DROP

BENEFIT OF GOVERNANCE
IN DROUGHT ADAPTATION



Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IVB

Practice measures example book

# Benefit of governance in DROught adaPtation

A handbook for regional water authorities



# Table of contents

# Preface

'Water shortage and drought are becoming increasingly common, and the situation is expected to become further aggravated as a consequence of climate change'

**In 2013, the European Commission adopted an EU strategy on adaptation to climate change that has been welcomed by the EU Member States. The aim of the strategy is to make Europe more climate resilient.**

Water shortage and drought are becoming increasingly common, and the situation is expected to become further aggravated as a consequence of climate change. Urgent actions are required to adapt to these changes. The 'Benefit of governance in DROught adaPtation (DROP)' project aims to enhance the preparedness and resilience of the regions of North-Western Europe to such periods of drought and water shortage. The core pillars of the DROP project include transnational knowledge exchange and integration between science, policy and practice, and the exchange of knowledge between regional authorities in the form of drought expert teams, and between practice and science through governance assessment.

First and foremost, there is an urgent need to raise awareness on the topic of drought and water shortage. To date, in North-West Europe, drought and water shortage as water management issues have been considered less significant than flooding. The real key to finding a solution is to view drought and flooding as two sides of the same coin.

There are major discrepancies between the working methods and organisation approaches employed by the partners, to say nothing of the differences between the geography and spatial planning policies of the participating countries. We can overcome these differences through joint development.

The DROP project has demonstrated that the issue of drought and water shortage calls for a broad set of technical solutions in combination with a system of water governance capable of putting the right measures in place at local, regional and national level.

This handbook provides the reader with a raft of possible measures and actions that could be undertaken to combat drought, and on that basis aims to inspire other regional water authorities.

I would like to express a special word of thanks to all partners in the DROP project. Without the pilots in the regions and the results they have generated, this book could never have been written.

*Stefan Kuks,*
*chairman of the international steering group* ***DROP***

Water scarcity and drought can harm agricultural production, nature and fresh water supplies. Although the problems caused by drought in North-West Europe are currently not overwhelmingly visible, early action should be taken to reduce costs and prevent damage. How can European regions increase the resilience of their catchments to drought periods?

# Introduction

This book presents the key practice findings of the three pilots (Nature, Agriculture and Freshwater) of the DROP project (benefit of governance in DROught adaPtation). In the period 2012-2014, eleven organisations, both practice and science, have learned from each other through cooperation in pilot actions and governance assessments, to enhance the preparedness and resilience of North-West European regions to periods of drought and water scarcity. The DROP-project recieves funding from the Interreg IVb Programme North-West Europe of the European Union.

## The DROP-project and this handbook

The Commission's recent "Blue Print on European Waters" states that existing climate adaptation policies are good, but that the implementation of (technical) solutions is especially difficult. A future challenge for Europe is therefore to improve the implementation of adaptation measures, regarding both technical measures and governance contexts. DROP dealt with both issues for North-West Europe regions: technical drought adaptation measures and assessment of the governance setting of regions. Each of the six regional water organisations (the practice partners) carried out studies and realised drought adaptation measures.

It turned out that these measures are most effective if relevant stakeholders are on board and engaged in drought adaptation. Strong governance is needed to help to unify the different interests of stakeholders at different levels of policy and practice. Therefore, the project consortium was complemented by five knowledge institutes (knowledge partners) who developed a governance toolkit which was used in the six regions of the practice partners. The toolkit and some of the results of this scientific endeavour are presented in another DROP report: The governance assessment guide. In this handbook we introduce the measures and studies carried out by the practice partners, aiming at providing an inspiration and guidance for other regional authorities in the process of finding innovative solutions to adapt to drought and water scarcity situations. More extensive descriptions of the pilots can be found online at www.dropproject.eu.

'How can European regions increase the resilience of their catchments to drought periods?'

## How this book is organized

This book is organized as follows. The description of the general framework on drought, water scarcity and climate change in Europe (chapter 2) is followed by three pilot chapters, dealing with the pilot Nature (chapter 3: regions Twente and Somerset), pilot Agriculture (chapter 4: regions Salland and Flanders) and pilot Freshwater (chapter 5: regions Eifel-Rur and Brittany).

Each chapter contains a description of the studies and measures carried out in each region. These chapters are complemented by a text box on the specific governance context in the regions. These boxes summarize some of the achievements of the governance team.

The lessons and recommendations the DROP partners draw from the three pilots are formulated in chapter 6.

The seperate chapters for Nature, Agriculture and Freshwater may suggest that these themes can be regarded in isolation from each other. Nothing could be less true. In fact, Nature, Agriculture and Freshwater are closely interrelated when it comes to dealing with drought and water scarcity. To illustrate the interrelation, the book ends with a figure of three overlapping circles illustrating the interrelations between the three pilots (page 60). The DROP researches and measures in the circles show that most research and measures influence more than just Nature, Agriculture or Freshwater.

## DROP partners

DROP is a transnational project and integrates knowledge from science, policy and practice. The project is implemented through collaboration between six practice partners and five knowledge partners. From the Netherlands, Waterschap Vechtstromen (lead partner), Waterschap Groot Salland and the University of Twente are participating. Germany is represented by Wasserverband Eifel-Rur. The French partners are the Institution d' Aménagement de la Vilaine, IRSTEA and Université François Rabelais. Belgium is represented by the Vlaamse Milieumaatschappij and the Brussels office of Ecologic. From the United Kingdom, Somerset County Council and The University of Manchester are involved.

# Drought, water scarcity and climate change in Europe

'Changes in drought occurrences are closely related to changes in temperature and land use'

Water scarcity and drought is an increasingly frequent and widespread phenomenon in the European Union. The challenge from water scarcity and drought has been recognised in the Communications from the European Commission 'Adressing the challenge of water scarcity and drought' (adopted in 2007) and 'The Blue Print to Safeguarding European Waters' (adopted in 2012). Underlying studies show that in 2007 11% of the European population and 17% of its territory have been affected.

The communications from the European Commission stated that long term imbalance resulting from water demand exceeding water resources availability is increasingly a problem within Europe. Over the past thirty years, droughts have dramatically increased in both frequency and severity. Changes in drought occurrences are closely related to changes in temperature and land use. In the last decade (2002-2011), the average temperature was no less than 1.3 centigrade above the pre-industrial level, and predictions of future climate conditions indicate that this tendency might persist in the future decades. In several regions, extreme events such as heat waves, forest fires, floods and droughts are occurring (or expected to occur) more often. Changes in land use amplify this effect, resulting in more and more intense droughts and periods of water shortages. The heat wave and drought experienced by Europe in summer 2003 caused the loss of thousands of human lives and severe economic damages, including 10 billion euros of agricultural damage.

In Europe, the number of people and areas that are affected by drought (or a temporary decrease in water availability) has increased by 20% between 1976 and 2006. It is expected that water shortages will increase in the near future, if temperatures keep rising as a result of climate change. Equally, changing and competing 'demand' needs for agriculture, drinking and urban water, and environmental/nature flows will place even greater pressures on increasingly scarce resources. Adaptation – of demand and supply systems – is necessary to prevent high costs in the future. Many European countries are working on drought adaptation strategies and policies. However, the implementation of such strategies is just starting. Many studies are still needed to test the effectiveness of adaptation measures in periods of drought and scarcity, and to enable the engagement of key stakeholders and users in planning and decision-making.

Drought and water scarcity are no longer concerns of only the hot and dry Mediterranean regions; they are becoming a concern of North-West Europe as well. Although the problem is not yet overwhelming visible early action should be taken to reduce costs and prevent damage.

'The heat wave and drought experienced by Europe in summer 2003 caused the loss of thousands of human lives and severe economic damages, including 10 billion euros of agricultural damage'

## The challenge

Nature conservation, drinking water production and agricultural production often take place side by side in the natural environment. However, the needs for water within and between these different sectors are not always aligned. The water needs must be balanced, especially during drought events. Conflicting situations might occur and it is of great importance to increase the resilience of nature areas, and thus prevent negative effects of drought on flora and fauna, without harming the neighbouring land use or the production of drinking water. While the interests initially appear competing, in fact, there are several opportunities for collaboration which enhances adaptation and resilience across all of these sectors. The challenge is to find governance structures and practical measures, which link nature conservation to economically viable and sustainable agriculture and drinking water production.

'We want the right amount of water of the right quality in the right place at the right time'

# Pilot Nature

## General introduction

The effects of higher temperatures and drought on nature are diverse and complex. However, it is clear that the effects are extensive. During a drought period, groundwater levels drop, the vegetation competes for the water and dehydrates, and faster mineralization (eutrophication) can occur. Studies have shown that increased droughts contribute to the emission of carbon in the atmosphere, through increased degradation of dead and decaying plant material such as peat land. In Twente (NL) and Somerset Levels (GB), several innovative measures related to drought and nature conservation have been tested and implemented. These projects show how farming and nature conservation can go well together. This is further enhanced by engagement and awareness efforts to create a sense of ownership among farmers and nature organisations.

## Facts

**Region**
Twente, The Netherlands

**Project scale**
From farm-level (less than 1 km$^2$)
to catchment level (100 km$^2$)

**Project owner**
Waterboard Vechtstromen

**In collaboration with**
Province of Overijssel, Municipalities, Staatsbosbeheer (State Forest Service), Landschap Overijssel (Foundation for nature and landscape conservation in Overijssel) and Natuurmomenten (National foundation for nature conservation).

