INITIATIVES POUR L'AVENIR DES GRANDS FLEUVES
INITIATIVES FOR THE FUTURE OF GREAT RIVERS

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France
DELTA DU RHONE

European and Mediterranean Deltas facing the effects of climate change:
What are the paths of sustainable development?

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Thanks

IAGF warmly thanks all the partners and speakers, whose commitment and the quality of their contributions made this session of collective work possible and enriched.

The Mairie d'Arles, the Compagnie Nationale du Rhône, the Camargue Regional Natural Park, La Tour du Valat, the SYMADREM, the Conservatoire du Littoral, the CPIE Rhône Pays d'Arles and the Festival dans les bras du Rhône, the Musée de la Camargue, the Salins Group, the French Rice Centre, the Manade Jacques Mailhan, Vicat Group, Sweetch Energy, Arles Tourist Office, Rhône Mediterranean Corsica Water Agency, Plan Bleu, OIEAU, CNRS, IRD CESSMA, The Danube National Institute form research and development, Zone Atelier Santé et environnement en Camargue,

TU Delft, ENGIE laborelec, Technical University of Lisbon, Centre International UNESCO ICIREWARD Montpellier, Parc Natural del delta del Ebre, Università degli studi di Ferrara.

The Rhône, from its source to the delta, and all its wonders...

PREAMBLE

From the Mekong to the Paraná, the pincers of climate change that encircle all the planet's deltas are increasingly threatening. Caught between rising sea levels and decreasing river flows, where a growing and often destitute population lives, deltas are the most vulnerable areas to natural disasters. **Globally , there are about 10,000 deltas, home to 500 million people (8% of the world's population) and a multitude of ecosystems.** The health of rivers and their ecosystems depends on the health of people and territories... But they are threatened, impacted by climate change and human activities.

Faced with this observation, the NGO Initiatives for the Future of Great Rivers was founded in 2015 by Erik Orsenna and the Compagnie Nationale du Rhône, with the aim of alerting and mobilizing on the challenges and the future of rivers and their ecosystems and inviting more sustainable practices.

A collective of multidisciplinary experts, IAGF forms a space for international dialogue and knowledge sharing open to stakeholders in rivers from all over the world. Four axes structure its actions:

- Networking, production and sharing of multidisciplinary knowledge
- Advocacy and cooperation
- Sensitization
- Enhancement of territorial projects

Each year, an international session of IAGF members is organized to meet the actors of a river or a portion of it, in particular its delta. In October 2024, the 13th IAGF international session was held in the Camargue, on part of the Rhône delta around the issue "European and Mediterranean Deltas facing the effects of climate change: what sustainable development paths?"[1].

In her opening speech at the 13th IAGF International Session, Laurence Borie Bancel, Chairman of the Board of Directors of the Compagnie Nationale du Rhône and Director of IAGF, made the following observation: *"The Rhône Delta in the Camargue concentrates all the challenges of deltas, from economic, social and cultural issues, to the need to preserve biodiversity, identities, in the face of a climate that is going haywire. »*

This Rhône delta is indeed in many respects subject to different pressures, raising the question of adaptation, change and innovation to everyone. It is therefore as an extension of the IAGF work initiated in 2016, during the 3rd IAGF Session in Avignon, that Erik Orsenna and the expert members met for a new week of cross-dialogues in the Camargue.

On the basis of the study of the Rhône delta, and the opening up to a panorama oriented towards European and Mediterranean deltas, the work of this session questioned the development trajectories for these precious territories in motion.

[1] This work is part of a three-year IAGF programme on deltas (Bengal Delta in 2023, Rhone Delta in 2024, Amazon Estuary in 2025).

Because if deltas are on the front line of climate change, they are powerful vanguards of change. Bearers of resilience, these schools of exchange and permanent metamorphosis require new development trajectories.

Faced with the urgency to act, anchored in its mission of warning and cooperation, IAGF worked during this session with various stakeholders from the Camargue territory and international experts in order to bring together multidisciplinary knowledge and perspectives nourished by experiences from all over the world.

How can we reconcile economic, social and cultural development and the preservation of nature? In partnership with the city of Arles, Erik Orsenna and the IAGF experts presented, during a conference open to the public and remotely[2] at the end of this week of exchanges, a summary of their work as well as their recommendations. The aim is to share and federate for a territorial project with sustainable trajectories of habitability.

Figure 1photo exposition © Delta du Rhône-ESA_lab@leman-IAGF

Summary of proposals from the IAGF session

[2] 18 October 2024, Arles. Public restitution conference of the 13th IAGF International Session - *The future of rivers and deltas: Crossed views of the Rhône deltas, the deltas of the world*

Thanks to the exchanges and sharing of the work of the various stakeholders, the experts of the NGO Initiatives for the Future of the Great Rivers have been able to progress in their knowledge of the issues that are increasingly expressed in the different deltas of the world. In particular, the question of dialogue around the future of delta territories threatened by marine submersion by rising sea levels and impoverishment of sediment transport in rivers, is becoming preponderant.

The Rhône crisis has particularly challenged them and, beyond the findings, it seems urgent to take action on several fronts.

The analyses confirm four emergencies:

- **The urgency of acting in the face of the effects of climate change**: to face the challenges (marine submersion, salinization of the land, floods or drought versus the evolution of the flows of the Rhône), a whole balance of uses in the short and long term must be rethought.
- **The urgency of renouncing permanence**: Faced with the shift, we must reinvent ourselves;
- **The urgency of a holistic and anticipatory vision,** which is supported by a territorial project
- **The urgency of strengthening dialogue** through collaborative governance:

  By embarking on this path, the Camargue will be able to project itself and co-build, thus positioning itself at the forefront of new habitability trajectories.

In this document, Erik Orsenna and the IAGF experts propose, as a follow-up to their work, to the actors of the Camargue territory several concrete avenues, grouped into 3 possible areas of investigation:

- Enhancing the identities of the territory (actions 1 to 3),
- Enriching opportunities for dialogue (actions 4 and 5)
- Promote relations with other territories (actions 6 and 7).

IAGF is at the disposal of the territory and its stakeholders to discuss, deepen and, if deemed relevant, continue the development of these different avenues by offering the skills of its experts if necessary. It should be noted that there is no hierarchy between the proposed actions, but that their succession over time is an orientation that should not fail to be discussed.

POSSIBLE ACTIONS:

ENHANCING THE IDENTITIES OF THE TERRITORY

1. **Strengthening the enhancement of local traditional heritage at the scale of the delta**

A strong marker of the identity of this territory, the local traditional heritage is a unifying element for local actors. The dynamism of the existing cultural, heritage and environmental education associative and institutional network in the Camargue is important and deserves to be strengthened with long-term resources, in order to sustain the enhancement of these heritages. Additional exchanges through participatory pooling tools could further facilitate collective ownership.

This cultural richness contributes to promoting an integrated and sustainable management of resources, which necessarily includes the intangible dimensions (beliefs, social practices, ancestral knowledge) while taking into account the value and heritage of the multiple identities that make up the Camargue population and the Rhône delta.
Research projects dedicated to documenting the cultural and heritage richness of the delta could emerge, with the support of local or European funding.

IAGF proposals

Our historians specializing in rivers could lead or supervise dedicated research missions to document the richness of the heritage of the Rhône delta.

Our tool "Trésor des fleuves" (collaborative platform to share the heritage and imaginations of rivers) could be used by the various actors to promote the heritage of the Rhône delta.

2. Fostering innovation in the delta

Faced with the challenges of this territory, which is in the process of reconnecting, after a century and a half of stability, with the inherent unstable nature of deltas, it is necessary to continue to explore adaptive solutions, whether they are new technologies, nature-based solutions or hybrid approaches combining civil engineering and ecosystem functions.
Innovations such as osmotic energy must be able to find their place in a territorial project such as that of the Camargue
Innovations in the agricultural field (agro-ecology, conservation agriculture, innovative irrigation, experimentation with crops adapted to salt, etc.) should benefit from support at the delta level.
Local sectors that are better valued could contribute to the collective satisfaction of a territory that is exemplary in terms of sustainability.

IAGF proposals

Our association could facilitate connections with innovations tested elsewhere in the world, for the sharing of good practices or help to take a step back from the advantages and disadvantages of each

of the innovation avenues, thanks to our multidisciplinary expertise. For example, replanting can be cited as a brake on the retreat of the coastline.

3. Fully integrating the river into the life of the delta

The many developments following the devastating historic floods have physically and emotionally distanced the Rhône from the inhabitants of the territory. New stories, connections and imaginaries of the inhabitants must be able to unfold, to restore this founding link between the river and this territory. The challenge is both a duty to remember in the face of devastating floods in order to maintain a culture of risk, but also to make visible all the assets of the river for the territory and the populations, in particular its cultural dimension, while highlighting the link that the river represents for the territory, between upstream and downstream, the right bank and the left bank, etc. Telling the history of the river, in conjunction with its inhabitants, should make it possible to overcome this lack of cohesion in the telling of a common history.

