

# SciencesPo

URBAN SCHOOL

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## REINVENTING THE RELATIONSHIP BETWEEN WATER AND CITIES

PROPOSALS FOR  
ADDRESSING CLIMATE  
AND WATER-RELATED  
CHALLENGES

Picture: Creative Commons

TRANSFORMING TERRITORIES • LESSONS FROM THE LAB





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# ABOUT THE COLLECTION

The “Lessons from the Lab” collection aims to fuel public debate on major contemporary territorial and urban issues, drawing on the results of collective projects carried out by students at the Sciences Po Urban School. Some forty collective projects are carried out within the Urban School each academic year, with as many institutional, public, private and associative partners. This is the result of intensive work by nearly 200 students in their first year of master’s as well as the Executive Master’s program in Territorial Governance and Urban Development. They are accompanied throughout the year by a tutor who is an expert in the subject concerned. It is a comparative and forward-looking work on various territorial issues, covering French, European and international fields, from metropolises to small and medium-sized towns. The question of transitions, and first and foremost, the ecological transition, occupies a central place. Our partners have chosen to draw on the reflections of the younger generation of urban governance professionals to better understand the issues at stake in a context of uncertainty and to identify possible responses to these numerous and sometimes contradictory challenges. We believe that dialogue, organised and fueled by field surveys conducted using robust social science methods, is the only way to move forward collectively.

This collection is intended to inform professionals. Each issue is a transversal synthesis of the main lessons learned from several collective projects carried out in the Urban School master’s programs on a given theme. The collection is part of the TIERED\* project (Transforming Interdisciplinary Education and Research for Evolving Democracies), a strategic institutional project for Sciences Po that aims to address the challenges facing democratic systems amid significant environmental and digital transformations. To this end, the project launches a new phase in developing research, education and disseminating knowledge on these two themes. The results of collective projects by Sciences Po students are part of this dynamic, supported by TIERED through this collection.

This synthesis contains information exclusively from the collective projects of the Urban school students, which you can consult in the "Sources" section. ■

*\* TIERED is funded by a French government grant managed by the National Research Agency as part of the France 2030 programme, under reference ANR-22-EXES-014.*

# PRESENTATION OF GROUP PROJECTS

## DEVELOPING FLOOD-PRONE URBAN AREAS IN THE MEDITERRANEAN

### Masters in Urban Planning, 2025

**Students:** Yuria CHIBA, Ulysse DUHAYON, Achille MOURRAIN, Virgile HAËCK, Manon PHILIP

**Partner:** Altémed

**Tutor:** Bruno MORLEO, Mission Director - Operational and sustainable development (Ville en Œuvre, SCET Group)

In response to the questions raised by the development of flood-prone areas, this study, conducted in the Montpellier Sud sector, calls for the creation of new frameworks for urban transformation. The students propose to engage in new collective and imaginary narratives of settlement in the area, developing a multidisciplinary and more resilient approach to risk.



## FRESHWATER MANAGEMENT IN THE MEDITERRANEAN

### Masters Governing Ecological Transition in Cities, 2024

**Students:** Maëlle ROUX, Alice TORT, Salomé LENZ, Ginevra FIGINI

**Partner:** FNAU (National Federation of Urban Planning Agencies)

**Tutor:** Joffrey LAPILUS, Project Officer at the UNESCO Intergovernmental Hydrological Programme, for SDG 6 "Capacity Development Initiative"

Faced with the growing challenges of urban freshwater management, what can we learn from Mediterranean cities in terms of urban planning, development and governance? By proposing a comparative approach between several Mediterranean cities (in Spain, Italy, France, and Morocco), the objective is to develop appropriate, replicable, and sustainable solutions that urban planning agencies can adopt.



## A NORTH-SOUTH COMPARISON OF NATURE- BASED SOLUTIONS FOR URBAN WATER MANAGEMENT: EXPERIENCES FROM MEXICO CITY, CAPE TOWN, AND PARIS

### Masters Governing the Large Metropolis, 2025

**Students:** Ebou CEESAY, Maxwell GARCIA, Maxwell KILMAN, Sallyrose SAVAGE

**Partner:** Nature and the City, supported by the Gérard B. Lambert Foundation with the participation of Sciences Po's Maison des Arts et de la Création

**Tutor:** Joffrey LAPILUS, Project Officer at the UNESCO Intergovernmental Hydrological Programme, for SDG 6 "Capacity Development Initiative"

This project provides critical data and policy guidance for urban water management through a comprehensive comparative analysis of nature-based solutions (NBS) in Paris, Cape Town and Mexico City. As cities around the world face increasingly significant water-related challenges, this research aims to bridge the gap between successful NBS pilot projects and their systematic large-scale implementation.



Gérard B. Lambert Foundation

## SUSTAINABLE RAINWATER MANAGEMENT IN URBAN PLANNING

### Masters Governing Ecological transition in Cities, 2025

**Students:** Itri AGUENAOU, Dario BELLENOUE, Kieran BYRNE, María Alejandra NARANJO, Manon RIOU

**Partner:** Nexity

**Tutor:** Christian PIEL, urban planner and hydrologist, director of Urban Water

Runoff water management is a significant challenge in preventing flood risks and preserving water resources. Integrated Stormwater Management (ISWM) reduces the impact of cities on the water cycle by promoting temporary retention of rainwater on the plot and its evacuation through infiltration. Nexity wanted to have the right tools to provide local authorities with the best possible support in implementing ISWM. This project is intended as a support guide, easily accessible to non-specialists, summarising visits, interviews, testimonials, observations and analyses carried out by students.



# PRESENTATION OF GROUP PROJECTS

## **COST-BENEFIT ANALYSIS OF BUILDINGS' ADAPTATION TO FLOOD RISK**

**Masters Governing Ecological transition in Cities, 2025**

**Students:** Chiara ANDREAZZA, Iris AUBE, Jonathan MOTTE, Clémence PAUTRAT, Léon RUBE

**Partner:** Observatoire de l'Immobilier Durable (OID)

**Tutor :** Pauline Gleizes, Head of Office at the Sub-Prefecture of Étampes (91)

In response to the increase in large-scale flooding in France and Europe, the OID and five students from the Urban School have collaborated to create a new tool that assesses the costs of flood damage to residential buildings and proposes possible adaptation measures: the Inond'Act model. This model performs a cost-benefit analysis of different building adaptation scenarios and suggests the most cost-effective one to the user.



## **WATER AS A PROJECT BASIS IN SEINE- SAINT-DENIS**

**Masters in Urban Planning, 2024**

**Students:** Lola BASKA, Émilie CAI, Zoé GRYSPEERT, Élise MARTINOT

**Partner:** Water and Sanitation Department (Direction de l'eau et de l'assainissement) of the Seine-Saint-Denis

**Tutor:** Grégoire Deberdt, HMONP architect and urban planner

This collective project is part of a growing awareness concerning the vulnerability of territories to climate change, as illustrated by the manifesto "*La Seine-Saint-Denis territoire d'eau*" (Seine-Saint-Denis, a territory of water), published by the Department of Seine-Saint-Denis in April 2024. The project aimed to explore one of the manifesto's key development themes in greater depth, namely the consideration of water as the foundation for projects in Seine-Saint-Denis. The final output of this project, the "*Révéléateur*" (Revealer), is a graphic tool that highlights the hydrological potential of a wider area, enabling its nuances to be understood when developing new projects. As part of a city-building initiative, the Revealer aims to support development stakeholders in making water a primary concern in their practice.



# THANKS TO OUR TUTORS

## JOFFREY LAPILUS

is Project Officer at the UNESCO Intergovernmental Hydrological Programme, where he coordinates the capacity building initiative for UN SDG 6; a country-focused, inter-agency initiative aimed at accelerating action on this SDG (Ensure access to water and sustainable management and sanitation of water resources for all) through institutional and individual capacity building.

Joffrey previously served as Advocacy Lead at the French Water Partnership where he focused on water and climate change as well as global water governance. He holds a Master's degree in Environmental Policy from Sciences Po Paris School of International Affairs.



## CHRISTIAN PIEL,

an urban planner and hydrologist with 30 years of experience, is the founder and director of the Urbanwater design office in Paris. He works in areas where water and cities intersect, in France and abroad, focusing on both resource conservation and flood prevention. A geographer by training, he favours nature-based solutions with a view to adapting to climate change. He also teaches at Sciences Po Urban School, the Ecole des Ingénieurs de la Ville de Paris and several national architecture schools.



## GREGOIRE DEBERDT

is an architect who graduated from ENSA Versailles and Sciences Po Urban School. His practice combines architectural project management, territorial analysis and strategy studies, and research-creation residencies. He is now partnered with Helena Hiriart, with whom he formed ADÉLAÏDE, an

urban planning, pre-operational architecture and research firm founded in 2023. After teaching spatial representation at ENSA Clermont-Ferrand, he joined ENSA Paris-Est in 2019 when the Fragments master's programme (directed by Ido Avissar) was created, working in project workshops and research seminars.

Since 2022, Grégoire Deberdt has also been involved in the Master's programme in Urban Planning at Sciences Po Paris, supervising group projects and mapping workshops.

## PAULINE GLEIZES

holds a double Master's degree from Sciences Po Urban School and the London School of Economics (LSE). She is currently Head of Office at the Sub-Prefecture of Étampes (91). She is responsible for supporting around a hundred local authorities in the area of regional development: sustainable land use planning and urban planning, renovation of built heritage,



mobility, environmental transition, agriculture, economic development and employment, education, public health policies, sports, culture and heritage, tourism, and digital transition. She provides engineering support to rural communities, small towns and urban centres.

Prior to this role, she was responsible for steering local public policies aimed at improving housing quality in the urban community: energy renovation, building safety and the elimination of substandard housing.



**BRUNO MORLEO** A versatile urban planner with a Master's degree in Urban Engineering from Gustave Eiffel University, Bruno has developed a multi-stakeholder understanding of urban development through his work in design offices, local authorities and development companies. He strives to reconcile environmental issues with new operational solutions, seeking to move beyond the evaluation model guided solely by short-term financial logic, always in the public interest.

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# INTRODUCTION

Water crises are deeply **systemic**. This issue, therefore, takes a cross-cutting approach rather than focusing on a specific sector of intervention to understand water comprehensively. From Montpellier to Cape Town, the same issues arise: the vulnerability of the resource and the weight of sectoral governance. Hence, there is a need for tools that enable development stakeholders to understand the **water system as a whole**. Considering all its dimensions paves the way for the creation of multifunctional spaces that can contribute to urban regeneration. Training professionals and residents, who are the primary users of these spaces, thus becomes essential, as water management is, above all, a **democratic** issue. ■



Xochimilco, Mexico City, Credits : Maxwell Garcia, 2025





Valencia (Spain) after the October 2024 flooding. Credits: students from the Urban Planning Master's degree (project with Altémed), 2025

The background is a solid red color. On the left side, there is a large, abstract graphic consisting of multiple concentric, semi-circular arcs. The arcs are colored in alternating shades of red and white, creating a sense of depth and movement. The arcs are most prominent in the upper left and lower right quadrants, framing the central text area.

# Part 1

## CONTEXT AND CHALLENGES

Before offering concrete solutions, the six selected projects present the stakes associated to water, the evolution of the relationship to this resource and the existing framework to tackle challenges. Cities are considered as the privileged scale of action, and Mediterranean cities offer examples of initiatives.

# CHALLENGES EXACERBATED BY CLIMATE CHANGE AND SOIL SEALING

Cities around the world are facing **growing water-related challenges, exacerbated by climate change**, which threaten urban resilience. While some face prolonged droughts, others suffer devastating floods, and many must manage both extremes. Most of the risks to which French territories are exposed are linked to **disruptions in the water cycle**, exacerbated by climate change

## RISK: BETWEEN HAZARD, EXPOSURE AND VULNERABILITY

Risk is the probability of damage occurring, taking into account the interactions between damage factors (hazards) and vulnerability factors (population, distribution of assets) (*Géococonfluences*). Risk, therefore, characterises the **encounter between a hazard and vulnerabilities**, which are the presence of assets, populations, flows, and activities. Natural risks, linked to natural processes, are likely to be amplified by the impacts of climate change.

There are **several types of risk**: hazard, exposure, and vulnerability. Hazards refer to immediate events such as drought or flooding (e.g., if a city faces a water shortage). Exposure is the presence and potential of a population or ecosystem to be affected by drought or flooding (e.g., if a group of individuals migrates to a flood-prone area, they are exposed to flooding).

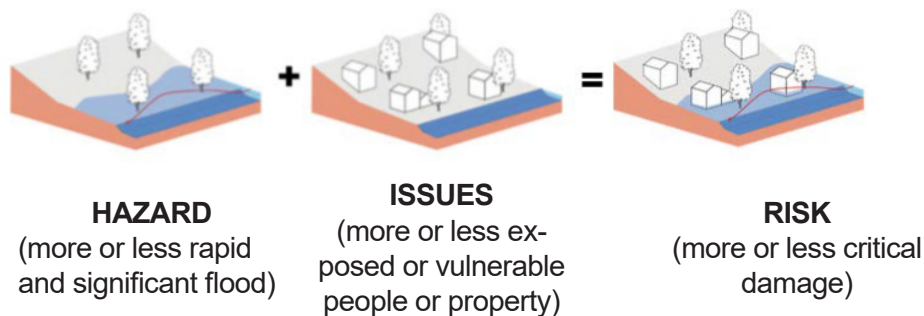
Finally, vulnerability is a broader term used to describe a group's predisposition to greater exposure due to its functioning and social processes (Vigerstol et al., 2023).

## FLOODING

Floods can be of **various types**, differentiated by geomorphologist Johnny Douvinet<sup>1</sup>, whom the students of the collective project with Altémed met:

- Flooding caused by the overflowing of large rivers and waterways, where the speed of rise and fall is slow, as in the case of the Loire, Garonne, or Seine rivers.
- Rapid-kinetic floods, which are almost torrential in nature, with water levels rising within a few hours. These are found mainly in the south of France and in very small catchment areas in the north of France.
- Flooding caused by runoff, which sometimes occurs in urban areas without a nearby watercourse, due to the saturation and overflowing of the drainage system.
- Torrential floods, which occur mainly in mountainous areas with steep watersheds. In the south of France, flooding is significant, with flow rates sometimes reaching 1.5 m/s or even 6 m/s.
- Flooding caused by rising groundwater levels, which is more common in northern France, grows very slowly, but once the water table is saturated, it takes several weeks for the water to recede.

1. Teacher at Avignon University and research associate at the Géophen and GReD laboratories. His research focuses on alertness and natural risks management.



The increase in flooding may be linked to **urbanisation, deforestation, and certain agricultural practices** that limit water infiltration and create more runoff. This creates other problems, as floodwater can be contaminated by pollution from various sources. Flooding, therefore, also has long-term effects, such as a decline in drinking water quality.

**Climate change amplifies the frequency and severity of floods** by increasing rainfall amounts and intensities during wet events. It also affects wind behaviour and trajectories, and therefore how storms form, evolve, and move, as well as condensation rates, which release heat and can intensify rainfall. Thus, the nature of precipitation, i.e., its frequency, duration, and intensity, will continue to change as the climate warms. It is important to note, however, that heavier rainfall does not necessarily mean more flooding, as this also depends on other factors such as the type of river basin, the surface landscape, the extent and duration of the rainfall, and the degree of soil moisture before the rainfall event (IPCC, 2021).

Flooding is the **leading natural hazard** in terms of the severity of damage, the number of municipalities affected, and the proportion of the population affected. Globally, more than 1.6 billion people are affected by flooding, including 250 million directly. This number is likely to increase as residential areas expand into flood-prone areas.

Flooding is a **complex phenomenon** that involves climate, culture, and regulations, and it would be simplistic to address it solely from a safety or utility perspective. Indeed, the case studies enabled the students to realise that material damage was only part of the consequences of flooding. The case study conducted in Nord-Pas-de-Calais (in Saint-Omer, Arques and Blendecques) in March 2025 by students participating in the collective project with the OID was particularly striking in this regard: in Arques, the price of properties exposed to flooding had fallen, while others were advertised as "unaffected by the floods in 2023-2024", giving them a competitive advantage on the property market. Non-economic costs, such as the **psychological trauma** suffered by residents, must also be considered.

## DROUGHT

Drought refers to "periods characterised by **below-average moisture conditions**, generally over large areas, where limited access to water causes hydrological imbalance and negative consequences for natural systems" (Vigerstol et al., 2023, p.15). Drought can be caused by

a lack of rainfall, insufficient soil moisture, or anomalies in surface water levels (Vigerstol et al., 2023).

Water levels and drought are **strongly influenced by climate change and human activities** related to soil and water management. According to the United Nations Convention to Combat Desertification (2023), changes in the hydrological cycle have led to droughts that affect more than 1.84 billion people worldwide, 85% of whom live in low- and middle-income countries. Droughts have many consequences, including reduced agricultural yields, declining water resources, and increased vulnerability to heat waves, which can lead to loss of life. ■



House in Arques (Nord-Pas-de-Calais) during the 2023-2024 flooding. Picture generously given by the landlord.

# THE CHANGING RELATIONSHIP BETWEEN CITIES AND WATER : FROM RISK TO BE ELIMINATED TO A RESOURCE TO BE PRESERVED

## WATER IN THE COLLECTIVE IMAGINATION

From early mythological tales to pictorial representations and modern scientific approaches, water has fuelled contrasting imaginations. Sometimes a source of fertility and prosperity, sometimes a sign of destruction and divine punishment, these representations reflect an **ambivalent relationship between humans and water**.