**For more information**
Waterboard Vechtstromen
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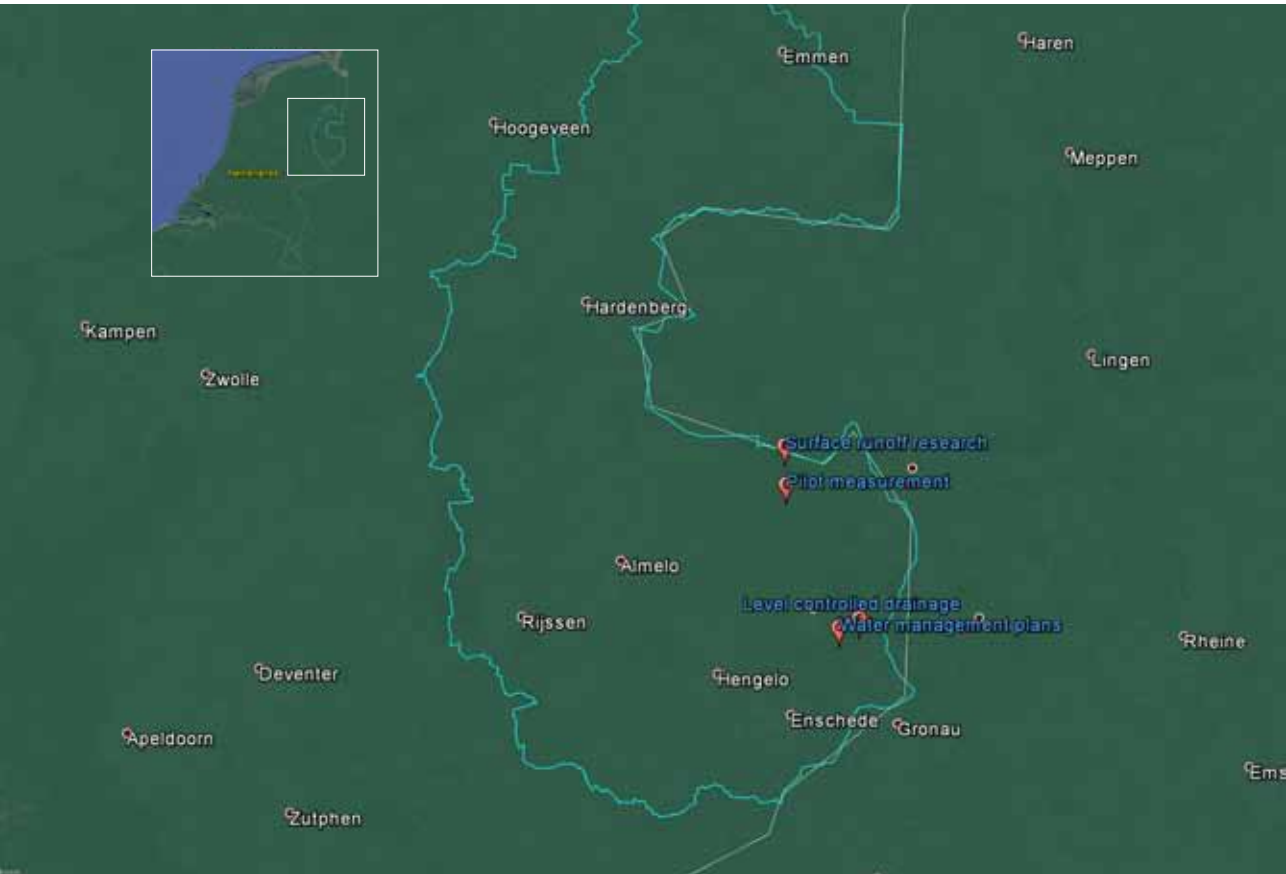
Koen Bleumink: k.bleumink@vechtstromen.nl


'The groundwater sensitive flora responds very quickly to level improvement measures. You will soon see special plants occupy the area'

TWENTE | THE NETHERLANDS



Nature ›

Waterboard Vechtstromen

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# Region Twente

## Challenge

The first challenge has been to increase the resilience and retention capacity of the water system to better serve nature and agriculture during periods of drought and flooding. The second challenge has been awareness raising. Measures can be more efficiently implemented if stakeholders are aware of the consequences severe drought engenders. The third challenge is to get from numerous small-scale and scattered projects to an approach that covers larger areas.

# Pilot description

## Context

Waterboard Vechtstromen is situated in the east of the Netherlands and responsible for the management of water and treatment of wastewater in the Twente region.

In recent years, water shortages have occurred in the sandy soils in North-East Twente during dry summers. Due to climate change the average annual precipitation surplus (precipitation minus evaporation) is decreasing. As a result, less water will be available in the near future causing problems both for agriculture and nature: damage to crops and damage to both terrestial and aquatic nature.

In the North-East region of Twente, already about 90% of the water streams carry too little water or even run dry. Desiccation has a great impact on the aquatic nature. Lower groundwater levels reduce the river discharge with the impact particularly seen in spring and summer periods, when precipitation is low and river levels are maintained by groundwater. Not only in streams and their valleys, but also on high ground in the catchment area nature will deteriorate with desiccation. In the whole catchment area, substantial impacts are expected, which may be only partly countered by measures.

## Strategy and measures

Seven implementation projects were realized: drainage systems were removed, ditches were muted, streams were shoaled and water storage areas were constructed. Due to these measures, it is expected that the groundwater level will rise, creating a water buffer for dry periods. In addition, water management plans were written for 15 farming enterprises, and two research projects have been carried out, dealing with a level-dependent drainage system and the reduction of surface run-off.

### Water management plans

Water management plans have been made together with the farmers, tailored to their specific situations. The plans include tips and tricks on how to influence the water balance by storing water, resulting in a mutual gain for the farmer and the adjacent nature areas. The aim of these plans is to work on drought adaptation on a small scale, fitting in an overall vision for the area. The intensive communication established with the farmers created awareness, and motivated other stakeholders to work on drought adaptation as well.

### Testing of a level-dependent drainage system near a nature conservation area

Many water managers see level-dependent drainage as the primary means of preventing water depletion and of optimizing agricultural use of areas of land. However, this idea lacks theoretical underpinning. There is only limited knowledge about the effects that level-dependent drainage has on nature. A study in Duivelshof (a nature area that is surrounded by a water-depleted area of intensive agriculture) aimed to better serve both nature and agriculture during long periods of drought. Waterboard Vechtstromen has constructed a system of level-dependent drainage in combination with raising the drainage basis of a small water-depleted nature conservation area.

### Research and measures for reducing surface run-off

Surface runoff in North-East Twente is commonly observed in hilly areas, where soil layers with low permeability reach the surface. Extreme precipitation events, together with impermeable layers at shallow depths, can result in pool formation. If precipitation events follow shortly after land fertilization, pools with high phosphate concentrations are formed. As a result, the surface water is enriched with phosphates, leading to eutrophication. Research has been carried out to estimate the potential of conceivable measures to reduce run-off (e.g., contour ploughing or constructing earth banks along the low parts of fields for water infiltration).

## Governance

In the Netherlands, the recognition of the drought and water scarcity problem is still at an early phase. There is only legitimacy for soft voluntary approaches to prevention policies and measures. In this context, partnerships with as many stake-holders as possible, are the best way to create success. In Twente, a close collaboration with stakeholders has been found. Trust relations have been built and each other's goals and visions are taken into account when planning drought measures. This provides coherence and enables the successful implementation of drought measures. However, it can also be seen as a successful adaptation to deal with an incoherent and fragmented governance context for the implementation of preventive drought measures. While normally incoherence and fragmentation would lead to stalemates and ultimately disinterest in the topic, it now has led to the recognition that the various parties need each other, and to the absence of fear that one of them will become too dominant.

'Recognition of the drought and water scarcity problem is still at an early phase'

## Facts

**Location**
Somerset Levels, United Kingdom

**Project scale**
100km$^2$, 60,000 inhabitants

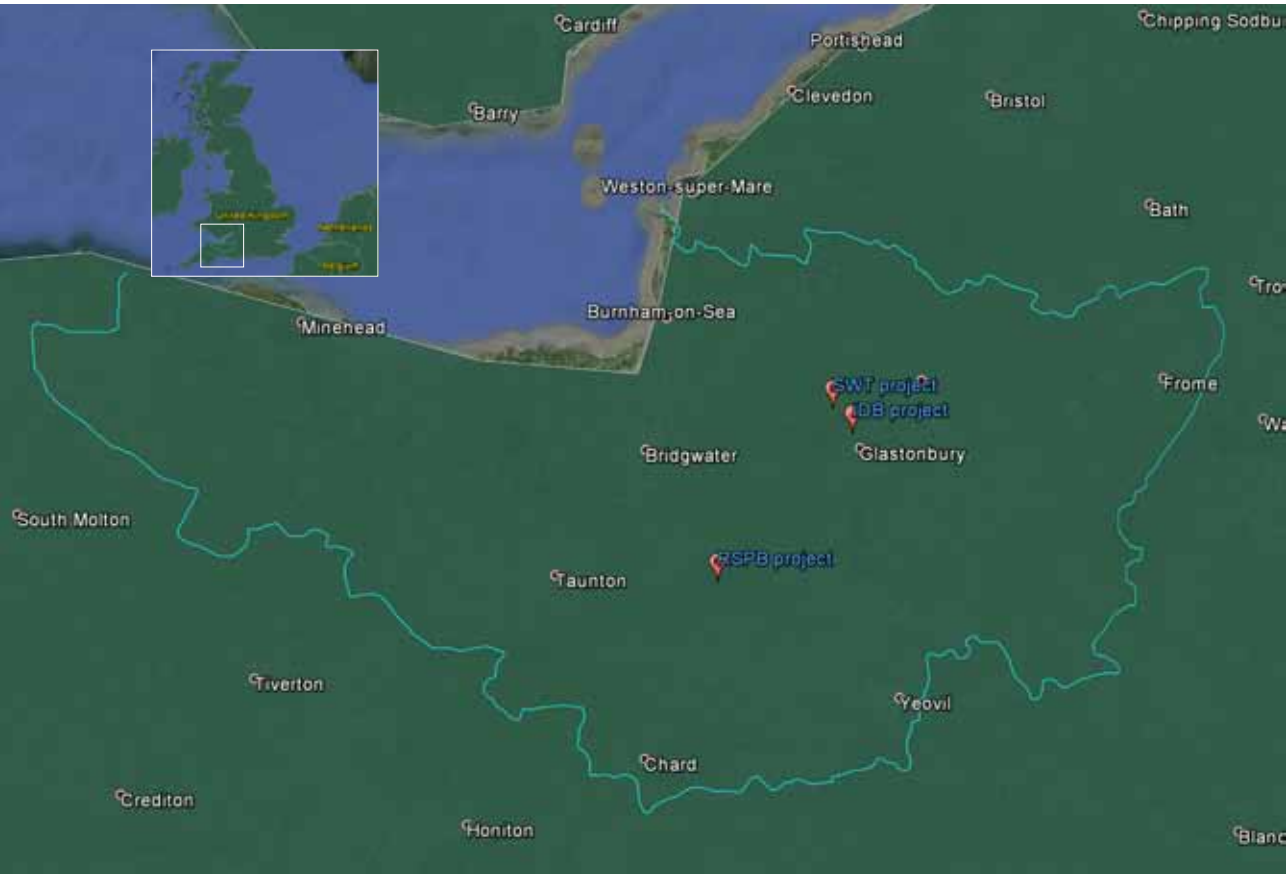
**Pilot owner**
Somerset County Council

**In collaboration with**
Farming & Wildlife Advisory Group South West (FWAG SW), Royal Society for the Protection of Birds (RSPB), nature organizations, farmers and (private) land owners.