Many associations are mobilised in the area to help strengthen the link between the river and the inhabitants of the Camargue.
The CPIE Pays d'Arles, a major player in the region, must be able to pursue its "Rhône Aval" mission, as well as its Festival in the arms of the Rhône, whose missions are to reconnect the populations to the river and its challenges.
The Festival of the Camargue and the Rhône Delta is also a unifying place.
The Regional Natural Park, via its Camargue museum but also through its authorities, also owes a key player in this reconnection.
The sustainability and the resources available to these actors must be strengthened over time.

A link with the Rhone Festival, organized in Switzerland and in the French Rhône Valley in the 1990s, could be made.
The deployment of educational river areas could encourage schoolchildren to take ownership of the issues specific to the Rhône delta.
In addition, a stronger link between the populations and the river should be able to guide future urban development projects (dikes in particular).

IAGF proposals

Our association could help to disseminate the various initiatives in the territory, through the "Living with Rivers" label, but also to connect with other actors organizing this type of activity in other river territories. We could also help think about programs and activities to propose, and engage stakeholders. We could make our "Fresco of the rivers" available, by training facilitators on the delta territory and thus facilitate workshops open to all to talk about the river and the delta.

A reactivation of the "Rhone Festival" in the Camargue could be considered in order to strengthen the upstream-downstream dialogue.

Our "River Challenges" tools (under construction) could be tested with schools in the territory. Our urban planning and development experts could help in the development of future urban development specifications.

ENRICHING OPPORTUNITIES FOR DIALOGUE

4. Innovating on tools for consultation at the delta level

As in all deltas, developing a framework for participation is a major challenge in a territory that is changing by nature. For the proper development of governance processes, consultation frameworks must be found in a culture specific to the territory. This is a major challenge for the structures in charge of the animation of this deltaic territory, Regional Natural Park, Syndicat mixte de Camargue Gardoise, but also SYMADREM in its prerogatives for the management of water, aquatic environments and protection against floods. Innovative approaches are needed in order to benefit from tools combining scientific, technical, economic, cultural, social disciplines and data, etc.

New methodologies involving civil society can be tested, thanks in particular to the expertise developed on this subject by the Universities of the region (participatory sensitive maps, serious games, Hackathons, river frescoes, etc.).

Data must also be shared in transparency between the different actors, to understand the trends, the elements at stake, discuss possible scenarios and engage in a realistic and unifying territorial project. Tools such as digital twins, or an observatory of views of the territory, can facilitate this pooling and better collective ownership.

IAGF proposals

Our experts in consultation and mediation could recommend methodologies or partners to facilitate these times of exchange, in collaboration with the specialized actors already mobilized in the territory (PNRC, SMCG, SYMADREM, CPIE, etc.).

5. Developing a new space for dialogue, on the scale of the Rhône Delta

IAGF was very struck by the lack of dialogue between the actors of the territory, which we interpreted as the consequence of the current absence of a space, physical or not, where all the actors could experience the benefit of exchanging and talking to each other on the scale of the delta. We are aware that the Camargue Regional Natural Park, the Syndicat Mixte de Camargue Gardoise and SYMADREM are, in their respective mandates, in charge of leading this dialogue at the delta level, but we nevertheless note a real deficit.

It would be a place where actors invest and concretize their desire to talk to each other. Supported and driven by all the stakeholders in the region, this "forum" could, for example, aim to develop a 2050 strategic vision for the Rhône delta, on the scale of the UNESCO Man & Biosphere Reserve, in order to structure globally and for the long term the issues related in particular to water management, biodiversity, agriculture, heritage and economic development.

In order not to waste resources and energy, this system must be strictly complementary to and coordinated with the other approaches and bodies in place.

A strong institutional support is a major condition for its success. The mobilization of the historical actors of the territory's consultation, in all their diversity, will also be essential, as will the inclusion of external observers, in order to cross-reference representations and bring a new and zoomed-out vision.

IAGF proposal

If such a place for dialogue and long-term anticipation were desired and supported by the territory's stakeholders, IAGF could bring its multidisciplinary vision and feedback from other deltas around the world to it.

FOSTERING RELATIONSHIPS WITH OTHER JURISDICTIONS

6. Promote upstream-downstream solidarity in the catchment area:

In view of the changes that the Rhône is already showing (in particular the modification of its hydrological regime and its sedimentary bedload, but also the evolution of the withdrawals to which it will inevitably be subject in the coming years), the Rhône delta region must prepare to make its needs and necessities known upstream of the watershed. Indeed, with a decrease in water resources from upstream (several sub-watersheds with the Saône, the Swiss Alps, the French Alps, the Durance, etc.), the consequences on the dynamics of the delta and on the socio-economic activities that take place there will become tangible.

IAGF was marked by the perception of a territory that is experienced as quite isolated, poorly connected to the surrounding territories and in particular to its watershed.

Dialogue with the actors influencing the state of the river that arrives at Beaucaire or Arles is essential, and deserves to be prepared now, without waiting for future tensions. The objective is to be able to establish solidarity between upstream and downstream, as well as between the 2 banks of the river, at the scale of the catchment area

To this end, exchanges, study visits, joint actions – for example the Rhone Festival – must be able to be carried out and supported by the respective institutions, from upstream to downstream.
A twinning between the cities of Geneva and Arles, recently labelled "Ramsar Wetland Cities", could be announced at the Ramsar COP in July 2025.

IAGF proposals

Our association offers to facilitate the organization of study or exchange trips with the cities of Lyon and Geneva, or even at the regional level. It can activate other levers of upstream-downstream dialogue, such as the Rhone Festival. If the actors are interested, the facilitation of round tables crossing the views between the actors of the different upstream-downstream territories.

7. Cooperate with other deltas around the world:

In conjunction with the territory's stakeholders, it has been noted by IAGF on several occasions that twinning between territories and rivers can bring about a sharing of concerns, experiences and innovations, and thus strengthen the emergence of ideas or measures useful to each territory. The global situation of deltas and their common challenges makes this observation even more attractive with regard to these dynamic territories on the front lines of change.

For example, the Camargue Festival, a vector of cooperation between the world's deltas, should have its resources strengthened, in order to be able to carry out long-term international cooperation (Mekong and Australia in particular), in order to strengthen the sharing of expertise between deltas.

The Regional Natural Park, whose charter includes an international cooperation component, could also strategically invest in this area.

IAGF proposals

Our association proposes to facilitate a twinning or cooperation programme between the Rhône delta and other deltas around the world, in particular within the framework of the PNR Camargue and the Festival de la Camargue.

These different proposals, which can be mobilized on different scales of time and space, require the mobilization of human and financial resources but also a real investment by all stakeholders.

Other actions or opportunities may also emerge according to the wishes of the territorial actors. IAGF is at the disposal of each stakeholder in the Rhône Delta territory, or partners as a whole, in order to discuss the proposals summarized above, and if necessary to develop them in their relevance and feasibility.

INTRODUCTION

1. The world's deltas: between climate change and adaptation policies

Regardless of the continent where they are located, deltas around the world face the same climatic, political, economic, land and social challenges, as Sylvie Fanchette, Director of Research at CESSMA (Centre for Social Science Studies on the African, American and Asian Worlds), pointed out. He added

that **"governments, international donors, the media and some researchers highlight climate change as the main source of environmental degradation in deltas ".**

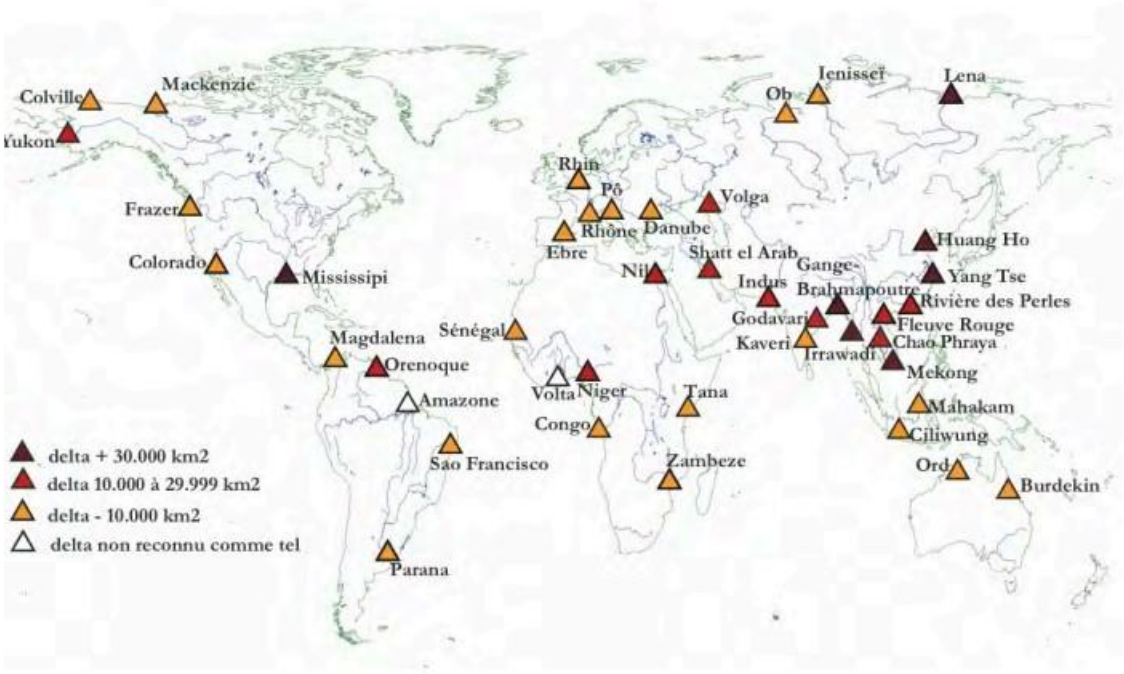


Figure 2 from the presentation of S. Fanchette

Deltas are increasingly experiencing flooding due to:

