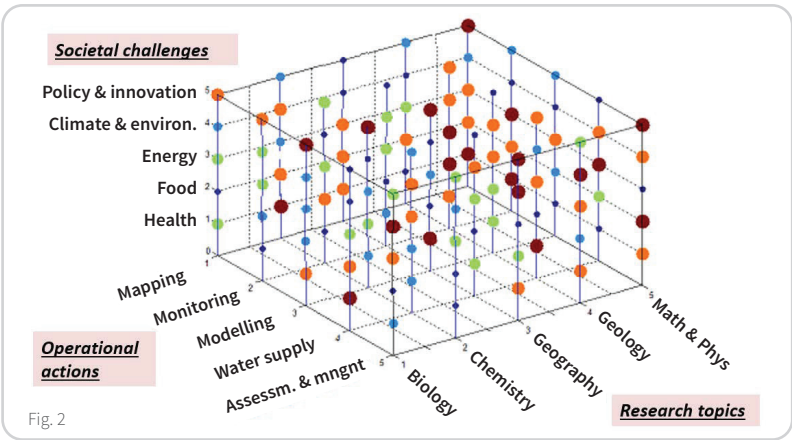


Fig. 2

The proposed classification system allows the immediate comparison of the two "technical categories" with the Societal Challenges identified by the European Commission in Horizon2020.

Societal Challenges (SC) include the pertinent fields included in Horizon2020, as: Health; Food; Energy; Climate, environment and resources; Policy, innovation and society Research Topics (RT) correspond to basic scientific disciplines: Biology; Chemistry; Geography; Geology; Physics and mathematics; Operational Actions (OA) are related to the hydrogeological activities: Mapping; Monitoring; Modeling; Water supply; Assessment and management.

The classification intends to enhance interdisciplinary and impact of groundwater studies on society. A 3D approach will be helpful to identify trends and gaps, more easily shown by 2D graphs for each of the societal challenge. In figure 3 an example of the intersection between RT and OA is shown, based on the SC main category (see EIGR explanation on the following page).

