

# Water and climate change

## Preface

**Grégoire Postel-Vinay**, Editor-in-Chief of the *Annales des Mines*

## Introduction

### Water and climate change: what are the challenges and how can we meet them?

**Pierre Roussel**, Former Water Director, member of the National Water Committee and the Loire-Brittany Basin Committee

## General framework

### Water and climate change: intertwined destinies

**Pascal Berteaud**, Managing Director of Cerema 2000

Water, a major societal issue, is increasingly becoming one of the first markers of climate change. The threats posed by the hydroclimatic changes, affecting both the quality of the resource and its quantity, as well as the increase in the risks associated with water, challenge our ability to continue to inhabit the territories and to live there. Meeting the challenge of adapting to climate change requires realizing that water is a limiting factor in our development, and as such we need to learn to deal with water-related risks, to rethink our uses and to project ourselves into a sharing of the resource. It is our very paradigm of development that we must immediately review by putting water back at the centre of our concerns if we want to face the upheavals in progress.

### The impact of climate change on the water cycle using the new DRIAS-Eau portal

**Jean-Michel Soubeyroux**, Deputy Scientific Director of Climatology and Climate Services at Météo-France

Climate change is causing major changes in the global water cycle, particularly by increasing the variability of average hydrological components and extremes. In France, the rise in average temperatures as a result of climate change is leading to an increase in evapotranspiration and an overall reduction in water resources. In the future climate, the new hydrological simulations prepared as part of the Explore2 project confirm that this trend will continue and intensify until at least the middle of the century, with impacts on hydrological variables qualified by uncertainties over precipitation trends. The new DRIAS-Eau portal, which opened in March 2023, will make it possible to specify the future of water and the associated uncertainties at local level, and to make data and indicators available to make it easier for those involved in the water sector to take climate change into account.

## Water-related risks

### in the context of climate change

**Anne-Marie Levraut**, Deputy Vice-President of the French Association for the Prevention of Natural and Technological Disasters (AFPCNT) with the contribution of **François Gérard**, **Régis Thépot**, **Michel Luzi** and **Bernard Guézo**

How will water-related risks in France evolve with climate change? What challenges do we face? How can we prepare to deal with them? These are complex questions fraught with uncertainty. Only by working together can we gradually build these answers. Learning to live with risk is, and will continue to be, an ongoing process: the nature of the risk is changing, and populations are changing. We need to be prepared to deal with unprecedented situations, and to factor the potential consequences of hazards into public and private choices at a very early stage. In short, we need to build a more resilient society.

## International and european issues

### International sharing and solidarity?

**Diane d'Arras**, Chair of the European and International Affairs Committee of the Scientific and Technical Association for Water and the Environment (Astee)

While water sharing and solidarity are essential on a local, regional or national scale, they are underdeveloped on an international scale because they are generally not "intrinsically" useful. In cases where countries are required to share a common resource, solidarity currently relies heavily on the ability of these countries to work together outside the framework of highly developed international law. Fortunately, scientific and financial cooperation does exist in the field of continental water management. What remains to be done is to develop more intense and effective cooperation on the maritime waters that we all share, and to realise that cooperation to mitigate climate change is probably the most important area in which we can act together to preserve our local water resources.

### France's international contribution to addressing the impact of climate change on water resource management - A review of the 2011-2023 period

**Éric Tardieu**, Director General of the International Office for Water (OiEau) since 2017 and Secretary General of the International Network of Basin Organizations (INBO)

France, which for nearly sixty years has been organised on a basin basis for the integrated management of water resources, has gradually introduced adaptation to climate change into its national policies. The French

(and now largely European) model of consultation, planning and management has thus contributed to France's messages on the international stage, particularly in the context of the Climate COPs.

### **The Rhine basin and climate change: the work of the International Commission for the Protection of the Rhine**

**Adrian Schmid-Breton**, Scientific assistant at the International Commission for the Protection of the Rhine (ICPR)

The International Commission for the Protection of the Rhine (ICPR), an intergovernmental organisation founded in 1950 and bringing together eight states located in the Rhine basin as well as the European Union, has been working on the issue of climate change in a cross-border context since 2007. It has carried out studies into the possible repercussions of climate change on water regimes, water temperature and ecology. On the basis of flow scenarios for the near future (up to 2050) and the distant future (up to 2100), the ICPR developed a climate change adaptation strategy in 2015, which will be updated by 2025 under the "Rhine 2040" programme. The main negative impacts of climate change and the ICPR's response to them are described in this article.