- To the rise in sea level,
- The increasing and uncertain river overflows linked to the thawing of glaciers,
- To the variation in rainfall,

They are also subject to the negative effects of:

- Large hydroelectric facilities (dams) and dikes,
- Urbanization (artificialization of soils, pumping of water, construction of many roads) at the origin of subsidence. Subsidence corresponds to a gradual sinking of the Earth's crust into

trenches where large thicknesses of sediment accumulate. It is due to various factors such as the extraction of underground resources, the decomposition of organic matter or the compaction of materials.

- Drainage difficulties,
- Erosion by limiting alluvium,
- Of the saline rises of seawater in the arms of rivers,
- Increasingly severe droughts, which are linked to the lack of water upstream.

" Adapting to climate change is a long-term process, but action must be taken immediately. Communities must be at the center of adaptation planning and action and must co-create solutions ," said Wolfgang Cramer, CNRS Research Director and IPCC Contributor.
According to him, a long-term systemic vision is essential, which involves considering all the changing factors by carrying out integrated analyses in order to understand what makes a delta habitable.

Bangkok en 2011

Hanoi en 2008

While recalling that some tipping points in the climate system have already been crossed, the researcher insisted on the fact that Nature-based Solutions (NBS) are one of the keys to action in adapting to climate change. Whether it's preserving ecosystems, improving their management, restoring them, or creating new ones, these nature-based solutions need to be part of the planning process. Combined with traditional grey infrastructure (such as dikes, dams, roads, bridges), they form an economically viable, adaptable and sustainable alternative.

Sylvie Fanchette agreed with Wolfgang Cramer on the need for a scientific and interdisciplinary assessment of the cause of climatic hazards, particularly those linked to the artificialisation of environments. This understanding is all the more important in the face of the environmental injustice that reigns within certain deltas, she recalled. Thus, the populations that manage to protect themselves from hazards are those who live in elevated areas, while the poorest populations live in areas at risk of submersion and flooding.
Cities such as Shanghai, Saigon and Dhaka, located on the deltas of the Yangtze, Mekong and Ganges rivers, respectively, are particularly vulnerable to rising sea levels and sinking grounds.

"Will yesterday's adaptations still work with tomorrow's scenarios?"
Sylvie Fanchette

However, it is possible to live with floods, as demonstrated by the hydraulic civilizations of the Mekong and the Ganges. These populations have thus developed nomadic or semi-nomadic habits depending on the season. Transhumance, seen as positive mobility, is integrated into their way of life: it invites us to rethink the very concept of habitability. Hamed Diane Sénéga, former High Commissioner of the SenegalRiver Development Organization and IAGF member, insisted on the **need to take into account the social and human aspects, in addition to the technical aspects, and in particular the acceptability of solutions by local populations.**

While European deltas are small and sparsely populated, this is not the case in Asia and Africa, for example, where they are "bowls of rice and wheat," Fanchette explained. For comparison, the majority of Asian deltas and the Nile delta have an area of more than 10,000 km2, while European deltas cover hundreds or even a few thousand km2 at most (850 km2 for the Camargue, 1,300 km2 for the Po). Asian deltas are highly urbanized, with between 500 and 1,000 inhabitants per km2. These are dynamic regions because they are located at the crossroads of local, national and international trade routes.

With the globalization of trade and the liberalization of economies, these deltas, with their very numerous resources (agricultural, fish, tourist, communication), are overexploited. Salinization also presents a crucial problem, putting agriculture at risk. Finally, hydraulic development choices are embedded in geopolitical conflicts between the riparian countries upstream and downstream of the rivers and locally between industrial, agricultural, tourism and energy activities, as well as the preservation of the environment.

2.European and Mediterranean deltas: geographical diversities that do not prevent common challenges

Founded in 1991, the Mediterranean Wetlands Initiative (MedWet) brings together 27 Mediterranean and peri-Mediterranean countries. Its mission is to support the effective protection of wetland functions and values and the sustainable use of their resources and services.
Jean Jalbert, biologist, agronomist, Director of the Tour du Valat and member of the MedWet steering committee, presented a **comparative analysis of five Mediterranean deltas: the Ebro, the Gediz, the Rhône, the Po, and the Nile.** Between strengths and weaknesses, these five deltas have many things in common, starting with their rich ecosystems that are home to a wide variety of plant and animal species, their fertile soils and their economic potential.

"We must consider nature as a precious ally in the face of current challenges."
Jean Jalbert

However, these deltas are subject to flooding and salinization and are all the more vulnerable to the effects of climate change (including sea level rise and the increase in the frequency of extreme weather events) because:

- Tides are limited in the Mediterranean basin, leading to developments as close as possible to the water,
- They are disconnected from their river (dams, dikes) whose flows have been greatly reduced,
- The excessive extraction of underground resources (methane, water) leads to the deep sinking of several of them.

These deltas are ever-changing environments, shaped by natural forces as well as human activities. Most of them have managed to cope with past threats, but those that focus solely on the exploitation of natural resources have low resilience to environmental and socio-economic changes. Jean Jalbert stressed how the adaptation of these deltas to change depends on the distribution of power among all the actors.

FOCUS: Po Delta

The Po Delta is distinguished by its profoundly artificial nature, the result of extensive hydraulic works undertaken as early as the sixteenth century, as explained by Alessandro Massarente, architect and associate professor at the University of Ferrara. The diversion of sediments to the south, to avoid the filling of the Venetian lagoon, has shaped a unique landscape, characterized by a dense network of canals and hydraulic infrastructures. This human intervention has led to a profound fragility of the territory, which is particularly exposed to the risk of flooding, in particular due to the rise in sea level, and subsidence, due to the excessive extraction of groundwater.

Agriculture, fishing and tourism face conflicts of use and challenges for the sustainable management of the territory. Like all the speakers, Alessandro Massarente advocates an integrated approach to deal with the complex management of the Po Delta: this requires coordination between the different actors and levels of governance. Environmental, economic and social aspects, as well as local specificities and traditional knowledge, must be taken into account.

In the case of the Po, Alessandro Massarente concluded, the importance of sustainable sediment management, the restoration of natural processes and the search for a harmonious coexistence

between human activities and ecosystems appear to be key elements for its future. Collaboration between the different actors, scientific research and the involvement of local communities are essential levers to meet the challenges facing the delta.