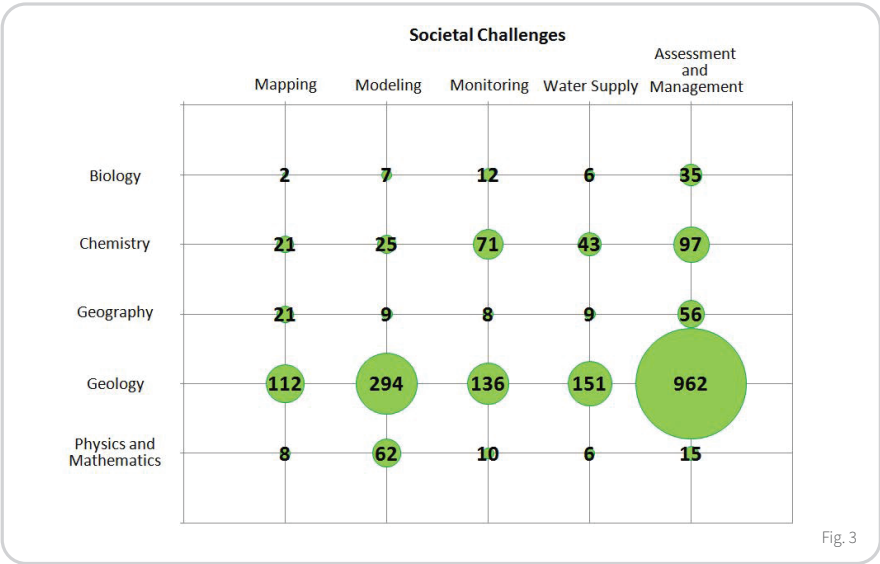


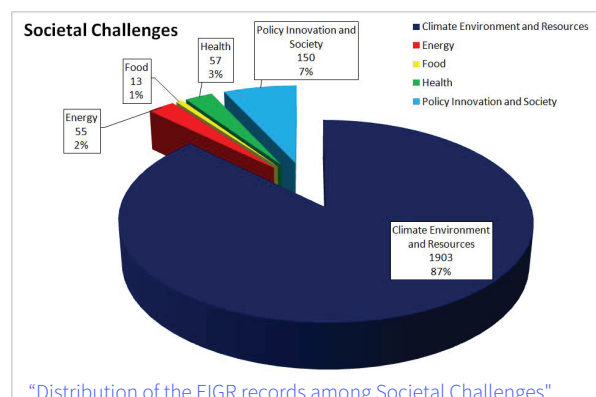
Fig. 3

European Inventory for Hydrogeology Research

The European Inventory of Groundwater Research (EIGR) is a tool which allows the application of the proposed classification. The EIGR currently contains well over 2178 records, metadata of documents related to the groundwater knowledge, such as scientific reports, articles, projects etc., illustrating and providing links to research efforts carried out throughout Europe since 2000, indicating where data can be retrieved, following their classification per the proposed methodology. Innovative features of EIGR include that uploaded metadata distinguish between 'research' and 'knowledge' according to four different classes identified by the level of performed quality assurance.

Both the harmonised methodology (HRC-SYS) and the EIGR tool, are key to achieve the overall aim to create an overview of the scientific knowledge covering European countries by means of an accurate assessment of hydrogeology research in various geographical and geo-environmental settings, and to allow direct comparison and exploit synergies. A quick assessment of the contents published through the EIGR, by means of tools which have been developed for a rapid analysis and visualization of the groundwater related information published through the EIGR. <http://kindra.kindraproject.eu/kindra/>

The information can be queried according to the contributions related to each European Member State as well as the most popular Keywords related to the Groundwater Research. Additionally users will be able to visualize the resources published through the EIGR according to the Hydrogeology Research Classification System by interacting with 2D Graphs.



Finally, the feature "CSV Data from Geonetwork" allows the data extraction of a file to be used for further analysis. The query will search for the term in the title, abstract, keywords, organization name, date, author name and the resulting resources included in the table can be downloaded in CSV format.

Quality
France Aquifer Monitoring
Groundwater body
Groundwater resources
Mapping Drinking water
Modeling
Geophysical methods

Here represented are the 10 most popular keywords in the EIGR, related to the records which have been uploaded and published through the Inventory.

Become an editor

In order to contribute to the EIGR by uploading new records, please register and you will receive a password that gives you access. To enable easy data entry and search we have created a tutorial video that guides you through the inventory by following the major steps to be taken all while highlighting the most common mistakes to avoid, as well as a User's Manual available for download in our webpage or scanning this QR:



ADDED VALUES OF PRESENTING YOUR RESEARCH IN KINDRA EIGR

- 1 VISIBILITY IN THE FIRST ONLINE TOOL EXCLUSIVELY TO GROUNDWATER RESEARCH & KNOWLEDGE**
- 2 ALLOWS LIKE-MINDED PROFESSIONALS TO FIND EACH OTHER**
- 3 CLASSIFICATION OF YOUR RESEARCH, PRODUCTS, PAPERS AND PROJECTS**
- 4 EXPOSE YOUR RESEARCH TO DATABASE ANALYSIS FOR EU POLICY SUPPORT AND WATER DIRECTIVES IMPLEMENTATION**

ACCESS EIGR: [HTTP://KINDRAPROJECT.EU/EIGR/](http://kindraproject.eu/eigr/)

Linked Third Parties

20 Linked Third Parties (LTP-s) of the European Federation of Geologists actively contributed to the success of the project by being part of the following actions:

NATIONAL WORKSHOPS

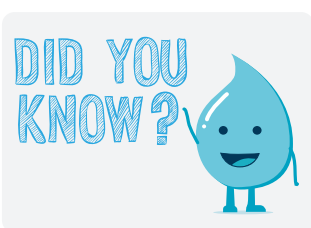
The European Federation of Geologists National Associations from 20 European countries organised national workshops on hydrogeology with a total number of 540 participants in 17 European countries. These workshops served as a platform for disseminating the project at a national level and at the same time facilitated interaction and discussion between workshop participants and KINDRA national experts. Participants discussed the involvement of the EU Member States related to the implementation policy according to recommendations of the WFD in the field of the protection of groundwater resources and improvement of water quality, as well as the degree of national involvement in the implementation of policy of sustainable development was also assessed.