From the 18th century onwards, technological and scientific progress offered new ways to control natural processes or, failing that, to better protect ourselves from them. From the 19th to the 20th century, the era of major national land development projects began: drainage, canalisation, damming, land reclamation, and sanitation profoundly transformed landscapes and water management. Today, in the Western world, flood and river management is based on a rational approach, detached from religious and emotional considerations.



"The world destroyed by water", illustration for The Holy Bible, Gustave Doré, circa 1880.

However, the influence of flood myths in literature and the arts can still be felt in our **personal representations of disaster**.

These historical accounts, therefore, retain real value, not as scientific descriptions but as a collective heritage to be cultivated and passed on to foster a culture of risk.

## URBAN SANITATION AND SOIL SEALING

Although wastewater and rainwater drainage systems have existed since Neolithic times, it was particularly in the 19th century that water came to be seen as a threat to cities, with the **establishment of modern drainage networks** driven by hygienist thinking and the discovery of the microbial origin of contagious diseases. For example, English doctors established a correlation between soil drainage and reduced mortality from consumption (Euzen et al. 2015)<sup>2</sup>. As a result, two complementary measures were implemented: soil drainage and urban water drainage (sewerage).<sup>3</sup>

The **transfer of water risk management responsibilities** from local communities to state bodies, along with the complex mechanics of water management systems, led the inhabitants of a territory to become less involved in understanding the natural systems around them. This management stems from excessive confidence in modernity and in human ability to predict and cover all natural hazards, leading to a **"security illusion"** (Dourlens, 2004)<sup>4</sup>. This has led to numerous developments which, rather than reducing risks, have increased them; for example, confidence in these structures has led many local decision-makers to authorise the urbanisation of floodplains.

The corollary of urban drainage is soil sealing, which is different from artificialisation. **Soil sealing** refers to the "permanent covering of the soil with an impermeable material. It irreversibly alters most soil functions, particularly those related to water flow regulation" (Scientific Interest Group on Soil - Groupement d'intérêt scientifique Sol). **Artificialisation** is a "change in the effective state of an agricultural, forest or natural area to artificial areas, i.e., urban fabric, industrial and commercial areas, transport infrastructure and its dependencies, open-cast mines and quarries, landfills and construction sites, urban green spaces, and sports and leisure facilities, including golf courses.

2. EUZEN, Agathe, JEANDEL, Catherine, MOSSERI, Rémy (dir.), L'eau à découvert. CNRS Éditions, Paris, 2015, 365 p.

3. IMBEAUX, Edouard. L'alimentation en eau et l'assainissement des villes. Paris, Bernard et Cie, 1902, 960 p.

4. DOURLENS, Christine, BOURRELIÉ, Paul-Henry, POTTIER, Nathalie, et al. La question des inondations au prisme des sciences sociales : un panorama de la recherche publique. 2001PLUS, 2004, n°63, 53 p.

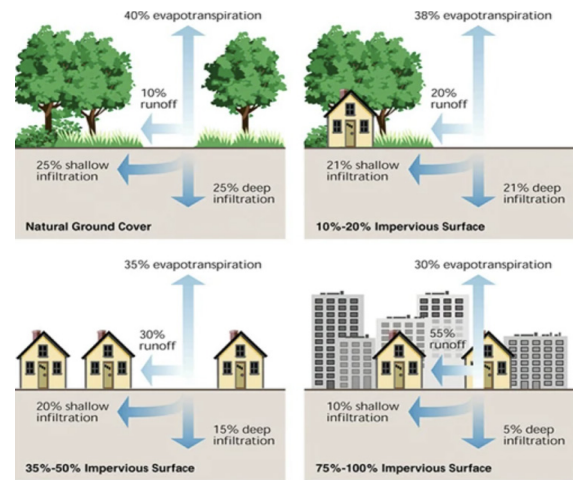
Areas undergoing artificialisation are no longer available for uses such as agriculture, forestry, or natural habitats" (Observatoire des espaces naturels, agricoles et forestiers). Artificialisation can be broken down into several levels of intensity, from impermeable surfaces to permeable open ground, so artificialisation does not necessarily mean soil sealing.

To enable soils to fulfil their biological and hydrological functions as effectively as possible, it is necessary to limit impermeabilisation in development projects (Resource Centre for Adaptation to Climate Change, 2022)<sup>5</sup>. Soil sealing significantly impacts the volume of water that infiltrates the soil and has multiple consequences for soil health and biodiversity, as well as for the quality of the water that flows and is stored there. In natural soil, 50% of precipitation usually infiltrates, half of which remains in the top 20 centimetres of soil, and the other half infiltrates into underground drinking water reservoirs (groundwater). Of the 50% of rainwater that remains on the surface, 10% runs off into a watercourse or natural basin, and 40% is returned to the atmosphere through evapotranspiration. The more impermeable the soil, the more these dynamics are altered: in highly impermeable areas, infiltrating rainwater accounts for only 15% of precipitation, and runoff increases from 10% to 55%. This phenomenon is causing **increasingly frequent urban flooding**.

### THE LIMITATIONS OF THE "ALL-PIPE" APPROACH

Managing rainwater as a risk through the installation of a piping system designed to contain it represents a form of "maladaptation" <sup>6</sup>, as it allows for the expansion of soil sealing and retroactively reinforces runoff phenomena. In addition to the risks of saturation of the limited capacity network and overflow onto public roads, this has numerous consequences for the natural water cycle, soil health, groundwater quality, and rainwater pollution. Combined with high levels of soil sealing in urban areas and the low proportion of permeable soil, urbanisation increases runoff and exacerbates sewer system congestion. **Overflows** are therefore becoming increasingly common, amplifying the recurrence of flooding.

Although rainwater is perceived as clean when it falls, it is quickly **assimilated into wastewater** due to its contact with the city's soil. Thus, in the 19th century, rainwater was drained through combined sewer systems, under the roads, into large pipes.



Distribution of rainwater drainage methods. Credits: Federal Inter-agency Stream Restoration Working Group (FISRWG), in Stream Corridor Restoration: Principles, Processes and Practices (10/98).

With the expansion of cities, natural environments could no longer cope with the combined load of rainwater and wastewater that was discharged into them. To optimise costs, rainwater gradually underwent separate treatment during the 20th century: it was conveyed through specific networks to natural environments, while grey and black water were conveyed to treatment plants (Cerema, 2025). However, rainwater is still polluted by runoff in cities. The second approach, which emerged in the 1960s, is "source control", which aims to store and gradually release rainwater to avoid overloading the networks. However, rainwater is still viewed through the **prism of risk and in isolation**, serving no purpose for the city. The structures dedicated to it have no other use and quickly fall into disrepair. No thought is given to the urban integration of this rainwater, its connection to the city, its inhabitants, and their uses.

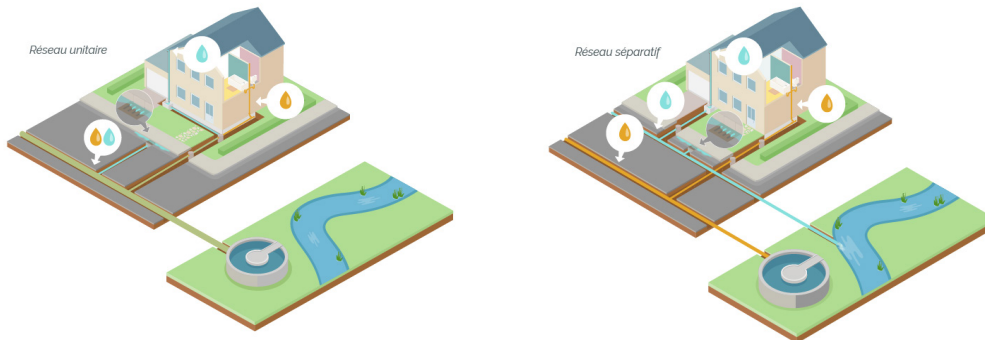
Faced with changes in the water cycle and precipitation patterns, **sanitation and drainage infrastructure are now proving inadequate**. The "all-to-pipe" system is revealing its limitations in water resource management, specifically in absorbing the meteorological phenomena induced by changes in rainfall patterns: according to the reference warming trajectory for climate change adaptation (TRACC), based on "Météo France" projections, by 2050 there will be increasingly long periods without precipitation, coupled with extreme episodes of intense rainfall (Resource Centre for Climate Change Adaptation, 2025). ■

5. Le sol, un trésor à protéger face au changement climatique, CRACC, 2022

6. La maladaptation est définie par Barnett et O'Neill (2009 : 211) comme « les mesures visiblement adoptées pour éviter ou réduire la vulnérabilité au changement climatique, mais qui ont des répercussions négatives sur d'autres systèmes, secteurs ou groupes sociaux, ou qui augmentent leur vulnérabilité » [traduction de l'auteur].

	Tout à l'égout	Assainissement séparatif	Gestion durable des eaux pluviales
<b>Situation</b>	<ul style="list-style-type: none"> <li>Eaux usées et pluviales mêlées en réseau</li> </ul>	<ul style="list-style-type: none"> <li>Eaux usées et pluviales séparées en réseau</li> </ul>	<ul style="list-style-type: none"> <li>Gestion des eaux pluviales à la source, infiltration</li> </ul>
<b>Objectifs</b>	<ul style="list-style-type: none"> <li>Évacuer les eaux sales au plus vite, au plus loin</li> </ul>	<ul style="list-style-type: none"> <li>Réduction du flux en arrivée de station de traitement</li> <li>Limiter les rejets non traités</li> </ul>	<ul style="list-style-type: none"> <li>Favoriser le cycle naturel de l'eau, intégrer l'eau à l'aménagement</li> </ul>
<b>Problèmes</b>	<ul style="list-style-type: none"> <li>Risque inondation</li> <li>Pollution du milieu naturel</li> </ul>	<ul style="list-style-type: none"> <li>Patrimoine important</li> <li>Pollution du milieu naturel</li> </ul>	<ul style="list-style-type: none"> <li>Contraintes à prendre en compte à l'amont de tout projet</li> </ul>

"Historique de la gestion des eaux pluviales" (Rainwater management history) Cerema (Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement - Center of studies and expertise on risks, environment, mobility and development).



Unitary system vs. separate system diagram. Credits: monbranchement.fr, public service of sanitation operators

# BUILDING IN FLOOD-PRONE AREAS

## URBAN PLANNING RESPONSES

Building in flood zones is not impossible. **The Netherlands**, a leading example of adaptation to the risk of flooding from sea water, has demonstrated centuries of resilience. The Dutch motto *Luctor et emergo* (literally: "I struggle and I emerge") characterises the country's attitude, which sought early on to implement protective measures against rising sea levels, given that nearly a third of its territory is below sea level. Almost 9 million people and 65% of the Gross National Product are located on the coast or near rivers, protected by dykes and dunes, and 1.8 billion euros are at risk of flooding in the country (Castillo-Soler, Philip, 2024). After the disaster of 1953, when a high tide combined with a tidal wave, causing the flooding of almost the entire province of Zeeland, the Netherlands launched the largest flood defence project in the world: the **Delta Works** (*Deltawerken*), with eight dams and the construction of 500 kilometres of dykes and barriers.



Amsterdam, IJburg district, built on a series of artificial islands to the east of the city (Urban Planning Master students, group with Altémed, 2025)

After years of technical solutions and faced with the unpredictability of rising sea levels, the Netherlands' approach is to address the risk through **nature-based solutions** (NBS – see part 2, page 33). Examples of floating neighbourhoods in Europe include Rotterdam and Amsterdam.

Long before them, however, it was the Ma'dan people in the marshes of southern Iraq, at the confluence of the Tigris and Euphrates rivers, who had learned to live with and on the water for 6,000 years (Roge,



Amsterdam (Crédits : étudiants du Cycle, groupe avec Altémed, 2025)

2020). NBS ahead of their time, *al-tahla* technology enabled them to live on the water, in tune with the seasons, using locally harvested reeds, known as *qasab*, while helping to maintain biodiversity. They settled on a group of artificial and natural islands made from a single material, reed.<sup>7</sup>

**In the West**, resilience is achieved in particular through the creation of so-called sacrificial ground floors, work on building waterproofing, the use of materials that are resistant to moisture, or, according to Béatrice Gisclard, PhD in geography and spatial design, in the case of Nimes, the doubling of electrical circuits and the use of cofferdams. Buildings on stilts or floating structures are also regularly used in flood-prone areas.

## THE REGULATORY CONTEXT FOR BUILDING IN FLOOD-PRONE AREAS

Gradually, in the second half of the 20th century, the "logic of construction" and the paradigm of water as a risk in cities were called into question, in favour of **new practices based on regulation and greater individual involvement**. The "PERs" (*plans d'exposition aux risques naturels* or natural risk exposure plans), introduced in 1982 and replaced by the PPRs (*plans de prévention des risques* or risk prevention plans) in 1995, enable the identification of areas at risk of flooding to inform urban planning. Similarly, the culture of risk, based on the ideal of "zero risk" by fighting against the elements, is evolving towards greater resident involvement in risk mitigation. Today, French regulations, particularly through the Flood Risk Prevention Plans (***Plans de Prévention du Risque Inondation - PPRi***), strictly regulate the right to build in flood-prone areas.

<sup>7</sup> However, the inhabitants of the marshes were forced to flee due to the extensive marsh drainage and economic development program initiated by Saddam Hussein in the early 2000s.

**At the European level**, the 2007 Floods Directive defines the general framework within which Member States organise their risk management policy, aiming to reduce negative externalities on human health, economic activity, the environment, and cultural heritage (European Centre for Flood Risk Prevention - CEPRI).

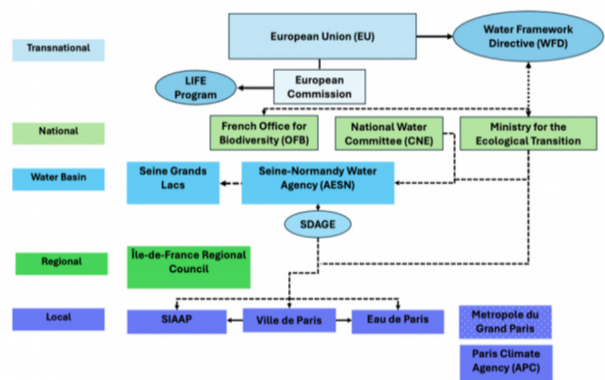
**In France, the government** proposes Flood Risk Management Plans (*Plans de Gestion des Risques d'Inondation* - PGRI), which aim to prevent and manage flood risks by defining strategic priorities at the level of large river basins (CEREMA, 2019). These PGRI are part of the State's National Flood Risk Management Strategy (2014), which is based on three priority objectives: increasing the safety of exposed populations, stabilising in the short term and reducing in the medium term the cost of flood-related damage, and significantly shortening the time it takes for affected areas to return to normal.

**Local authorities:** since 2002, they have been encouraged to manage flood risk at the level of a risk basin through **Flood Prevention Action Programmes** (*Programmes d'actions de préventions des inondations* - PAPI). PAPI programmes address the main areas of flood risk prevention: knowledge and awareness of the risk, monitoring and forecasting of high water levels and floods, alerts and crisis management, integration of flood risk into urban planning, and reduction of the vulnerability of people and property. Public establishments for inter-municipal cooperation are also responsible for managing aquatic environments and flood risk prevention (GEMAPI).

**Municipalities** (and sometimes public establishments for intermunicipal cooperation, called EPCs) draw up PPRi plans, which are approved by the prefect and appended to Local Urban Planning Plans (PLUs). These plans enable the identification of vulnerabilities and thus the control of development in flood-prone areas, based on ten-year floods (a flood that has a 1-in-10 chance of occurring each year) or hundred-year floods, and the preservation of floodplain areas (Genouel, 2023) to reduce risk.

**Flood Risk Prevention Plans (*Plans de Prévention du Risque inondation, PPRi*)**, planning documents for flood-prone areas specific to France, are based on an insurance law (1982). They were created to define rules for limiting damage during disasters, thereby preventing the "Cat Nat"<sup>8</sup> guarantee fund from being de-

pleted at the first disaster. The PPRi was designed as a counterpart to ensure insurance continuity in this type of scenario. Although the regulations allow a degree of flexibility in their application and interpretation, zoning enables areas to be designated by exposure level (with red zones being the most exposed). Comparisons with documents equivalent to PPRi in other countries can be complex. For example, in Japan, there are zoning indicating hazards and hazard maps, but almost no restrictions apply to areas in flood zones. It is therefore acceptable to live in areas at high risk of flooding. ■



Simplified water governance map in Paris (Credits: Sallyrose Savage)

	ZONE NATURELLE	PARTIES ACTUELLEMENT URBANISEES	ZONES D'ACTIVITES	CENTRE URBAIN
ALÉA FORT	VERTE FONCÉE	ROUGE	ROUGE	ROUGE
ALÉA MOYEN	VERTE CLAIRE	BLEUE FONCÉE	BLEUE FONCÉE	BLEUE CLAIRE
ALÉA FAIBLE	VERTE CLAIRE	BLEUE CLAIRE	BLEUE CLAIRE	BLEUE CLAIRE

Standard regulations on natural flood risks issued by the Departmental Directory for the Territories and the Sea (Direction Départementale des territoires et de la mer (DDTM), 2020.