**For more information**
Somerset County Council
www.somerset.gov.uk
Steve Dury: sdury@somerset.gov.uk

'It is very challenging to talk about drought, after the significant flooding in 2013. We're working on measures that address both flooding and drought'

SOMERSET | THE UNITED KINGDOM



Nature ›

Somerset County Council

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# Region Somerset

## Challenge

The challenge has been to bring together two areas of drought adaptation – nature conservation needs and agricultural demands and needs. This requires an overhaul of the water management infrastructure and governance arrangements. Climate change is expected to have a profound effect on farming and land management. Therefore, water conservation measures needed to be implemented and innovative approaches to water management needed to be explored.

# Pilot description

## Context

The Somerset Levels are a sparsely populated wetland area of central Somerset. They consist of marine clay levels along the coast and often peat based moors inland. The peat soils of the Somerset Levels provide multiple ecosystem services including food production, nature, carbon storage and protection of historic environment. These peat soils are vulnerable to sudden and irreversible changes as a direct result of drought. These changes include a lowering of the land as water is lost, which then leads to difficulties in managing water levels cost-effectively at a landscape scale.

Therefore, decent water management in the area is extremely important in sustaining valuable environmental features, like exposed peat soils and wetland wildlife (meadows, ditches).

Somerset will be faced with changing rainfall patterns under climate change. These changes will likely mean wetter winters and drier summers, which is likely to have a profound effect on land management and farming.
In order to increase resilience to climate change, the water management infrastructure and governance arrangements with respect to water need an overhaul.

There is a need for winter storage of water to alleviate flooding and also to cope with reduced summer rainfall. This winter storage could be anything from floodplain retention areas and creation of wetland habitats, to interception ponds, water recycling, collection pits and water collection tanks. At a farm level, climate change is expected to have a profound effect on land management and farming. Farmers will need to implement water conservation measures and explore innovative approaches to water management on farms. Additionally, nature conservationists have acknowledged the need to work at a landscape scale to address problems of habitat fragmentation and isolation. Climate change gives added impetus to work at a landscape scale to mitigate and adapt to increased flood and droughts. There is a need to create a landscape in which flora and fauna can migrate in response to change.

## Strategy and measures

Somerset has implemented a number of innovative approaches to increasing drought resilience. FWAG SW has developed modelling and technology transfer in the Upper Parrett catchment on irrigation scheduling and water application management. Water demands for agriculture (e.g. potato production) are high in the Upper Parrett, and there is an urgent need to reduce water demand from irrigation. Use of soil moisture probes and data analysis has led to a more effective and efficient use of water for application via irrigation. FWAG SW has also worked with farmers, trialling different types of cover crop to help build organic matter. Healthy soil structure and high organic matter levels are important to help increase soils resilience against the effects of waterlogging and drying.

This is especially important on arable farms where the normal sources of organic matter are in shorter supply due to the removal of biomass. Results indicate that these methods have been successful by increasing soil organic matter content, soil water holding capacity, soil microbial activity, and earth worm counts, and by decreasing soil density.

In a managed lowland landscape, the conservation of peat soils and their associated habitats is dependent upon the functioning of a managed water system. During droughts, pinch points in the water system can result in interruptions to the water supply to large areas, and the consequent desiccation of peat soils. Conservation NGOs RSPB and Somerset Wildlife Trust have identified pinch points in the water system on nature reserves, to plan and implement works to improve the flow of water.

As elsewhere across North-West Europe, there has been a dramatic decline in the area of lowland raised bog habitat since around the start of the nineteenth century. The area of lowland raised bog in the UK, retaining a largely undisturbed surface, is estimated to have diminished by around 94%. The majority of the raised peat bog has been lost to peat extraction and agricultural intensification. The remaining fragments, which are now all within nature reserves, are raised above the surrounding peat voids, and are, consequently, very difficult to keep wet. The largest remaining fragments of raised bog (about 20Ha at Westhay Moor NNR and about 10Ha at Street Heath) are managed by Somerset Wildlife Trust, who together with RSPB have planned and implemented a programme of work including scrub clearance, re-grading of peat soils and improvement of structures that retain rainwater, to improve the drought resilience of this fragile but valuable habitat.

'The challenge for Somerset is to avoid maladaptation between these two policy areas and to integrate the adaptive measures for flood and drought'

## Governance

The drought period in the South of England in 2010-2012 had created substantial momentum to improve the processes of drought and water scarcity adaptation, preparation and communication. There are a number of ways that drought and water scarcity are included in water resources or crisis planning of various stakeholders, including the regional Water Companies, the Environment Agency, the Irrigation Board, and a range of other community and council stakeholders. During and after this period of drought, there was an increased emphasis on coordinating responses to drought and water scarcity across stakeholders. This was seen to somewhat overcome the fragmented way that drought and water scarcity had been experienced, planned for, and communicated in the past. However, as the area is also prone to flooding (e.g. winters 2012 and 2013/14), the challenge for Somerset is to avoid maladaptation between these two policy areas and to integrate the adaptive measures for flood and drought.

## The challenge

Droughts with considerable damage to agricultural production have already occurred in the past and their impacts are expected to increase through increases in water demand and climate change. An increased frequency, duration and severity of droughts and water shortages will result in higher uncertainty in crop production, and thus more frequent and severe drought-related agricultural crises.

The challenge for agriculture is to increase its resilience against drought and water scarcity, while remaining economically viable and retaining its environmental and social values. The expectation is that investing pro-actively in the development of agricultural drought adaptation and mitigation measures, as well as in policy will be cheaper than the economic, environmental and social costs of future droughts. Pilot Nature has highlighted some of the complexities of balancing drought adaptation for nature conservation in landscapes which also include agriculture. Pilot Agriculture will highlight these complexities from an agricultural point of view.

'Addressing drought impacts on agriculture requires the adaptation of existing tools for new challenges, and urges different stakeholders to work towards common solutions'

# Pilot Agri-culture

## General introduction

There are different perspectives on drought. The meteorological perspective on drought focuses on the degree of dryness, in comparison to a normal or average amount, and the duration of the dry period. The hydrological perspective on drought refers to the low discharge of water in streams and reservoirs, lasting months or years. Hydrological drought can be a natural phenomenon or the result of human activities depending on the cultivation of the land. Changes in land use and land degradation can affect the magnitude and frequency of hydrological droughts. The agricultural perspective on drought is the impact of meteorological and hydrological drought on agriculture production, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil-water deficits, reduced groundwater or reservoir levels, and so on. In Flanders (BE), instruments for agricultural drought monitoring and impact modelling have been developed. In Salland (NL), two pumping stations with an innovative control system that makes use of weather-predictions have been built.

## Facts

**Region**
Flanders, Belgium

**Project scale**
Drought monitoring indicators were developed for the whole of Flanders. Hydrological models were developed for the catchments of the Velpe and Dommel rivers.