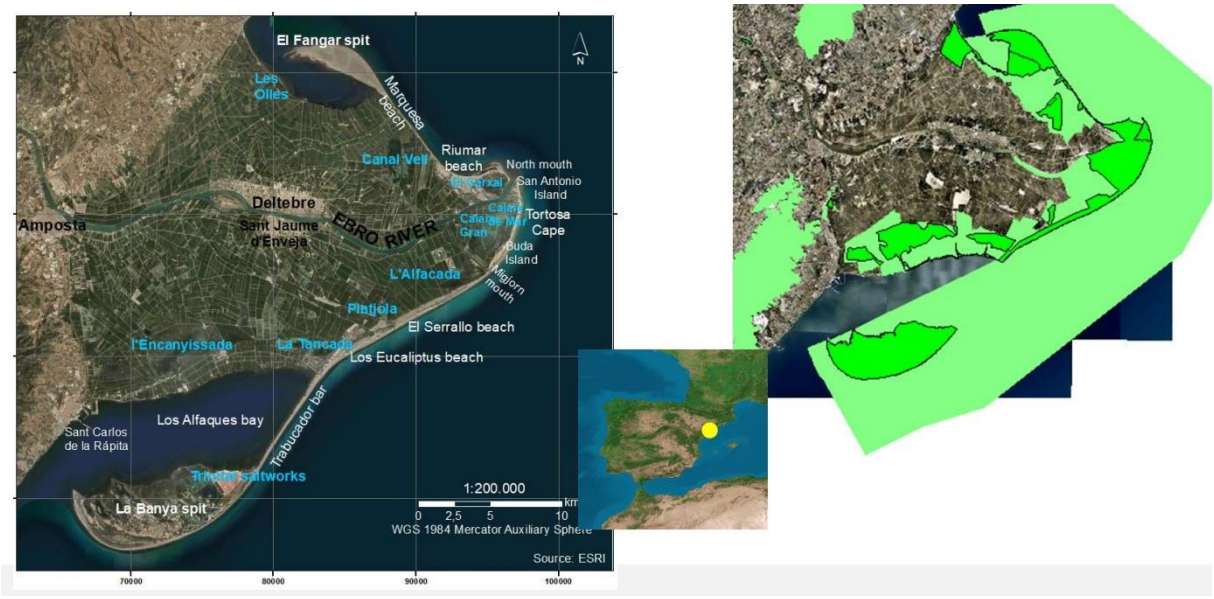


Figure 3issue presentation F.Vidal

FOCUS: Ebro Delta

The second largest wetland in the western Mediterranean, the Ebro Delta is home to an exceptional biodiversity, including a wide variety of migratory birds. However, its geographical location and low altitude make it particularly vulnerable to the effects of climate change, explained the director of its Natural Park, Francesc Vidal. The construction of dams along the Ebro River has profoundly changed the hydrology of the delta, considerably reducing the input of sediments and accentuating the phenomenon of erosion and the retreat of the coastline. This situation is exacerbated by rising sea levels and delta subsidence. In addition to the threats common to all European deltas, the Ebro suffers from the proliferation of invasive alien species, a major cause of biodiversity erosion.

As in the Po Delta, **the restoration of sediment input appears to be an essential measure for the protection of the Ebro Delta in the medium term.** Other possible protection and adaptation actions include the construction of protective dikes within the delta, the adaptation of lagoons and bays, including the installation of pumping stations, the strengthening of the coastal front by widening beaches and the restoration of dune systems. These measures will be all the more accepted by the population if local communities are involved in their implementation and the socio-economic realities are taken into account.

FOCUS: Tagus Estuary

Ana Morais de Sà, professor at the Technical Institute of the University of Lisbon, highlighted the **need for a new approach to the urban transformation of seafronts, especially in the context of the Tagus estuary.** She pointed to the lack of cohesion and effectiveness of spatial planning since the 1980s, which is often decentralized at the municipal level. This situation is particularly complex in the Lisbon metropolitan context, which is made up of 18 municipalities.

Urban transformations are mainly driven by large-scale projects, without any real coordination with municipal development plans. This lack of coordination leads to a juxtaposition of competing visions and projects that do not fit harmoniously, harming territorial cohesion. Faced with the challenges of climate change and urban growth, new models of cross-border governance are needed. They must incorporate the complexities of metropolitan contexts, public participation, and coordination between different levels of planning. The "Cidade Tejo" research project, whose multidisciplinary team is a successful example of this collaborative approach.

FOCUS: Rhine Delta

As for the Rhine delta, it is emblematic of the need to reconcile industrial development and environmental preservation. Carola Hein, professor and chair of the history of architecture and urban planning at Delft University of Technology, and Han Meyer, professor of urban design at the same university, painted a picture of a highly industrialized and urbanized delta.

Located on the Rhine delta, the port of Rotterdam, Europe's largest port, concentrates fossil fuel activities. The integration of the port into a natural environment and the restoration of the delta's self-building capacity appear as solutions for a more sustainable future. These capacities have been undermined by the channelization of rivers and the construction of dams, which have profoundly modified the natural dynamics of deltas by depleting sedimentary inputs, as Han Meyer explained.

Their presentation was illustrated with a mapping work from "Port City Atlas",[3] a reference work co-authored by Carola Hein, the LDE PortCityFutures research groups and the Faculty of Architecture TU Delft. This book offers a comparison of 100 European port territories and highlights the diversity of situations and challenges.

FOCUS: Danube Delta

[3] https://books.open.tudelft.nl/home/catalog/book/73

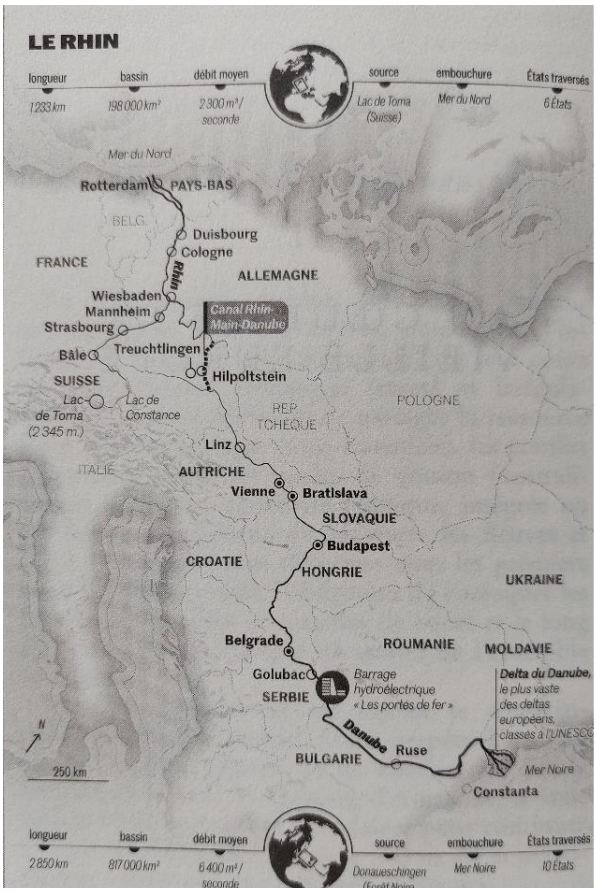


Figure 4excerpt from the book The Earth Is Thirsty

The Danube delta is the largest of the European deltas after the Volga delta. Romania and Ukraine share its mouth, which flows into the Black Sea. It is also a protected natural region and classified as a World Heritage Site by Unesco for about thirty years. Indeed, the economic development programme for the area started in the 1960s had led in three decades to the destruction of the already unstable balance of the area. Since 1991, the area has been declared a "Biosphere Reserve", imposing strong ecological constraints on its inhabitants.

The challenge of this area in terms of sustainable development is to define a global strategy and a balanced management capable of reconciling respect for biodiversity and economic activities. Several cross-border cooperation projects have already been implemented, in particular with a view to the restoration of agricultural and fish farming polders. They aim to restore the natural ecosystems of the delta in a logic of renaturation.

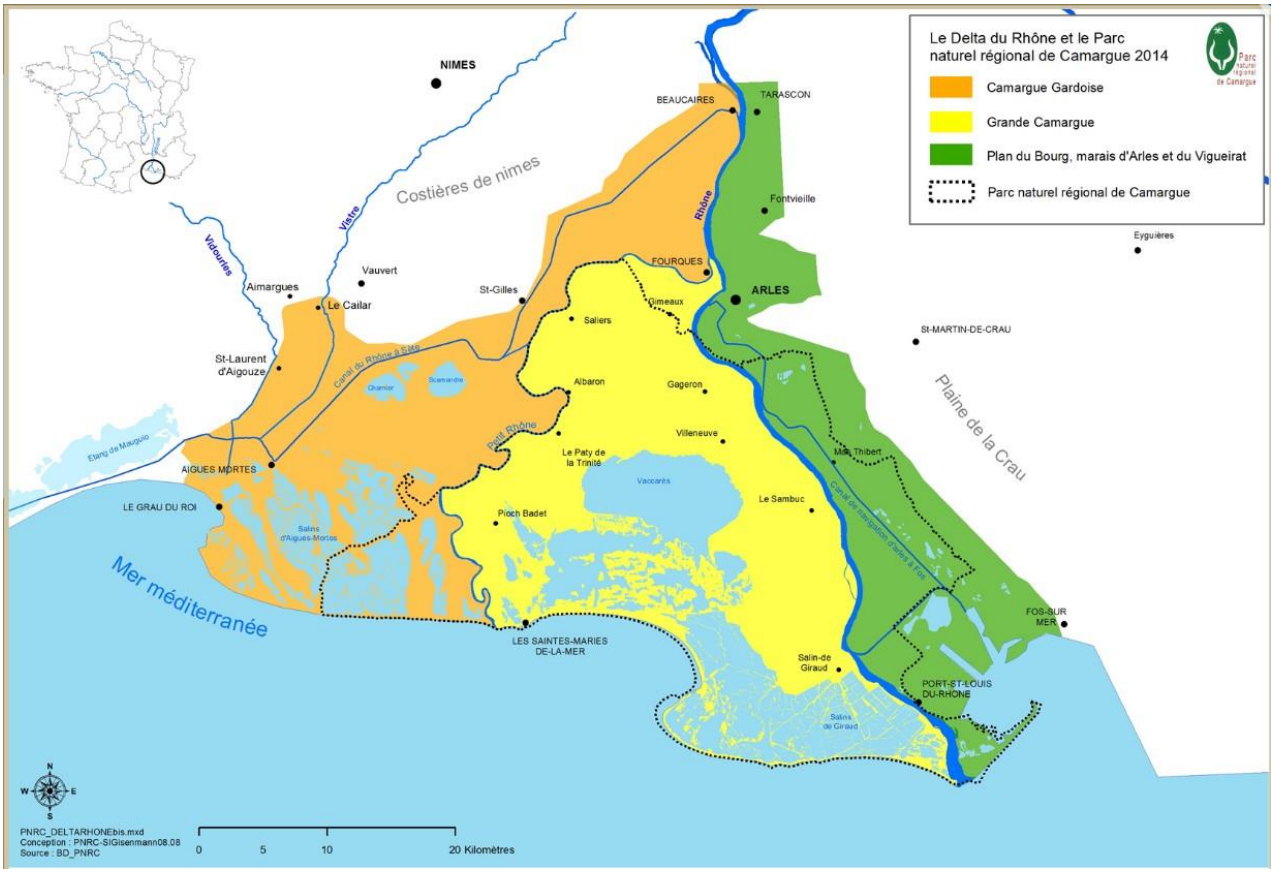
Whether European or global, it is by adopting an adaptive, transdisciplinary and resilient approach that deltas will be able to cope with climate disorders. In order to restore physical and ecological connectivity between deltas and their watersheds, and to enable sustainable and integrated management of water resources, land use planning choices are also crucial.