8 Created by the law of July 13, 1982, the natural disaster compensation scheme, known as the "Cat Nat" scheme, covers damage caused by natural disasters through a public-private partnership based on the principles of solidarity, responsibility, and fairness. (Caisse Centrale de Réassurance, CCR)

# THE CITY, A PREFERRED SCALE OF ACTION IN THE FACE OF UNCERTAINTY AND A MULTITUDE OF STAKEHOLDERS

**Disruptions to water cycles** can explain climate-related water issues. There are many disruptions to the large cycle: reduced snowfall and irregular precipitation, which affect the capacity of watercourses, and rising sea levels, which increase salinity in coastal waters. These consequences also lead to a redefinition of the small water cycle, defined as the anthropogenic water use cycle, from collection to wastewater treatment. Adapting to variations in the large water cycle, therefore, means modifying or transforming the functioning of the small cycle. At the city level, **urban areas must thus be adapted to a new water cycle** to make cities more resilient.

In a context of uncertainty linked to climate change and its socio-economic consequences, **urban areas are a prime location for action** to adapt to emerging water issues. The flexibility of cities and their scale of governance enable the development of innovative tools grounded in a sound understanding of the territories and in dialogue with residents. Unlike private initiatives, they can develop a holistic long-term vision thanks to the leverage of public authorities and consideration for ecosystems and future generations. These assets are all the more valuable given that policymakers also have to deal with other types of uncertainty when considering adaptation measures, linked to the socio-political context, technologies, budgetary constraints, etc. (Buurman and Babovic, 2017).

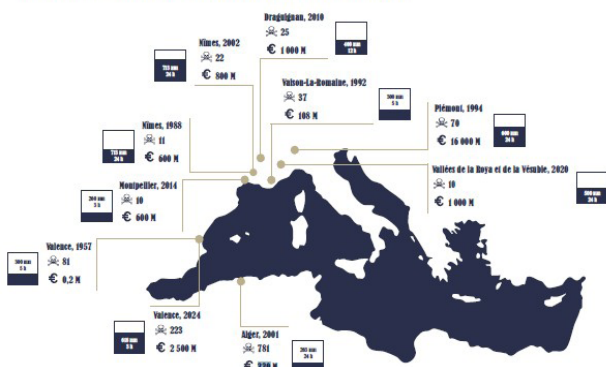
Adapting to a resilient city means **changing the way we manage water** through various practices: urban planning ("the process of defining and implementing territorial strategies", Douay 2013), development ("the deliberate transformation of a geographical space for the benefit of the society that occupies it", Larousse), and governance.

## THE EXAMPLE OF MEDITERRANEAN CITIES

The Mediterranean region has been identified as a **global hotspot for climate change**. As indicated by the IPCC, this region will be particularly exposed to the negative effects of the climate crisis due to its specific socio-environmental conditions, increasing rates of coastal urbanisation, and the degradation of natural resources. These sensitivities are reflected in water scarcity (particularly in the south and east), severe droughts (in the north), and coastal flooding risks. Cities are also more exposed to erosion, saltwater intrusion into groundwater, and forest fires that lead to the loss of terrestrial and marine ecosystems. These changes indirectly threaten production, food security, and human health in this region (Ali et al., 2022).

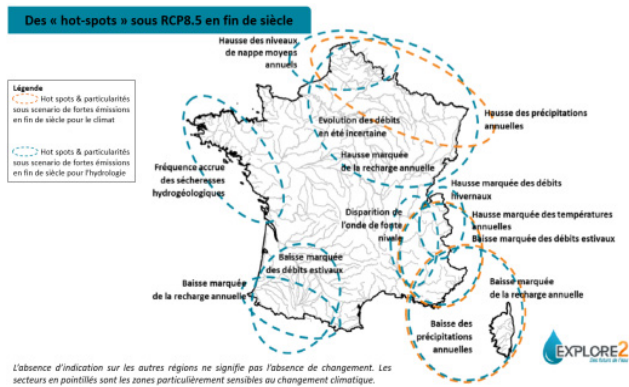
Although these climate projections involve some uncertainty, the current challenges in water management in the Mediterranean offer a glimpse of those that lie ahead in France and northern Europe.

Les épisodes méditerranéens les plus marquants depuis 1950



Map of significant Mediterranean episodes since 1950, Crédits: Urban Planning Master students (group with Altémed)

In 2022, 35% of French territory experienced drought conditions that lasted 10 months, from March to the end of December (Resource Centre for Adaptation to Climate Change). Météo-France estimates that across France as a whole, the coming years will see a 10% decrease in summer rainfall and an increase of 15 to 27 days of soil drought per year, on average, compared to the period 1976-2005.



Map taken from the Expore 2 study - horizon 2100. Credits: INRAE and DRGM

Many Mediterranean cities have been facing significant water stress for longer, due to their drier climates, which are below the French average, and are therefore more accustomed to managing droughts. Water issues are particularly acute in places such as Perpignan, where the region has been on red alert for drought for nearly three years. Economic development, based on continued resource exploitation, now poses serious problems for urban water management. Thus, **there is much to learn from Mediterranean cities** regarding water management across planning, development, and governance.

## THE CASE OF MEDITERRANEAN FLOOD ZONES

### The Cévenol episodes

In the Mediterranean context, these are more specifically **rapid-onset floods** caused by Cévenol episodes. These violent, unpredictable, and sudden hazards occur mainly at the end of summer, when warm sea waters form a reservoir of vapour while cold air flows in from the north. When these cold flows meet the unstable, humid air in mountainous areas, convergence zones form, sometimes causing brief but heavy, sudden precipitation, leading to localised rainfall accumulation and very significant flooding.

In Spain, the cold drop phenomenon is called DANA (*depresión aislada en niveles altos*), or isolated high-level depression in English. It corresponds to a pocket of very cold air located at an altitude of over 5,000 metres, which descends to our latitudes when the jet stream becomes distorted, causing stationary storms. When this phenomenon combines with Mediterranean episodes, it leads to situations such as those experienced in Valencia on 28 and 29 October 2024, where very heavy rainfall fell in a short period of time: nearly 180 mm of rainfall in 1 hour, and as much rain in 3 hours as in the previous 21 months, in a context of severe and prolonged drought.



Valencia après les inondations d'octobre 2024, étudiants du Cycle d'urbanisme (projet avec Altémed), 2025



Half of the Mediterranean coastline where these Cévenol episodes occur is part of watersheds. This steep topography causes severe flooding, mudslides, and landslides (Huet, 2024). A watershed is defined as "a portion of land within which all surface and underground water flows towards the same outlet (river, lake, or sea)" (Géococonfluences, 2023).

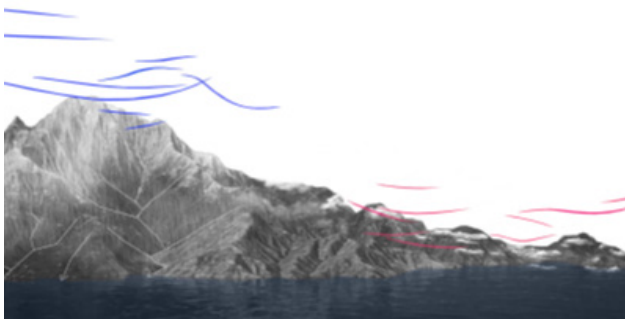
A veritable regional amphitheatre facing the Mediterranean, the **Hérault department** is thus closely linked to the issue of water. Halted by the high limestone plateaus of the Causses, the Cévenol episodes cause rivers to overflow, leading to severe flooding and runoff. At the same time, the gradual rise in sea level by several metres is leading to coastal flooding.

The probability, frequency, and intensity of these Cévenol episodes remain **difficult to predict**, making risk management considerably more difficult. Cévenol episodes and other sudden, violent hydrometeorological events along the Mediterranean coastline are thus responsible for significant human and material damage.

The Mediterranean coastline is recognised as **one of the French regions most affected by natural disasters per municipality**. In 1988, the city of Nîmes was severely affected by a Cévenol episode in which the equivalent of six months of rain fell in less than 12 hours, with a total of 14 million m<sup>3</sup> of water collected in less than 6 hours (Dartois, 2021, City of Nîmes). In 2014, the city of Montpellier experienced a significant rainfall event, with 300 litres of water per m<sup>2</sup> recorded, which, combined with heavy flooding of the Lez and Salaison rivers, caused damage estimated at several million euros (Le Monde, 2014). To study the constructability of flood-prone areas, the students involved in the Altémed project conducted a case study of the Montpellier Sud district, a real-life laboratory for the management of urbanisation in such areas (see part 2).■



Carte du littoral méditerranéen . En rouge : Montpellier métropole.  
Crédits : étudiants du Cycle d'urbanisme, projet avec Altémed.



Intense precipitation phenomenon: The sea temperature rises, causing high evaporation of water into the air. This warm air meets the cold air from the mountains and cools suddenly, turning into violent rain that causes flooding and torrential downpours. The condition of the soil – impermeability, dryness, and lack of vegetation – will then influence runoff and, consequently, people's vulnerability. (credits: Virgile Haeck)



Numerous scientific studies warn about the state of water management worldwide: its degradation, increasing scarcity, conflicts caused by inadequate management, and disruption of the water cycle. In Chapter 4 of its sixth report, published in 2022, the IPCC reports on the disastrous impact of global warming on the water cycle and the worsening of extreme weather events, for which adaptation is necessary. Reasonable and sustainable management is therefore essential to respond to key social, economic, and health issues, as water is a cross-cutting element that affects issues such as habitability, food sovereignty, health, biodiversity, and cultural heritage.

This mainly involves how we develop our territories. Indeed, natural disasters are ultimately highly human in nature, as they result from development choices that increase the vulnerability of human societies to natural hazards and the likelihood of their occurrence. The option to build on floodplains, to seal the soil, or to favour water management systems outside urban areas rather than integrating them into cities contributes to inadequate water management in the face of current challenges.

Through their field trips, the students observed different ways of coexisting with water: enduring, adapting, or reacting. The relationship with water, which is technical, political, and sensitive, is more than just a planning issue; it is a culture. To live with risk, we must understand it, adapt to it, and use it as a lever for transformation. It is important to recognize the potential of water in land-use planning to meet residents' expectations regarding issues as diverse as nature in the city, the habitability of living spaces, and landscape value.





The blue trees in La Rochelle mark the highest known water levels to preserve the memory of the risk. (Credits : Urban Planning Master students, project with Altémed)

The background features a vibrant red color with abstract, concentric curved lines in white and lighter red. These lines form a series of nested, rounded shapes that create a sense of depth and movement, particularly on the left and bottom sides of the page.

# Part 2

## RESULTS AND LESSONS LEARNED

To tackle the challenges associated to floods or water scarcity, the six groups put forward several suggestions, such as the strengthening of risk awareness and alertness, the necessity of an integrated governance of water, or the implementation of Nature-Based Solutions, drawing inspiration from existing initiatives.

# BUILDING A CULTURE OF RISK AND ALERTNESS

A quarter of the population lives in flood-prone areas, but only a quarter to a third of these exposed residents are genuinely aware of the risk. Efforts must be made to inform local authorities and residents, especially as memories of the risk tend to fade – events are generally forgotten after five to ten years. A culture of risk does not eliminate vulnerability, but it can mitigate its effects when widely shared.

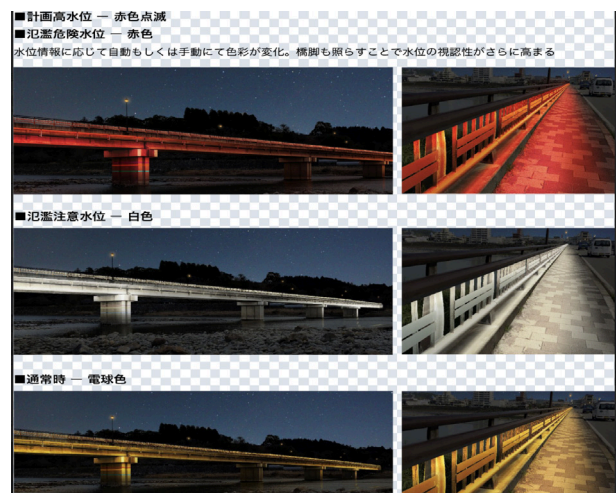
## TWO COMPLEMENTARY CONCEPTS

**Risk culture** relates to issues of anticipation, prevention, and appropriation of territory. It can also be defined as the set of knowledge, practices, attitudes, and behaviours that a community develops in response to water-related risks (Cerema, 2021). The **culture of alertness**, i.e., knowing how to react, requires communication and coordination between stakeholders when a hazard occurs.

Whether it is the culture of risk in the preliminary stages or the culture of alert on the day itself, the two are complementary and serve to inform, raise awareness, and explain what to do before and during these episodes. Acting on these two aspects requires moving away from expert and regulatory language, which is often opaque, and engaging residents and decision-makers through accessible formats (sensitive maps, workshops, exercises), and clarifying warning signals with simple messages that are immediately understandable and can be translated into action. A better distribution of roles in crises, education on the right reflexes, and multi-media communication are essential. Saving lives requires raising public awareness of safe behaviours. It is not enough to know, in theory, how to react: **these behaviours must be internalised so that they can be mobilised under stress.** The EPTB (*Etablissement Public Territorial de Bassin* - Public Territorial Basin Authority) Seine Grands Lacs has therefore developed the EpiSeine website, a public service aimed at raising awareness of flooding in the Île-de-France region. The website offers kits, games, and escape games to address the issue of risk culture and memory.

On the other hand, launched in 2020 for €50 million, the **FR-Alert system** has been sending alert messages to mobile phones since 2022, in the form of recommendations to the exposed population. It

complements, or even replaces, sirens, which are often ineffective both technically (range, coverage) and psychosocially, due to a lack of understanding of how to react. FR-Alert allows the authorities to send notifications and messages specifying the danger, its location, and instructions, or to trigger sirens. In Japan, in addition to sirens and mobile phone messages, the Japanese have developed nighttime light alerts. These tools aim to improve residents' responsiveness in flood-prone areas. However, alerts are sometimes insufficient, particularly during rapid-onset floods.



Lighting for prevention in Japan Source : SystemForest. (2022, 26 avril). [Communiqué de presse]. [https://www.systemforest.com/news/2022/04/pressrelease\\_hitoyoshi-water-level-alert/](https://www.systemforest.com/news/2022/04/pressrelease_hitoyoshi-water-level-alert/)

## THE IMPORTANCE OF A LOCALISED AND SHARED CULTURE OF RISK AND ALERTNESS IN THE FACE OF FORGETFULNESS

In recent years, there has been an increase in catastrophic events across the country, the impact of which has revealed a heightened vulnerability fuelled by a false belief: that complying with the PPRi (Flood Risk Prevention Plan) is enough to eliminate risk, when in fact it only limits it. It is therefore crucial that France develop a genuine risk culture in such situations. Faced with a weakening risk culture, **with traditional knowledge gradually being forgotten and risks being overlooked**, it is necessary to strengthen operational capacity by developing real prevention and preparedness strategies for the population and decision-makers.

For geographer Bruno Ledoux, there is a real **disconnect** between the information efforts made by local authorities and the low level of engagement among residents. This phenomenon is understandable: to protect ourselves, our minds attenuate traumatic memories, but this makes it necessary to remind ourselves of our vulnerability regularly. Furthermore, in the face of significant migratory movements, the need to move, change residence, where individual mobility and relocations are frequent, the territorial anchoring that supported this collective memory has disappeared. As a result, individual memory takes over: the memory of the drama or trauma experienced, which leaves a lasting mark on the victims of these disasters. This individual memory reveals the limitations of the technocratic vision of the interventionist state of recent decades: the idea that technology, heavy engineering, or protection techniques alone could suffice to respond to natural hazards is collapsing.

Béatrice Gisclard, PhD in geography and spatial design, explains that to best alert individuals, we need to understand their journeys and identify each person's key entry points into a territory. For example, estate agents (particularly with their IAL (Information for Buyers and Tenants) obligation), tourist offices, etc. Basing our entire risk culture on regulatory obligations, such as DICRIMs (Communal Information Documents on Major Risks), shows a failure to account for the sensitive, real-life realities of our cities. Despite prevention campaigns, tourists and residents are unaware of these documents. It therefore seems essential to define the **appropriate scale for communication**, the frequency, and the medium to reach residents effectively.

If it is to be **proportionate** to the risks, a risk culture must both take into account the scale of the risk involved and, by producing and integrating the necessary knowledge, also include the uncertainty of risk in its functioning and therefore be flexible. If the risk culture is to be **shared**, the question of the scale at which it becomes shared is crucial: to develop a "local" risk culture that unites communities in the face of risk and valuable knowledge, the challenge is to go beyond the logic of security alone to promote **horizontality, co-construction, and communication around risk**. According to Béatrice Gisclard, social design is a relevant lever for raising awareness and shaping a risk culture. It does not seek to impose solutions, but to reformulate problems with beneficiaries, integrating social issues. This approach is based on in-depth research to identify needs and aims to empower residents by valuing their lived expertise. In Japan, the Urban and Architectural Planning Laboratory at Hiroshima University

has co-constructed an evacuation map with residents, identifying risk areas and routes to safe places, while accounting for the speed of older adults. This map has become a reference tool for preventive urban planning, encouraging the adaptation of infrastructure and the development of local emergency plans.

Recent initiatives are promoting **local expertise** to develop a culture of risk awareness. For example, Living Planet Morocco identifies and promotes ancestral water management knowledge in the Sebou basin. As the risk of drought increases, basin authorities are increasingly viewing water as a common good, which is in line with many ancestral water management practices in arid environments, such as terraced farming and irrigation using "underground pockets". Living Planet is therefore taking a two-pronged action: preserving elements of intangible cultural heritage and creating a more inclusive dialogue on resource management.



Awareness-raising and mapping workshop with residents. Urban and Architectural Planning Laboratory, Hiroshima University.