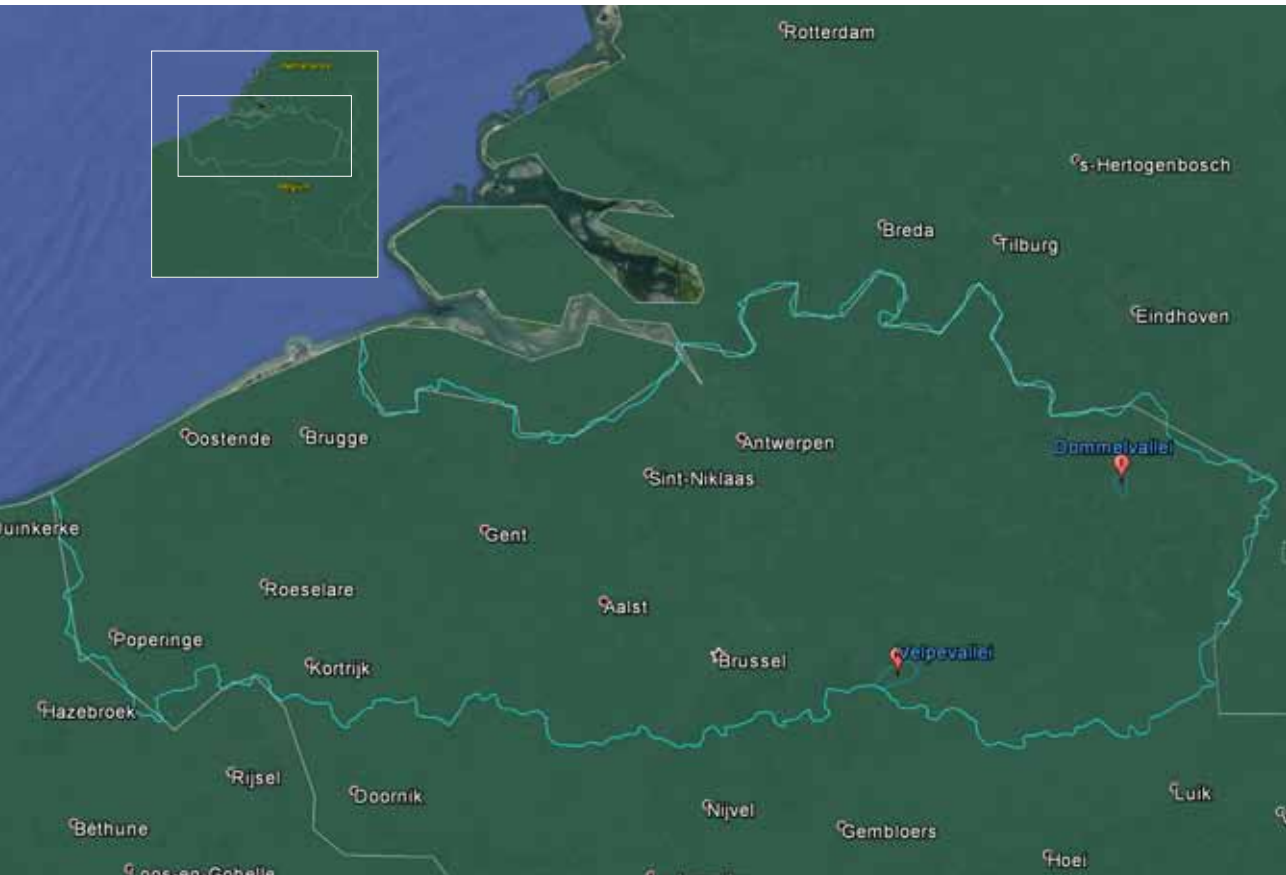
**Pilot owner**
Vlaamse Milieumaatschappij (Flemish Environment Agency)

**In collaboration with**
Different departments and agencies of the Flemish Government, water managers, farmers' associations, local authorities.

**For more information**
Vlaamse Milieumaatschappij (VMM)
www.vmm.be, www.waterinfo.be
Willem Defloor: w.defloor@vmm.be

'A better understanding of drought occurrence and impacts supports more effective and efficient future drought adaptation and mitigation strategies'

FLANDERS | BELGIUM



Agriculture ›

Vlaamse Milieumaatschappij

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# Region Flanders

## Challenge

The challenge was to develop an approach which allows monitoring and reporting the drought status to enable pro-active water management, estimating the impact of droughts on agriculture, and evaluating measures for drought adaptation and mitigation in the Flemish framework.

# Pilot description

## Context

Existing monitoring and modelling tools for water management are largely geared towards flooding instead of drought. Nevertheless, agricultural droughts may have severe socio-economic impacts if not well forcasted and monitored. The development and use of a set of indicators for the monitoring and reporting of a drought situation is still needed in Flanders. Furthermore, existing hydrological models require adjustments, so they can be used for the modelling of low flow conditions and in support of defining strategies of drought adaptation in relation to agriculture.

The goal of this project is twofold: to set up adequate instruments for drought monitoring and impact modelling, and to provide important information in support of future strategies for drought management. In this pilot project, drought monitoring indicators are developed for the whole of Flanders, while more specific drought impact models are developed for the catchments of the Velpe river (141 $km^2$), in the Belgian loam belt, and for the Dommel river (176 $km^2$), in the sandy area of Eastern Flanders.

Dutch and Flemish stakeholders from the agricultural sector meet and discuss solutions for drought-related agricultural problems.

## Strategy and measures

An operational set of indicators for drought monitoring and reporting was developed (e.g. standardized precipitation index, rainfall deficit, standardized streamflow index). This allows monitoring different levels of drought (meteorological, agricultural and hydrological) on the local scale (measuring station) and at a larger scale (here, Flanders). The integration of these indicators in the existing framework of data management and reporting at VMM contributes to a more effective drought status reporting. It also represents a technical step towards the development of an integrated water management strategy that addresses both high flows (floods) and low flows (droughts). In 2014, the web portal www.waterinfo.be was launched in cooperation between five Flemish water management services. Drought is included as one of the four main themes of the portal. Through the website, the drought indicators developed in the DROP pilot case are published and disseminated.

Modelling tools focusing on the impact of droughts on different aspects of the water system (e.g. soil moisture, streamflow) and on agricultural production (yield loss) have been developed.

'Model results for the pilot catchments show different drought impacts'

SWAT (Soil and Water Assessment Tool) and SWAP (Soil - Water - Atmosphere - Plant) models were set up for the two pilot river catchments. These models allow an estimation of the impact of droughts on water availability and crop production. Past droughts (for understanding existing drought impacts), present droughts (for operational drought management) as well as expected future droughts (in support of drought adaptation measures) can be modelled.

Model results for the pilot catchments show different drought impacts depending on the severity of the drought, time of drought occurrence during the year, and soil and crop type.

While model conclusions have been restricted to the project areas, the future application of these modelling tools over the entire Flanders area will provide essential information to support the development of a drought adaptation and mitigation policy in Flanders. The modelling exercise for the project areas also outlined knowledge and information gaps that are to be addressed by further model improvement and an increased cooperation among different experts and stakeholders. For instance, there is a lack of accurate soil moisture data, a key variable in assessing drought impact on agricultural production. For the project areas, this was addressed through a measuring campaign.

The drought monitoring and modelling framework that was implemented can be used by decision makers, such as water managers, the agricultural department and farmers' organisations, to evaluate the impact of droughts and to take action accordingly. While initially focused on agriculture, the framework might be extended towards drought-sensitive nature reserves, groundwater extraction, water quality and navigation on waterways. At the same time, a coordination platform was created by bringing together governmental agencies and organizations involved in water management and agriculture. This will further stimulate the cooperation between different stakeholders, such as the Flemish agricultural department, the Flemish Land Agency, regional and national water managers, the provinces and municipalities. The aim is to develop this approach in such a way that it can be used in other countries as well.

'A strong governance context for drought adaptation involves mechanisms to support the engagement of various relevant stakeholders'

## Governance

In Flanders, the Flemish Environment Agency (VMM) is the main actor organizing awareness-raising initiatives on the issue of drought in the region. In general, awareness for drought issues is lacking in many stakeholder groups. The approach used by VMM to change this situation has been based on making a scientific case for drought action on the part of stakeholders. Scientific results have been used to create awareness and as a basis for a discussion of potential adaptation actions for drought in the region. The development of indicators for agriculture is one example.

This kind of approach was already used successfully for floods by VMM. Therefore, an established 'organizational logic' is being followed when introducing regional awareness for droughts. However, a strong governance context for drought adaptation does not just involve the development of technical expertise. It also involves mechanisms to support the engagement of various relevant stakeholders.

Drought problems are already included in some strategies and visions, and various policy instruments are in place. These policy instruments stem from different strategies and, consequently, coherence and synergy between these instruments is missing.

## Facts

**Region**
Salland, the Netherlands

**Project scale**
The project is part of a larger project which covers an area of 180 km²

**Pilot owner**
Waterboard Groot Salland

**In collaboration with**
Province of Overijssel, farmers, Vitens (water supply company)

**For more information**
Waterboard Groot Salland
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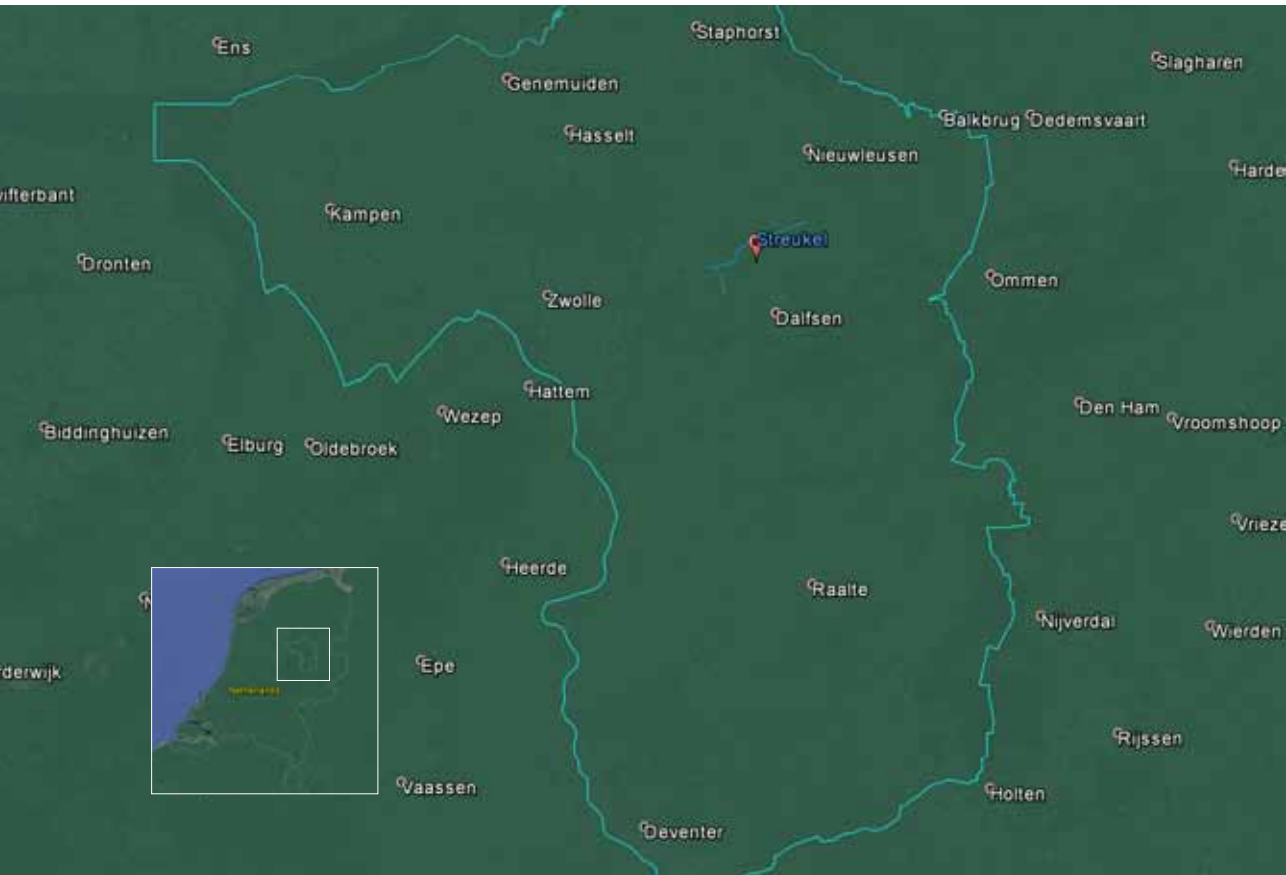
Hilde Buitelaar - van Mensvoort: hbuitelaar@wgs.nl


'People from different functions and disciplines came together to talk about the future workings of the system. It is good to have all their differing perspectives on board'

SALLAND | THE NETHERLANDS



Agriculture ›

Waterboard Groot Salland

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# Region Salland

## Challenge

The challenge in this project has been to build a water system that is more resilient to extreme and changing weather conditions by dividing up a catchment area into two catchment areas. The new water system then will have a double function: water supply from the river Vecht to the catchment area and water discharge from the catchment area to the river Vecht.

