N° 1 EXPERTISE COLLECTION

Better knowledge for better management

WATER, CLIMATE AND DEVELOPMENT

french water partnership

fwp pfe

partenariat français pour l'eau

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KNOW-HOW

Editor's note

After the adoption of the Sustainable Development Goals in September 2015 and the Paris Climate Agreement at the COP21 in December 2015, comes the time for implementation. Governments must now translate their commitments, for the most part associated with water, into national strategies for sustainable development, adaptation and mitigation, in line with all their sectorial policies. Civil society also has an important role to play. It's up to us, actors in the water community, to confront the major challenges of the future together!

So the French Water Partnership, with its multi-faceted pool of experts, has launched its new 'expertise' collection to reflect on strategies, mobilise our forces and act together. Knowledge of water resources–the essential foundation of any judicious decision–was an obvious choice for our first issue, particularly now, when major U.N. agreements are being implemented.

It is our hope that this publication will serve as a reference, a guide to light our way forward and accompany us on the path to progress in the domain of water.

So in this issue you will find a panorama of the main challenges associated with knowledge of water resources, as well as three major types of solutions of French actors involving:

- Acquisition of extensive, quality hydrological and meteorological data;
- Setting up functional Water Information Systems;
- Developing models that will help us deal more effectively with future water challenges.

These actions, pre-selected by a multi-actor steering committee composed primarily of scientists from the FWP's Water and Climate working group, demonstrate the dynamism and capacity for innovation of French water actors.

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President of the French Water Partnership

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Foreword

Today human societies must confront significant changes in the context–in particular the environmental context–in which they are constructed, evolve and develop. The use that societies make of natural resources is a primordial factor in their growth and development. Water resources, in particular, are linked to crucial and very diverse challenges related to environmental, nutritional, societal and health issues, as well as economic, financial, political and geopolitical concerns, and so on.

Yet water resources are often little known, poorly managed and poorly protected. Water resources are increasingly stressed as a result of many different factors: climate change, demographic growth, food security needs, urbanisation, economic pressures, industrialisation, pollution, etc. Since 1950, for example, the world has seen a tripling of the amount of water extracted for agricultural, industrial or domestic use. In addition, the fifth report of the Intergovernmental Panel on Climate Change (IPCC) confirms that climate change introduces a significant amount of uncertainty to the issue of useable water resources, increases the risk of localised flooding and drought, etc. These elements further harm an already fragile environment.

In such a context, there can be no effective action without knowledge and understanding of all the challenges related to water resources. Organising access to existing data, and processing this data to produce useful information, are fundamental and vital to the success of policies and action plans for the sector. Data is sorely needed: to plan water resources and investments, adapt to climate change, provide sectorial management (surface water, underground water, quality control, irrigation, energy, water and health, etc.), reduce risks (flooding, drought, etc.), manage resources on an operational level and make decisions, for example, on territorial development or how to deal with the consequences of major events. Operators and managers of water resources often need timely access to data and information to understand current conditions, determine how they are likely to change, specify objectives and define coherent action programs to be implemented.

Yet, as former UNESCO director Koïchiro Matsuura pointed out, "despite the vital nature of water, political leaders are often uninterested, and the sector suffers from poor governance and a lack of investments" [1], particularly in the most vulnerable countries. To prevent a global crisis the international community must act now.

[1] The United Nations World Water Development Report 3: Water in a Changing World (2009)

TWO PRIORITIES FOR ACTION

• Finance knowledge

Given these challenges, and the current context of climate change, we need to develop and strengthen the international, national, basin-level and/or local mechanisms that support projects to improve knowledge of available resources and systems for producing information. Financing tools suitable for countries, in particular the least developed countries, need to be found. The French Development Agency (AFD) and French Global Environment Facility (FFEM) are particularly active in this area. For example, since 2011 they have supported the development of water resources knowledge in the Congo River basin, the world's second-largest hydrological and forest basin. The International Commission of the Congo-Oubangui-Sangha Basin (CICOS) has thus been able to acquire a forecasting tool to help it make decisions concerning sustainable development of the basin.

• Strengthen capacities and raise awareness

It is also vital to strengthen the capacities of actors at all levels. The technicians, engineers and scientists who will be responsible for managing, maintaining, using or developing hydrometric or meteorological stations, databases, modelling software, etc. must be adequately trained so that data is reliable and well-used. Decision-makers at all levels, but in particular local authorities, must be trained and encouraged to use this information to make better decisions. Finally, information and knowledge must be spread to all levels so that local communities–the first affected by climate change–are aware of what is at stake.

PART 1

Knowledge networks: metrology and the 'data-banking' of hydrological information

THE EXPERT'S DEFINITIONS

What is metrology?

Metrology is the science of measurement. In the field of water sciences, metrology includes defining and implementing the technical tools needed to acquire basic data. Equipment used must be checked regularly for quality, and applicable standards followed. Metrology requires technological monitoring–to keep abreast of changes in equipment–and the people involved must have initial and on-going training. The control of measurement chains and their uncertainties should be a priority for all actors in metrology.

What is data-banking?

It is the process of storing data in the organised framework of a database, so that it can be easily retrieved with database queries and used, for example, in Water Information Systems.

CHALLENGES

ACQUISITION OF HYDROLOGICAL DATA: AN ABSOLUTE NECESSITY

In the current context of increasing stress on water resources, it is more important than ever to have reliable data at hand. This data must be acquired at different time intervals and suited to its planned use (management of the resource, for example, or for flood warning systems, which do not require the same information at the same time and with the same time intervals). In parallel, we also need to be able to base our actions on historical hydrometric data, the only data that allow us to put observations into perspective and that provide the necessary framework for planning and decision-making. The use of a database to store, process and use information is also clearly needed, so that the most complete knowledge possible of hydro-systems can be made available and implemented for their use and protection.

Paradoxically, at a time when the need for all information – and thus hydrometric data – has never been so great, there has been a decrease in the density of hydrometric measurement networks across the globe. The cost of setting up and maintaining such networks is high – practically prohibitive in some developing countries. Beginning in the 1980's, there was a steep fall in the number of observation stations in African countries, and consequently a decrease in hydrometric data. The World Bank and other international organisations found this phenomenon very worrisome, and at the beginning of the 1990's decided to fund a study whose final aim was to mobilise donors and public authorities around the issue [2]. Figure 1 is based on SIEREM (Environmental information system for water resources and their modelling) data. It illustrates the sharp drop in data density. It should also be noted that the decrease in the quantity of data available was also accompanied by a sharp decline in quality, which greatly complicates its use.