COUNTRY REPORTS

One of the main objectives of the KINDRA project is the Europe-wide assessment and data collection of existing groundwater-related practical and scientific knowledge, focusing on EU dimensions, national and regional activities in a format suitable for use beyond the lifetime of the project. The 20 National Associations participating in the project individuated the hydrogeology-related information from diverse sources, consulting at national level the relevant reports and databases of universities, research centres, government bodies, territorial administrative offices and other parties involved in hydrogeology research. Furthermore, they provided information about the gaps and barriers.

DATASHEETS

The collected information for EIGR comprise inputs from the LTPs participating in the project as well as from Project Partners. They provided the information on the EIGR, where more than 2000 metadata have been uploaded, identifying Research and Knowledge class 1-4 classification and HRC-SYS (Operational actions, Societal challenges, Research topics) together with Technological and Policy readiness level overview. The prevalent type of metadata uploaded to the EIGR is hydrogeology related reports (48%) followed by scientific papers from international and national scientific journals, popular journals, newsletters (26%) and other publications such as conference proceedings.



Horizontal Aim: Making Groundwater Visible

Water is a key-topic in modern society: not only it is a pivotal human, biological and environmental requirement, it also represents the engine for several research topics which are interconnected and cover the water-food-energy-climate nexus. It has an impact on urban systems too.

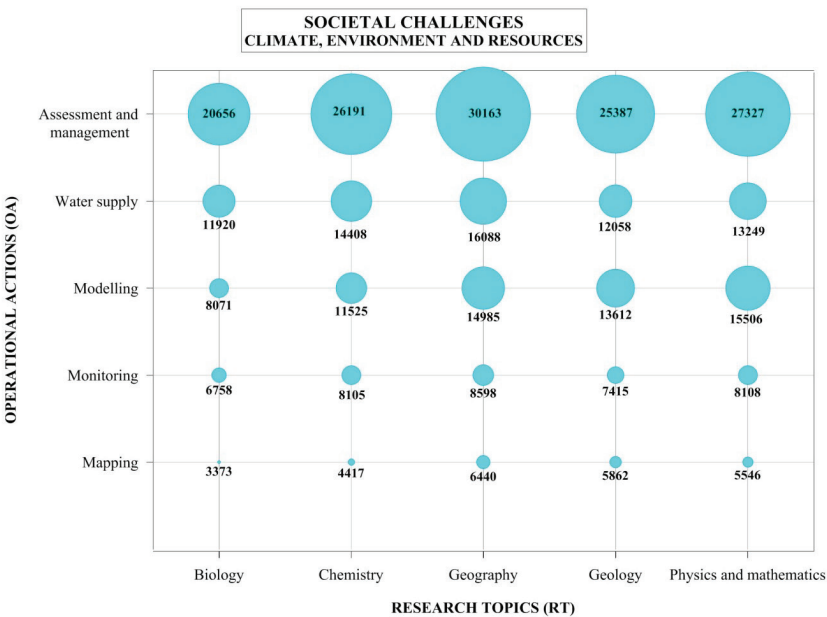
Groundwater, on the other hand, is the hidden component of the water cycle, and is difficult to assess, evaluate and communicate, even though it plays a fundamental role in our life by sustaining the health of our ecosystems, ourselves and our industrial and agricultural production. KINDRA seeks to help achieve a better understanding of the groundwater topic by adapting its technical content and results into outreach materials that help citizens to understand the relevance of groundwater in daily life. As part of this task, developed two Did you know? booklets, three videos, a set of interviews to hydrogeologists, and much more social media content.



Trends and Gaps

The final step of the project has been the gap and trend analysis of groundwater research and knowledge, particularly research relevant for implementing EU directives. The classification system and the data collected in the EIGR, coupled with a wider search on the scientific database SCOPUS, have been used for this scope. Resources are extracted from EIGR and Scopus database using search strings that contain all keywords belonging to each of the categories (5 for each of the three main axes: SC, OA, RT).