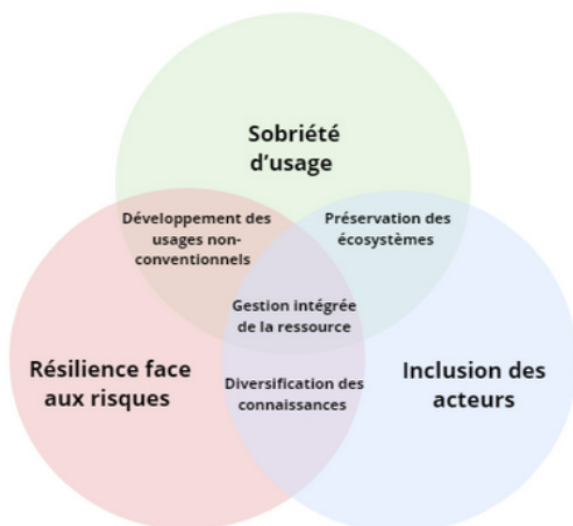
***Flooded Matra neighbourhood, Romorantin (Loir-et-Cher)***

(Credits : students of the group with Altémed, 2025)

*Some examples seek to go beyond the strictly regulatory logic of PPRs, drawing on a genuine culture of risk. Romorantin-Lanthenay (Loir-et-Cher) offers an emblematic illustration of this. On the site of the former Matra factories, now a 6-hectare flood-prone residential neighbourhood, architect Éric Daniel-Lacombe has designed a development that integrates water as an urban component, with obstruction-free spaces and rapid water drainage systems. The neighbourhood combines houses on stilts, sacrificial ground floors and a central retention basin, enhanced by a footbridge, belvederes and plants adapted to wet environments.*

# ESTABLISHING INTEGRATED WATER MANAGEMENT AND DECOMPARTMENTALISING RISK MANAGEMENT

To mitigate the effects of current and projected changes in water resources, a new paradigm for the urban relationship with freshwater must be established through an **integrated approach to water and urban planning at all scales**.



The three pillars of urban planning and freshwater. Source : students of the project with FNAU

## DECOMPARTMENTALISING PUBLIC ACTION AND INTEGRATING MULTIPLE PERSPECTIVES

The case of the La Bocca neighbourhood in Cannes illustrates the importance of project governance in flood-prone areas. Faced with the strict constraints of the PPRi, the mayor initiated a dialogue with government departments, in particular the DDTM (Departmental Directorate for Territories and the Sea), to obtain **risk management at the project perimeter level**, rather than at the plot level. This recognition enabled greater flexibility in the project's design.

This case teaches us three things: co-construction is possible, provided there is strong political support; negotiation can adapt regulatory tools without challenging

them; risk management becomes a project lever when it is thought out collectively and upstream. Faced with a pile-up of standards, **horizontal governance** must be encouraged, where different institutional levels cooperate. While political and economic interests may sometimes take precedence over crisis management, collaboration among all stakeholders is necessary.

Thus, land-use planning and water management actors can no longer work in their respective silos without consultation. More coherent governance requires **involving all stakeholders and strengthening their acculturation to the issues at stake**. For example, Bruno Ledoux points out that floodplain management suffers from the absence of a single competent actor for the entire watershed. He calls for effective coordination between all stakeholders to ensure continuous monitoring of projects. Flooding is a phenomenon of varying intensity that differs from place to place. Relying solely on the PPRi and on unforeseeable events covered by the law risks creating a significant disconnect from how floods actually operate in their context and thus being overwhelmed.

## HAVING A WATER MASTER PLAN: THE FOUNDATION OF ANY STRATEGY

The water master plan is a technical tool, but above all, a project lever. It allows for the precise location of:

- :
- minor and major river beds
- potential expansion areas
- outlets and runoff points
- shallow groundwater

This plan provides a basis for identifying controlled building zones, planning buffer zones, de-sealing certain soils, and managing resources in an integrated manner. Its implementation requires the involvement of hydraulic engineering firms, designers, and elected officials. This document is **as much a tool for anticipation as a medium for mediation**: it clarifies the site's hydrological functioning and aligns urban forms with natural logic.

## MANAGING ACCESS TO WATER FOR THE MOST VULNERABLE

Faced with competing needs among different water users, integrated water resource governance, encompassing human and ecosystem uses of the resource, is essential. This means considering and including all water users and allocating the resource in a spirit of **social justice**.

In July 2010, the UN recognised the universal right to drinking water and sanitation as a **human right**. This right was then recognised by the European Parliament in 2015. In France, this has been the case since 2006. Vulnerable populations refer to people who are often excluded from decision-making processes. There are several sources of vulnerability in access to drinking water: socio-economic, racial, gender, spatial, and environmental.

Furthermore, these sources of vulnerability are changing in the face of climate change, underscoring the need to **integrate access to fresh water into climate change adaptation strategies**.

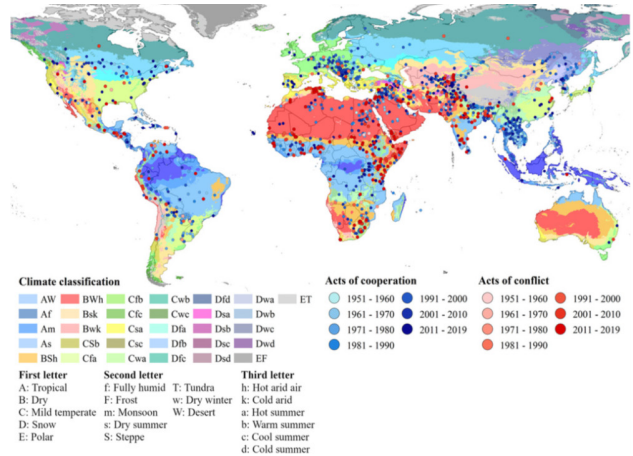
A new Catalan law stipulates that, in the event of drought, swimming pools may be filled with drinking water under two conditions: they must be declared a "climate refuge" by the municipality and be open to the general public at the same rates as public swimming pools. This law redefines access to water for the most vulnerable, thereby incorporating a social justice dimension into climate and water adaptation.

## MANAGING CONFLICTS OF USE

### *The use of participatory methods*

Freshwater can be a source of conflict and rivalry between users. According to Kåresdotter et al. (2023), since the 2000s, conflicts over this issue have increased and have surpassed acts of cooperation, particularly in regions characterised by an arid climate (the Middle East, East Africa, and Central and South Asia).

Conflicts over water use are increasing significantly in the Middle East, Algeria, and Tunisia, while in Europe, cooperation is increasingly becoming the norm. Indeed, the European Environment Agency states that Member States must develop river basin plans in collaboration with territories that share access to the same water-courses, including non-EU Member States (EEA, 2021).



Map of global climate zones and location of acts of cooperation and conflict worldwide, 1951-2019. Revised by Kåresdotter et al. (2023) from the map by Chen&Chen (2013).

To deal with these conflicts, the southern Mediterranean



regions have historically developed several methods. One practice that spread from North Africa to Spain following the Muslim conquest in the 13th century is that of **water tribunals**, the best known of which today is that of Valencia (Spain). More modern, participatory practices for managing water-related conflicts include scenario workshops, media modelling, serious games, and more.

The door of the cathedral where the Water Tribunal of Valencia is held and the proceedings of the tribunal, photos taken by students from the FNAU project (below)



The freshwater management sector is therefore taking a participatory approach. The common thread among these practices is dialogue among local water-sector stakeholders and with actors working in related fields, such as energy and agriculture.

Sources of tension or rivalry are integrated into a **democratic participatory process** so that they are not expressed elsewhere and become productive, as they allow perspectives and needs related to water that might otherwise not have been taken into account to be expressed. However, participatory methods have their **limitations**: a lack of scientific knowledge among participants, a lack of participation when interests are threatened, etc.

**Encouraging dialogue with large-scale users**

Large consumers are those who use more water than individuals. A significant number of them are part of the **tourism sector** in Mediterranean countries. France, Spain, and Italy have the highest number of tourists in the Mediterranean region: in 2016, non-resident tourist arrivals at the French border totalled 82 million, in Spain 75 million, and in Italy around 55 million (Tecer et al., 2020).

However, tourists generally consume more water than local populations due to the services offered by tourist accommodation (washing, irrigation, recreational activities) (Tirado et al., 2019). For example, average water consumption in European establishments is estimated at 394 litres per guest per night (Herbert, n.d.). It is therefore crucial for this sector to better control and manage water demand.

**The Wat'saveureuse project**, funded by the European LIFE programme, is an international and interregional initiative to encourage conscious use and constructive sharing of good freshwater management practices. It brings together eight partners from Catalonia, the Balearic Islands, and the south of France. Its main objective is to raise awareness among the tourism sector, suppliers, local authorities, and municipalities about legislation on water conservation, reuse, and reduction through communication campaigns, events, workshops, and meetings organised in the three territories involved.

This project demonstrates how actors in the private and public sectors can encourage better water management by increasing communication and collaboration.



Campaign: "In the Balearic Islands, we have many things, but little water", 2023. Source: Balearic Islands campaign - Wat'saveureuse

**CASE STUDY: BARCELONA, INTEGRATED WATER GOVERNANCE**

On February 1<sup>st</sup> 2024, the Government of Catalonia declared a state of emergency due to drought in Barcelona, describing it as "the worst drought of the century" (Costa, 2024). At a time when they should be filling up, the Ter and Llobregat reservoirs were at 16% of their capacity. As the economic and tourist hub of the Mediterranean basin, Barcelona is facing water challenges linked to climate change before its neighbours. It is implementing several urban freshwater good governance practices that combine concerns for sobriety with those of social justice.

The municipality has set a target to reduce consumption to less than 100 litres per capita per day by 2030. To achieve this, the aim is to develop a local culture that is more respectful and aware of the issues surrounding freshwater use, known as a **"water risk culture"**, through initiatives to inform the population and encourage them to commit to its preservation (posters, drought warning lights) and a series of activities on the value of water (round tables, conferences, exhibitions, etc.).

Over the last two decades, Barcelona has developed an **Integrated Water Resources Management (IWRM)** framework that emphasises the fair and flexible distribution of this scarce resource. First defined at the International Conference on Water and the Environment in Dublin in 1992, IWRM aims to promote the coordinated management of water, land, and related resources to maximise economic and social benefits equitably, without compromising the sustainability of vital ecosystems. This approach involves stakeholder participation, long-term planning, and the integration of environmental, financial, and social factors into water management decisions in an urban context.

IWRM brings together three crucial elements to ensure resilient, fair, and effective urban adaptation in freshwater management: sobriety of use (which depends on the efficient use of water and non-water resources), resilience to risks (which depends on flexible long-term planning), and the inclusion of stakeholders (with different perspectives and uses) in urban planning.

The system for reusing treated wastewater, in accordance with IWRM principles, enables Barcelona to address the three structural challenges mentioned above: water scarcity, uncertainty in projections, and governance for all. However, the case of Barcelona shows that good water governance practices do not always lead to an end to the crisis. To govern access to water fairly and sustainably, the Barcelona authorities must adapt to a **new paradigm in the city's relationship with fresh water**. This relationship is one of dependence on fresh water, awareness of its scarcity, and a commitment to evaluating and re-evaluating what constitutes a need or a fair distribution of this resource.



Water sources in the city of Barcelona. Source: Aigües de Barcelona, translated by students participating in the FNAU project

Only a holistic and participatory vision will ensure resilient water management in the face of future challenges. ■



Posters in the city of Barcelona: "Drought emergency – water does not fall from the sky. Save water. It's urgent." Photos taken by the authors in April 2024 in Barcelona.



Diagram of the operation of the Bas-Llobregat wastewater treatment plant (Gullón Santos & Aguiló Martos, Niza 2009)

# COPING WITH THE INCREASING SCARCITY OF RESOURCES

## ENCOURAGING SOCIALLY FAIR WATER CONSERVATION

Today, the Stockholm Resilience Centre considers that six of the nine planetary boundaries have already been exceeded, including the freshwater boundary. Our water consumption choices are therefore intrinsically linked to **an unchanging water limit**: the planet does not generate water, and only a limited amount is available to us. However, the available water is threatened by **new challenges**: population growth and urbanisation, increased per capita water consumption, the expansion of new forms of energy that require water (biofuels), and the consequences of climate change, which point to a decline in water resources, which may hurt water quality (a higher concentration of pollutants in a reduced amount of water will increase its toxicity). The water rebound effect refers to a situation in which gains in water-use efficiency paradoxically lead to a net increase in water consumption. Hence, there is a need to **control demand** to avoid the illusion of resource abundance.

Often used in countries such as Spain, Tunisia, and Morocco to control water consumption, **progressive water pricing** encourages consumers to use less water. Introduced by the ONEE (National Electricity Office) in Morocco, it distinguishes between five degressive water price brackets to encourage households to reduce their consumption while accounting for the economic situation of the most modest households. This pricing policy is therefore based on a balance between ecological and social objectives. However, the success of this process is controversial, as the ONEE reports that it is not always the most modest households that benefit from this type of practice.

TRANCHE	CONSOMMATION MENSUEL	PRIX €/m <sup>3</sup>
1	0-6 m <sup>3</sup>	0,7775 €/m <sup>3</sup>
2	7-9 m <sup>3</sup>	1,5551 €/m <sup>3</sup>
3	10-15 m <sup>3</sup>	2,3326 €/m <sup>3</sup>
4	16-18 m <sup>3</sup>	3,1099 €/m <sup>3</sup>
5	>18 m <sup>3</sup>	3,8874 €/m <sup>3</sup>

Degressive water prices, Aigües de Barcelona. Credits : Tarifes de Subministrament - Web Oficial - la Gestió Responsable, s. d.

Water conservation, in addition to offering financial opportunities for the private and public sectors through water savings, is essential in the face of new challenges and the growing water needs of natural environments. However, the success of all the envisaged approaches depends on **adequate support in terms of policies and awareness-raising regarding water supply**.

## DEVELOPING ALTERNATIVE WATER RESOURCES

### Reuse of treated water

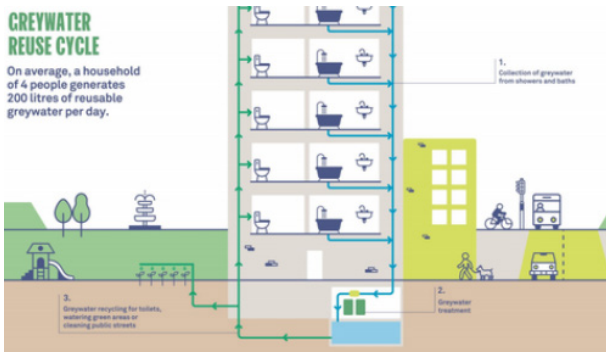
While the reuse of treated wastewater has only recently developed in France, where it has been authorised for street cleaning since the AGECE law (2020), cities in Catalonia have been implementing reuse systems since the beginning of the century, both at the municipal level and in buildings.

### Decentralised reuse. Reuse of grey water in buildings.

In two decades, water consumption in Sant Cugat del Vallès, one of the wealthiest municipalities in the Barcelona metropolitan area, has fallen by 47% per capita, while the population has almost doubled. In 2002, a municipal ordinance was passed introducing an innovative measure: any construction or major renovation of a building with at least eight flats must include a greywater reuse system, i.e., recycling wastewater from showers and bathtubs for use in the building's toilet flushing systems.

Today, this method works thanks to an inexpensive membrane system, costing €600-800 per dwelling for construction and €50-95 per year for maintenance. From this cost, the savings in water consumption must be subtracted at the building level, which amount to 35-40% for Sant Cugat (Sant Cugat Town Hall, 2020; interviews in April 2024 with local authorities in Sant Cugat and Barcelona). For this system to work, users must be made aware of its operation. Residents are taught not to put toxic chemicals or large waste items in their showers or bathtubs, as the membrane cannot fully filter these products, making it impossible to extend the system to washbasins or dishwashers.

The operation of this technology is explained in the ordinance's appendix, so its installation in Catalonia does not depend on a single company.



Greywater cycle at the building level (Barcelona City Council, 2024)

Today, this system has been replicated in around 100 municipalities in Catalonia, and Barcelona's citizens have been consulted on replicating this system for all construction projects or major renovations of buildings with more than 16 dwellings in Barcelona. However, there are limitations to replicability: a sufficient number of residents must take showers and baths for the tanks to fill regularly. In addition, at least one technician must be appointed to verify the proper functioning of the systems at the municipal level. Finally, any attempt at replicability outside Catalonia will require regional, national, or European legislation to regulate reuse standards and encourage the installation of such systems on a larger scale.

**Centralised reuse.**

Reuse of treated wastewater in the network. Some municipalities choose to develop treated wastewater reuse centrally, by building a parallel distribution network alongside the existing network. This is the case in Sabadell, Catalonia.

**Desalination**

Faced with the increasing scarcity of fresh water, more and more stakeholders in Mediterranean countries are installing desalination plants. The students focused on the desalination of saline rivers, including the Tara River in the Sinni basin in Italy. The river has a salinity level of 2g/L, which means it can only be used for industrial and agricultural purposes. The desalination plant project aims to make the river water drinkable for the inhabitants of Taranto, to increase alternative water resources, and thus reduce pressure on groundwater and prevent seawater intrusion. The plant is expected to be the largest desalination plant in Italy when

it opens in 2026, with a production capacity of 60,000 m<sup>3</sup> of water per day, enough to meet the drinking water needs of 385,000 people (Scialoja, 2024) and represent an important source of fresh water for the ecosystems and inhabitants of the entire Apulia region.

Despite the benefits to local populations and ecosystems, this project has been heavily criticised for its high environmental costs, including increased GHG emissions and impacts on aquatic ecosystems.