PART 1: Rhone Delta, multiple challenges in the face of climate change

The 13th IAGF session was held in partnership with the Arles City Hall, and the mayor, Patrick de Carolis, gave the opening speech. He spoke of the cultural effervescence that the city enjoys thanks to the power of the river. He also mentioned, of course, the challenges of protecting the population and the survival of the territory in the face of the overflow of the Rhône and its drying up.

Indeed, the main problems of the Rhône delta and the Camargue are salinization and the rise of the sea, the evolution of the flows of the Rhône, the decreases in sediment transport crystallizing many challenges and responses to be provided

Recalling that the Camargue territory has been cultivated since Antiquity and saw the construction of dikes begin in the Middle Ages, **Patrick de Carolis expressed the hope he has for his territory: that Man will know how to adapt, as he has already been able to do**, and meet the challenges of marine submersion, rising water levels and salinization. For him, the survival of the territory (fauna, flora and people) will depend on its resilience, the desire of everyone to take a new look at local governance, and the solidarity of all. "It's a balance to find and maintain," he concludes.



Biodiversity conservation and nature-based solutions

The Tour du Valat is a scientific laboratory working for the conservation of Mediterranean wetlands founded in 1954. The organization relies on multidisciplinary scientific research programs and databases shared with the international scientific community. Its philosophy, inherited from its founder Luc Hoffman, is based on the conviction that **the preservation of wetlands requires a "global dynamic that includes and interacts with human activities".**

At the beginning of the session, Jean Jalbert, Director General of the Tour du Valat, spoke about the **vulnerability of the Camargue, 70% of whose territory is located at an altitude of less than one metre,** making it extremely vulnerable to marine submersion, especially as sea levels are rising at an accelerated rate. He recalled the permanent dynamics of the delta, an area in constant evolution despite attempts at stabilization.

"The delta is, in essence, the place of the impermanence of things."

Jean Jalbert

The Director General of the Tour du Valat also recalled the resilience of the Camargue people who have been able to adapt to changes throughout their history, drastically modifying their agricultural practices on several occasions. He noted that this adaptive capacity is a major asset in addressing current climate challenges. **It is a real paradigm shift that is necessary: that of rethinking the territory differently.**

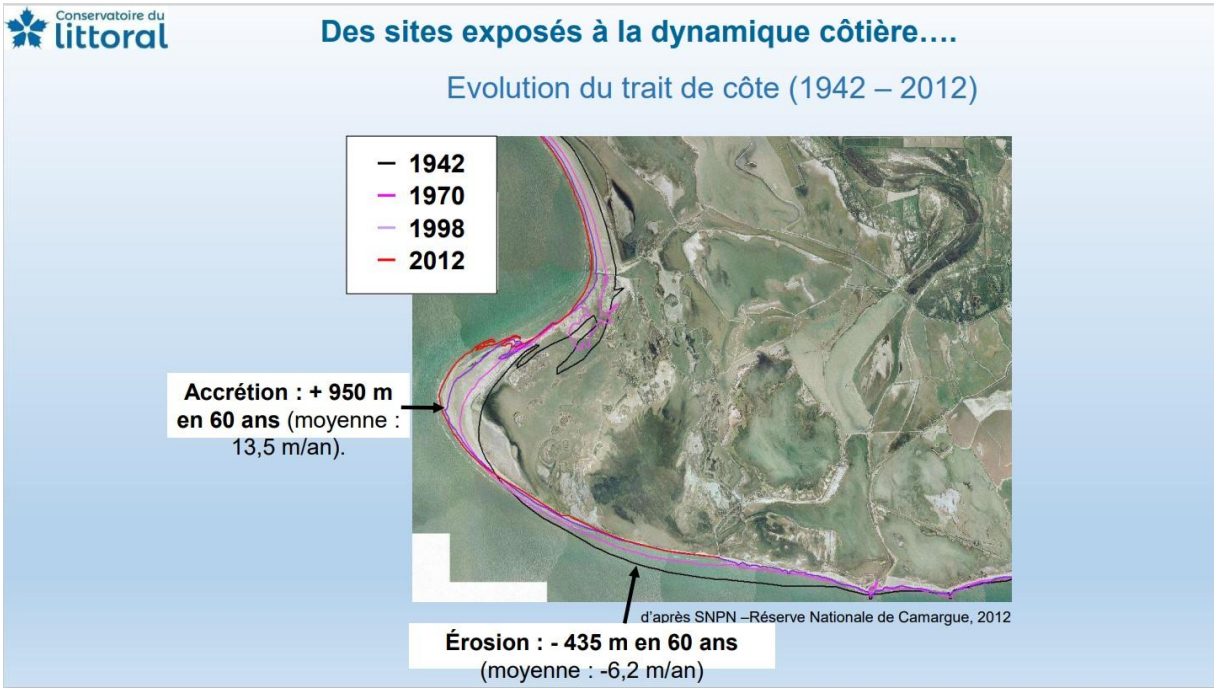
It is a question of finding a balance between the needs of man and the protection of nature, in particular by promoting environmentally friendly agricultural practices. Only then can wetlands be preserved. These areas are *" the ecosystem [that] contributes most to the development and livelihood of humanity ".* [4]*. They provide a multitude of vital ecosystem services, such as water purification, flood protection, carbon sequestration, and the provision of food and building materials. For example, peatlands, which cover only 3% of the Earth's surface, store about 30% of the Earth's carbon*[5]

[4] *(Global Wetland Outlook 2018*
[5] *(Ramsar, 2021).*

These ecosystems are also home to a rich and varied biodiversity, which is essential for the survival of many animal and plant species. Freshwater wetlands contain more than 40% of the world's species and 12% of all animal species[6]
However, about 35% of wetlands have disappeared since 1970, a rate of loss three times faster than that of forests [7]
These ecosystems play a crucial role in regulating the climate and protecting human communities from natural disasters. For example, coastal wetlands like mangroves can sequester carbon up to 55 times faster than tropical rainforests [8]

In addition, wetlands are important sources of economic resources, supporting millions of livelihoods around the world. More than a billion people depend on wetlands for their livelihoods, including through fishing, agriculture, tourism and the harvesting of natural materials[9]

Paradoxically, they are the most threatened and destroyed by agricultural expansion, urbanization and pollution. **Since 1970, 48% of wetlands in the Mediterranean basin have disappeared and this trend is only getting worse.** Jean Jalbert stressed the urgency of acting in the face of the accelerated destruction of these areas.



[6] (Ramsar, 2021).
[7] (Global Wetland Outlook 2018).
[8] (Ramsar, 2021).
[9] (Ramsar, 2016).

François Fouchier, Provence-Alpes-Côte d'Azur Delegate of the Conservatoire du Littoral, described the Camargue as "a fragile raft" in constant evolution. He emphasized **the shifting nature of the delta, illustrated by the variations of the coastline over the centuries**, insisting that this natural dynamic is a central element to be taken into account in any conservation action.

Protecting the "natural third"[10] of the French coast is the main mission of the Conservatoire du Littoral, a national public administrative institution. F. Fouchier underlined the unique character of this body at the national level, in particular thanks to its power of land acquisition and the inalienability of the land acquired. **The Conservatoire du Littoral owns but does not manage the sites,** which implies collaborative work with local stakeholders and management plans developed in consultation.