## **France**

### **Water and climate change - consultation between stakeholders**

**Jean Launay**, Chairman of the National Water Committee

Consultation is one of the fundamentals of water management in France, and the 1964 and 1992 Water Acts are the pillars of this decentralised, devolved organisation, which promotes ecological taxation and participatory democracy.

These commitments as a local elected representative and then as a member of parliament naturally lead to the search for solutions, which requires listening to the stakeholders.

The National Water Committee, the "Water Parliament", is a key forum for consultation. Even if we have to work hard at it, the conditions of access to water, the conditions of its sharing and its quality will never be definitively stabilised.

Water is the marker of climate disruption in terms of both its shortages and its excesses. The revision of climate change adaptation plans at national level and in the river basins will have an impact on future dialogue.

Water has been pushed to the top of the political agenda! From the water conference to the Varenne agricole on water and climate change, the subjects of water saving, sharing water between different uses, the quality of water and aquatic environments and biodiversity have been raised.

The difficulty of talking to each other. Despite the mission of prefect Pierre-Étienne Bisch and the search for a method for developing regional water management projects, disagreements persist. The question is how to find ways of working together again in the future.

The contribution of science is essential. Political and public responsibility requires that we find ways and means of renewing dialogue between all the players involved.

### **Water and climate change: action by basin authorities, the example of the Rhône-Méditerranée basin**

**Laurent Roy**, Managing Director of the Rhône-Méditerranée Corse Water Agency

For nearly 60 years, water policy in France has been defined and implemented under the aegis of basin committees, with the support of water agencies. These basin institutions have mobilized to meet the challenge of adapting to climate change in the water sector, in particular through basin plans for adaptation to climate change. In the Rhône-Méditerranée basin, 65 water resources management plans involving all stakeholders have made it possible to promote the sharing of water resources while respecting the proper functioning of aquatic environments. The first results are encouraging, but faced with the perceptible acceleration of the effects of climate change, we must act faster and stronger. This will be a key issue for the next programs of the water agencies, in line with the water plan announced in March 2023.

### **Local authorities and their groupings at the heart of adapting quantitative and qualitative water management to climate change**

**Régis Taisne**, Head of governance, performance and transparency of public water and wastewater services, FNCCR and **Mélissa Bellier**, Head of the FNCCR water cycle department

"Water is life", because water is necessary for man, the environment and society. Climate change is disrupting the large water cycle, triggering an increasing number of extreme events (notably droughts and floods), and impacting the small water cycle, that of "human water".

In France, local authorities are responsible for water management: drinking water supply, wastewater treatment, stormwater management, management of aquatic environments and flood prevention. Most of their other responsibilities also relate to water: regional planning, tourism, economic development, social action, etc. At the heart of water issues, they are therefore key players when it comes to promoting a local consultation approach and an ambition to decompartmentalise the actions carried out in the area, which must now take into account the challenges of climate change, the protection of water resources and biodiversity, sober use, etc.

To guarantee water quality and its availability for essential uses (including natural environments), awareness, consultation and commitment on the part of all are required. It will also be necessary to give the players involved the means to act, at a time when the fall in consumption is undermining the economic model of the entire sector.

### Consumers and the ups and downs of water management

**Robert Mondot**, Honorary engineer general of bridges, waterways and forests, responsible for UFC-Que Choisir

From the consumer's perspective, water policy has long been seen as drinking water policy, mainly driven by local authorities. Consumer associations, for their part, have supported the implementation of environmental water policy, by validating and then promoting its principles and main applications. But they were as disappointed as they had hoped when it became clear that the actual results were a long way from what had been announced, and that the public authorities were increasingly catering to the needs of intensive agriculture, which requires both more farming inputs and more water.

So everything seems to be set for water-related conflicts to become more heated, even violent. And yet we have the legal "toolbox" to avoid them. We just need to use it properly.

## Economic players

### Le varenne agricole on water and climate change towards sustainable and balanced water management at local level

**Luc Servant**, Chairman of the Nouvelle-Aquitaine Regional Chamber of Agriculture and Vice-Chairman of the Chambre d'agriculture de France in charge of the environment and water

Meeting the water needs of agriculture is becoming a crucial issue in the face of climate change and the goal of food sovereignty.

With water resources and availability becoming increasingly limited in summer in areas under pressure, sustainable solutions need to be found to meet the various challenges. Saving water remains the priority, but climate change could increase the need for water, particularly in agriculture. Will resources be sufficient?

The Varenne agricole de l'eau et du changement climatique, launched by the government in May 2021, and its theme 3 on water requirements for agriculture, has made it possible to get all the players and users of water around the table. While solutions must be found as close as possible to the local area, all uses and available resources must be considered in order to share sustainable and balanced water management.