[2] The World Bank, UNDP, African Development Bank, French Fund for Aid and Cooperation, Mott MacDonald International et al (1992), "Sub-Saharan Africa Hydrological Assessment – West African Countries", Regional Report, December 1992

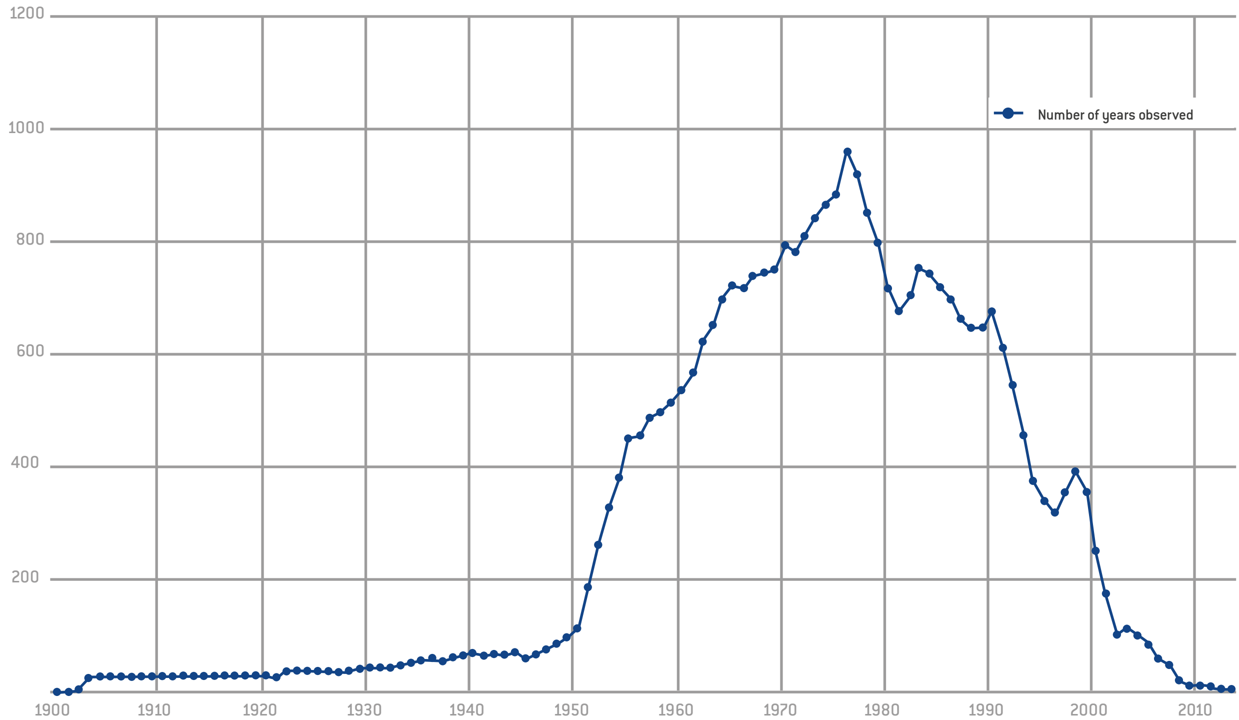

Figure 1 - Hydrometric data recorded in the SIEREM database: number of daily and/or monthly flow rates per year in Africa – Situation as of April 2016

Note: recent years are not significant because updating has not yet been completed.

Along with a decrease in the density of hydrological measurement networks, there has been a loss of know-how in the field. Such know-how is the only guarantee of quality, and collected data must be of good quality to be useful, particularly for decision-making. This phenomenon has been observed in many regions of the world in the past three decades, especially in developing countries.

In developed countries, managers rather focus on optimizing hydrometric networks to reduce operating costs while maintaining capacities for managing water resources or funneling information to warning systems. In France we are now seeking to rationalise networks so that investment and operating costs can be reduced, while maintaining a level of information that is adequate in view of our objectives.

FOCUS

The French national hydrometric and piezometric network

There are currently more than 3,000 active measurement stations in the French national hydrometric network [3]. They cover all types of waterways, from catchment basins of only a few square kilometres to the 117,480 km2 Loire basin in Saint-Nazaire. While most of the network is directly managed by the Government, it also includes stations managed by establishments such as the french electricity producer Electricité de France, waterway management companies (Compagnie d'Aménagement des Coteaux de Gascogne (CACG), Compagnie Nationale du Rhône (CNR), Société du Canal de Provence (SCP), BRL etc.) and research organisations such as IRSTEA and INRA. Data from stations in the French national hydrometric network is available and can be accessed from the HYDRO website (www.hydro.eaufrance.fr). HYDRO, managed by SCHAPI, is the national database for hydrometric data. Water level measurements are stored in the database, along with information on stations (purpose, exact location, quality of measurements, history, data available, etc.). For a given station, the HYDRO database calculates flows for different time intervals (instantaneous, daily, monthly, etc.) using water level values and the corresponding rating curves. Thus at any given moment the HYDRO database provides flow values that are as exact as possible, given the information that station managers communicate to it.

The national groundwater monitoring network includes 1,700 surveillance points. The Geology and Mining Research Institute BRGM is responsible for quantitative monitoring of 1,428 of these points. The ADES database (www.ades.eaufrance.fr) is used to store and manage data on water quantity and quality from many contributors (Water Agencies, Regional department of the environment, development and housing (DREAL), Regional Agencies for Health, etc.).

[3] ONEMA, 2015, 'Knowledge for action' series, "What extrapolation methods can be used to determine river flow rates when there are no permanent measurement stations?" L. Lebecherel, V. Andréassian, B. Augeard, E. Sauquet, C. Catalogne.

KNOW-HOW

IN FRANCE, A WIDE RANGE OF WELL-ESTABLISHED TOOLS FOR MEASURING, COLLECTING, TRANSMITTING AND STORING INFORMATION IN DATABASES

Decades of groundwork on technical and technological aspects of hydrometric measurement, storage and retrieval of data, as well as the financing and rationalisation of networks, have made France an internationally recognised expert in the field.

1

Improve water resources assessment and management and encourage regional and international cooperation in collecting and sharing data

WHYCOS AND HYCOS PROGRAMS

A number of international initiatives combining the know-how and experience of French hydrologists and hydrometrists have been created. One important example is the WHYCOS program sponsored by the World Meteorological Organization (WMO)[4]. WHYCOS focuses primarily on transboundary catchment basins (Congo, Mekong, Niger, Volta) and regional groupings (Caribbean islands, countries in the Southern African Development Community). It aims to create de facto optimised networks by strengthening the technical and institutional capacities of National Hydrological Services (SHN) to collect and transmit—in real or near-real time – quality hydrometrological data measured at strategic points. The ultimate goal of WHYCOS, which works through its regional components (known as HYCOS), is to improve water resources assessment and management while also promoting regional and international cooperation in data collection, sharing and research.

In setting up WHYCOS, WMO often looked to the French for know-how in both financing and technical areas. Thus there are many French actors involved in financial and/or technical aspects of various phases of HYCOS projects, particularly in Niger, the Congo and Mekong. These actors include: The Ministry of Foreign Affairs and International Development (MAEDI), French Development Agency (AFD), African Water Facility (FAE), French Global Environment Facility (FFEM), Institute of Research for Development (IRD), the electricity producer Compagnie Nationale du Rhône (CNR), AGRHYMET institute for agriculture, hydrology and meteorology, International Office for Water (OIEau) and the engineering company ISL Ingénierie.