# Pilot description

## Context

The jurisdictional area of Waterboard Groot Salland (NL) is located in the North-East of the Netherlands. The catchment area of the pumping stations Streukelerzijl-Galgenrak, located in the North-Eastern part, is prone to flooding due to an insufficient drainage system and to water shortage in periods of drought. The aim of this project has been to protect this catchment area of about 18.000 ha against flooding and drought events.

This required a water system that is able to drain and supply enough water in, respectively, wet and dry weather conditions, and also a water system that responds quickly and effectively to changing weather circumstances. A good steering mechanism for the water system is essential and key for good water mangement. Another challenge of the project is to generate knowledge about how to enhance cooperation with all stakeholders involved, in order to come to new implementations to prevent drought related agricultural losses.

Grand opening of the project Streukelerzijl. Schoolchildren give the sign for turning on the pumpingstation

## Strategy and measures

A large part of the catchment area has been disconnected to form a new catchment area, for two reasons: to compensate groundwater extraction by the drinking water company and to secure the water supply for farmers in the catchment area. Two new structures built during the project and one still to be built pumping station at the Vecht river together will drain and discharge the new catchment area. The new build structures are double-acting, i.e. they are able to discharge water to the River Vecht and to pump water from the river Vecht into the catchment area.

Until the new double-acting pumping station near the river Vecht is fully working, a temporary water inlet is used to be able to supply the new catchment area with water. This temporary water inlet is located higher upstream the river Vecht than the future location of the new double-acting pumping station. The water drained from the new catchment area is temporarily transported via an already existing watercourse to the North-West.

## Governance

A vivid governance context has been observed here. The emphasis of national and EU policies on river basin management encourages the regional water authorities to coordinate their actions. One of the regional initiatives has been the development and implementation of a common irrigation policy, which aims to balance the use of water by farmers close to natural areas. The investigation on the governance context revealed that all stakeholders involved discuss the issue of irrigation in terms of (a lack of) water supply, an approach culturally and historically firmly rooted in this region.

As such, the focus of the policy shifted towards zoning, a solution that aims to reserve scarce water for nature, during periods of drought. However, the governance assessment also revealed some evidence that stakeholders on a regional level learn to treat the issue of drought as a phenomenon in itself through participating in a regional initiative, which aims to preserve and increase the freshwater reserves in the region, whereby stakeholders are willing to address drought as an issue in itself that influences the vulnerability and adaptability of their activities.

An optimization study on the water management of the double-acting water system has been carried out. The new build pumping stations are equipped with the new innovative steering mechanism based on the results of the optimization study. It involves a remote-controlled control system that is linked to output of weather forecasting models.

'The emphasis of national and EU policies on river basin management encourages the regional water authorities to coordinate their actions'

## The challenge

Decreasing water quantity prompts for innovative solutions for guaranteeing water quality and optimizing resources management in freshwater reservoirs. The implementation of reservoirs for water storage is a means of regulating the natural variability of water in space and time and, therefore, controlling water volumes in excess (flood protection) or the occurrences of extreme low levels of water availability (drought management). Challenges arise when reservoirs have multiple objectives and users (e.g. water supply, agriculture, tourism, environment protection) and water availability is restricted, either by quality issues or by a reduction in its quantity (e.g. low precipitation, leading also to reduced river flows).

'Without adaptation a change in the precipitation pattern can lead even in water rich regions to water shortage in reservoirs'

# Pilot Fresh-water

## General introduction

Worldwide, many examples of unsustainable management have shown that water shortages can have significant social and economic impacts. Reduced river flows and lowered lake and groundwater levels lead to a decrease in the quality of surface water, as less water is available to dilute pollutants. It also leads to insufficient water to meet environmental and industrial needs, as well as household demands for fit-for-purpose water. Water supply infrastructures (e.g. transfers, reservoirs and desalination plants), and efficient drought monitoring and forecasting systems are means to prevent and handle situations of severe drought.
The supply-demand balance and the needs to address and create reductions and efficiencies in the demand side of sustainable water management are part of the solutions to cope with more prolonged periods of water shortage. Solutions for a sustainable management of water resources, including an optimized management of multi-purpose reservoirs, are still necessary to increase resilience to drought and water scarcity. The urge to induce new demand and supply strategies is high, due to the economic interests of the reservoirs and the increasing demands of their different users. The pilot Freshwater illustrate the experiences in realizing innovative technological measures for reservoir management in Brittany (France) and Eifel (Germany), to better manage droughts and combat water scarcity for freshwater supply.

## Facts

**Location**

Arzal, Morbihan, France

**Project scale**

The Arzal dam is located at the outlet of the Vilaine River basin, which has an area of approximately 10 000 km$^2$. The water storage capacity of its reservoir is about 50 million m$^3$, and supplies nearly 1 000 000 people (local inhabitants and tourists) in summer.

**Implementer**

Institution d'Aménagement de la Vilaine (IAV) and IRSTEA (Institut national de recherche en sciences et Technologies pour l'environnement et l'agriculture)

**In collaboration with**

Local and regional municipalities

'The misty rains and the long-lasting winters do not ensure immunity against droughts'

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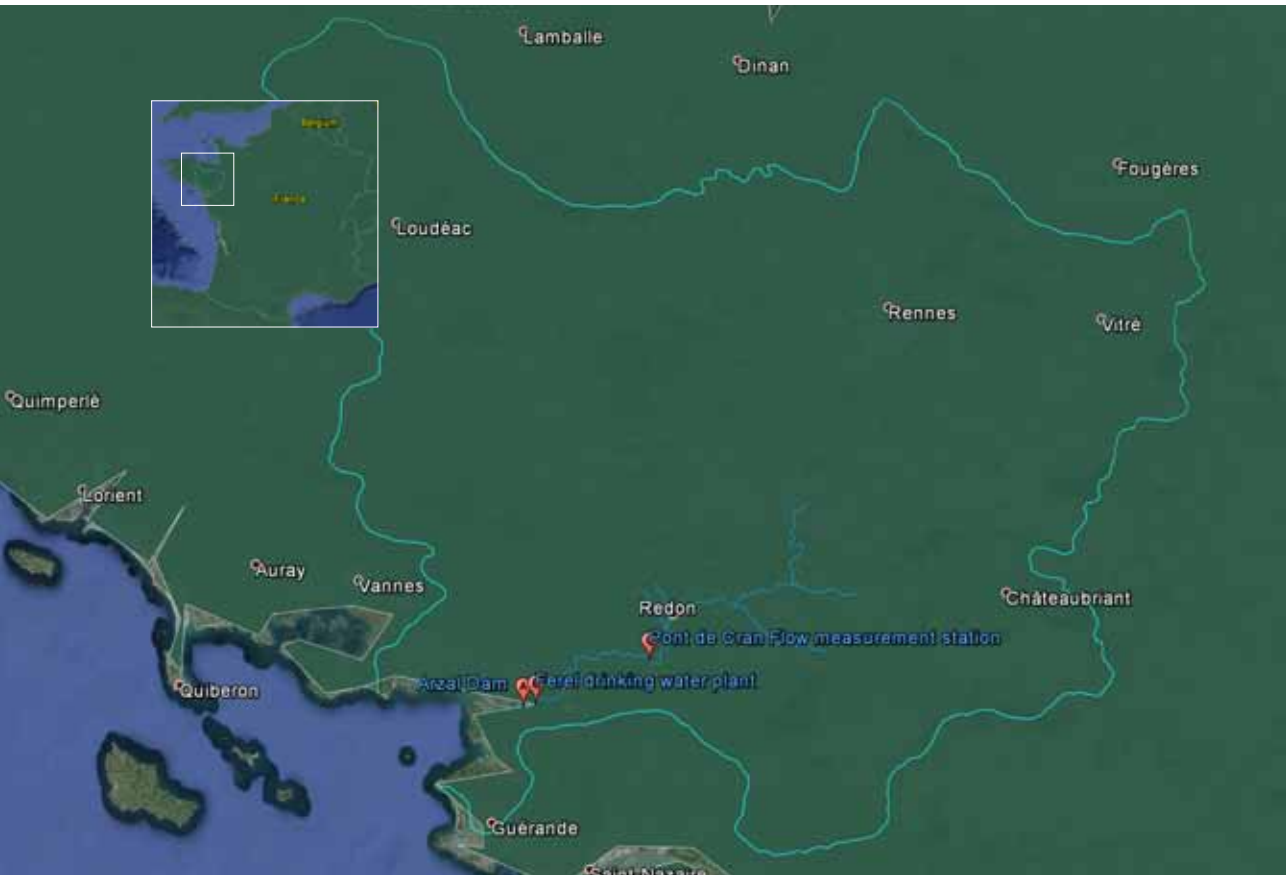