The Projet de Territoire pour la Gestion de l'Eau (PTGE) is reinforced as a planning tool. It will have to define all

the needs and resources available in its area, and be supported by local communities and public authorities in its implementation.

### From agricultural cooperative to seed and agri-food business: limagrain, at the heart of the water challenge

**Sébastien Vidal**, Chairman of Limagrain

Between episodes of drought and excess rainfall, the management of water resources is becoming a strategic priority for our societies. Essential for plant growth, water is the primary resource of agriculture and the agricultural processing industry. The stakes go beyond the simple economic argument: to feed men and women, to guarantee the food sovereignty of countries, water is essential.

Limagrain, an agricultural cooperative based in the Puy-de-Dôme region (63), the world's fourth largest seeds company and an agri-food group, is fully aware of the scale of this collective challenge, and is proposing concrete, complementary solutions to both save and increase water resources. Committed to sustainable and resilient agriculture, Limagrain is convinced that water management must be approached in a multi-use, global way, adapted to the situation of each territory.

### Faced with the challenges of water, accelerating solutions is no longer an option

**Aurélie Colas**, General Delegate of the Professional Federation of Water Companies (FP2E)

While the effects of climate change on water are tangible in France, with recurring droughts and extreme events, awareness of the need to act is growing beyond expert circles. Faced with these challenges, water companies have long been calling for the structural backlog of investment to be made up, and for innovative solutions that have proved their worth to be deployed, so that public water and wastewater services can be adapted to climate change without delay. In France, the Water Plan announced by the President of the Republic in March 2023 is consistent with the need to speed up action. It will have to be implemented within a tighter timetable and an appropriate regulatory framework. Similarly, the European Union is showing its strong desire to see water policy evolve to meet the climate and environmental challenge, by setting demanding targets. Against this backdrop, while solutions do exist, there is an urgent need for local authorities and their operators, who are in the front line when it comes to water issues that are eminently local.

### Industrial progress in water management

**Christian Lécussan** and **Aurore Friès**, President and General Delegate of the Fédération nationale des associations de riverains et utilisateurs industriels de l'eau (Fénarive)

Access to water is a key factor in economic development, and industry is no exception. For many years, manufacturers have been carefully managing their

water to save money and/or reduce pollution. With the pressure of climate change increasing, progress needs to be made in terms of technology and management (voluntary certification of manufacturers), economics (water prices, shareholder influence, etc.) and administration (regulations, governance, support, control, etc.). A systemic and partnership-based vision is needed when dealing with water issues, because everything is linked: from upstream to downstream, from summer to winter, including cross-sector synergies between users.

### Water and energy in climate change

**Luc Tabary**, EDF Hydro, Water Coordination

Water and energy are two essential goods that are closely linked: EDF's highly carbon-free production rely for more than 90% on water resources and in turn contributes to preserving water by participating in the fight against climate change. The ambitious objectives of decarbonising our societies cannot be thought without developing carbon-free electricity production.

EDF has long been involved in all water fields: on water cycle knowledge through its R&D and engineering services, on metrology (with more than 1,000 measuring stations), in governance by being present in local representative entities where around its production plants, but also in the so-called "local water parliaments" that are the basin committees (under the French Union of Electricity – Union Française de l'Électricité).

The evolution of water under the effect of climate change and its consequences on the power plants has been studied for a long time within EDF but remains a very complex subject due to the extremely variable nature of hydro-meteorology.

Since 2000, nuclear production losses for environmental reasons (regulatory limits of water temperature or flow) represent on average less than 0.3% of the annual production of the nuclear fleet. Its evolution is estimated at 1.5% by 2050.

For hydroelectricity, the loss related to the increase in air temperature (additional evapotranspiration and induced flow decrease) is estimated at about 0.5 TWh per decade, excluding changes in precipitation and anthropogenic pressure (multi-use, regulations, etc.).

EDF Hydro power plants have a special role insofar as two-thirds of EDF hydroelectric concessions contribute to the multi-use of water (low-water support, drinking water supply, irrigation, tourism, etc.) and thus to adaptation to climate change by helping to secure the resource, particularly during low water levels. One of the key challenges is to succeed in preserving the balance between the potentially antagonistic needs of the carbon-free flexible hydroelectric production essential to the ecological transition and multi-use water needs.