FOR MORE INFORMATION:
www.whycos.org/whycos/

[4] D. Jouve, Ch. Brachet, J.P. Bricquet, 2014, 'The French contribution to the management of transboundary hydrometerological networks', La Houille Blanche, n°1, 2014, p. 53-59

2

Link the skills of a research institute and a measurement network manager

HYDROMET

The electricity producer Compagnie Nationale du Rhône (CNR) and the Institute of Research for Development (IRD) have developed a product known as HYDROMET, a database management system intended not only for hydrological and meteorological services, but for all organisations that manage and monitor water resources and are responsible for making the corresponding data available. The purpose of HYDROMET is to (i) collect/receive hydrological and meteorological data, (ii) store this data in a database, (iii) process the data and turn out various products, (iv) make data available through an operator interface. In the framework of an agreement linking CNR and IRD, HYDROMET has been successfully marketed and sold and is currently in use in many international projects: Niger Basin Authority (ABV), Volta Basin Authority (ABV), Caribbean States, Paraguay, etc. The HYDROMET project clearly demonstrates the value of associating the skills of a research institute and a measurement network manager. Their combined experience was instrumental in developing a product that is now internationally recognised as a particularly high-performance tool suitable for managing catchment basins of all sizes.

FOR MORE INFORMATION:
http://www.cnr.tm.fr/
http://www.ird.fr/

3

Strengthen capacities in hydrometrics and hydrological monitoring

OIEAU - IRD TRAINING MODULE

The International Office for Water (OIEau) and the Institute for Research and Development (IRD) have combined forces to develop top notch know-how in the area of training for SHN (National Hydrological Services) engineers and technicians working on hydrometric networks. The goal is to give SHN personnel the entire range of knowledge they need, including both actual field know-how and information on new technologies and analysis of the data collected. OIEau and IRD have thus defined a very complete set of training modules: installation and management of a hydrometric station (hydraulics, sensors), actual measurement and the equipment used (metrology, maintenance, advantages and disadvantages), measuring flows, etc.

Since OIEau and IRD both have extensive experience and proven skills in training, their association in this field is of major international importance.

The existence of other potential partners in the framework of this training opportunity should also be noted. These include, in particular, CNR and CNES. Regional centres (such as the AGRHYMET Centre in Niamey) may also be called on, and this would facilitate the link with transboundary basins. Transboundary hydrological information brings with it many real advantages: risk prevention in downstream countries, strategic transboundary planning, coordinated management and intra-country sharing of benefits.

FOR MORE INFORMATION:
www.oieau.fr

PERSPECTIVES

KNOWLEDGE NETWORKS, FERTILE GROUND FOR INNOVATION

New technologies will most certainly be called on to make up for the deficiencies and decline in hydrological measurement networks. Another fact worthy of note is that new products are already being developed almost systematically in multi-State cooperative frameworks, particularly in Europe.
The technical and technological know-how of French teams, organisations and companies, as well as their field knowledge and long-standing partnerships with local actors, are truly important here.

Two of many examples showing how new technologies are likely to become more and more important:

The Rain Cell Africa [5] consortium has developed an extremely innovative method for monitoring rainfall, based on the fact that water droplets attenuate the signal between two relay antennas in a mobile phone network. By analysing this attenuation, scientists were able to obtain exact information on type and location of rainfall. This research suggests a new way to compensate for deficiencies in traditional systems, particularly in urban areas where there are dense networks of relay antennas to serve mobile phone users.

Another solution, developed by CNES on the basis of the previously mentioned insufficiencies of traditional land-based measurement networks, involves the use of satellite data to complete measurements recorded *in situ*. Added value products and specific information useful for the management of water resources could then be produced from the combined data. The SWOT satellite programme is a cooperative project (CNES and the Space Agencies of the U.S., U.K. and Canada) that will provide information on spatio-temporal variations in the water levels of rivers, lakes and oceans by 2021. CNES has also set up the SWOT-Aval programme which is aimed at developing products adapted to users' needs, and which has confirmed satellites' important contribution to water challenges.

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[5] Rain Cell Africa is a consortium that brings together teams from various research institutes and universities: University of Ouagadougou, and the Office for meteorology (Burkina Faso), University of Abidjan (Côte d'Ivoire), Universities of Yaoundé and Douala (Cameroon), IRD (France), WASCAL and KIT (Germany), University of Tel-Aviv (Israel), KMNI (Netherlands).

PART 2

Water Information Systems: producing the information needed for decision-making

THE EXPERT'S DEFINITION

What is a Water Information System (WIS)?

An Information System is a combination of all the resources needed to collect, store, process and use information, including organisation, actors, procedures and IT systems. So Water Information Systems (WIS) are Information Systems designed to meet the needs of stakeholders (including the public at large) for public environmental information in the field of water. We must develop and extend these systems in order to meet the challenges of water management, particularly in a context of climate change. They are indeed vital tools to organise access to the data produced by various institutions. These tools allow to use the data available to produce necessary information for decision making and increase awareness of partners and general public.

CHALLENGES

THE IMPORTANCE OF ORGANISING ACCESS TO DATA, ITS PROCESSING AND USE

Access to necessary information and data is often complicated by many factors: the large number of themes treated, a multiplicity of data producers, legal obstacles when there are no agreements between organisations, technical issues such as difficulties in collecting information or harmonising data formats, analysis methods, or collection frequencies, inadequate density of monitoring networks, problems processing data or using data in models, etc.

Data and information are often scattered, heterogeneous or incomplete; they are rarely comparable and suited to needs. Numerous public, semi-public and private organisations produce and manage data, but often they do not have the resources or documentary guides needed to exchange, assemble, standardise, summarise and capitalise on the data that they and others possess. Over and above these difficulties, there is also the more general problem of a natural and widespread reluctance to share information, particularly when it is considered strategic because it can be used for paid services or to provide access to power.

One result is that decisions and action plans may be adopted on the basis of information that is incomplete and/or poorly suited to needs leading to great economic impacts. Another is that existing data 'capital' may not be used to its full extent because there are no suitable procedures for doing so.

While most countries and basins (national or transboundary) clearly need to make an effort to alleviate current data deficiencies, it is also vital that they develop links between data producers and users no matter what the theme or level of intervention (local, basin, national, international) and reinforce capacities for accessing, processing and using existing data.
The need to organise access to data is particularly important in the field of adaptation to climate change because to take changes into account it is first of all necessary to integrate their 'cascading consequences' and the reactive nature of natural and human-caused phenomena (resilience of natural systems and adaptation of actors).
On the national and major basins levels, access to comprehensive data is indispensable in identifying vulnerabilities and impacts and developing adaptation strategies and scenarios.
Consider the case of the Adour-Garonne Basin, where extensive data analysis showed that higher temperatures and less rainfall will not only directly impact river flows, waterways quality, aquifer replenishment and snowfall, but will also have a significant impact on the availability of water for irrigation, and on animal-raising, forests, energy, tourism and coastal development.
Consequently, we need to guarantee the collection and sharing of data and information that concerns the entire water sector, and combine it with other environmental and socio-economic data.