Desalination infrastructure © goodcat/Shutterstock.com

**Taking resource balance into account.**

The development of unconventional resources and the improvement of water technologies require **more intensive consumption of secondary resources and significant investment.** The use of unconventional water must therefore be considered within a holistic understanding of costs and benefits (energy, finance, ecosystems). Due to the high initial costs and long operational life of energy and water infrastructure systems, it is important to understand the current nature of this coupling, estimate its impacts under various scenarios, and identify robust policy options to improve energy and water security based on environmental objectives (Siddiqi & Anadon, 2011: 4539).

Yoon's (2019) work illustrates these interdependencies using the example of Benidorm (Alicante, Spain). In this European mass tourism centre, the city's water network consumes nearly 109 GWh/year. Twenty per cent of Benidorm's energy consumption is dedicated to this sector. Grey water reuse and desalination methods are particularly energy-intensive, consuming six times more electricity in a dry year than in a normal year (Yoon et al. 2018:5). In a situation where desalination is increasingly being presented as the solution to creating an abundance of fresh water, it is fundamental to remember that it only becomes more energy-intensive. This balance between resources is therefore a major public policy issue.

## PLANNING IN THE FACE OF UNCERTAINTY

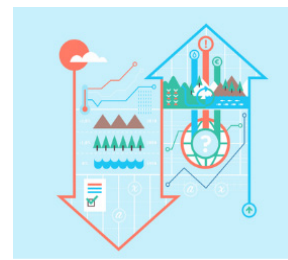
In addition to the challenges posed by the increasing scarcity of freshwater resources, there are uncertainties linked to climate projections. Resilient planning practices that are flexible and rooted in local expertise are therefore necessary to enable adaptation over time.

### ***Ensuring resilience in the face of climate and water risks***

Resilience, from the Latin *resilio*, meaning "to bounce back", refers in ecology to "the ability of an ecosystem [...] to recover after an external disturbance" (Larousse, n.d.). It also aligns with a strategy to make society more resilient. When faced with an identified risk, the concept represents an inevitable phase of acceptance of that risk while attempting to reduce its short- and long-term impacts. John Matthews, researcher and executive director of the Alliance for Global Water Adaptation (AGWA), recognises three objectives of resilience (Dauphiné and Provitolo, 2007):

- **Persistence**, or the ability to 'return to normal' by effectively dealing with the impacts of a disaster. This involves restoring the system to what it was before the shock, without calling the system itself into question.
- **Adaptation**, or the ability to change and quickly incorporate new norms to respond to new environmental characteristics.
- **Transformation**, or the ability to initiate a radical reorientation beyond a critical threshold of environmental or economic conditions.
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To ensure the resilience of tomorrow's cities, local stakeholders must accept future risks and their unpredictability. Uncertainty is not a new issue in water management. Still, challenges related to water quality and quantity, particularly in the context of climate change, have highlighted the **need to reassess how we address two types of uncertainty**: those caused by natural variability and those related to the coordination of different water users (Mendoza et al., 2018). Many tools have been developed in recent decades, as it became clear that quantifying and predicting all risks would be difficult and insufficient.



### **THE CRIDA METHOD**

- CRIDA: Introduction to Climate Risk-Informed Decision Analysis (Collaborative Water Resources Planning for an Uncertain Future): The CRIDA programme is a methodology developed in 2019 for water

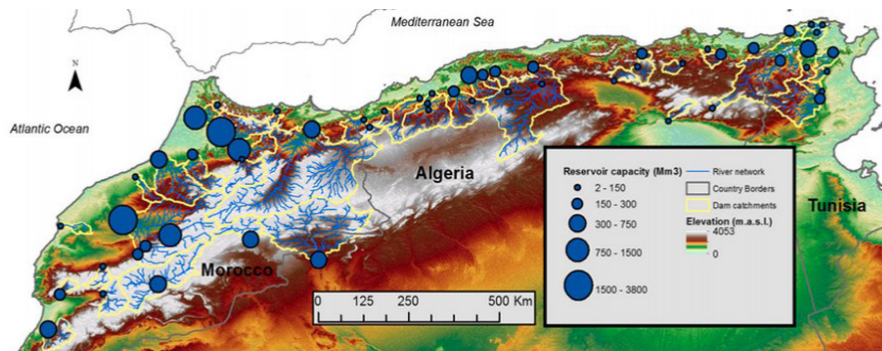
resource planning and management in the face of significant uncertainty about future conditions. This collaborative effort between the Alliance for Global Water Adaptation (AGWA), the US Army Corps of Engineers, Deltares, the Dutch Ministry of Water and Infrastructure, UNESCO and the International Centre for Integrated Water Management has resulted in a tool that enables effective assessment, management and communication of risks to stakeholders and decision-makers, including successfully avoided risks and residual risks that cannot be avoided, quantified or isolated.

*CRIDA logo, credits : CRIDA, Mendoza et al. 2018: 19*

### ***"Grey" water risk management***

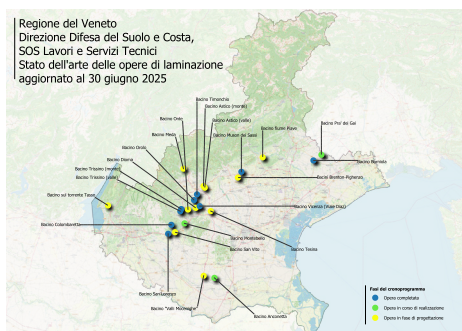
To improve their resilience to climate and water risks, i.e., their ability to return to normal after a shock such as a flood, cities can opt for storage infrastructure, which can both reduce the risk of flooding and the seasonal nature of water resource availability.

**Dams** are an example of large-scale infrastructure widely used in Mediterranean countries to store water reserves, redirect them to other arid regions, facilitate irrigation, develop hydroelectric power, and prevent flooding. However, they can have significant environmental and socio-economic impacts if not implemented properly. Indeed, they not only block water flows but also river sediments, which are among the main components of coastal sediments that shape coastal ecosystems and provide nutrients to marine biodiversity, such as fish, mangroves, and wetlands (Snoussi et al., 2022). Furthermore, according to Aoula et al. (2021), although dams are generally considered to protect against flooding, the accumulation of river sediments in reservoirs and the reduction in their capacity paradoxically cause more flooding.



Map of dams in the Maghreb in 2011 (watershed size greater than 100 km<sup>2</sup>). Source: Tramblay et al., 2018, p. 1294

**Reservoirs or basins** are now more commonly used in European cities to combat the growing risk of flooding. These are "containment areas" built near watercourses to collect and store excess water from rivers during floods, preventing them from overflowing. The authorities in the Italian region of Veneto have built more than 20 basins following several recent episodes of extreme flooding. Veneto's strategy is not easily replicable in other European or North African regions, as it is a very costly investment that can harm local ecosystems.



Map of reservoirs built in Veneto. Source: Regione Veneto, 2024

### **Planning for uncertain structural change in cities**

For better urban water management, it is essential to develop an understanding of the potential changes to the city's infrastructure, which shapes the possibilities for water infrastructure development. A city is defined in part by the flows that pass through it, such as its place in production chains. Urban authorities must anticipate sectoral changes in the city and their impact on water resource use. Milan provides an example of adaptation to these changes since the beginning of its deindustrialisation process in the 1970s. This economic transition has led to the displacement of industries (and populations) from the city centre, where they previously pumped significant amounts of water from the water table, making Milan more vulnerable to flooding (De Caro et al., 2019). Finally, it is necessary to anticipate changes in social dynamics and governance networks, as these may affect water-related challenges. ■

### **Flexible adaptation through coordination of local actors**

Implementing measures to coordinate local use can complement the development of large-scale infrastructure to adapt urban systems to climate and water uncertainties. In Benidorm (Alicante, Spain), where the main risk is drought, the municipality has built a 40 km water network connecting the municipalities between the Tajo and Segura basins. This is accompanied by an exchange of treated and untreated wastewater between farmers and the tourism industry. It is therefore not just a question of securing access to water through new infrastructure, but also of adapting water distribution systems and accustoming users to the uncertainty of the water cycle, so that all stakeholders are better able to withstand water-related risks.

# A NEW CULTURE OF **SETTLEMENT** IN **FLOOD-PRONE AREAS**, BEYOND RENUNCIATION

Developing flood-prone areas can be an **opportunity to rethink the relationship between cities and water**, and to cultivate more resilient urban forms that are attentive to soils and environments. Indeed, addressing the risk of flooding in an urbanised Mediterranean area cannot be reduced to the strict application of regulations or to a logic of systematic withdrawal.

It is about embracing a new culture of settlement, not turning our backs on disaster, but recognising it as a physical and cultural reality: building where the risk is manageable, where networks exist, where densities can be increased without compromising territorial balance. And in high-risk areas, to engage in more open transformations: climate regulation, urban resilience, and de-urbanisation through re-naturation. **It is not a question of giving up on the city, but of inventing a new one**: more contextual, more sustainable, in tune with the changes to come.

## **BETWEEN LIVING AND DWELLING, A SCALE OF COMPROMISE**

Rather than approaching the issue solely from the perspective of constraints, the students propose to think about development in terms of the dual concepts of living and dwelling. Dwelling is understood as the act of housing; living is understood as the act of passing through or engaging in leisure activities within a limited time frame.

The State's attitude could be summarised as being guided by the **precautionary principle**. This attitude seeks to deny the habitability of flood-prone areas, without, however, excluding the possibility of living there. This stance is justified by the protection of the general interest and the need to minimise the vulnerability of property and people. It is also a question of the State avoiding having to explain to residents after the event that they need to be concerned about the resilience of their homes, which would imply acknowledging the inadequacy of protective structures in the face of risk.

As a result, certain areas have been declared unbuildable by the State, such as in the Alpes-Maritimes region of France, following Storm Alex (2020) and

Storm Aline (2023). However, the State's position should not be caricatured, as there are many examples of positive co-construction, such as the city of Cahors. Flooded several times in the 1990s, 2000s, and 2010s, the valley was already completely urbanised. The State then authorised urban planning in the red zone, on the condition that vulnerability be reduced relative to the existing situation.

There is, therefore, a **spectrum of nuances** between total renunciation and risky construction, between absolute laissez-faire, living with it, and inhabiting it. Risk can become a **potential** for feasibility, innovation, and creativity in responses.

## **RECONNECTING WITH GEOGRAPHY AND THE WATER CYCLE**

**Cities have often been built against the grain of geography**, erasing relief features and wetlands and establishing settlements in areas historically unsuitable for construction. However, it is important to take into account the specific geographical, climatic, and urban context to better assess risk.

In Montpellier, where housing needs are real and land pressure is intense, it is not a question of shifting urban development solely to constrained areas, but of **rethinking the distribution of built forms** by mobilising other, better-equipped, less exposed, and even elevated sites.

A watershed-scale vision is necessary to gain a detailed understanding of hydraulic dynamics, uses, and feedback loops, from upstream to downstream. Faced with a form of territorial amnesia, the students propose to **re-anchor the project in the wider landscape**, placing **long-term development** at the forefront and focusing on water cycles, climate adaptation, and future generations. It invites us to prepare the ground for future changes, restoring coherence to a fragmented territory while anticipating the effects of climate change. While the neighbourhood scale remains essential, it must be considered within a larger system to assess the area's habitability and liveability.

The **Montpellier Sud** site, studied by students on the Master's programme in Urban Planning, offers an opportunity to step back and consider the **buildability of a flood zone** that is currently not authorised for construction, with limited room for manoeuvre. The complexity of this site allows local issues to be linked to a broader reflection on the adaptation of urban planning policies to climate risks and territorial resilience.

As a strategic gateway to the city, this rapidly changing area of nearly 120 hectares crystallises many issues related to social diversity, urban resilience, and the transformation of Mediterranean landscapes. Montpellier Sud also raises issues of urban renewal, linked to the observation of high soil impermeability and a lack of vegetation (shopping centres, car parks and bus storage areas, infrastructure that is undersized in relation to the risk, and, in the future, increased housing density).

More specifically, the northern part studied by the students focuses on the challenges of development in flood-prone areas, due to the presence of the Lantissargues, which cause very severe flooding from runoff during heavy rainfall. The presence of shallow groundwater limits rainwater infiltration and exacerbates runoff, thereby increasing the risk.

In the case of Montpellier Sud, the students are using the soil as the basis for their project. The aim is to reactivate hydrological and ecological processes, adopting **an adaptation-based rather than protection-based approach**. In Lantissargues, this strategy involves creating a streambed, resizing the banks, and making the waterways visible even when dry. These measures make it possible to deal with risk rather than neutralise it: **water is no longer a threat, but a visible, structuring presence** that marks the traces of risk and exposes the dynamics of the environment. The landscape then becomes a language, a vehicle for understanding, appropriation, and collective narrative.

## EXPERIMENTING WITH NEW URBAN FORMS

### *Towards a system of metropolitan parks: a porous and shared city*

In this logic, the park is not simply a leisure facility. It is a hydraulic and climatic infrastructure, capable of capturing, storing, and redistributing water, thus protecting the entire metropolis, in a logic of risk adaptation, climate regulation, and transmission of a productive and resilient landscape heritage. It relies on nature-based solutions, ecosystem services, and ecological engineer-

ing: riparian forests, reed beds, windbreaks, orchards, meadows, and floodplain gardens. **The plant-based approach is becoming a major lever for adaptation:** planting today means anticipating a Mediterranean climate that is warming faster than the global average, with already noticeable impacts on ecosystems (tree mortality, proliferation of invasive species, etc.).

The park city is designed as **an open and permeable space**, far from the rigid typologies of traditional public spaces, where squares and parks are strictly separated. It is with this in mind that, in Montpellier Sud, students are proposing an open and porous neighbourhood designed to accommodate water, biodiversity, and diverse uses. The city's parks are connected, both physically and visually. De-artificialisation, permeability, and alternative rainwater management are essential levers for reducing heat islands and adapting to climate change. Welcoming water means both **managing the resource and revealing the memory** of a Mediterranean landscape marked by scarcity.



Green spaces in Montpellier. Credits : Urban planning Master students, project with Altémed

Creating shade is also essential for preserving soil moisture, slowing evaporation, and providing cool spaces. More than a technical response, it is an approach that links climate resilience and landscape aesthetics.

Designing this park also means opening up a **new project economy**: combining land use logic, urban planning rules, and regulatory levers to rebalance densification elsewhere and renaturation here. This calls for a renewed, multi-scale, multi-stakeholder governance model, rooted in cross-cutting planning that links ZACs (joint development zones), development operations, mobility, and urban planning.

Finally, designing a city within a park means imagining **high-quality public spaces** that are true places of sociability and citizenship. Too often reduced to mere practical functions or places of passage, these spaces must become more desirable, inclusive, and welcoming. To achieve this, it is necessary to move beyond traditional approaches to create spaces that can adapt to change, anticipate users' needs, and support evolving lifestyles, while respecting the cycles of nature and its temporalities.

### ***Detaching from the ground: building on stilts***

In Montpellier Sud, students are considering elevation as a principle of adaptation. The ground is reserved for the least vulnerable functions: parking, shared gardens, and public spaces. The ground floor is not a void, but an active, traversable space, designed to be permeable during floods. The buildings are elevated, connected by footbridges and terraces. This elevated grid forms a pedestrian network, a route of retreat in the event of flooding. Emerging from the tree canopy, the buildings are integrated into the landscape matrix in a respectful relationship between architecture and landscape, where the built environment gives way to the ground, light, and ecological continuity.

The height chosen relative to the **PHEC** (Plus Hautes Eaux Connues, or highest known water level) is a key factor: it determines the project's design, the use of the space "under the stilts," and the neighbourhood's very image. In Montpellier Sud, the low floor level is defined by a simple rule: PHEC + 30 cm, or PHEC + 50 cm, depending on constraints. These 20 cm of difference are decisive: they influence the habitability of the space below, its appropriation, and its value in use.

One of the major challenges in designing an elevated neighbourhood is to **ensure the relationship between this new space and the rest of the city**. The main pitfall lies in the plinth effect, which tends to dissociate the two strata of the city through two types of breaks: physical and visual.

The **physical break** can be mitigated by accessibility features (stairs, ramps, or lifts) that connect spaces of different heights and ensure functional continuity. However, physical continuity does not guarantee effective urban integration.

The **visual break** further accentuates this problem. Passers-by prefer routes that offer long visual perspectives, which facilitate orientation and reinforce the feeling of safety (Piombini et al., 2013). Conversely, open spaces that are difficult to navigate or punctuated

by dead ends can cause apprehension. Without specific, identifiable destinations, an elevated neighbourhood risks becoming an isolated residential space, disconnected from urban dynamics. The issue of stilts, therefore, requires careful consideration, both above and below ground.

To avoid fragmentation of the urban fabric, it is essential to integrate these spaces into a coherent project, proposing specific and differentiated uses that meet the specific needs of the neighbourhood while providing it with its own identity. The aim is to design places that find their place in the city by **providing real value in terms of use**.



Petit Building, Paris, RIVP, ©Jeudi Wang



Itamaraty Palace, Brasilia, Niemeyer, Burle Marx

### ***Adapting Montpellier's follies to the context of Montpellier Sud***

Beyond these structural choices, the students believe it is essential to design **architectural and landscape features that mark the identity** of Montpellier Sud. These artefacts, or "follies" in Montpellier vocabulary, are physical features integrated into the urban landscape. These hybrid objects or structures play both a functional and symbolic role, mediating between risk, everyday uses, and the identity of the place. They allow for a shared understanding of the site's vulnerability, while offering concrete responses to the challenges of prevention and resilience.