The national water plan unveiled in 2023 marks the strong desire to preserve the resource as well as the environment that rely on it by promoting in particular sobriety: EDF has long been part of this dynamic and aims to continue to improve the performance of exist-

ing power plants in terms of water abstraction and consumption and to seek the best possible efficiency in terms of water use at the scale of territories and river basins. Regarding hydroelectricity, EDF believes that it is still possible to develop the performance of its fleet (power increase, pumped hydro storage, etc.) by coupling it in some cases with multi-use issues.

## Impacts on nature and biodiversity

### Liquid water, a key molecule for living organisms

**Gilles Boeuf**, Emeritus Professor at Sorbonne-Université, Former President of the Muséum national d'Histoire naturelle, Visiting Professor at the Collège de France, President of CEEBIOS

Water is actually the key-molecule constituting the living. All the living beings are made of water, from a few % (plant seeds) to more than 98% (a jellyfish). It is because the conditions were favourable on the planet Earth at the origin that Life was able to emerge some 4000 millions years ago inside the "old ocean". Under its solid form (ice) on poles and in altitude, its vapor status (water vapor) and liquid phase, water constitutes the organic universal solvent. Water dissolves salts becoming electrolytes which, so, develop an osmotic pressure (mOsm.l<sup>-1</sup>) and are essential in the hydromineral regulation. Present climatic disruptions (including temperature and precipitations) facilitate complex conditions which influence biodiversity and economic human activities. Changes are rapid and responses have to be faster and faster. And clearly, to adapt, and the living always reacted in the past, the living needs time and always accepted to change: a reaction, mankind seems to delayed permanently...

### Preserving biodiversity at the heart of water resource management issues under climate change

**Olivier Thibault, Bénédicte Augeard and François Hissel**, French Office for Biodiversity (OFB)

The climate and hydrological models used in the climate change scenarios point to a significant reduction in surface and groundwater reserves over the coming century. The intensification of drought events will lead to increased pressure on aquatic and wetland ecosystems, which in France are already among the most threatened, and yet the source of many services useful to our societies, such as food production, flood mitigation and the regulation of pollutant flows.

The scale of the challenges we face in achieving sustainable and rational management of water resources means that we need to reinvent the way we govern water, taking greater account of the issues involved in preserving biodiversity, and radically transforming the way we produce and consume, with a view to reducing consumption. In return, ecosystems offer us a panoply of solutions for adapting to climate change, often with joint benefits for our health and quality of life.

### France Nature Environnement's (FNE) action to deal collectively with climate upheaval in the water cycle

**Florence Denier-Pasquier**, France Nature Environnement (FNE) representative on the National Water Committee

The profound effects of climate change on hydrosystems now pose threats to both ecosystems and water resources. This article traces the mobilization of the France Nature Environnement movement, the leading federation of nature protection associations in France, in the field of water policy. We identify the obstacles and opportunities of public action that must now address both the preservation of ecosystems and the sharing of resources, quality and quantity, anticipation and collective governance. We emphasize the fundamental role that nature-based solutions and sobriety must play.

### Protecting and managing wetlands to adapt to and mitigate the effects of climate change on the water cycle, an action by the Conservatoires d'espaces naturels (nature conservatories)

**François Micheau**, Director of Programmes, Fédération des Conservatoires d'espaces naturels, **Jérôme Porteret**, Scientific Manager, Savoie Conservatory of Natural Areas and **Julien Saillard**, Territorial Division Manager, Auvergne Conservatory of Natural Areas

Using a number of concrete examples of wetland preservation and restoration in France, carried out by the Conservatoires d'espaces naturels, this article proposes

to look at wetlands both as objects of climate change, directly or indirectly suffering the deleterious effects on their functions, and also as subjects of climate change, providing a solution for adapting to and mitigating climate change, in particular by storing carbon.

### The Camargue, a delta facing the climate challenge

**Jean Jalbert**, Managing Director of Tour du Valat, research institute for wetland conservation

The Rhône delta, like all deltas in the world, is on the front line of climate change. Following its dyking up after major floods at the end of the 19th century, this vast deltaic plain was the site of an extraordinary story of conquest and mastery: dykes, pumps and hydraulic networks made it possible to tame this restive land, freeing it from the main constraints – flooding, salt, marine submersion – and finally to “develop” this territory, develop productive agriculture and provide security for its inhabitants. Yet this period of stability is probably coming to an end. Under the powerful effects of climate change, this territory is reminding us that the wealth of a delta comes precisely from its dynamics, from the flows that cross it. Fresh water and sediment flows, salt water flows, biological flows, human flows... It reminds us of its profound nature: a moving territory, mobile by essence, the seat of the impermanence of things.

What if the Camargue were a perfect laboratory for inventing a new narrative, one of adaptation and resilience?

Issue editor:  
**Pierre Roussel**