FOCUS

Principal data themes and geographical information in WIS

- Identification-localisation of water resources: (sub-)basins, rivers, lakes, snow cover/glaciers, underground water, wetlands, etc.
- Administrative and environmental context: administrative boundaries, digital elevation models, land use, satellite images, aerial photos, deforestation, erosion, protected areas, marine life, etc.
- Monitoring (quantity and quality): characteristics of measurement networks; climatological, pluviometric, hydrological and piezometric data; and data on the quality of surface water, seawater, groundwater, etc.
- Characterisation of pressure from current and future users and polluters, by user and by sector (hydroelectric, agricultural, transportation, tourism): volumes withdrawn, volumes discharged, quality of abstractions and discharges, etc.
- Characteristics of infrastructures: dams/dikes, boreholes, drainage obstacles, drinking water and sanitation infrastructures, etc.
- Characterisation of risks: floods, droughts, water shortages, pollution incidents, etc.
- Specific socio-economic characteristics: sociological characteristics, sector-specific economic indicators, economic data on water usage and water-related services, etc. Governance: actors' areas of intervention, data from management plans and measurement programmes (orientation, application, follow-up), etc.

KNOW-HOW

FRANCE ON THE CUTTING EDGE OF WATER INFORMATION SYSTEMS

With the water laws of 1964 and 1992, France adopted a basin-based water management system with many actors producing and using data on water and its usages, so French authorities were aware of the need to organise a global access to this data very early on.

In the 1990's, under the authority of the French Ministry in charge of the environment, agreements and processes for cooperation and shared management of data were adopted. These agreements led to the progressive creation of the French National Water Data Network (RNDE) and its successor in 2003: the Water Information System. Amongst the strengths of this system are the accessibility of data on water (via public websites) and its tools for visualising data (in particular via Geographic Information Systems - GIS).
Experience has shown that the principles of organisation and operation chosen for the French WIS are particularly well-suited and useful for most countries and basins experiencing problems with access to data on water. These WIS can in fact be used to:

1. highlight and strengthen the areas of competency of both data producers and data management partners by coherently organising the complementarity of the actions involved in producing and processing data,
2. organise the provision and exchange of comparable data between partners using definitions of references and joint procedures for data sharing and by developing the interoperability (automatic exchange capacities) of partners' existing information systems,
3. strengthen capacities for processing data and producing information that meets the needs of end users,
4. adapt to changes in data and information needs that may appear, for example, as the result of a new European Directive or international data collection process (case of the Sustainable Development Goals of the United Nations, which define a new international data framework for the next 15 years).

4

Access reliable information thanks to harmonised data standards:

EAU FRANCE AND SANDRE

Ordinary citizens can access the French Water Information System (WIS) through the Eau France portal, which is managed by the French National Agency for Water and Aquatic Environments (ONEMA). This is the access point to public data and information on water and aquatic environments in France, data that has been stored and made available for more than three decades in various information systems:

- More than 15 organised and regularly updated national databases, including Ades (underground water), Quadrige (coastal waters), Hydro (heights and flows of waterways), SISPEA (price and quality of public water and sanitation services), BDmap (fish), etc.
- 30 websites (Ades, Quadrige, Hydro + websites that provide information on services, reports, economic issues, images, glossaries, etc.) including those managed by OIEau (Gest'eau, Les Zones Humides, SANDRE, etc.).

SANDRE, the National service for the administration of water data and references, was created in 1993 to guarantee use of a common language and exchange of comparable, high-quality data amongst the various actors and systems involved in the WIS, and in particular:

- More than 15,000 data producers (Water Agencies and Offices, ONEMA, OIEau, decentralised services of the Environment, Agriculture and Health Ministries, BRGM, local authorities, industrial companies, environmental associations, fishing federations, the Météo France weather forecasting agency, etc.),
- More than 1,200 data collection systems listed, including 1,047 measurement networks,
- Nearly 160 certified laboratories that carry out chemical and biological analyses.

SANDRE's technical secretariat is provided by OIEau in the framework of an agreement with ONEMA. It develops and diffuses the references required to make information systems interoperable: data dictionaries, exchange scenarios, reference data on Web services, services for controlling and displaying data on the Web, cartographic atlas, metadata catalogue, information system audits, certificates of conformity, etc.

FOR MORE INFORMATION :
www.eaufrance.fr
www.sandre.eaufrance.fr

5

Develop information systems for water supply and sanitation

In addition to the water cycle information systems, French actors have developed information systems focusing on water supply and sanitation. The goal of these systems is to improve the performance of entities that supply drinking water and sanitation services, and meet the increasing requirements for governance, transparency and supervision of these entities' activities.

WAT.VIEW WEB PORTAL

The innovative Wat.view Web portal created by Groupe des Eaux de Marseille/SOMEI provides real-time access to the data of public water and/or sanitation suppliers or private surrogates. It thus meets the growing need for both governance and steering of the activities of public services and transparency vis-à-vis of local authorities.

FOR MORE INFORMATION :
www.somei.fr

EFFLUENT MANAGEMENT SUPPORT MODEL OF THE SIAAP (INTERDEPARTMENTAL SYNDICATE FOR SANITATION IN THE PARIS METROPOLITAN AREA)

Other systems such as MAGES (the SIAAP's Effluent management support model) collect and use large amounts of data. MAGES is a powerful decision-support system that helps prevent, in particular, the discharge of untreated water into the natural environment. It collects all data from actors in the field (water flow, network status, sewage plant operation) 24 hours a day and also integrates weather forecasts from Météo France. The system analyses this information in real time and suggests the most suitable scenarios in the case of heavy storms, maintenance work on the network, etc. This data, in addition to its main use for real-time operations, can also be used for studies.

FOR MORE INFORMATION :
www.siaap.fr

6

Develop a Water Information System (WIS) on the hydrology of African basins

SIEREM

The Hydro-Sciences Montpellier Laboratory (HSM) has developed an information system, known as SIEREM, which contains several types of environmental variables for the whole of Africa. With 13,000 measurement stations and 33,000 chronological series (i.e. more than 117 million recordings) for 1837-2015, this is the largest environmental information system in Africa. Hydro-climatic data is combined with spatial data: 201 contours of catchment basins and 2,962 rivers. SIEREM has also been enriched with data recovered from hydrological archives. More than 1,342 photos have been brought together in 391 geo-referenced albums. The SIEREM site provides free access to all information except raw measurement data, which is the property of the national services of African countries.

FOR MORE INFORMATION :
www.hydrosciences.fr/sierem

7

Improve weather forecasting, early warning systems and climate services

MÉTÉO FRANCE

Météo France exports its know-how and solutions to help foreign national weather services (SMN) improve their meteorological forecasting, early warning systems and climate services. A large part of this activity involves the strengthening of observation networks. Météo France International (MFI), a subsidiary of Météo France, has worked in Africa and Indonesia, in India and many other countries, introducing and implementing technologies and competencies that have been proven effective in France. To address hydro-meteorological and Water Information System needs in an integrated way, MFI and OIE participate in an MAEDI-sponsored working group whose purpose is to cooperate in the preparation of an integrated French offering. This offering will include meteorological and hydrological infrastructures, dedicated information systems and the transfer of know-how to cover all national needs for meteorology and hydrology. It will bring international attention to French products and know-how.