The objective of the Conservatoire du Littoral is to find a balance between the protection of natural environments and human activities, taking into account local specificities and issues related to climate change. It has thus entrusted the management of the ponds and marshes of the Camargue salt marshes to three co-managers: the Camargue Regional Natural Park, the Tour du Valat and the National Society for the Protection of Nature. This vast coastal area is home to an important biodiversity but is also a place for tourism, extensive livestock farming and hunting.

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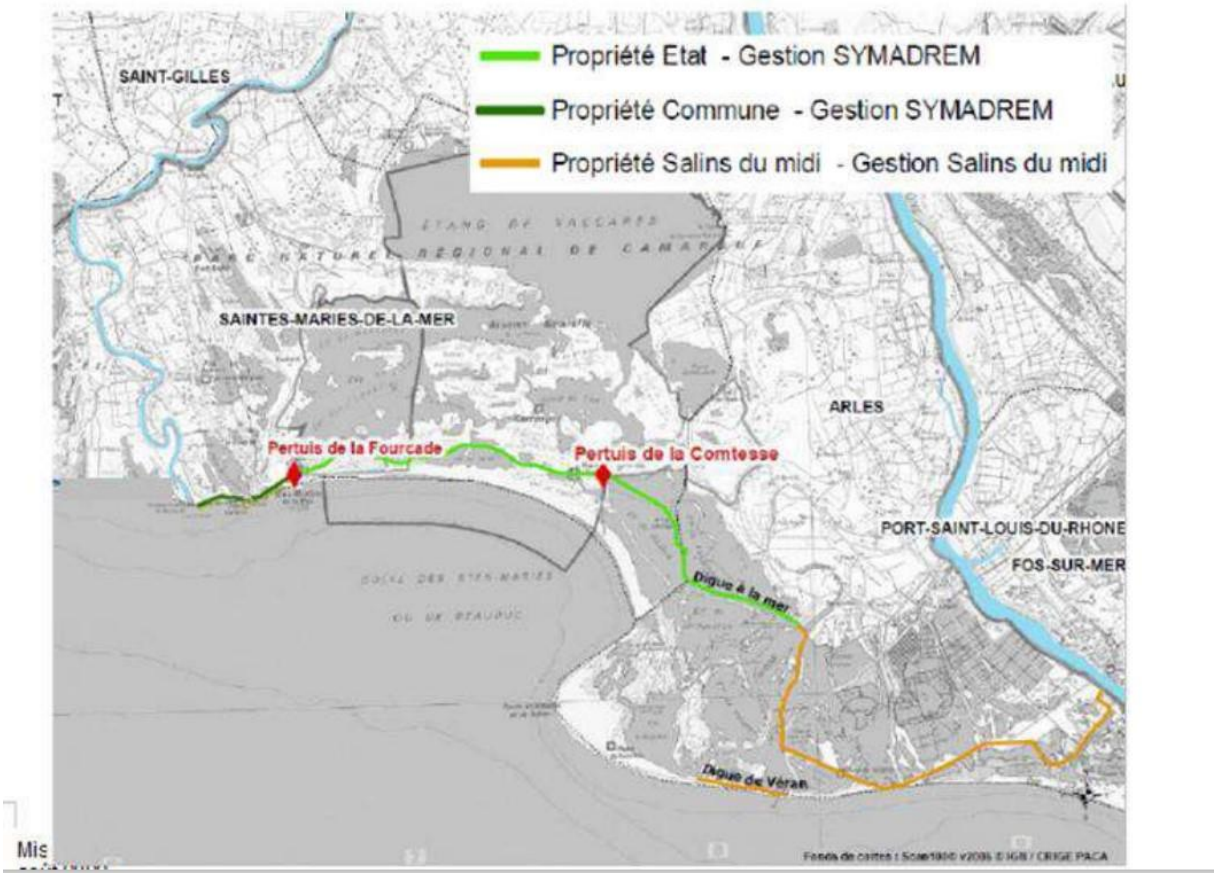
[10] Réseau Canopé: The natural third (or "wild third") establishes the principle that a significant part of the space must be conserved or reclaimed in a given territory, i.e. preserved from artificialisation.

marshes to three co-managers: the Camargue Regional Natural Park, the Tour du Valat and the National Society for the Protection of Nature. This vast coastal area is home to an important biodiversity but is also a place for tourism, extensive livestock farming and hunting.

Since the acquisition of the site by the Conservatoire du Littoral between 2008 and 2012 following the end of salt production in this sector, an adaptive management of the site based on **Nature-based Solutions** (SbN) has been carried out between the coastal strip and the seawall. These NBS include a set of techniques for the preservation, sustainable management or restoration of ecosystems recognized for their ability to rely on natural processes to solve environmental and social problems. Beyond the seawall, agro-pastoral activities have been maintained. Hydraulic works have also been carried out in order to re-establish hydrobiological connections between the ponds, the sea and the peripheral sub-watersheds and to connect the waters of the Rhône to agricultural land. Artificial islands have also been created to encourage the reproduction of birds, in particular colonial chararo-waders.

Maritime dikes to the right of the ponds and marshes of the Camargue salt marshes:
Example of an adaptive strategy

Tracé actuel de la digue à la mer et ses différents gestionnaires



The ponds and marshes of the Camargue salt marshes, located in the south-east of the delta, in the Regional Natural Park, represent a coastal area of more than 6,500 ha. The coastal dikes in this area proved ineffective in stopping the advance of the sea: it was decided to abandon them when the salt mining activity they were supposed to protect ceased.

Since their maintenance has stopped, seawater has largely penetrated the ponds during winter storms. The latter serve as a natural buffer zone, preventing storms from reaching inhabited land further north. They are also home to an important biodiversity. As the front dike collapses, the waves submerge them during storms, depositing very large quantities of sand behind the dike, thus recreating a sandy lido (barrier beach separating a lagoon from the sea). It is proving to be a key element of the future adaptation strategy, evolving as sea level rises and providing flexible resilience to future storms.

The inland dikes, on the other hand, must be reinforced, such as the sea wall dating from 1859. The responsibility for their maintenance lies with the Syndicat Mixte d'Aménagement des Digues du Delta du Rhône et de la Mer (SYMADREM), which also has responsibilities in terms of aquatic environment management.

Faced with the risks associated with weather events and the rapid evolution of the site, working groups have been initiated in order to better understand the dynamics at work. It is a whole integrated management process that ensures a better functioning of the restored ecosystems while protecting property and people from the risks associated with sea level rise and submersion.

This solution is facing many debates, with some preferring a protective solution (with ever higher dikes) to avoid rising sea levels and salinization; others preferring to let the sea enter the land where the direct impact remains limited, in order to accept the phenomenon and recreate "climate shock absorbers" where it has a limited impact on economic activities.

Economy: salt farming, agriculture, livestock and tourism

Thanks to the invitation of Hubert François, CEO of the Salins du Midi group, IAGF was able to visit the Salin-de-Giraud site, and discover the methods of salt production by the company, which has existed since 1856, a true institution of the Camargue industrial heritage. The Salins Group has facilities throughout Europe and Africa and masters all salt manufacturing techniques: solar, thermal and mining. **In the Camargue, salt is produced by evaporation of seawater**. The seawater is gradually conveyed to successive basins where evaporation takes place naturally under the effect of the wind and the sun and allows the concentration of salt. This process does not require chemicals or fresh water consumption, making it an activity with a low environmental impact.

The company is also committed to the preservation of biodiversity through the Salins Foundation. Its site in Aigues-Mortes has become the first territory to receive pink flamingos thanks to the work of salt workers: it can accommodate more than 15,000 of them. It is also a major site for the reproduction of colonial chararo-waders in the French Mediterranean.

Water, and in particular that of the Rhône, is both the best friend and the worst enemy of the site. Fresh water is needed to rinse and preserve brine as well as clean pumps. So it's a problem when it runs out. But its excess is also very problematic: it can be a disaster in the event of flooding, especially during the harvest period. It's all about balance. An automatic control by sensor with an alert system is not desired at this time: it is too energy-intensive.