They help to structure space, guide movement, signal sensitive areas, and, more broadly, incorporate risk into everyday life without resorting to sensationalism or alarmism. In this way, these artefacts become structuring elements of resilient urban planning, fully embracing uncertainty as a condition of the project.

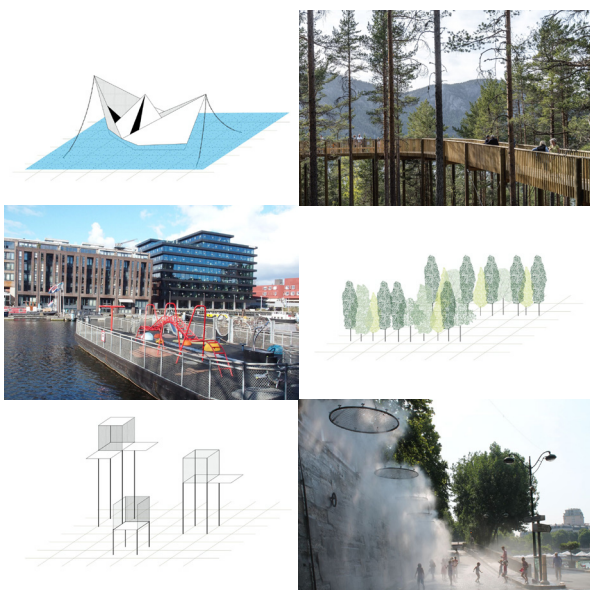
- **Transmission and education:** in a neighbourhood prone to flooding, an educational trail along the Lantissargue, marked with archive photos, flood markers, and photomontages, makes the invisible visible: water, its overflow, and the spaces designed to adapt to it. This path is a learning tool that links the area's hydrological history to everyday life.
- **Water management and water stress:** in the Mediterranean, designing cities with water in mind requires consideration of two extremes: flooding and drought. In this context, artefacts take the form of retention and recovery systems. The condensation tower captures moisture from the air to produce water and provide localised cooling, while creating a shaded area that provides comfort during hot weather.
- **The alert:** faced with the suddenness of certain floods, it is not only a question of broadcasting a signal, but of making it understandable, visible, and actionable. Artefacts can thus play a spatial relay role, serving as sound or visual devices integrated into public spaces. A resilient neighbourhood is one where alerts are part of the landscape, and

everyone knows how to interpret the signals. These systems must therefore be based on clear, tested scenarios that are shared at the local level.

- **Refuge:** in a neighbourhood exposed to flooding, refuge is not just a matter of passive protection: it embodies a space for welcome and social continuity. Refuge buildings must be identifiable and accessible. They can take the form of multi-purpose, elevated facilities that remain functional during crises. High points, independent access points, and safe gathering places must be provided, such as stairs and footbridges that allow people to take shelter without interrupting their activities. The network of footbridges ensures safe movement during floods and, in normal times, forms a pedestrian route that structures movement and contributes to urban continuity.



*The Floating Piers*, Christo et Jeanne-Claude. An ephemeral contemporary artwork on the lake Iseo in Italy, 2016. It is made of platforms covered by a 100 000 m<sup>2</sup> piece of fabric. Credits : Lake Iseo website.



Examples of artefacts in the city. Credits : students of group with Altémed.

### Exploring hybrid and experimental forms

Building in flood-prone areas involves significant structural constraints. But this context also becomes a **testing ground**: it encourages the development of more flexible configurations capable of coping with water, and the exploration of alternative forms of housing, where architecture and landscape overlap, dissolve, or extend into one another. The image of a city on stilts, a light structure raised above the ground, resonates with the utopian visions of Supersstudio (Continuous Monument) and Constant (New Babylon), or the ephemeral works of Yona Friedman (The Mountain of Venice) and Christo and Jeanne-Claude (The Floating Piers). These projects share the same ambition: to question the relationship between humans, the ground, and the landscape, to open up a field of experimentation, to propose models that go beyond the limits of traditional urban forms. ■

# WHEN NATURE HELPS CITIES COPE WITH WATER CRISES: **NATURE-BASED SOLUTIONS**

Nature-based solutions (NBS) are increasingly seen as promising approaches to addressing both water scarcity and flooding in urban contexts.

## DEFINITION AND CONTEXTUALISATION OF NBS

NBS are solutions **"based on nature and its many services"** (Ministry of Ecological Transition and Territorial Cohesion). They are becoming increasingly popular because they benefit both the environment and communities by helping to restore habitats and provide ecosystem services. The objectives of NBS are varied: restoring natural flows, improving habitat quality in watercourses, increasing habitat in floodplains, reducing freshwater pollution, etc. (van Rees et al., 2023). Although the focus here is on urban areas, water management depends on processes that take place far from cities, and their effectiveness depends on the urban or extra-urban environment.

The NBS framework encompasses a wide range of pre-existing practices and knowledge but also proposes a new set of guiding principles for **effective and sustainable mitigation of water-related crises**.

In 2022, the member states of the United Nations Environment Programme (UNEP) adopted the first universal intergovernmental definition of NBS as "measures to protect, conserve, restore, use and sustainably manage natural or modified terrestrial, freshwater, coastal and marine ecosystems that respond effectively and adaptively to social, economic and environmental challenges, while ensuring human well-being, ecosystem services, resilience and biodiversity benefits" (UNEP, 2022). NBS do not exclude entirely artificial solutions, such as the construction of more porous cement pavements, which facilitate the reinjection of water into aquifers.

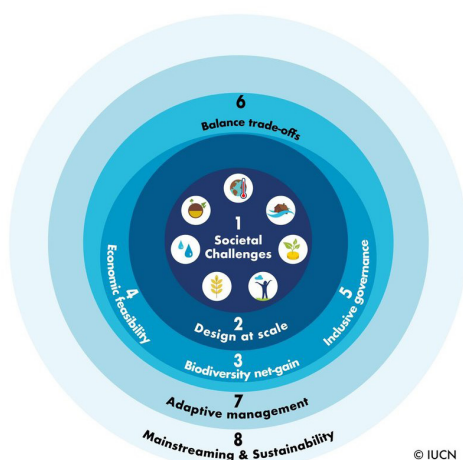
Although important in reducing the impacts of floods and droughts, "grey infrastructure " (built by humans) have limitations in the face of climate change, including low adaptability, serious consequences in the event of failure (collapse of a dyke, dam breach), increasing construction and maintenance costs, negative impacts on ecosystems and limited associated benefits (ICRF and WWF, 2022; Hoffman and Henry-Shepard, 2023). In contrast, NBS offer a multitude of options for implementing long-term responses to floods, droughts, and other climate vulnerabilities.

They have great potential for adaptation due to their **associated benefits and ease of integration into large projects** (Climate Adapt, 2021; OECD, n.d.; Kabisch et al., 2016; Chausson et al., 2020; de los Casares & Ringel, 2023). An example of their adaptation potential is the introduction of green infrastructure to sequester water, reduce the effects of urban heat islands, and provide essential ecosystem services.

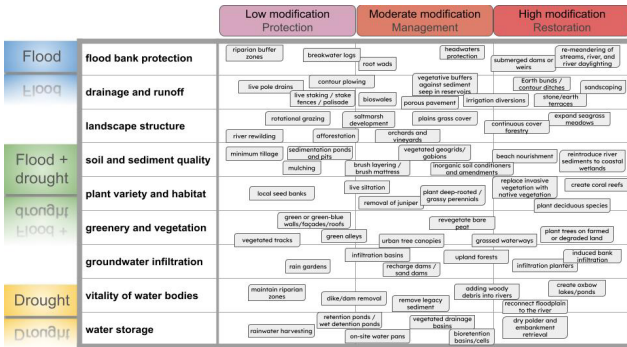
There is no standard method for classifying NBS, but there is a trend towards three principal axes: targeted risk, depth of intervention, and relationship with natural processes.

### NBS governance

NBS are governed by a multitude of stakeholders, from the micro level (citizens, property owners, business leaders) to the macro level (regional, national, and international levels) and local governments. **Cooperation** among these diverse stakeholders is essential to the success of NBS.



Global NBS ranking by the International Union for the Conservation of nature (IUCN), 2020.



NBS ranked by students from the Nature and the City group using existing typologies.

The *CEO Water Guide (2022)* has created a guide to stakeholder engagement that includes 10 of its best practices – involving a wide range of stakeholders, prioritising transparency and accountability, co-creating rather than imposing, etc. These measures and this guide were developed in response to criticism of NBS by indigenous and local communities. One concern is that the term NBS is too vague, allowing governments or companies to take advantage of this political trend without taking appropriate action, or even causing harm, under the guise of 'greenwashing'. Secondly, local knowledge and existing communities are sidelined, often leading to expropriation and displacement in the name of 'progress'. Finally, some fear that the focus on NBS distracts from the more important need to decarbonise.

The United Nations Convention to Combat Desertification (2023) explains how governments can adopt **laws that create an enabling environment** for the implementation of NBS. This legislation may include financing for drought risks, enforcing environmental, social, and governance standards that incentivise the market to invest in resilience and NBS, or using drought resilience financing for projects to attract private investment. At the international level, several initiatives are also in place to support the expansion of NBS, such as the United Nations Sustainable Development Goals.

### ENSURING THE SURVIVAL OF FRESHWATER ECOSYSTEMS

The Ramsar Convention, which established international protection for **wetlands** in 1971, defines them as "areas of marine water whose depth at low tide does not exceed 6 metres". Currently, sites protected by this convention cover 257 million hectares worldwide.

These environments are being damaged by numerous coastal infrastructures and the overconsumption of marine resources: we are losing wetlands three times fas-

ter than forests (UNEP, 2022). According to the Donor Collaborative for Mediterranean Freshwater Ecosystems (DIMFE), Mediterranean freshwater ecosystems are particularly affected by the climate crisis and the increasing scarcity of water sources: in 65 years, the Mediterranean has lost nearly half of its wetlands and nearly 30% of freshwater vertebrate species on average.

The loss of these ecosystems threatens both the preservation of species that are an integral part of local cultures and the **freshwater ecosystem services** that are essential to Mediterranean cities. These include drinking water, irrigation, and municipal sanitation services, as well as services related to combating climate change in cities, such as carbon sequestration, flood management, water pollution remediation, and biodiversity support. The services provided by freshwater ecosystems also have enormous economic value in the Mediterranean region. For example, in south-western Europe alone (south-western France, Spain, and Portugal), ecosystem services in terms of drinking water and water used in agriculture have been valued at €56.7 billion (García-Rubio et al., 2024).

These protected areas are part of a broader approach to **taking ecosystems into account from the planning stage onwards**. Vitoria-Gasteiz in the Spanish Basque Country is a good example of a city that has integrated the management of these ecosystems into its urban water cycle management. This provincial capital of more than 250,000 inhabitants plans the city in concentric circles that ensure the presence of a green belt in the peri-urban area, surrounded by an agricultural belt and then a forest area that guarantees water filtration. Within its green belt are natural and semi-natural spaces, parks, and wetlands dedicated to soil permeability in the event of heavy rainfall, greater resilience to heat, and the presence of biodiversity close to the city.

It therefore seems essential to integrate green infrastructure projects into the land-use planning process (Fotografos, 2014). The European legal framework provides concrete support for developing this type of project and giving a voice to ecosystems (Natura 2000 sites, Commission Biodiversity programmes).

The most effective urban policies and actions for enhancing local areas while protecting freshwater ecosystems are NBS, which can be **supported by digital and technological measures**. Indeed, data collection and artificial intelligence can help predict water consumption at different scales and thus manage the various stages of the water cycle and its use in cities: acquisition, storage, distribution, use, treatment, and reuse (Iervolino, 2021).

The "OurMed" project in Arborea (Sardinia, Italy) shows how NBS and digital solutions can be used together to protect ecosystems, enhance territories, and enable local communities to participate in freshwater management policies.

Thanks to European funding, OurMed has collaborated with the region of Sardinia, the municipality of Arborea, and the local population to solve problems related to the management of scarce water resources and ecosystems in three local wetlands, which are protected at the national and international levels. One of the main issues is nitrate pollution of groundwater caused by intensive dairy farming, on which a large part of the population depends economically.

The implementation of NBS and digital solutions, such as modelling, high-definition sensors and cameras, and digital twins<sup>9</sup>, has helped restore the ecosystem of natural wetlands while managing water consumption and discharge through technological means and enhanced dialogue. This practice is easily replicable in the Mediterranean and beyond, as this project, designed within a European framework, offers digitally-based solutions that are affordable both financially and technically.

## NBS LIMITATIONS

Despite the many advantages of NBS, recent work has highlighted their **potential drawbacks**. These range from natural challenges such as irrigation requirements (Pataki et al., 2011) to societal challenges such as the high costs associated with modifying, renovating, or building around existing infrastructure, as well as institutional, political, social, and behavioural factors that evolve during a project and affect stakeholder engagement (Puppim et al., 2022).

In addition, there is a growing body of work on NBS and **equity**. NBS can be used as a tool to dismantle historical systems of land dispossession and exclusion of certain groups from nature and ecological resources, but they can just as easily contribute to exacerbating these harms. As with grey infrastructure, the selection, design, implementation, and management of NBS can also negatively impact historically disadvantaged communities.

## EXAMPLE OF NBS FROM CASE STUDIES

### *Cape Town*

Natural hazards such as drought and flooding must be understood from a **socio-ecological and politico-ecological perspective**. Water-related risks in coastal cities result from a combination of biophysical and social factors.

For example, flooding disproportionately affects informal settlements in Cape Town (Cape Flats), where residents have limited resources to cope with it. Unlike more affluent neighbourhoods located at higher elevations, the Cape Flats lack adequate drainage systems, are frequently affected by sewer flooding, and suffer from poor sanitation. The low elevation of the area, its proximity to the coast, high water tables, and sandy soils further increase exposure to flooding. These risks are deeply rooted in social inequalities and historical power relations, particularly the legacy of racial inequality in South Africa that led to the forced displacement of hundreds of thousands of 'black' and 'coloured' residents to low-lying, flood-prone areas (Enqvist et al., 2019).

Recognised globally for its biodiversity and wetland habitats, the City of Cape Town has incorporated NBS principles into its urban management approach for more than two decades. The recent drought crisis has catalyzed a more systematic integration of NBS into the management of the city's watersheds and watercourses, and for a more holistic governance of the entire urban water cycle. However, governance challenges and persistent structural inequalities continue to hamper the effectiveness and inclusiveness of these interventions.

### *Liveable Urban Waterways*

Cape Town has numerous watersheds, rivers, wetlands, and lakes. However, many watercourses are in critical condition due to intense urban development and stormwater engineering practices implemented since the 1950s. Wetlands have been drained, rivers have been channelled or buried in pipes, and the natural water cycle, as well as the river-wetland-aquifer continuum, has been disrupted. Pollution has worsened due to the uncontrolled discharge of waste, sewage, and wastewater into watercourses.

<sup>9</sup> The digital twin is a technological and digital tool that enables the creation of a virtual replica of physical water systems (rivers, lakes, reservoirs, and others). With this accurate representation of freshwater ecosystems, local authorities and stakeholders can develop models and simulations of how physical water systems evolve, providing detailed analyses and an overview of the state of ecosystems and freshwater resources.

However, waterways provide provisioning services (food and water resources), regulating services (climate regulation and flood protection), cultural services (recreation and education), and supporting services (soil formation and the water cycle). To restore these important functions, the city has undertaken more than 19 waterway rehabilitation projects since 1994, including the Liveable Urban Waterways (LUW) programme. Launched in 2018, LUW is managed by an interdepartmental team comprising five municipal departments and takes a systematic and collaborative approach to rehabilitating waterways across Cape Town. Starting with eight rehabilitation projects, the programme has a total investment of over R100 million (approximately €5 million) and aims to expand its activities to other catchment areas in the future (CoCT, 2021). Objectives include creating space for water, improving water quality, restoring ecological function, reconnecting watercourses with groundwater, strengthening social cohesion, and providing social and economic benefits.



Rehabilitation site along the Weslatke river in Cape Town. Credits : Ebou Ceesay

### **Mexico City - Chinampas de Xochimilco**

Xochimilco is a neighbourhood in the southern part of Mexico City that was once composed of Lake Xochimilco, but is now mainly composed of canals and waterways. In pre-Hispanic times, indigenous peoples dug canals to navigate and created floating gardens in the river, known as *chinampas*, by excavating the lakebed. The *chinampas* were used as agricultural sites, as their fertile soil allowed for up to seven harvests per year and the cultivation of a wide variety of plants. Spanish colonisation led to the misuse and destruction of the land and *chinampas*. Over time, continued urbanisation encroached on the *chinampas*, leading many to be abandoned due to poor soil quality or to be used for other purposes, such as city expansion. With the rapid growth of the town in the 1980s, the *chinampas*

of Xochimilco were designated a UNESCO World Heritage Site. Despite this designation, the municipality has devoted little time and resources to maintaining this historic and ecological site. The end of the communal land system in 1992 (Pathways Network, 2021) led to increased fragmentation and privatisation of the *chinampas*, as well as land and water pollution.

Furthermore, as the city centre of CDMX developed, large quantities of water from Xochimilco's springs were pumped to the city centre, preventing the aquifer from recharging. This has been going on for so long that today the water in the Xochimilco canals no longer comes from natural sources but from treated wastewater pumped from the city centre to this area. This continuous pumping has also caused the ground to subside, leading to flooding during heavy rains and landslides on the *chinampas*, which further erode them. The *chinampas* have also become an increasingly popular tourist attraction in CDMX, polluting the canals with boat fuel and disrupting the local flora and fauna.