Recent improvements in weather forecasting tools have enabled the provision of many climate-related services for the general public and professionals: climate change diagnosis at the regional or local level, anticipation of risks of marine submersion, drought warnings, storm and flood warnings, agricultural forecasts, wildfire warnings, etc. Recent changes in concerns sparked by climate change have led many actors to complete these services with more specialised offerings. With the support of various research organisations, a number of new tools are now available: improved flood prevention in urban areas through radar monitoring of storms (at the initiative of several local authorities in France), improved agricultural information for irrigation management (at the initiative of various farming organisations), etc.

FOR MORE INFORMATION :
www.meteofrance.fr
www.mfi.fr/fr/

8

Develop a Tsunami warning system in the Caribbean

CARIBBEAN TSUNAMI WARNING SYSTEM (CARTWS)

A basin-level global warning system is needed to protect populations in the Caribbean (an area including 38 countries) in the case of a tsunami. Following the devastating tsunami of 2004, Governments, public services, monitoring and research organisation, civil defence services and citizens worked together to design a tool for confronting tsunamis. Their efforts led to the installation of a warning system known as the Caribbean Tsunami Warning System (CarTWS). CarTWS provides monitoring, evaluation of risks, warnings and information to increase awareness of dangers, primarily through development of a system of real-time exchanges of seismological and tidal data.

FOR MORE INFORMATION :
www.inforisk.cg972.fr/IMG/pdf/Un_Systeme_d_Alerte_des_tsunamis_dans_la_Caraibe.pdf

FOCUS

Promotion of French expertise abroad

On the international level, this know-how in the areas of organisation and inter-institutional cooperation for data sharing, common language elements to enable sharing of comparable data, interoperability of information systems and system integration, etc., is now being diffused by OIEau and the International Network of Basin Organisations (INBO) in the framework of development projects and twinning programmes (such as those financed by French water agencies) that bring in French experts from various administrations. It should be noted that Europe-INBO is also studying the development of a cooperative information-sharing portal focusing on know-how in water data management.

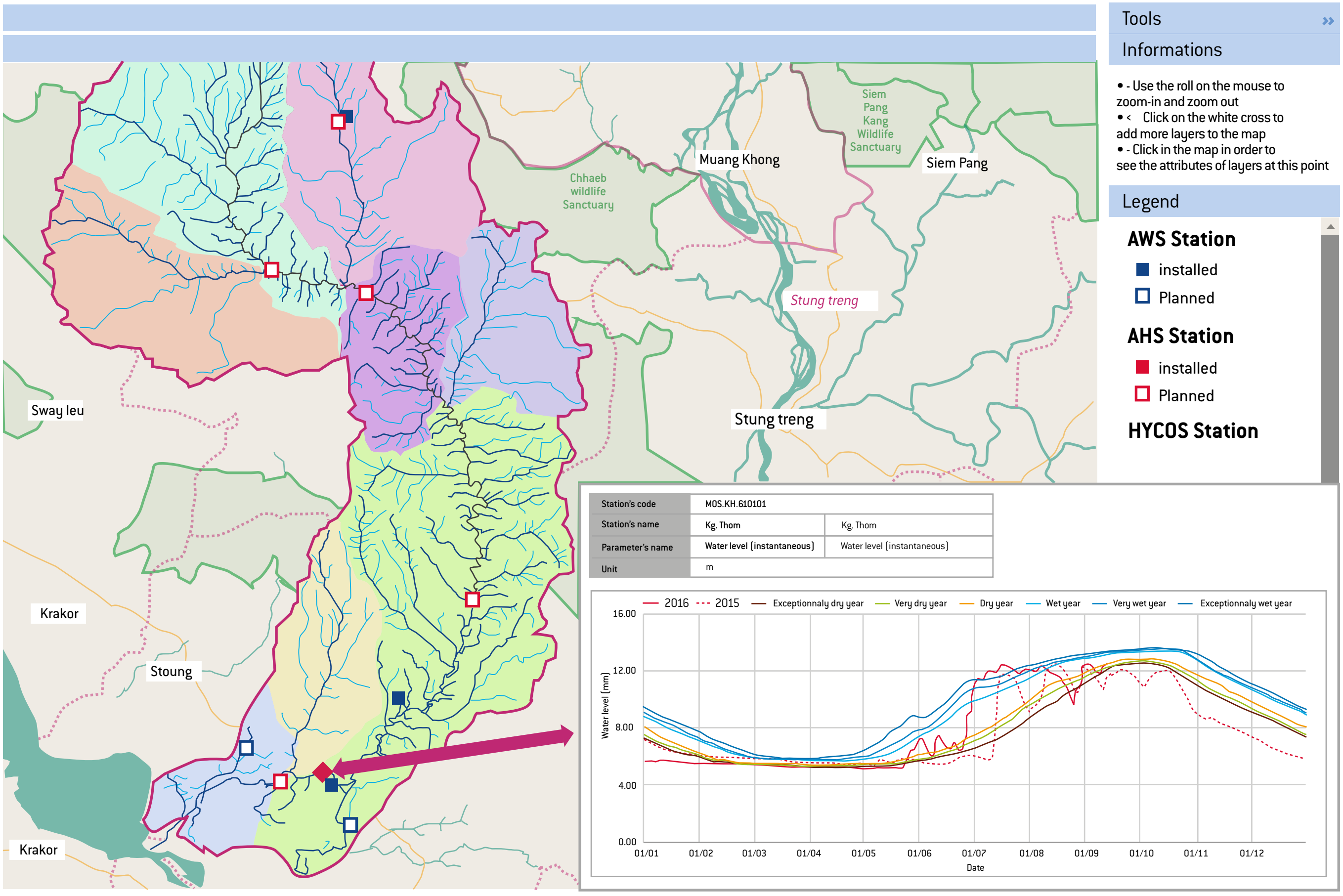

Figure 2 - Dynamic mapping of the Stung Sen basin (Cambodia) with access to hydrological data (p roject implemented by the International Office for Water with funding from the Loire-Brittany and Rhin Meuse water agencies)

The graph shows the evolution of the water level measured by the hydrometric station HYCOS (symbolised on the map). It's possible to follow the evolution in real time: **http://37.187.128.205/cambodia/index.php/mos-kh-610101**

PERSPECTIVES

MAKE WATER INFORMATION SYSTEMS MORE COHERENT AND WIDE-RANGING

There have been very significant changes in the world of information systems in the past few years (cloud computing, service-oriented architectures, web services, open data, interoperability, big data, 3D visualisation, etc.) and the majority of people, in all countries and even in the most remote areas, now have access to the internet via computers, tablets and smartphones.

So the technical solutions needed to set up effective Water Information Systems are now available, but in many cases much work remains to be done on the transboundary, national or local basin level to:

1. Develop partnerships and shared data management agreements that define the role of each actor on the basis of a shared vision,
2. Organise sustainable financing for the development of basin, national and regional WIS such as WISE (Water Information System for Europe), SADIEau (African system for documentation and information on water) and SEMIDE (European-Mediterranean information system on know-how in the field of water),
3. Strengthen main producers' capacities to manage their own data effectively and make it available to partners in real time when necessary,
4. Develop/adopt the joint references needed to exchange comparable data, and protocols to guarantee the interoperability of existing Information Systems,
5. Develop capacities to integrate available data (including satellite and crowdsourced data) and transform it into useful information,
6. Develop and make available easy-to-use tools for visualising data and indicators (in particular in the form of 2D and 3D maps) and provide for their integration in end users' devices and applications.