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Freshwater ›

Institution d'Aménagement de la Vilaine

# Region Brittany

## Challenge

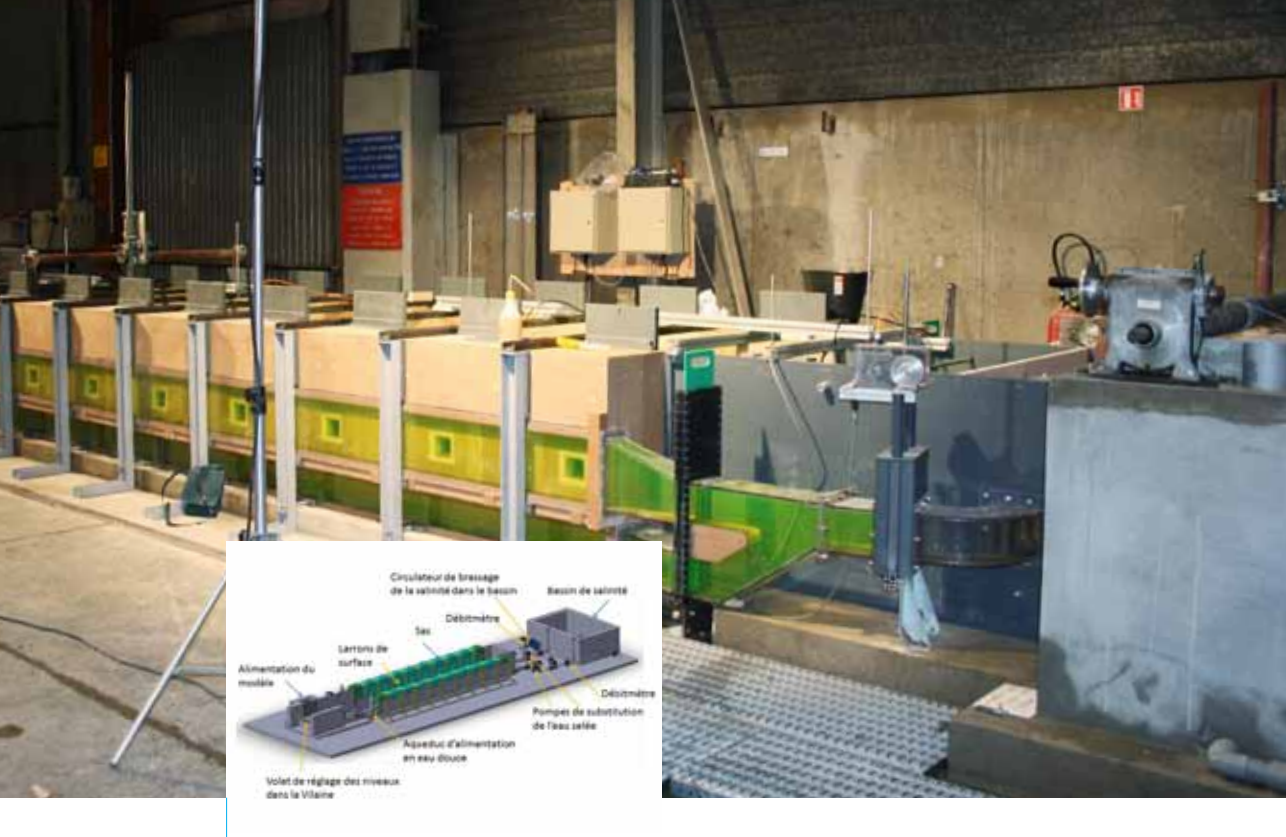
The challenge of this project is to ensure an adequate level in the reservoir for all uses to be possible, and at the same time to keep saltwater out of the reservoir as much as possible so as to preserve freshwater quality and guarantee drinking water supply.

# Pilot description

## Context

The Vilaine River basin has an area of approximately 10 000 km$^2$, which drains to the estuarine Arzal dam located just before the Atlantic Ocean in Brittany (France). Built in 1970, its original goal was to protect inlands (and especially the city of Redon) against flooding, by disconnecting the tide wave of the river flood wave. Nowadays, even if flood prevention remains one of the major issues, another very important purpose of the dam is the regulation of the fresh water reservoir (50 million m$^3$) controlled by the dam, mainly during low flow periods.

Regulation actions comprise the management of water levels and the protection against salt water intrusions. The drinking water plant, which collects water in the freshwater reservoir controlled by the Arzal dam, supplies nearly 1 000 000 people (local inhabitants and tourists) in summer. The challenge of the freshwater regulation in the Arzal dam lies mainly in the multi-purpose nature of the resource. It has a central role in providing water supply, but, also to agricultural activities and for recreational purposes, such as sailing and fishing. This can lead to severe conflicts among users, especially in drought periods and under risk of water scarcity.




The possibilities for development of a new lock, preventing salt water from penetrating into the fresh water reservoir, was studied. A scientific model has allowed to verify the technical data in this innovative project.

IAV, the institution which manages the Arzal dam, faces several challenges related to salt water intrusion and reservoir management during the low flow season (June to October), when both water quantity and water quality constraints apply on the management of the dam. Salt intrusions in the reservoir mainly occur when boats cross the lock of the dam. When water inflows tend to be the lowest (during the low flow season), touristic activities, including sailing, are generally at the highest (since it involves the summer period), and lead to a peak of salt water intrusions in the reservoir, which can affect fresh water quality. To prevent salt intrusions, siphons have been installed upstream of the dam to pump the contaminated water from the reservoir back to the sea. However, this system leads to huge losses of fresh water, which, during prolonged periods of droughts, may aggravate the problem of freshwater supply. Currently, the only solution to limit salt water intrusions and, consequently, pumping losses, is to make restrictions in the use of the lock in summer, the period when the traffic of boats is at its highest. This generates conflicts and has prompted IAV to the implementation of new solutions through this project. In the context of climate change, which may result in longer and more intense periods of low flows and droughts in the region, and aggravated conflicts, these new solutions will also contribute to the implementation of adaptation measures.

## Strategy and measures

The two principal strategic management objectives in the Arzal reservoir during low flow periods are:

1. to ensure an adequate level in the reservoir for all uses to be possible, and
2. to keep saltwater out of the reservoir as much as possible so as to preserve freshwater quality and guarantee drinking water supply.

Current and future challenges related to declining water quality and quantity push towards automated and integrated tools for improved drought management and efficient adaptation initiatives for the Arzal reservoir. IAV and the national research institute IRSTEA are working in close collaboration to take up these challenges, through two main actions: the implementation of a new lock, and the development of drought forecasting and risk management tools.

IAV has worked on developing an innovative lock on the dam that prevents salt water to intrude when boats pass the dam to and from the Atlantic Ocean. Significant efforts have been put into developing a physical model of the new lock. Currently, all preliminary studies are finished, model calibration is achieved and all simulations have been completed. The global cost of the project is estimated to be 20 million euros (based on preliminary studies). In parallel, IRSTEA has developed a tool that forecasts inflows to the reservoir during the low flow season and helps in anticipating critical situations for a better drought risk management. The tool incorporates information from a hydrological forecasting model into a graphical representation of the drought risk. The model transforms future possible weather scenarios over the Vilaine catchment into river inflows right upstream to the dam.

The graphical representation of the drought risk provides a visual assessment of the risk of being below given critical low-flow thresholds in the next weeks or months, both in terms of flow intensity and duration (i.e., mean flow and number of days below each critical threshold, respectively). This risk assessment visualisation tool aims to help the managers of the dam in deciding on whether or not to release water from the reservoir and on how to operate the corresponding dam components. It can be integrated into the various reservoir operations and management rules necessary to fulfil its multiple operational uses, connecting the utilities in a pre-operational framework.

'As soon as drought perceptions are raised, drought adaptation measures can rapidly be designed and implemented'

## Governance

In addition to managing the Arzal dam, IAV hosts the Local Water Committee, where water issues are discussed with all the stakeholders. This Committee defines the Vilaine river basin management plan, where measures are taken to prevent low flows in several tributaries. However, except for emergency measures, there is no global plan set up to manage drought vulnerabilities induced by climate change.

The overall current situation is of low drought risk perception, compared to a more significant flood risk perception. This is explained by a lack of drought risk awareness, due to the absence of critical drought events in the past years in the region, and the lack of a culture of drought forecasting and risk communication. However, it is expected that as soon as drought perceptions are raised, drought adaptation measures can rapidly be designed and implemented by the efficient, existing water governance for freshwater in the basin, which is supported by a dense stakeholder network driven by IAV.