Due to these challenges and the lack of government intervention, several NGOs are campaigning to prevent the deterioration of these *chinampas*, restore natural waterways, and preserve traditional agricultural practices. Among these is *Chinampas en Movimiento*, whose mission is to "revive the production of ancestral *chinampas* through an agroecological, sustainable and shared responsibility model, to improve the social ecosystem, raise awareness of natural, cultural and food value, and contribute to the local economic development of Mexico City" (*Chinampas en Movimiento*, n.d.). This work is carried out through five lines of action: support for farmers, conscious tourism, innovation, ecological education and workshops, and joining forces through strategic alliances.



Sailing on the *Chinampas de Xochimilco*. Credits : Maxwell Garcia, 2025.

This example illustrates the fragmentation of water governance, the colonial legacy of water extraction and use, the relationship between protected lands and housing, the economic link with NBS, and the value of indigenous practices in restoration projects.

## WAYS TO ENCOURAGE NBS IN THE FUTURE



Jeanne d'Arc school's educational garden | © CAUE de Paris, Théo Ménévard

The three cities studied emphasised the importance of **raising public awareness** of the water crisis and the measures that can be taken at the individual and community level to improve the success of NBS projects.

In Mexico City, for example, the *Canal Nacional* project promoted educating children about the canal and encouraging them to play around it to motivate their parents to take care of it and stop throwing waste into the waterway. In Paris, the "*Cours Oasis*" (Oasis schoolyards) programme demonstrated the integrated nature of NBS projects as places of co-design and teaching, with many schools incorporating environmental education into their curricula after involving their pupils in consulting on school playground development plans.

Given historical inequalities in access to nature and natural resources, land dispossession, and persistent socio-economic disparities, nature-based solutions can also be an opportunity for game-changing **economic empowerment**. In Cape Town, for example, the Khayelitsha Community Hub removes water hyacinth from wetlands and produces biochar, which is then sold as fertiliser in local markets. Empowerment, whether individual or community, allows more time and attention to be devoted to continued growth and development, which, for many, involves environmental conservation measures such as NBS. ■



Informal habitat along the canals, Xochimilco, Mexico City. Credits : Maxwell Garcia, 2025.

# INTEGRATED STORMWATER MANAGEMENT (ISWM)

## RAINWATER TRANSFORMED INTO A RESOURCE FOR URBAN ECOSYSTEMS

At the turn of the 1990s, a new paradigm emerged: after being viewed through the prism of risk and in isolation, stormwater is finally considered a resource for residents and development. Urban projects can now be built around soil and vegetation, connected by water.

To **rebalance the water cycle**, "alternative techniques" have been developed to manage rainwater at the source. These developments take the form of **vegetated structures that allow gravity-fed, open-air infiltration of water**, which appear to be a relevant response to move beyond the "all pipes" approach. The performance of these nature-based solutions (green roofs or green spaces, hollows, swales, ditches, and dry basins) is generally superior to traditionally favoured structures such as underground basins or storage pipes. The table below illustrates the diversity of possible stormwater management solutions at the plot level.

Type de solution	Coût global	Mise en œuvre	Entretien	Robustesse	Possibilité d'adaptation	Emprise au sol	Pollution chronique	Pollution accidentelle	Climat	Paysage / cadre de vie / nature	Performance
Toitures stockantes végétalisées		Pas de technicité particulière mais très soignée		Durée de vie de l'étanchéité				Sans objet	Isolation thermique		+++
Espaces verts en creux, noues, fossés et bassins secs						Variable selon le type de solution. Réduite pour noue ou fosse, plus importante pour espace vert creux ou bassin à sec. (voir si utilisation pour agèment.)					+++
Revêtements perméables		Variable selon le type de solution. simple pour grilles, revêtu ou béton poreux, dalles, longue pour pavés	Solution à éviter dans des zones où beaucoup de lignes sont susceptibles de venir coloniser le revêtement	Type de revêtement à adapter aux usages (trafic, grilles/ dallage...)						Variable selon le type de solution. solution végétalisée plus favorable aux aspect environnementaux et esthétiques	++
Structure réservoir			Technique recommandée sans contrainte particulière si facteur de concentration < 1								.
Tranchée d'infiltration											+
Puits d'infiltration					Déconseillé car très sensible au colmatage (facteur de concentration important, pollution du la nappe, entretien)						-
Bassin enterré					Déconseillé car facteur de concentration important et conception, entretien et voirie délicats						-
Espace inondable											++
Conduite stockante											-

Nantes Métropole, « Intégrer la gestion des eaux pluviales dans son projet. Volets 1 & 2 », 2021. (Integrating rainwater management in one's project)

Students wanted to explore Integrated Stormwater Management (ISWM) in greater depth, as it now requires integrating rainwater into urban projects. City stakeholders are particularly involved, as the urban fabric, due to its impermeable nature, generates runoff and reduces infiltration. These two issues have led to laws and regulations requiring cities to reduce their impact on the water cycle by promoting temporary retention of rainwater on the plot and its infiltration into the ground.

ISWM is now widely used. A process with beneficial effects on soil and water quality, and urban liveability, it helps increase and strengthen nature in cities and, indirectly, develop **ecosystem services** such as urban cooling, biodiversity, and the amenity value of landscaped areas. These services are based on the juxtaposition of green (vegetation), blue (wetlands), and brown (earth and soil) infrastructure.

Firstly, rainwater infiltration helps **combat flooding**: thanks to de-impermeabilisation or the promotion of open ground areas, it limits runoff at the source. Encouraging the infiltration of light rain also helps keep the soil relatively moist, making it ready to absorb heavier rainfall and **less prone to drought**, thereby limiting the risk of erosion, soil subsidence, and clay shrinkage and swelling<sup>10</sup>. Rainwater infiltration also facilitates groundwater recharge.

Runoff from impermeable surfaces also increases the pollution of rainwater, which becomes laden with contaminants. Sewerage systems also pose a significant risk of cross-contamination between wastewater and rainwater, even when systems are separate. Infiltration, therefore, **limits the presence of pollutants in rainwater** by relying on the soil's filtration capabilities, provided by flora, or on the degradation of organic contaminants by soil fauna. Thus, vegetation is needed in rainwater infiltration structures to enhance retention and degrade contaminants, and to support the soil's protective role in groundwater.

Finally, infiltration helps **combat heat islands**. By increasing vegetation, rainwater management areas on plots facilitate photosynthesis. This process, made possible by sufficient soil moisture, has cooling properties.

10. Movement of clay soils, which, when saturated with water, suddenly shrink and swell under the effect of intense and occasional rainfall.

At the same time, vegetation and the intense activity of soil fauna play a central role in **capturing and sequestering CO<sub>2</sub>**. Urban rainwater infiltration, therefore, promotes healthy soil and enhances this process. All of this contributes to **urban liveability and well-being**, a central objective of urban planning. Numerous studies show that green spaces in cities contribute directly to residents' health, including stress reduction, improved physical condition, and a sense of belonging to a local community (Eder et al., 2012).

### MULTIFUNCTIONAL SPACES TO "REPAIR THE CITY"

Integrated stormwater management can serve as a **structuring axis for urban development projects**, in aesthetic, ecological, and cultural terms, if considered at an early stage. Integrated stormwater management enables rethinking the uses of spaces and the ecological footprint, in a context of land-use restraint and adaptation to climate change in cities. It thus promotes the creation of multifunctional spaces that are optimised and used more frequently.

This is achieved by facilitating dynamic interaction between the blue, green, and brown infrastructure and the social fabric to ensure the overall health of a neighbourhood. These spaces (basins, parks, squares) are designed for both dry and wet uses: sports fields, promenades, or infiltration areas change their use depending on the weather. An integrated design can reduce the initial cost if the uses and ecosystem functions are well thought out. On the other hand, overall maintenance costs increase, requiring a transfer of resources from sanitation services to green spaces.

In municipalities with limited financial or human resources, **sharing costs for multifunctional spaces** can ensure the long-term viability of ISWM, as the spaces designed meet residents' needs.

This type of management requires an **interdisciplinary approach**, and therefore, cross-functional collaboration and consultation on the design and implementation of the project. This necessitates more time for upstream design and development, involving urban planners, hydrologists, landscape architects, green space services, and sanitation services. Developers must advise local authorities (often with limited resources) to clearly include "at the source, open air and gravity-fed" management in local urban planning (PLU) documents, water law files (*dossiers loi sur l'eau*), and rainwater zoning, so that both the private and public sectors apply the same logic.

To build a **water culture**, avoid greenwashing and ensure sustainability, residents and managers must be informed and involved from the design stage onward: daily appropriation, understanding of hydraulic functions, and acceptance of a more "wild" aesthetic. The French garden model (control, homogeneity) is opposed to a dynamic vision that promotes biodiversity and self-regulation; mediation is essential to gain acceptance for this change. The integration of blue, green, and brown infrastructure must be complemented by "**social infrastructure**": co-production of spaces, awareness-raising, and consideration of actual uses to ensure their ecological and social functioning. Giving space back to permeable, multifunctional green spaces meets city dwellers' expectations for well-being and strengthens cities' resilience to climate change.



Grønningen-Bispeparken (Copenhague, Danemark) by dry weather and by rainy weather. By SLA architects. Credits : sla.dk

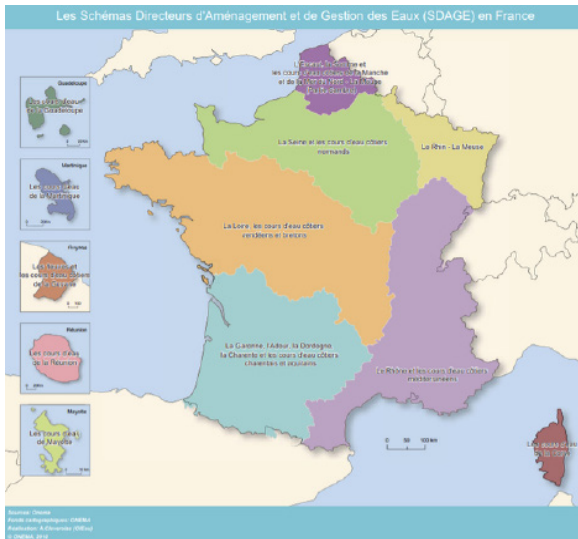


### ISWM: A LEVER FOR ADAPTING TO THE REGULATORY, ECONOMIC, AND ENVIRONMENTAL CHALLENGES POSED BY WATER.

#### *A lever for adapting to regulatory and legislative obligations*

The main obstacle to the effective implementation of water policy is the **multiplicity of institutional and administrative actors involved**.

The historical separation between land use planning and sanitation management continues to be reflected in the distribution of responsibilities within public services. Furthermore, the integration of ISWM into urban planning documents such as the Local Urban Development Plan (PLU) is not a prerequisite for its implementation. Operators can play a leading role by advising local authorities and guiding planning departments towards including ISWM in the PLU. Most of them welcome this advisory role, especially in a context where responsibility for the management of the aquatic environment and flood prevention (GEMAPI) has recently been transferred to them by decentralisation laws.



The 6 watersheds in metropolitan France and the SDAGE (*Schéma directeur d'aménagement et de gestion des eaux* - Water Development and Management Master Plan). The Rhône Méditerranée Water Agency includes Corsica in its missions. Credits : Gest'eau.

Several structural elements point to a **regulatory dynamic that is increasingly favourable** to the widespread adoption of ISWM in development policies. The Water Agencies, which have been structuring water policy in France since 2024, have strengthened their commitment to ISWM, reflecting a desire to integrate stormwater issues into land-use planning policies further. Organised under a watershed management approach, the Water Agencies are actively involved in fostering a common culture of sustainable water resource management.

A second lever for change is the **pooling of expertise between local authorities** through specialised inter-municipal associations, in response to the increasing technicality of ISWM-related issues. This pooling of expertise helps to strengthen the effectiveness of local public action while facilitating the adoption of regulatory measures by operational actors.

Finally, a third structuring factor is the **regulatory framework applicable to development projects regarding aquatic environment protection**. The *dossier loi sur l'eau* (Water Law File or DLE)<sup>11</sup> imposes a series of requirements on projects with potential impacts on watercourses, wetlands, or groundwater, obliging project developers to implement the ARC (Avoid, Reduce, Compensate) sequence, thereby strengthening the integration of environmental issues upstream of development. Although complex to implement, the DLE is a key tool for environmental governance in urban projects. It requires the implementing authorities to have a high level of technical expertise and enhanced coordination with decentralised government departments.

These regulatory and institutional developments mean that ISWM can no longer be viewed as an experimental or opportunistic approach, but rather as a **principle of action** that is set to become established in the long term in local authority practices and the management of development projects.

**A lever for adapting to the economic constraints weighing on development and property promotion**

Development projects seeking to integrate the principles of ISWM, urban re-naturalization, biodiversity preservation, and hydrological improvement can now draw on a variety of **public aid schemes** designed to encourage sustainable, climate-resilient, and nature-based development. For example, at the EU level, the ERDF (European Regional Development Fund) provides co-financing for sustainable regional projects, and more specifically, the LIFE programme (the Commission's financial arm dedicated to the environment and climate).

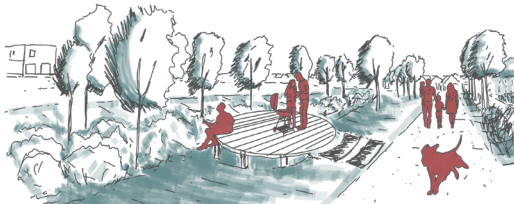
At the national level, the Green Fund, launched in January 2023, aims to accelerate the ecological transition, and the Water Agencies subsidise projects that incorporate the principles of sustainable rainwater management. There are grants focused on local authorities and developers, as well as some aimed at individuals who wish to manage rainwater sustainably (tax credit for ecological transition - *Crédit d'impôt pour la transition écologique*).

Furthermore, ISWM is recognised by development stakeholders as a **cost-reduction lever**. While it may represent an initial investment in specialised engineering, this requirement is largely offset by the savings made during the construction phase. However, this potential saving depends heavily on the quality of implementation, as poor organisation or unforeseen events can lead to additional costs.

11. In accordance with article L.211-1 of the *Code de l'environnement* (Environmental Code)

Moreover, the correlation between the technical complexity of the structures and their cost is a key factor in assessing the economic benefits of ISWM. The further the chosen solutions stray from a landscaping-based approach towards sophisticated technical systems, the higher their unit cost for managing one cubic metre of rainwater.

ISWM also appears to be a **sustainable development tool with high social added value**. Indeed, as we have seen, although the maintenance costs of green spaces may seem higher in the short term, their ability to generate co-benefits, such as improved living conditions, climate resilience, and urban biodiversity, is a decisive advantage.



Rethinking appropriate and inhabited spaces in Giberville.  
Credits : students of the group with Nexity

### ***An opportunity to develop certification into a project monitoring tool***

The ISWM label ("GIEP" label in French), developed by the QUALITEL association, offers a dynamic approach structured around monitoring the project throughout its various phases. It has the advantage of being compatible with many other certification schemes and the European Green Taxonomy. From this perspective, ISWM can also contribute to the growth of regulatory and extra-financial obligations, particularly in the field of CSR.

The **Label Signature Biodiversité** (Signature Biodiversity Label) thus enables accurate, continuous measurement of environmental impact, as well as driving and enriching companies' CSR policies. By offering a structured assessment tool, this label meets a need for project owners that goes beyond simple labelling or ad hoc monitoring of construction sites. Its comprehensive approach allows ISWM to be integrated into a broader vision of the ecosystem services provided by projects: regulation of the water cycle, improvement of local biodiversity, climate comfort, landscape anchoring, and quality of life for users. T

his systemic orientation helps to reposition ISWM not only as a technical solution but also as a **strate-**

**gic vector for the ecological and social transitions**, compatible with the contemporary expectations of businesses, local authorities, and citizens.

### **ISWM IS NOT SYNONYMOUS WITH VIRTUOUS PROJECTS**

Many projects that showcase integrated stormwater management techniques do not incorporate a comprehensive, cross-cutting approach to the role of water and are **more a form of adaptation to regulatory constraints than a genuine strategy** for adapting to and mitigating the effects of climate change. As a result, some stakeholders continue to manage stormwater traditionally, while labelling the technical systems used as "integrated". However, a neighbourhood that uses ISWM to obtain planning permission without engaging in a comprehensive reflection on reducing the development's environmental impact will be of lower quality in terms of urban planning, landscaping, and the environment.

This weakness in content can be explained primarily by a material weakness linked to the **complementarity between urban planning documents and enforceable hydrological documents**. Consequently, this creates inequality between cities that have the capacity to update their urban planning documents and municipalities with fewer resources. The PLU has become the primary document for imposing stormwater management obligations at the plot level in building permits. In many municipalities, this possibility is not being explored.

The second weakness lies in the **density of environmental standards** that the investigating authorities must verify for projects. Finally, building permit authorisations remain at the discretion of mayors. Local clientelism dynamics with elected officials or representatives of the investigating authorities can hinder the proper application of environmental standards. These mechanisms of information and power asymmetry lead to the granting of building permits that do not fully comply with the urban planning or environmental code.

### **THE CONDITIONS FOR EFFECTIVE ISWM**

#### ***A solid regulatory framework and governance***

The French legal framework, structured in particular around GEMAPI (*Gestion des Milieux Aquatiques et Prévention des Inondations* - Aquatic Environment Management and Flood Prevention), is a powerful lever for promoting the integration of ISWM into urban projects.

Water agencies have gradually imposed integrated planning approaches in response to growing challenges such as conflicts of use, degradation of water resources, and extreme events linked to climate change. This framework has led to an **increase in compliance obligations**, requiring project owners to incorporate measures to promote rainwater retention, infiltration, or local reuse from the design stage onward. In this sense, water policy acts as a **driver of technical and institutional transformation**.