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PART

Hydrological modelling: understanding and analysing how hydrosystems function when confronted with climate change

THE EXPERT'S DEFINITION

What is a hydroclimatic model?

Hydroclimatic models are constructed from conceptual models of hydrosystems and the characterisation of impacts caused by climate change. Their purpose is to simulate hydrosystem functioning. Hydroclimatic models must be sufficiently detailed to demonstrate not only normal functioning, but also the response of hydrosystems to disruption caused by the climate or human activity.

CHALLENGES

MODEL THE IMPACT OF CLIMATE CHANGE TO ASSIST IN FUTURE DECISION-MAKING

Water resources are closely linked to variations in climate that have a direct impact on run-off or replenishment of surface and ground water. Changes in the type or distribution of rainfall, as well as temperature and evapotranspiration, determine the availability of water in agricultural land, to what extent aquifer systems are replenished, and river flows. The impact of climate change on water resources is first of all important to local actors. Whether they belong to basin-level agencies or agricultural organisations, or are involved in territorial development, what they need is results and tools that can help scientists, decision-makers and citizens work together. Scenarios for the mobilisation of resources, extension of irrigation and development of agricultural systems (agroecological transition) and reduction of impervious surfaces, as well as management and governance modes, can only be developed if hydroclimatic models provide details on how climate change is likely to impact water resources on various levels (supra-regional, regional, local) and for different usages. In addition, global challenges associated with demographic growth and the development of societies must also be taken into account in hydroclimatic models. These challenges may sometimes be given priority over climate challenges in determining how water resources are managed.
Models are being progressively perfected so that they integrate all components of hydrosystems: evolution of water in top soil, rivers, underground water and exchanges with the surface, land use, hydrological consequences of development choices. They must be enriched with climate data (from the past, or future scenarios) and data on uses (cartography, land use, practices, economic data).

KNOW-HOW

FRENCH RESEARCH AT THE SERVICE OF TERRITORIAL ACTORS

The French scientific community, represented by AllEnvi, (alliance that federates, programs and coordinates French environmental research to meet the great societal challenges associated with food and water supplies, climate and territories) includes scientific organisations (BRGM, CNES, CNRS, INRA, IRD, Météo France etc.) with nationally and internationally recognised competencies in the hydroclimatic modelling of water resources. The role played by French scientists in the IPCC also attests to this high level of competency. Research carried out by the aforementioned organisations is conducted on catchment basins or groups of catchment basins in France and abroad (Africa and Asia in particular).

Climate change and water resources are a central concern for French actors on the State level, public establishments (Ministry of the Environment, Energy and the Sea, Water Agencies for the 6 major hydrographic basins, water offices in overseas territories, ONEMA) and on the local level as well. These actors are developing specific programmes that require hydrological modelling of water resources for climate change scenarios and adaptation scenarios at various levels.
French companies (engineering offices, large corporations and small- to medium scale companies in particular) are developing know-how by using climatic and hydrological models to create climate change adaptation diagnostics and schemas in line with the various components of the water cycle and at different levels.

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Modelling on the French territorial level

EXPLORE 2070

The Explore 2070 project has conducted an in-depth analysis of data and models on the scale of France and with a projection of about fifty years into the future. The goal was to understand the impact of climate change on aquatic environments and water resources, in order to draw up the most appropriate adaptation strategies for the field of water. The project was backed by the water and biodiversity department of the French Ministry of the Environment, Energy and the Sea (MEEM) with the participation of ONEMA, CETMEF (French institute for maritime and inland waterways), Water agencies, DREAL and various MEEM departments. It brought together about one hundred experts from research institutes and specialised engineering offices.
For rivers, results were obtained from a combination of seven climate scenarios and two hydrological models, which made it possible to quantify the uncertainty of results for the first time at this scale (Figure 3). For most stations, average annual flow in 2050 is expected to be 10%-40% less than in the period from 1961-1990. The Garonne River basin will be the most affected (with a decrease in flow of up to 50%), as well as the Seine River basin, as a result of increased evapotranspiration combined with a relative decrease in precipitation. South-east France is not expected to experience large decreases in terms of percentage, but this does not mean there will be little real impact, given the rarity of water resources in this region. With a 20% to 30% drop in replenishment rates (up to 50% in southwest France), aquifers will be highly impacted. Average levels of water tables will drop very little near waterways, but the decrease could attain ten or so metres on plateaus or in the foothills surrounding sedimentary basins.
Other regional projects also deserve mention: in the Garonne basin, the Imagine 2030, Garonne 2050 and REGARD projects; in the Rhone-Mediterranean basin the ANR VULCAIN and R^2D^2 projects, etc.

FOR MORE INFORMATION: http://www.developpement-durable.gouv.fr/Evaluation-des-strategies-d.html

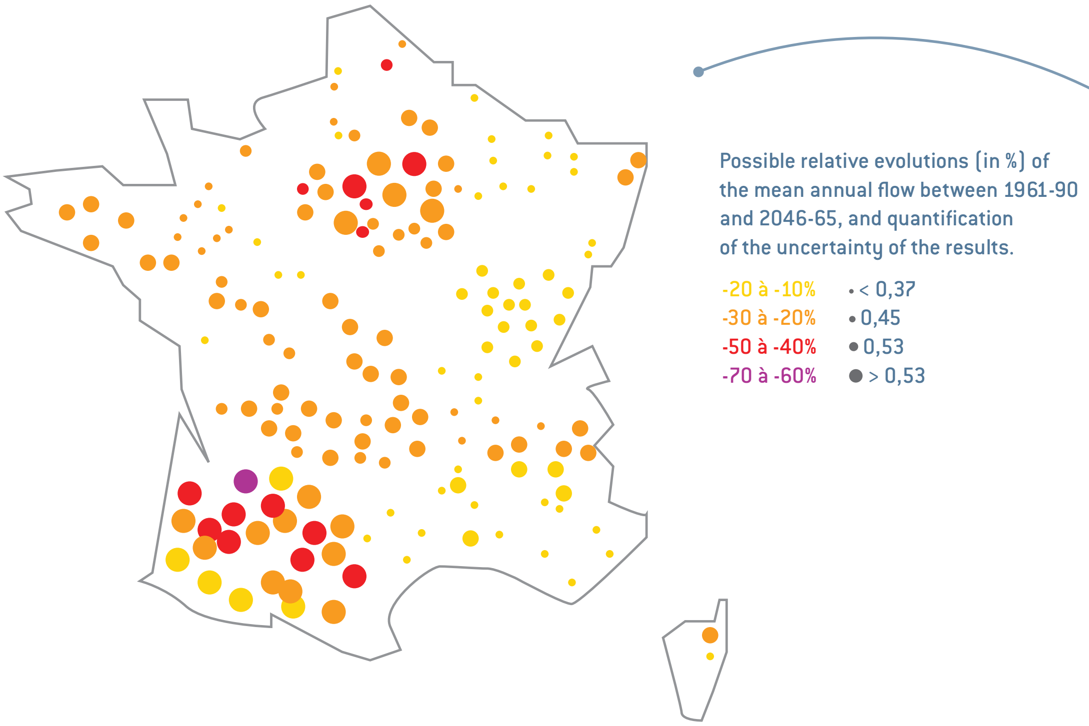

Figure 3 -One of the results obtained in the framework of the Explore 2070 programme