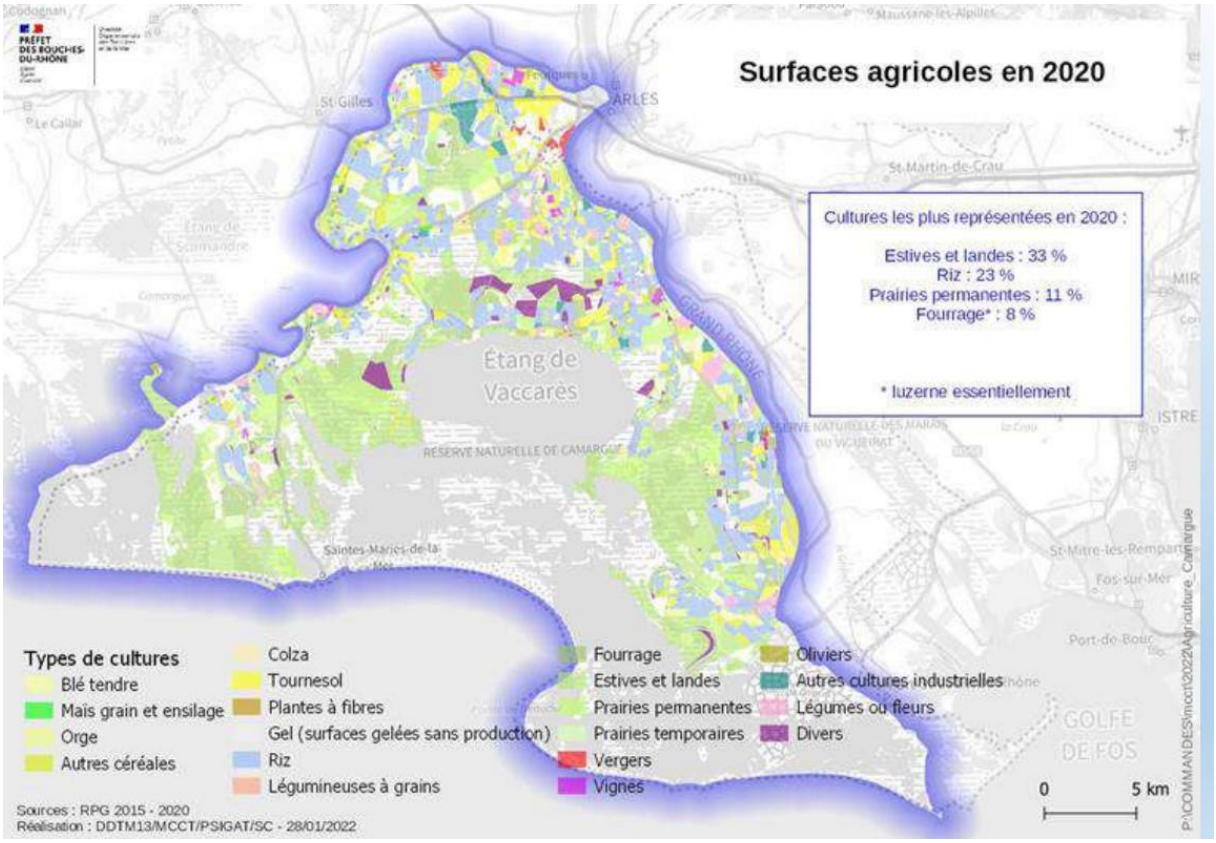
Despite the climatic challenges, the Salins group, which is established worldwide, has doubled its turnover in 10 years, from €250 million to €500 million. In Salin-de-Giraud and Aigues-Mortes alone, 350,000 tonnes are produced per year. The salt from this site is mainly used for snow removal, but new outlets have emerged, particularly for chemical companies in Fos-sur-Mer who are looking to limit their carbon footprint by importing one of their raw materials (salt) as close as possible to their production sites.

If the salt marshes are a strong marker of the landscape of the Rhône delta, **it is tourism , livestock farming and agriculture that represent the three pillars of the Camargue economy,** as Sébastien Abonneau, President of the Arles Tourist Office, explained.

Tourism is distinguished by its seasonal adjustment thanks to the presence of tourists in spring (32% of visitors) and its greater economic impact than in the rest of the department. It represents 8% of the departmental overnight stays in the Bouches-du-Rhône, i.e. 3.7 million overnight stays, a significant figure for a department that is already very touristic. It can also be an important supplement to the income of Camargue farms, particularly those linked to livestock farming.

Breeding, especially bull breeding, is a traditional activity in the Camargue, intrinsically linked to the culture and image of the territory. Revenues from Camargue races, bullfights and other bullfighting events represent only 25% of the total turnover of the sector, which amounts to around 18-20 million euros. The financial balance of farms is therefore largely based on the sale of meat, in particular the PDO Camargue Bull Meat, and on tourist activities related to livestock farming.

Finally, **rice cultivation is also an emblematic activity of the Camargue, developed in the 1940s.** Since 2000, Camargue rice has benefited from a Protected Geographical Indication (PGI) claimed in 2024 on 97% of cultivated areas. Its turnover is estimated at 120-125 million euros for a production of about 70,000 tons per year and a cultivated area of 13,000 hectares.



As we saw during the visit to the Domaine du Vedeau with Antoine De La Roche Aymon, its owner, and François Clément, director of the French Rice Centre, **water from the Rhône is essential for rice cultivation in the Camargue.** The irrigation system, managed by local associations, allows fresh water to be brought to the plots. However, the electricity bill for pumping represents a significant burden for the farms. Water is a source of concern with the decline in the flow of the Rhône and climate change projections that pose uncertainty about its availability in the years to come.

The salinization of the land represents a growing threat: the Domaine du Vedeau lost 10% of its surface area in 2021 because of this phenomenon. The causes of this salinization are multiple: increased evaporation due to the sun and the mistral, rise of the salt wedge.(Intrusion of brackish or salt water into the freshwater body) The visit highlighted a debate on the role of the sea wall in limiting salinization: if it protects against marine submersion, Its influence on the protection of salt penetration into the water table is certainly very limited.

FOCUS: agroecology

Faced with climatic and resource constraints, **Camargue rice farmers are seeking to adapt by combining technological innovations and agroecological practices.** No-till, plant cover and crop diversification, for example, aim to strengthen crop biodiversity and improve soil management, while reducing production costs. By alternating rice cultivation with legumes (such as alfalfa), farmers naturally enrich soils with nitrogen and reduce their reliance on chemical fertilizers. On the technology side, the installation of new sensors and pumps for the renovation of irrigation pipes and their supply via renewable energies are part of the ongoing experiments.

Some pastoralists apply rotational grazing techniques to preserve the quality of the soil and avoid overexploitation. The fact that bulls and horses are in semi-freedom contributes to the maintenance of wet meadows and sansouïres (natural salty areas): by grazing, they prevent the excessive development of woody species (such as tamarisk or tall salicornia), which could invade wet meadows and reduce habitat diversity. Finally, agroforestry practices are multiplying in order to fight against erosion and improve biodiversity. Tamarisk hedges are planted between agricultural plots, which also promote the presence of pollinating insects and insectivorous birds, thus limiting the use of pesticides.

PART 2: Governance - the need for multi-stakeholder consultation for a sustainable territory project

1. Actors in connection with the river

Roland Roux, President of the Permanent Centre for Environmental Initiatives (CPIE) Rhône-Pays d'Arles, and Liséa Donadille, Rhône downstream mission referent within the association, presented their structure. The CPIE works to raise awareness of the environment and promote the ecological transition through knowledge, dialogue and a forward-looking vision.

Created following the floods of 2003, the CPIE's Rhône Aval mission aims to reconnect populations to the river. The CPIE organizes events, workshops and educational projects to foster a better understanding of the Rhône, its ecosystem and its socio-cultural importance. Breaking out of the fear of the river and its threats, forging an identity link with the Rhône to make it a unifying element between the inhabitants, creating synergies between local actors: these are all challenges related to the ecological transition that the facilitating association is taking up.

Faced with the challenges of shared governance and the need for solidarity in the face of water resources, the CPIE advocates for an integrated and collaborative management of the Rhône that takes into account the complexity of the issues and the interdependence of political, economic, ecological and health issues. It encourages the establishment of spaces for dialogue and consultation, overcoming the logic of "siloing" that limits the effectiveness of actions.

Following the floods of 2003, the State also set up, alongside other public institutions, Electricité de France and CNR, **an interregional strategy for the sustainable development of the territories around the Rhône and the Saône called the Rhône-Saône Plan.** Beyond the contractual financing framework, the ambition is to promote common values, to ensure the synergy and complementarity of public policies throughout the Rhône-Saône axis. It is in this context that the CPIE is carrying out the Stakeholders' Forum, an important consultation mechanism.

This forum was initiated by a diagnostic phase to highlight needs and expectations. It now aims to create spaces for dialogue and meetings, with the intention of being a complementary body to those of governance of the territory.

FOCUS: The Camargue Regional Natural Park

The Camargue Regional Natural Park was created in 1970 and is included in the Camargue Biosphere Reserve (193,000 hectares). **This reserve, created by UNESCO in 1977, covers the entire biogeographical delta of the Rhône and is co-managed by the Camargue Regional Nature Park and the Syndicat mixte de la Camargue gardoise.** Jean-Christophe Briffaud, Head of the Natural Areas Management Department of this protected area, explained that the Park's dimension is not limited to the simple protection of the environment but also includes a social and human dimension. Its charter, drawn up collectively, defines the territory's development objectives and is binding on other urban planning documents. Revised every 15 years, it must adapt to changes in the territory, particularly those related to climate change.