However, its effectiveness remains uneven across



Small square in Rennes, adopting ISWM. Credits : picture taken during a field trip to Rennes by students from the group with Nexity.

the country and is constrained by several limitations. The proliferation of competence levels resulting from decentralisation processes makes water policy difficult for many stakeholders to understand. The distinction between GEPU (urban rainwater management) and GEMAPI (Aquatic Environment Management and Flood Prevention) perimeters requires clarification, particularly by consolidating these competences into specialised associations better able to coordinate actions at the watershed level. This diagnosis is reinforced by the lack of knowledge of the rules among certain local stakeholders, who are often untrained in the legal and technical subtleties of water management.

With this in mind, **consolidating water governance bodies**, combined with a general increase in the skills of training officers, is essential to ensure the fairness and effectiveness of national water policies. Specific governance structures, such as water syndicates, which have had GEMAPI powers since 2014, can drive strong territorial dynamics, establish enforceable rainwater zoning in urban planning documents, and ensure high-quality project monitoring.

### ***Preparing the retrocession***

The sustainability of a project is also ensured by considering its handover phase from the outset. This step, often overlooked, is crucial to ensuring the maintenance, proper functioning, and institutional ownership of the systems. When future management arrangements are anticipated, formalised, and discussed between developers and local authorities, the transition from construction to operation is smooth. However, in many cases, this coordination remains insufficient. The lack of mutual understanding and shared standards between local authorities and developers undermines the entire process. It is therefore essential to **establish consultation forums from the outset of the project**.

### ***Training stakeholders and encouraging their proactive approach***

The success of these projects also depends on **local elected officials' ability to promote a strong regional vision** that integrates water issues into urban planning, landscape, biodiversity, and climate policies. Clear planning, a shared project culture between different departments, and the support of a competent and committed design office are all favourable conditions. However, the lack of training on the technical, legal, and insurance aspects of ISWM prevents design offices from fully committing to the future performance of the structures.

It is also crucial to provide training or advice to local authorities to reduce their resistance to certain changes in alternative stormwater management, which may affect residents' perceptions and use, the cost of maintaining spaces, or health concerns. In addition, educational efforts are needed to **raise awareness of public subsidies**, which are often underutilised due to uncertainty about eligibility, opaque allocation criteria, or mistrust of institutional injunctions.

Finally, ISWM must be a **long-term endeavour and requires a cross-disciplinary approach**. Rainwater is an element that creates landscaped, nourishing, and inhabited spaces that, to be functional, require the involvement and consultation of landscape architects, green space services, residents, road services, and hydraulic engineers. This change requires **reorganising and upskilling services**. Medium-sized and large urban areas have the capacity to undertake these changes, but smaller ones face greater difficulties. The students provided the partner, Nexity, with a methodology to best support local authorities in implementing ISWM, based on an inventory and analysis of existing projects across France.

**Raising awareness and involving residents**

This training and awareness-raising effort must also reach residents, who will be the primary users of these spaces.

This is very different from the relationship residents had with the technical structures, often buried and invisible, used for stormwater management in the past. Residents play a key role in the daily management of green spaces, in their maintenance, but also in their **symbolic appropriation**. Environmental education, carried out from the design phase onward, is essential to create a link between users and technical systems that are often invisible or poorly understood. By giving residents an active role in the management of spaces, local authorities can reinforce the sustainability of structures, prevent damage, and, more broadly, integrate developments into a dynamic of local ecological transition. The aim is therefore to anchor ISWM in a shared and democratic culture, nourished by participatory tools and a landscape-based reading of the territory. ■

**Quand la mise en œuvre doit changer en cours de route :**

- Il faut s'assurer qu'une équipe pluridisciplinaire compétente en éco-hydrologie a construit une culture commune de la gestion intégrée des EP, afin de pousser la démarche jusqu'au bout, même quand des imprévus surgissent sur le chantier.



*Une structure de maison abandonnée en cours de chantier, à Laillé*



*Repenser les usages en cours de chantier, une serre et aire de jeux alimentée par les EP, à Laillé*

**Accompagner les acteurs dans la transformation des usages en cours de chantier :**

- Assurer une démarche transversale entre acteurs en décloisonnant les expertises, inclure le point de vue éco-hydrogéologique et écouter les envies des habitants en termes d'usage des espaces qui profiteraient des EP.
- À Laillé, une maison a été abandonnée en cours de chantier, mais rien n'empêche de penser à une serre, et à des espaces perméables arrosés par les EP.

# TWO CONCRETE TOOLS : THE INOND'ACT MODEL AND THE RÉVÉLATEUR (REVEALER)

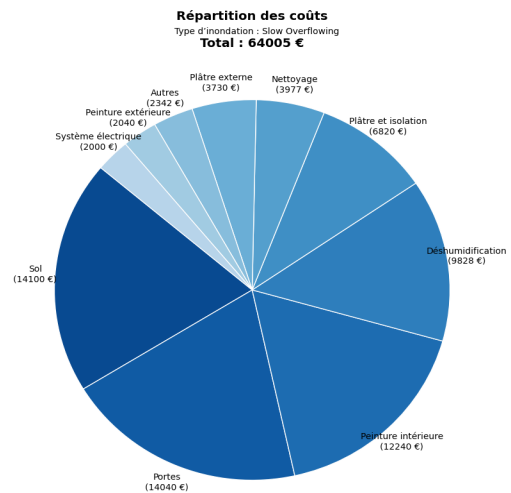
## THE INOND'ACT MODEL

Students at the Urban School, in partnership with the Observatoire de l'Immobilier Durable (OID), have developed an algorithmic model called "Inond'Act" that estimates the cost of freshwater flooding to residential buildings in France and identifies the most cost-effective adaptation measures to reduce damage.

### Why was this model created ?

According to the Caisse Centrale de Réassurance (CCR), approximately half of the economic costs of natural disasters in France since 1982 have been related to flooding. In 2023, flood damage cost more than €2 billion. This poses a challenge for the real estate sector and our insurance model alike, as the **limits of the French natural disaster coverage system** could soon be reached.

The CCR, the public body responsible for covering the cost of natural disasters, has been operating at a loss since 2016. In addition, faced with rising risks, private insurance companies are raising premiums and deductibles, prompting individuals and municipalities to cancel insurance policies that have become unaffordable. For example, according to the stakeholders the students met, around 2,000 municipalities in the Nord-Pas-de-Calais region are **self-insured**.



Costs distribution for a standard individual house, in case of flooding due to overflow. Credits: students of the groupe with OID.

As a result, funds that could have been allocated to municipal development are now being set aside to cover damage caused by flooding, among other things. Given the increasing intensity and variability of weather events driven by climate change, there is an urgent need to implement adaptation measures that reduce buildings' vulnerability. However, the **lack of quantitative information** to assess the economic benefits of these measures is holding back households and public and private stakeholders alike.





**"LE RÉVÉLATEUR" : A GRAPHICAL TOOL FOCUSED ON ALTERNATIVE RAINWATER MANAGEMENT AND THE BROADER CONTEXT OF THE WATER LANDSCAPE**

The departmental executive adopted the "Seine-Saint-Denis, Land of Water" (*La Seine-Saint-Denis, territoire d'eau*) strategy on April 4th, 2024. In the coming years, the Department of Seine-Saint-Denis will face many challenges related to maintaining the efficiency of its sanitation network, which must still adapt to future meteorological changes linked to climate change, and reducing the risk of flooding, while striving to provide a healthy living environment for its inhabitants.

In Seine-Saint-Denis, the approach prioritised by most of the interviewed stakeholders to address water-related climate issues is water infiltration at the source. However, the issue of water is still addressed primarily from the perspective of nature in the city and the quality of the living environment, rather than infiltration, with different acculturation depending on the profile of the operators.

Despite sanitation regulations within the Department and local public institutions, as well as financial incentives offered by several institutions (AESN, the Region, etc.), alternative management approaches (in reference to the the "all-pipe" system) are seen as a constraint on development projects. This is linked to the fact that urban development stakeholders sometimes seem to have a poor understanding of the full constellation of water stakeholders and the tools available to integrate them into development projects better.

It therefore seemed appropriate for the Water and Sanitation Department (DEA) of Seine-Saint-Denis and the students to produce a graphic tool focusing on rainwater management at the source and the broader context of the water landscape. The final product of this project, "Le Révélateur", aims to support development stakeholders in making water a primary concern in their practice (see the tool pages 57 to 59).

**Challenges and objectives**

The mission proposed by the Water in the City Bureau of the Seine-Saint-Denis Department (*Bureau de l'Eau dans la Ville du 93*) aims to redefine and materialise the place of water in Seine-Saint-Denis, both in perceptions and in development practices. Placing water at the heart of the project means taking a new look at water management: an integrated approach that pays particular attention to the project's geographical and territorial anchoring. In a context of land scarcity, this management

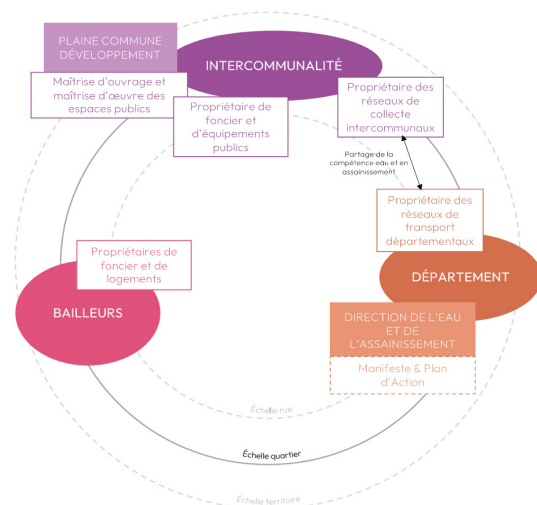
involves, in particular, considering the pooling of uses in infiltration and retention areas to benefit from ecosystem services and enhance the value of water resources.

**Breaking out of disciplinary silos** and engaging all stakeholders of the "urban factory" is essential to successfully integrating water issues systematically into development projects, beyond the technical aspects of traditional pipe-based engineering. This collective project addresses both governance issues and more subjective and sensitive issues: the representation of water in individual and, above all, collective perception. The project thus combines the strategic challenges of Seine-Saint-Denis as a "water territory" with the operational challenges of the departmental strategy through the creation of development tools.

The project team identified two main challenges in designing the Révélateur:

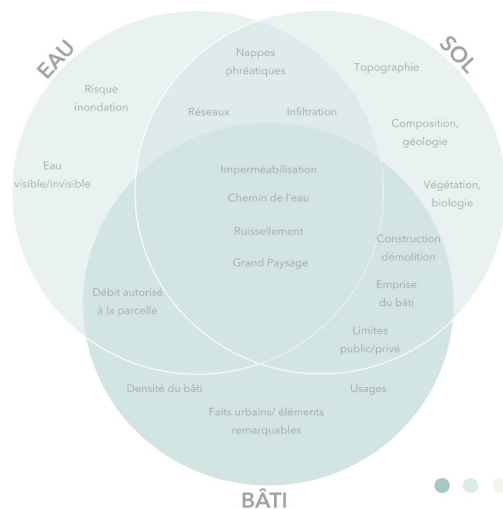
**1. Readability: Making the constellation of water stakeholders in Seine-Saint-Denis readable.** Reporting on the governance relationships between them, their skills, and the various initiatives to clarify collective action, legitimise it with the chosen interlocutor, and encourage synergies.

**2. Visibility: "Making the invisible visible"** by reporting on the elements that make up the water system (water, soil, vegetation, buildings). Highlighting the importance of technical solutions for integrated water management by making them more tangible to the target audience.



The governance at the neighborhood scale. Credits : students from the group with the Water and Sanitation Department of Seine-Saint-Denis.

The *Révéléateur*, therefore, aims to serve as a **decision-making tool and a means of dialogue**, enabling developers to justify their positions and share a common vision of water management for the project with other stakeholders. The tool highlights the world of water at different scales and through various modes of representation, revealing the links within the "water-soil-built heritage" system.



Understanding the articulation of the different issues. Credits: students from the groupe with the Water and Sanitation Department of Seine-Saint-Denis.

To test the *Révéléateur*, a project was identified, along with the stakeholders involved. The site at the centre of the first version of the Revealer is the **Orgemont neighbourhood** in Epinay-sur-Seine. Having already received initial funding from the ANRU (*Agence Nationale pour la Rénovation Urbaine* - National Agency for Urban Renewal) in the 2000s, this neighbourhood of large housing estates is once again undergoing redevelopment, supported by the NPNRU (*Nouveau Programme National de Rénovation Urbaine* - New National Urban Renewal Programme) since 2016.

The redevelopment of the neighbourhood will be organised around an approach to opening it up to the Seine, renewing the housing stock, and reviving the dynamics of shops and public facilities. The site covers several water-related issues (accessibility to waterways, rainwater runoff, potential for de-impermeabilisation, groundwater overload, etc.).

### Principles of representation

The *Révéléateur* was initiated to establish principles of representation: which legend and which graphic transcription should be used to highlight water issues

in an area such as Orgemont, and more broadly in Seine-Saint-Denis?

The team was confronted with several questions of representation, such as:

- How can the temporality of water be illustrated? How can the presence of water, between permanence and ephemerality, be illustrated while avoiding a representation of spaces that are either always flooded or completely devoid of water?
- How can we illustrate the movement of water? How can we indicate its different "states" or its level of pollution?
- How can we represent the permeability of soil (linked to the nature of the soil) in relation to its infiltrability (which takes into account the concept of risk)?
- How can we represent the superimposition of uses?
- How can we clarify the representation of the governance system? On the *Révéléateur*, a simplified version of the actors and governance is presented in a graph. On this graph, three concentric circles represent the three levels of involvement, allowing the public to understand which actors are involved at which project level.

The students focused on the following three scales:

- **The large landscape scale:** an analysis of the territory in all its dimensions (topological, geological, and landscape-related) that reveals visible and invisible water, both on the surface and underground.
- **The neighbourhood scale:** this scale allows for an assessment of the topography at the site level and a more detailed understanding of water runoff.
- **The street scale:** Rue de Rennes was identified for its stormwater management issues. Focusing on this level provides details on the identified issues and also highlights potentially changeable spaces by integrating the question of uses and their coexistence with rainwater.

This tool, based on an assessment of the various types of stakeholders in Seine-Saint-Denis's relationship with water, is intended to be replicated and reappropriated by other territories. Indeed, a subject such as that of the "water territory" challenges traditional urban planning practices, and this goes beyond Seine-Saint-Denis.

Like other topics related to ecological transition, it challenges well-established models of the artificial management of natural elements in highly urbanised environments. It goes beyond treating nature as a constraint to seek better composition with it. This collective project questioned traditional models of urban development and explored how to design projects that address issues such as water in cities.

Students sought to highlight **the need to produce graphic documents** that reveal specific issues, easily accessible and understandable to a wider audience, and, above all, to integrate water-related issues that had previously been overlooked in the development of new urban projects.■



The Révélateur's main objectives. Credits : students from the group with the Water and Sanitation Department of the Département de la Seine-Saint-Denis.







# EXECUTIVE SUMMARY

This third issue of the Lessons from the Lab collection offers a transversal analysis of the outcomes of six collective projects on water.

It first highlights the challenges associated with this resource, which are exacerbated by climate change and soil sealing. Recognition of water scarcity and the impacts of droughts and floods on populations and natural environments have led to a real paradigm shift, marked in particular by the questioning of the "all pipes" model. Despite urban innovations and a strengthened regulatory framework to protect territories and individuals, many obstacles remain, notably that of sectoral water governance. The city, therefore, appears to be the ideal scale for experimenting with new approaches.

The students in the six groups identified several areas for consideration. First, they emphasised the need to strengthen risk awareness and alert systems, with a stronger local focus. They also stressed the importance of integrated water governance, which would enable the perspectives of different stakeholders to be reconciled and conflicts of use to be better managed. Mediterranean cities such as Barcelona illustrate this transition through various projects implemented to address the increasing scarcity of resources, notably through alternative solutions (such as greywater reuse) and reduced consumption. Regarding development in flood-prone areas, the students call for a new settlement culture based on adaptation to the natural water cycle.

Students also highlighted the value of nature-based solutions (NBS) in responding to water crises. Among these, integrated stormwater management aims to promote rainwater as a resource for urban ecosystems.

Finally, this issue presents two practical tools designed by the students:

- *Le Révélateur*, a graphical decision-making tool highlighting the water system in Seine-Saint-Denis;
- Inond'Act, a model for estimating the cost of freshwater flooding to residential buildings in France, which identifies the most cost-effective adaptation measures to reduce damage. ■

# SOURCES

To access the full reports, please send an e-mail with the project title to [ecole.urbaine@sciences-po.fr](mailto:ecole.urbaine@sciences-po.fr)

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- [Link to access synthesis](#)
- Link to the website, where the model is accessible : <https://www.inondact.com/>
- The BatAdapt platform, developed by OID, allows to see the natural risks to which a building is exposed: <https://r4re.resilience-for-real-estate.com/resilience/analysis>
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# FIND OUT MORE

If you want to go further, here are a few examples of papers written by teachers associated to the Urban school:

- Le Gaudu Jules, Roffo Raphaelle, Sutra Galy Alice, sous la supervision des professeurs Jean-Bernard Auby et Vitale Tommaso (2013), [Accès à l'eau potable dans les pays en développement: Les composantes des systèmes tarifaires à visée sociale et leurs réels impacts sur les populations cibles. Comment mettre en place un véritable tarif social?](#)

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