## Facts

**Location**
Eifel, North Rhine Westphalia, Germany

**Project scale**
The catchment area is 662 km$^2$

**Implementer**
Waterboard Eifel-Rur

**In collaboration with**
District Government Cologne, drinking water producers, energy producers, national park Eifel, clubs

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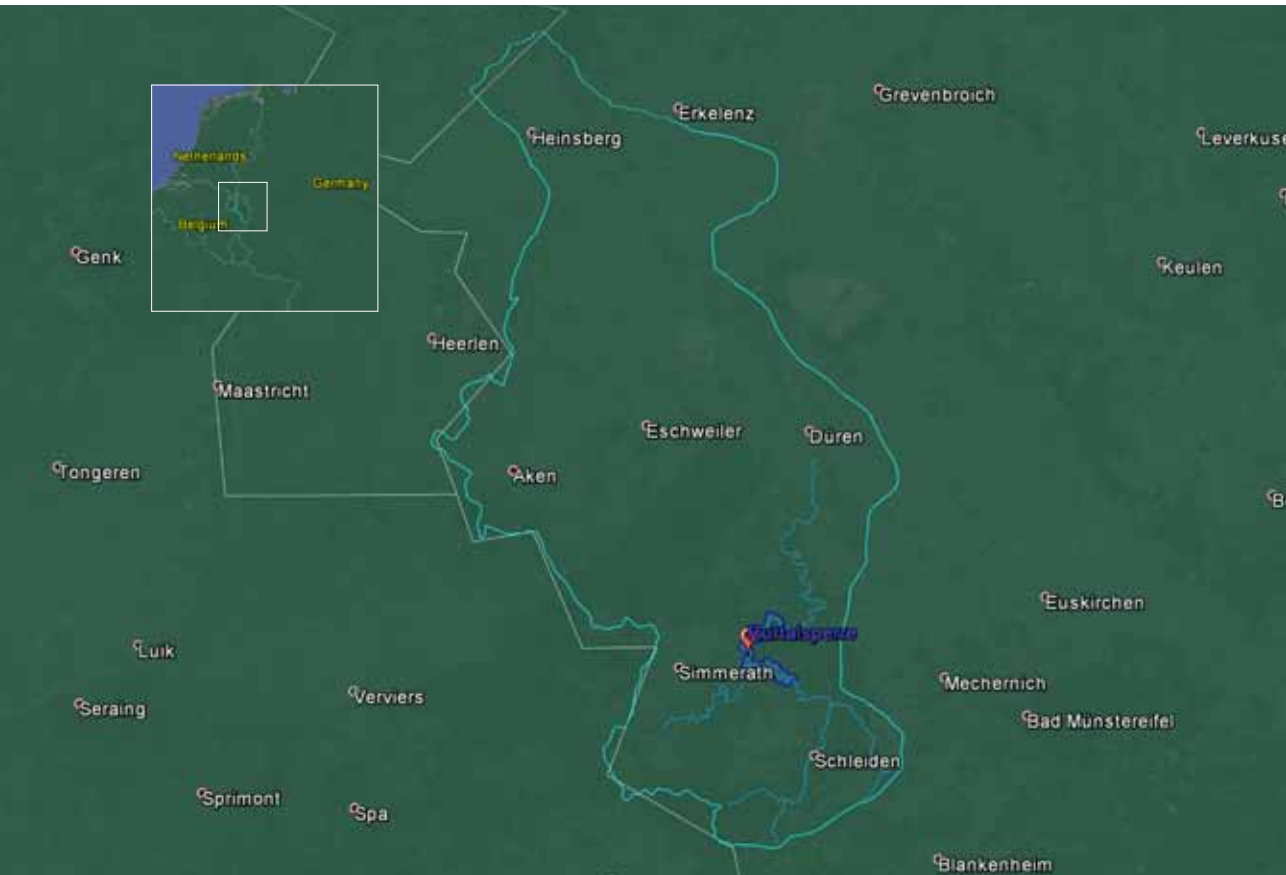
'Although our catchment area is in principle a water rich region, more attention is paid to drought'

EIFEL-RUR | GERMANY



Freshwater ›

Waterboard Eifel-Rur

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# Region Eifel-Rur

## Challenge

Recently, Eifel-Rur region has experienced somewhat dryer periods during the spring season. As a result, the water flow through the reservoirs decreases. Stillwater and falling water levels in reservoirs bear the risk of a decrease in water quality, which results in a higher amount of production work and possibly drinking water production problems. Climate change, which is expected to cause longer periods of drought, will make these problems more severe.

# Pilot description

## Context

The Waterboard Eifel-Rur has executed a project to improve water reservoir management. The project concerns a study about a large reservoir-system situated in the upper catchment of the Rur in the Eifel-hills, where six dams were built and are managed by the waterboard. The dams form an inter-connected system around the main reservoir 'Rurtalsperre', which is the largest in Germany.

The system has a total capacity of 300 million cubic meters. The main reason the system of reservoirs was built was to regulate the effects of flooding and to maintain the flow during dry seasons. This is still the main task for the management today. The system of dams also plays an important role as drinking water supply. Additionally, it is an attractive site for tourism thanks to its good water quality and its natural surroundings.

## Strategy and measures

The main aim of the pilot project is to prevent deterioration of the water quality in the water reservoir system. This is done by investigating possible changes of the inflow in the last decades. Based on the results obtained, the rules of the management plan for discharge downstream of the reservoir system are checked. The checking aims to bring new ideas for the adaptation of the management plan.

**Reservoir system Rurtalsperre**

The reservoir system in the northern Eifel has important different tasks, which do not always go in line with each other, but all of them have to be served. For example, sometimes a controlled high discharge out of the reservoir is needed in order to prevent flooding, but this can only be carried out to such an extent that there is still enough water in the reservoirs to produce drinking water and maintain the flow in dry periods.

Therefore, before adapting management plans to tackle the emerging problems, research was needed. The waterboard has analyzed the inflow patterns in the different dams. Based on these results, a study was carried out on the management system of the dams with respect to water quantity and quality. Suggestions for the adaptation of the management plan emerged: one of the best results obtained is to add a drought index in the management plan, which would help to prevent the release of too much discharge in an earlier stage compared to today's practice. This leads to a credit of water in dry periods. Aside from the work at the large reservoirs, a small project has been carried out at Uersfeld, where the water quality has been enhanced by segregating the stream from the retention reservoir.

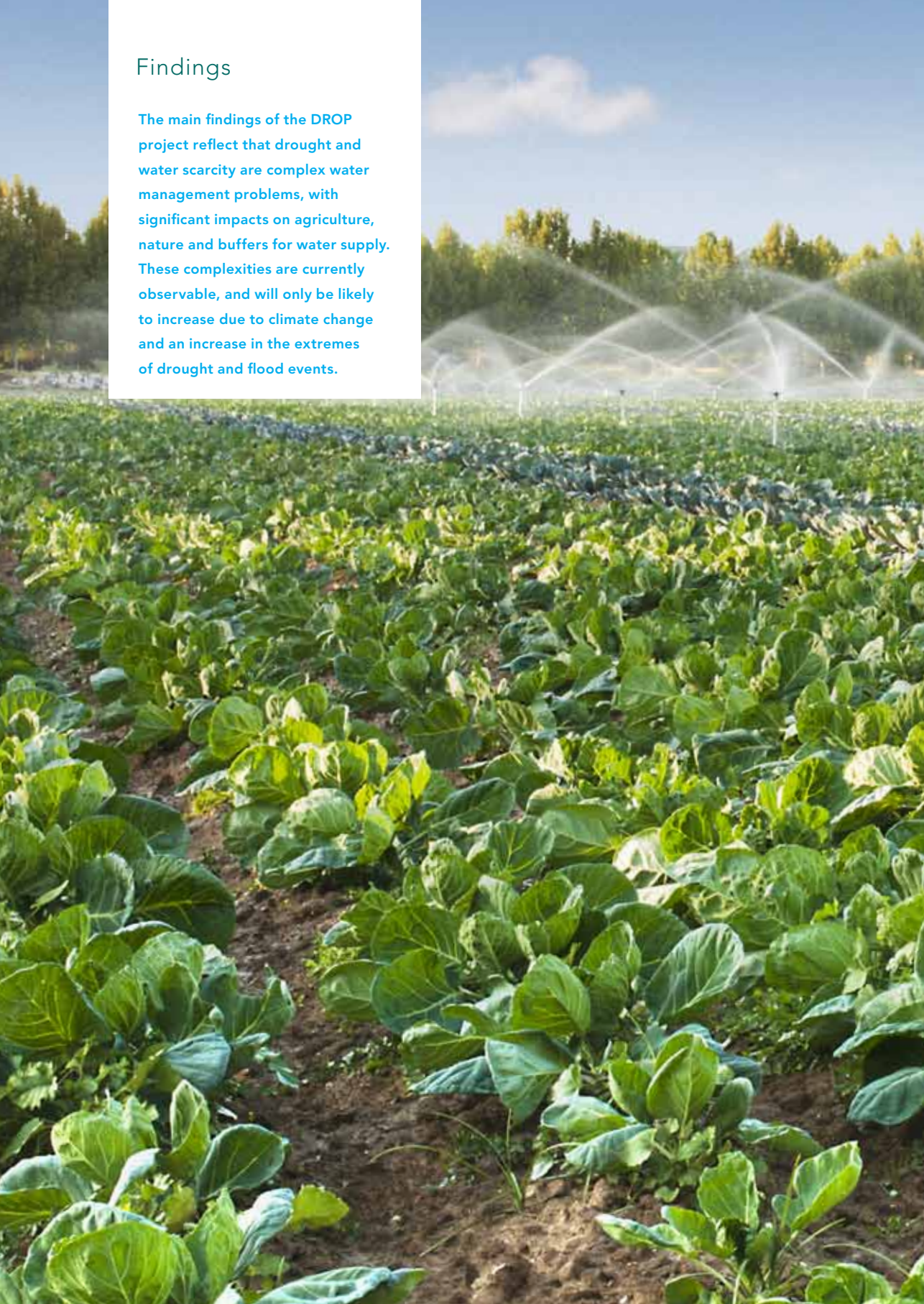
## Governance

The planning processes for nature and water in the Eifel-Rur region has a long tradition of collaborative approaches leading to voluntary implementation of actions. Since at least the early 1990s, this has been widespread in nature conservation, biodiversity protection, and water management. DROP research on governance for drought adaptation showed clearly the benefits of this approach in the region, as well as the bottlenecks currently being encountered in its use. Whereas actors agree that the approach delivers results, the lack of significant political drive behind some processes (e.g., the implementation of the European Water Framework Directive) means they have become entrenched. At stake in these discussions is less the implementation, but rather the requirement itself – i.e., where the goalposts are. Thus, the collaborative, somewhat hands-off approach used by authorities seems to reach its limits when questions being negotiated address key interests of stakeholders: security of water supply (and thus of economic production) and costs of measures.