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Analyse the response of the water cycle to climate fluctuations and environmental change in Africa

AMMA CATCH [6] INTERNATIONAL PROGRAMME

The generalised drought that struck West Africa during the 1970s and 1980s was one of the most significant regional scale climatic events of the 20th century. The consequences of this drought, which affected a densely populated area, were devastating due to both its spatial extent and continuity in time. In the last decades (since 1990) a return to wetter conditions was observed in much of West Africa, except in the Sahel region, where the situation changed somewhat later on. The possible role of changing surface conditions (land use, reduction of forested areas, for example) in rainfall patterns has been examined in many studies, including the AMMA CATCH international programme (African Monsoon Multidisciplinary Analyses, CATCH component linking the tropical atmosphere to the hydrological cycle), which has the support of many European, American and African research organisations. Several sites across the Sahel were studied to determine the response of the water cycle to climate fluctuations and environmental changes. The moisture content of soils was measured and hydrological conditions determined and modelled, in some cases taking groundwater into account. It was proven that changes in land use lead to changes in replenishment: Tens of thousands of m^3 of water seep into the soil in catchment basins less than $1km^2$ in size; run-off decreases by up to 50% in sandy areas and piezometric levels increase, modifying components in surface waters and groundwater in the water cycle and leading to new resource management modes.

FOR MORE INFORMATION :
http://www.amma-catch.org/

[6] Lebel, T., Cappelaere, B., Galle, S., Hanan, N., Kergoat, L., Levis, S., Vieux, B., Descroix, L., Mougin, E., Peugeot, C., Séguis, L., 2009. AMMA-CATCH studies in the Sahelian region of West-Africa: an overview. Journal of Hydrology 375 (1–2), 3–13. AMMA-CATCH Special Issue

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Develop an interdisciplinary approach in the Mediterranean

ANR AMETHYST PROJECT

The AMETHYST project[7] (2013-2017 - Assessment of changes in MEdiTerranean HYdro-resources in the South: river basin Trajectories) is an interdisciplinary project focusing on two highly anthropized catchment basins: Tensift (Morocco) and Merguellil (Tunisia). In these two basins the mobilisation of water resources approaches or even exceeds 100%, and there is significant social demand for a study of future change scenarios. The project puts current changes into perspective by analysing past and future decades. In the future, the basins will be subjected to an increase in temperature of between 1° and 1.3° by 2030 (in comparison with the 1986-2005 period) and an increase of between 1.5° and 2.3°C by 2050. Change in rainfall is uncertain, but will significantly impact crop development. As for recent crop monitoring, the project relies on satellite data coupling, which uses crop monitoring or operational management models to monitor surface conditions. The project analyses environmental and socio-economic factors in association with the spatio-temporal dynamic of water resources, in order to evaluate their joint evolution. Field surveys are conducted to gather information on irrigated public lands, their governance and any difficulties in management. This fieldwork is essential in identifying future scenarios and any levers that can be used to improve sustainable water management in the future.

FOR MORE INFORMATION :
http://anr-amethyst.net/

[7] AMETHYST ANR: Boukhari K., Fakir Y., Stigter T., Hajhouji Y., Boulet G. 2015. Origin of recharge and salinity and their role on management issues for a large alluvial aquifer system in the semi-arid Haouz plain, Morocco. Environmental Earth Sciences. 73(10): 6195-6212.

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Study the vulnerability of irrigators in southern India

ANR SHIVA PROJECT

The impact of global changes on water resources and their use is particularly clear in rural areas of southern India. Subsistence farming (rice and vegetables) in southern India relies primarily on groundwater for irrigation. Since the green revolution, and particularly during the 1990s, the surface area of land being irrigated has increased sharply, causing a significant drop in piezometric surfaces in aquifers. Aquifers are filled during monsoon rains, which determine replenishment rates and thus the availability of water. Successive governments have encouraged the creation of resources (reservoirs, water transfers, artificial replenishment) to meet demand, but a succession of dry years has forced farmers to cut back on irrigated surfaces. The ANR SHIVA project thus set out to characterise the economic vulnerability of users of the underground water resource in the south of India, in a context of global change, on the basis of climatic scenarios (2040-2060) and socio-economic scenarios (2020-2040) applied to hydrological models to simulate the availability of underground water for irrigation. Results were combined with field surveys of farmers to determine their vulnerability and capacity to adapt. Methods for changing scale, to translate this vulnerability to southern India, were then explored. IPCC projections suggest that in this region there will be an increase in average rainfall as well as an increase in climatic variability that will manifest itself in the more frequent occurrence of extreme hydrological conditions (very heavy or very light monsoons). Modelling results indicate that the increase in average rainfall will lead to an increase in water resources. The increase in extreme hydrological conditions will, however, result in an uneven spatial distribution of this increase: some parts of the basin tested–areas with high pumping density, low reservoir density or less underground storage capacity–will see an increase in the duration of periods of water scarcity.

FRO MORE INFORMATION :
www.agence-nationale-recherche.fr/fileadmin/documents/2015/posters/poster_SHIVA.pdf

PERSPECTIVES

ENCOURAGE THE CREATION OF MORE COMPLETE MODELS TO IMPROVE DECISION-MAKING

In addition to developing new applications that incorporate knowledge and experience acquired in past projects, there are three ways that models could be made more useful to decision-making: take users' behaviour and their impact on the resource into account in more detail, use satellite data to monitor the resource, and improve interaction between surface/underground water in models.

Operational, multi-level cooperation (from citizen to decision-maker) is an indispensable part of water resources management. This cooperation makes it possible to provide scenarios for hydroclimatic models, and to use and translate the results of these hydroclimatic models to determine actions to be set up. This type of interaction can be modelled in varying degrees of detail. The multi-agent MAELIA platform[8], for example, provides a very detailed representation of interactions between agricultural activities and water taken from the resource for various uses, and can be used to test scenarios.

For catchment basins with few measuring instruments, or to manage water resources spread over very large surfaces (continental scale), satellite data is indispensable in monitoring surface conditions in general, humidity (SMOS- Soil Moisture and Ocean Salinity) and total water content (GRACE - Gravity Recovery and Climate Experiment). Soon satellite data will also be used to determine water levels in waterways and lakes (SWOT - Surface Water and Ocean Topography) with a high degree of accuracy. Methods of integrating this data in models at various levels must be developed at all scales.
Finally, surface water/groundwater couplings in hydroclimatic models need to be improved for many applications.