The HRC-SYS three dimensional classification system is explored for resources at intersections for research topics, operational actions for each of the 5 societal challenges selected for the analysis of gaps and trends.

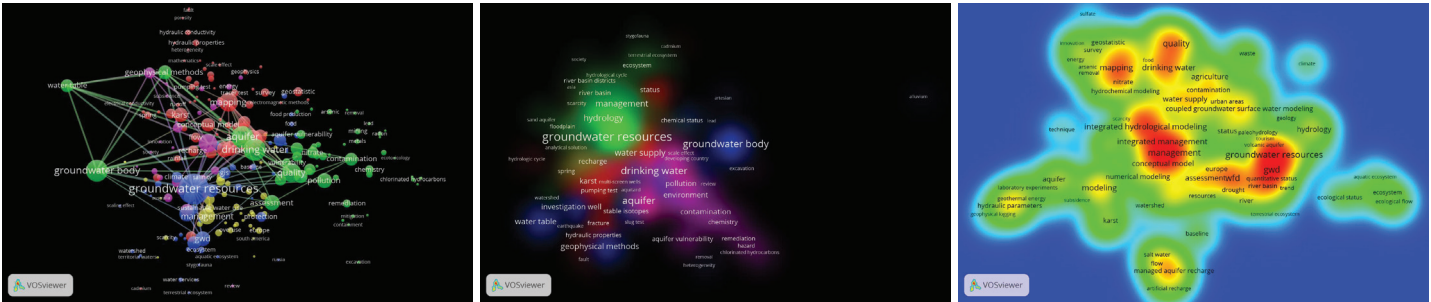


“Distribution of SCOPUS records for the SC Climate, Environment and Resources”

Analyses can be performed in all three directions, i.e. (RT, OA) for each SC, (RT, SC) for each OA and (OA, SC) for each RT, which complement each other. An example is shown above, related to SC ‘Climate, environment and resources’ for the Scopus database. Clearly, the EIGR has a population which is much smaller compared to Scopus. However, inspecting and analysing EIGR data gives insight in research topics and operational actions, associated to groundwater management, which is not available in the Scientific Scopus database.

For identification of gaps in groundwater research the VOSviewer software tool has been used to visualize co-occurrence links between keywords in maps. VOSviewer provides three visualizations of a map: The network visualization, the overlay visualization, and the density map. Links between keywords indicate research in which such keywords are linked. Missing links, where they are expected, may signify a gap in research. Each link has a strength, which indicate how keywords are coupled and interact. Some quick examples of the performed analysis are summarized below.

The cluster analysis of the entire EIGR database shows that networks are grouped in cluster around main keywords as ‘groundwater resources’, ‘groundwater body’, ‘mapping’ and ‘management’. How keywords from clusters are connected to other clusters is clearly shown and can be interpreted as a measure of relatedness within the resources from which they were extracted. In the periphery of the main clusters we also see ‘satellites’ like porosity, terrestrial ecosystem, etc., which have limited links with other keywords.



“Examples of analysis with different graphic tools of VOS viewer”

For visualizing temporal trends in number of resources, their importance and structure by means of the VOSviewer tool, records have been separated in two time period: 1997 until 2006 (adoption of GWD) and from 2007 to 2016. The distribution by overlay visualization for EIGR metadata since 2007, reveals a prevalence of keywords as ‘groundwater resources’, ‘groundwater body’, ‘drinking water’, and two main clusters representing groundwater management (green cluster) and water quality (purple cluster), with the influence of a third group (blue cluster) testifying the concept of ‘groundwater body’ introduced by the GWD.



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The KINDRA Partnership:

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EFG - European Federation of Geologists, BELGIUM
EFG 20 National Associations
REDIAM - Environment and Water Agency of Andalusia, SPAIN
LPRC - La Palma Research Centre for Future Studies S.L., SPAIN
UM - University of Miskolc, Faculty of Earth Science and Engineering, HUNGARY
GEUS - Geological Survey of Denmark and Greenland, DENMARK

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