'The Eifel-Rur region has a long tradition of collaborative approaches'

# Findings

**The main findings of the DROP project reflect that drought and water scarcity are complex water management problems, with significant impacts on agriculture, nature and buffers for water supply. These complexities are currently observable, and will only be likely to increase due to climate change and an increase in the extremes of drought and flood events.**



# Five needs for drought adaptation

## Five basic needs

A number of things contribute to the complexities of drought and water scarcity. First, there is the vague and tacit nature of the drought and water scarcity problem itself. Desiccation, for instance, is about the absence of water mostly in the capillaries of the system, the opposite of the overwhelming presence of flooding for many North-West Europe regions. Secondly and partly as a result of the first aspect, the absence of awareness of a range of climate change risks needs to be considered. For many water authorities in North-West Europe, the main focus of risk management lies in managing excesses of water, and not the shortages of water. To some extent, the same is true for many water users and local stakeholders, for whom flood awareness is more present than drought awareness. Thirdly, there are the (supposedly) opposing interests of flood prevention and drought and water shortage prevention, which, although acting on different levels and timeframes, may be reinforced given a general lack of integrated flood and drought risk management across the European water sector.

'A number of things contribute to the complexities of drought and water scarcity'

In the pilots of the DROP project, partners have experimented with several kinds of drought adaptation strategies and measures. They had to face specific challenges and, together, had the opportunity to exchange on the pros and cons of such adaptation 'solutions'. We have captured the experiences from these pilots in five basic needs for dealing with the complexity of adaptation to drought and water shortages, in the context of climate change and increased extreme events.

## The need for insight and data processing

The first need is for more joined up understandings of the problem of drought and water shortage. This includes better knowledge on the natural processes governing droughts, on the relation between groundwater and surface water systems, on the interactions between weather and climate variables and land-surface processes, and the impact of climate change on the supply-demand balance. This is specifically needed during dry summer periods to improve the modelling of interdependencies and to reliably predict the effect of current risk management rules and future drought adaptation measures. Due to extensive measurement programmes, data is often available on climatologic variables, river discharges,


First meeting and the symbolic start of DROP.

soil moisture or groundwater levels. However, this data needs to be translated into information (understanding relationships), into knowledge (understanding patterns) and finally into insight (understanding principles) to inform supply-side indicators with changes to demand side needs in periods of extremes. The web portal of VMM is a fine example of translating data processing into information (i.e., drought indicators) and making it available to water managers, farmers, and other stakeholders. Other actions on hydrological modelling, risk visualisation tools and probability analyses were also part of the DROP project, contributing to increased knowledge and insight on droughts for practical operations in NEW Europe. Increased investment needs to be made in understandings the potential changes that will occur to user demand under different climate conditions – that is householders, industry, business, farmers – and how adaptations can occur at these different levels of 'user' while still balancing the needs of nature for example, through minimum environmental flows.

## The need for engagement and awareness

The second need is for creating engagement and awareness on drought and water shortage across North-West Europe. Actions can be more efficiently implemented if stakeholders, decision-makers and the public are aware of the consequences severe drought may engender, if they acquire knowledge on the recent research achievements in physical and social sciences, and if they are engaged in the implementation of new solutions for water shortage management and drought adaptation. All actors benefit from a more transparent, engaged and trans-disciplinary approach (i.e., including multiple disciplines to define new approaches to problems that transcend disciplinary silos.) The pilots in Brittany and Eifel-Rur have shown that, even in areas with abundant rainfall, drought adaptation strategies are getting more and more important for water supply managers due to climate change affecting precipitation patterns.

The DROP project, in itself, and the regional projects, more specifically, were able to successfully raise attention to the issues of drought and water scarcity, by approaching actors at different levels: from raising awareness amongst personnel in the pilot organisations; to transboundary collaboration between water authorities and regional stakeholders across the six regions; governance team visits and discussions with a range of stakeholders from local to regional in each of the six catchments; and regional, national and international dissemination.

## The need for tailored action

Awareness-raising is especially of significant importance in regions where drought and, more generally, impact of climate change on water management is not considered an issue in societal, political and economic networks. This is however only a first step to action. Even in regions where drought awareness is raised concrete and tailored adaptation actions need to follow. This should involve setting up specific actions that respond to the concerns and needs of climate change and drought/water scarcity impacts within the specific region. Regional tailoring is important, as the adaptation actions that work well in one region will not necessarily work well somewhere else. One of the rationalisations for the need for regional tailoring is obviously the regional variability in climate impacts – which influences the experience of previous droughts. However, equally importantly regional tailoring is needed due to the variability in processes of governance across regions and nations. The governance processes that underpin water management vary significantly across regional and national boundaries in Europe in terms of whether water management is privatised or not, the level at which water management is organised (local government versus catchment boundaries), the degree to which public and stakeholders are involved in processes of water management, and whether there is a history of adapting to drought and water scarcity (and therefore existing measures to build upon) or whether the measures are being implemented from scratch.

For instance, in Brittany, talking about climate change itself revealed to be not the best way to draw more attention to drought and water shortage challenges. Climate change is not seen as a real problem, whereas water supply quality and water sharing among different, and sometimes concurrent, uses do receive attention, although mostly through the issue of low flows. Another example is Somerset, where even though a period of drought had preceded it, the significant flooding in the 2013-2014 winter season showed that talking about drought measures can be very difficult in the context of experiences of the devastation of the other side of water management extremes. Drought awareness raising and the implementation of tailored action for drought adaptation can thus be more challenging in some contexts and will include more than 'simple' arguing and convincing; it will require a very subtle and connected way of dealing with water issues in general.

'Drought awareness will require a very subtle and connected way of dealing with water issues in general'

## The need for an integrated approach

That leads to the fourth need we discerned clearly in the DROP project. Addressing the challenges of drought and water shortage requires an integrated approach to water and risk management. With an integrated approach we mean seeking smart combinations for discussing and problem-solving water shortage and water flooding within the same frameworks of water management. The flooding in Somerset showed that even though water scarcity and flooding are 'two sides of the same coin', and there is need for integrated water management, there is a risk that developments on one side of the coin – such as flood policy in reactions to climate extremes – could be maladaptive for the other side of the climate adaptation coin – drought policy. This integration proceeds beyond the connection between scarcity and excess of water.

The entire spatial context has to be integrated with water management that deals with both flooding and drought in order to favour the implementation of truly effective and climate-resilient strategies for the future.

## The need for multi-level strategy and action

At the macro level, people such as scientists, policy makers, the media or environment/water managers produce, reproduce and communicate particular discourses (big themes and big picture stories), through generic models, abstract theories and general policy on drought and water scarcity.
At the micro level, people such as farmers, water authority workers, and NGOs volunteers have experiences, tell stories of experience, take concrete actions and share opinions across farm fences or kitchen tables.

To move forward on the adaptation and resilience to drought and water scarcity across NWE we need to ensure that the macro level discourses and regional/national/international policies, reflect and are supported by the micro level stories and actions of people 'doing' water management on the ground.

In the 6 DROP pilot regions, partners have worked on a variety of measures and at a variety of scales (from field level to regional level to scientific discourse levels) to cope better with drought and water scarcity. Some measures involved the (re)construction of the physical water management system on-farm to influence landscape scale water management (Twente, Somerset, Salland); others addressed management plans (Eifel-Rur); and others still developed scientific knowledge, tool selection, model building, and communication of scientific risks (Flanders, Brittany).

Working across micro-meso-macro scales, the DROP partners have put in evidence that there is no such thing as 'the right level for drought adaptation'. Rather, drought has to be tackled at a large variety of levels and scales simultaneously. While a regional scientific overview say of climate risks will dictate which level or scale is the most important to make physical changes to the water management system, the local and regional governance conditions (including 'buy in' from stakeholders that drought and water scarcity is an issue worth addressing, or that it is a 'no cost' solution when implementing other adaptation measures for flood) will dictate at what level engagement can and should occur to enhance the socio-economic-political preparedness for drought and water scarcity under current and future climate for a region.

# Pilot Agriculture

- Testing of a level-dependent drainage system near a nature conservation area (NL)
- Realization of two new structures: a weir and a double-acting pumping station (NL)
- Design of an steering mechanism for management of the double-acting water system, in order to respond quick and effective to changing weather circumstances (NL)
- Research and measures for reducing surface run-off (NL)
- Development of modeling tools on the impact of drought on water system and agricultural production (B)
- Dissemination of data by www.waterinfo.be (B)
- Trialling different types of cover crop to help build organic matter (UK)
- Set up of models to estimate the impact of drought on water availability and crop production (Soil and Water Assessment Tool and Soil - Water - Atmosphere - Plant model) (B)
- Creation of a platform to stimulate cooperation between governmental agencies and local organizations involved in water management and agriculture (B)
- Development of a tool that provides to forecast inflows to the reservoir during the low flow season and helps in anticipating critical situations for a better drought risk management in the river basin (F)

This handbook contains separate chapters for Nature, Agriculture and Freshwater. That may suggest that these themes can be regarded in isolation from each other. Nothing could be less true. In fact, the three themes are closely interrelated when it comes to dealing with drought and water scarcity. This figure, with three overlapping circles, illustrates the interrelations between the three pilots. The DROP researches and measures in the circles show that most research and measures influence more than just Nature, Agriculture or Freshwater.


Pilot Nature
• Testing of a level-dependent drainage system near a nature conservation area (NL)
• Research and measures for reducing surface run-off (NL)
• Modelling and technology transfer in the Upper Parrett catchment on irrigation scheduling and water application management (UK)
• Restructuring and restoring streams and brooks at various locations (NL)
• Improvements of the drought resilience of raised peat bog (UK)
• Identification of pinch points in the water system on nature reserves, to plan and implement work to improve the flow of water (UK)
• Analysis of the inflow patterns in the different dams and a study on the management system of the dams with respect to water quantity and quality (D)
• Development of an innovative lock on the dam that prevents salt water to intrude when boats pass the dam (F)
Pilot Freshwater
• Development of a physical model of the new lock (calibration, simulations) (F)

# Colophon

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Waterschap Vechtstromen

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IRSTEA
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Vlaamse Milieumaatschappij
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Somerset County Council
The University of Manchester

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