[8] http://maelia-platform.inra.fr/

Appendix

List of French organisations providing expertise in areas identified by the French Water Partnership:

TOPICS RELATED TO THE DEVELOPMENT AND ADMINISTRATION OF INFORMATION SYSTEMS	ORGANISATIONS (PARTIAL LIST)
Meteorological	MFI
Hydrological	IRD, IRSTEA, CNR, BRLi, Geo-hyd, Tenevia, CACG, SCP
Water quality	Asconit, CNR, CACG, Geo-hyd, OIEau
Underground water	BRGM, Geo-hyd, imaGeau
Sea water	IFREMER
Uses/sampling	CNR, BRL, Geo-hyd
Irrigation	SCP, CACG, IRSTEA, BRGM
Urban services, water supply and sanitation	SEM, SIAAP, Veolia, Degremont, Saur, OIEau, Suez
Integrated water resource management	OIEau, CACG, BRL, Geo-hyd, Steria, BRGM, IRSTEA
Fight against flood risks	IRSTEA, Geo-hyd, BRGM, SCHAPI (e.g. Vigicrue), ISL Ingénierie, Predict service
GIS	BRL, SCP, G2C, Geo-hyd, BRGM
Methodological standardisation (measurement, sampling, analysis, reliability and comparability of data)	OIEau and Aquaref (BRGM, IFREMER, INERIS, IRSTEA, LNE)

A database accessible from the FWP website gives examples of other projects that we were unable to include in this brochure.

Glossaire

ABN: Autorité du Bassin du Niger (Niger Basin Authority)
ABV: Autorité du Bassin de la Volta (Volta Basin Authority)
AFD: Agence Française de Développement (French Development Agency)
AllEnvi: Alliance nationale de recherche pour l'environnement (French national alliance for environmental research)
ASECNA: Agence pour la Sécurité de la Navigation Aérienne en Afrique et Madagascar (Agency for aerial navigation safety in Africa and Madagascar)
BRGM: Bureau de Recherches Géologiques et Minières (Geology and Mining Research Institute)
BRL: BRL company (ex Compagnie d'aménagement du Bas-Rhône-Languedoc)
CACG: Compagnie d'Aménagement des Coteaux de Gascogne (Coteaux de Gascogne landscaping company)
CarTWS: Caribbean Tsunami Warning System
CETMEF : Centre d'Etudes Techniques Maritimes et Fluviales (French Institute for maritime and inland waterways)
CNES: Centre National d'Etudes Spatiales (French National Centre for Space Studies)
CNR: Compagnie Nationale du Rhône (Rhône National Company)
CNRS: Centre National de la Recherche Scientifique (National Centre for Scientific Research)
CSA: Canadian Space Agency
DREAL: Direction Régionale de l'Environnement, de l'Aménagement et du Logement (Regional department of the environment, development and housing)
FAE: Facilité Africaine pour l'Eau (African Water Facility)
FFEM: Fonds Français pour l'Environnement Mondial (French Global Environment Facility)
GIEC: Groupe d'Experts Environnemental sur l'Evolution du Climat (Intergovernmental panel on climate change, IPCC)
GRACE: Gravity Recovery and Climate Experiment
HSM: Hydrosciences Montpellier laboratory
IM2E: Institut Montpelliérain de l'Eau et de l'Environnement (Montpellier Institute for Water and the Environment)
INRA: Institut National de la Recherche Agronomique (French national institute for agricultural research)
IRD: Institut de Recherche pour le Développement (Institute of Research for Development)
IRSTEA: Institut national de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture (National Research Institute of Science and Technology for Environment and Agriculture)
ISL: ISL Ingénierie
MAEDI: Ministère des Affaires Etrangères et du Développement International (Ministry of Foreign Affairs and International Development)
MAGES: Modèle d'Aide à la Gestion des effluents du SIAAP (SIAAP's Effluent management support model)
MEEM: Ministère de l'Environnement, de l'Energie et de la Mer (French Ministry of the Environment, Energy and the Sea)
MFI: Météo France International (a subsidiary of Météo France)
ODD: Objectifs de Développement Durable (Sustainable Development Goals, SDG)
OIEau: Office International de l'Eau (International Office for Water)
OMM: Organisation Météorologique Mondiale (World Meteorological Organization, WMO)
ONEMA: Office National de l'Eau et des Milieux Aquatiques (French National Agency for Water and Aquatic Environments)
RIOB: Réseau International des Organismes de Bassin (International Network of Basin Organisations, INBO)
RNDE: Réseau National de Données sur l'Eau (French National Water Data Network)
SADIeau: Système Africain de Documentation et d'Information sur l'Eau (African system for documentation and information on water)
SANDRE : Service d'Administration Nationale des Données et Référentiels sur l'Eau (National service for the administration of water data and references)
SCHAPI: Service Central d'Hydrométéorologie et d'Appui à la Prévision des Inondations (French National Hydrometeorological and Flood Forecasting Centre)
SCP: Société du Canal de Provence (Canal de Provence water company)
SHN: Services Hydrologiques Nationaux (National hydrological services)
SIAAP: Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne (Interdepartmental syndicate for sanitation in the Paris metropolitan area)
SIEREM: Système d'Informations Environnementales sur les Ressources en Eau et leur Modélisation (Environmental information system for water resources and their modelling)
SIG: Système d'Information Géographique (Geographical Information System)
SMN: Services Météorologiques Nationaux (National weather services)
SMOS: Soil Moisture and Ocean Salinity
SOMEI: IT subsidiary of the Eaux de Marseille water company
SWOT: Surface Water and Ocean Topography
WASCAL: West African Science Service Centre on Climate Change and Adapted Land Use
WHYCOS: World Hydrological Cycle Observing System
WISE: Water Information System for Europe

Often little known, poorly managed and poorly protected, water resources are increasingly stressed as a result of many different factors: climate change, demographic growth, food security needs, urbanisation, economic pressures, etc. In this context, knowledge and understanding of all challenges related to water resources, and pressures being placed on those resources, are vital for effective water management.
Public and private French actors in the field of water have extensive and internationally recognised experience in knowledge-related areas, from the acquisition of hydrological and meteorological data to setting up functional Water Information Systems and developing the hydroclimatic models that will help us meet future challenges.
This first issue in the 'FWP expertise' collection highlights knowledge-related challenges, the expertise developed to meet these challenges in France and abroad and the urgent need to act.

The French Water Partnership is a French platform for exchanges and reflection that promotes a multi-actor approach to water-related issues at the international level. The FWP helps bring France's know-how to the world's attention and water to the forefront of the world's political agenda.
It brings together about one hundred public and private members from 6 groups representative of the water field in France (Governments and public establishments; NGOs, associations and foundations; local and regional authorities; economic actors; research and training institutions; and individuals from France and other countries).

In cooperation with:

IRD Institut de recherche pour le développement

International Office for Water

brgm Géosciences pour une Terre durable

irstea

AllEnvi

And with the support of:

afd Agence Française de Développement

EDF

Mairie de Paris

ONEMA

SIAAP Service public de l'assainissement francilien

Veolia

Suez

SEDIF Service public de l'eau

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