The President of the Park since July 2022, Anne Claudius-Petit, who is also a regional councillor in Provence-Alpes-Côte d'Azur, recalled her region's commitment to ecology since 2017 through the Climate Plan. Provence-Alpes-Côte d'Azur is the second most touristic region in France as well as a biodiversity hot spot. The region has nine regional natural parks and a tenth is planned in the Var, the Maures-Estérel-Tanneron Regional Natural Park, born following the devastating fires of 2021.

At the opening of the IAGF public restitution conference on 19 October, **A. Claudius-Petit presented the Park's charter as a territorial project built with local authorities, inhabitants and stakeholders,** whether rice farmers, bull breeders, tourism stakeholders or people involved in biodiversity research and observation projects. She explained how the revision of this charter encouraged reflection beyond the perimeter of the Park, the concerns of the Camargue being shared with the General Secretariat for Regional Affairs (SGAR) in particular.

"I am committed to renewing and strengthening the governance tool that the Camargue Regional Natural Park represents, to give it a new lease of life."
Mrs. Anne Claudius-Petit

The local consultation phase that precedes the renewal of the charter in 2026 will make it possible to invent the future within the Park. Many questions arise:

- How can the delta be managed by integrating climate change? The dikes protect against flooding but not against salinisation or the permanent evolution of the shoreline.
- What is the feasibility of building and maintaining dikes in a context of low public finances?
- What social cohesion, with more upstream-downstream solidarity?
- What water management policy? The Camargue was born out of the opulence of water, it is the largest wetland in Europe: is a water-saving policy adapted to a delta?
- What policy for the preservation of biodiversity?

- What new agroecological forms?
- What cooperation and knowledge sharing within the Mediterranean basin?

Faced with climate issues, a new relationship of trust must be created. The preservation of wetlands and biodiversity can only be achieved by keeping in mind local populations, health imperatives and economic activities. The inhabitants of the Camargue have adapted over the centuries, by building dams, dikes and adopting new food practices: this reinvention must continue if they wish to continue to live in the delta, which is essentially impermanent.

2.La science at the service of consultation

Eric Servat, President of the French National Committee of UNESCO's Intergovernmental Hydrological Programme, deplored the fact that deltas, hydrological objects of particular interest to him, are poorly represented in the framework of hydrological learned societies. He called for the mobilization of scientific institutions in order to correct this deficit.

Mr. Servat drew an enlightening parallel between Mediterranean coastal deltas and lagoons that share management, conservation and research challenges in the face of anthropogenic and climatic pressures. He also addressed the sensitive issue of water withdrawals from the Rhône, in particular to supply Languedoc-Roussillon, and called for in-depth studies to be carried out in order to better understand the consequences of these withdrawals. He warned the audience against a logic of "aquatic liberalism" that would privilege economic interests to the detriment of the sustainability of water resources and the balance of ecosystems.

"It is essential that science be included in all collaborative approaches."
Eric Servat

To prevent conflicts related to water management, E. Servat advocates **an approach that is both scientific and based on anticipation and consultation**. This approach aims to collect robust and reliable scientific data in order to understand the resources available, their uses and their impacts. This will allow prospective scenarios to be developed that integrate climate, economic, demographic and social dimensions. Armed with theoretically objective data because they are based on science, an enlightened consultation can be implemented, a source of consensus, in order to reconcile the different uses while preserving fragile environments such as deltas.

3.For a concerted and integrated approach to health

The Camargue is a privileged observatory for rethinking the links between human health and ecosystem health. The two are intrinsically linked because environmental degradation directly affects the health of populations. The mosquito, particularly the tiger mosquito in the Camargue, plays a crucial role in health risks, vectors of diseases (dengue, chikungunya, zika) In this context subject to multiple pressures, health cannot be reduced to its medical dimension alone: it requires a multidisciplinary systemic approach. It involves political choices, development practices, and a renewed cohabitation with the living, in connection with the global transformations affecting all the major deltas.

The 4 major issues related to health risks in deltas (to be weighed according to the case) are as follows:

1. Access to drinking water, due to population density, and water pollution, which lead to the risk of waterborne diseases such as cholera, typhoid, dysentery and parasitic infections;
2. Climate change, which is leading to population displacement, food insecurity and an increase in respiratory diseases;
3. Limited access to health care;
4. Degradation of biodiversity, which affects the availability of food resources, water quality and disease regulation.

The paradigm shift evoked by Jean Jalbert is also what Raphaël Mathevet and Thomas Frédéric advocate. The two CNRS research directors, who work on the "Health and Environment in the Camargue" Workshop Zone, **pleaded for the transition from a logic of adaptation to a logic of transformation.** According to them, **we must question the development models that generate health problems.**
A "full health" approach, which integrates socio-economic and political dimensions, not just biomedical ones, based on interdisciplinary research, will prevent epidemics rather than control them.

"Health cannot be understood only from a medical perspective, it is crucial to consider the systems that produce inequalities and injustices."
R. Mathevet & T. Frédéric

R. Mathevet and T. Frédéric also called for **greater involvement of local actors in the decision-making process**: their empirical knowledge and expertise are valuable for exploring new scenarios and strategies and fighting against the feeling of powerlessness that is rampant. Participatory modeling and serious games are presented as powerful tools to promote the co-construction of solutions and the understanding of complex socio-ecological systems.

The need for dialogue and collaboration is all the more urgent as scientific speech is often disqualified while populist and corporatist discourses are gaining ground. The different interest groups must go beyond their individual positions to **build a common vision** of the future of the Camargue.

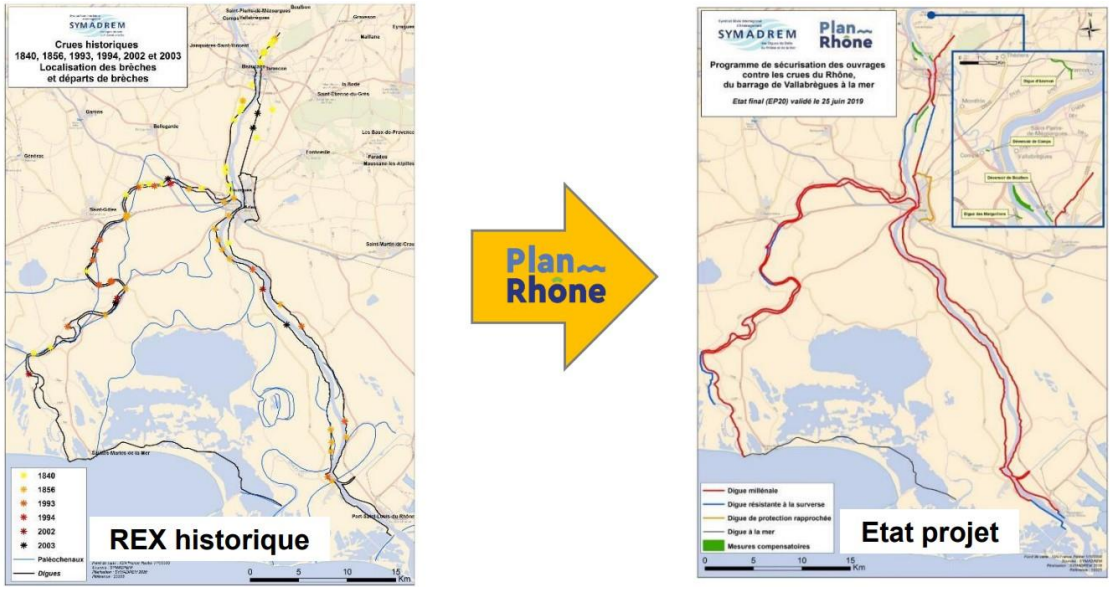
Benoît Miribel, Secretary General of the Sustainable Health for All Foundation, presented the "One Health" approach, which aims to **bring together the human health, animal health and environmental sectors to address complex health challenges in deltas.**

Solutions to mitigate these risks and improve the health of delta populations include:

- Improve water resources management through the establishment of drinking water supply systems, wastewater treatment and integrated water resources management ;
- Establish prevention and vaccination programmes against infectious diseases ;
- Monitor air and water quality;
- Strengthening health infrastructure and improving early warning systems ;
- Conserve and restore ecosystems through wetland protection, reforestation and sustainable management of agricultural and fish farming activities.

4.Risk and water resource management

The mission of the Syndicat Mixte d'Aménagement des Digues du Delta du Rhône et de la Mer (SYMADREM) is to manage the dikes and prevent flooding in the Rhône delta. His intervention is part of a historical context marked by devastating floods. Thibault Mallet, Director of SYMADREM, recalled that **the first dikes in the Camargue date back to the 12th century** and were initially built by monks to protect private interests. During the 19th century, following the floods of 1840 (2.8 billion cubic metres of water flowed into the delta for a good month) and 1856, a general damming of the delta took place.



Following the traumatic flood of 2003 (230 million m3 of water discharged), the Rhône Plan marked a turning point in flood management. **Instead of systematically raising the dikes, the emphasis has been on accepting the flood**, learning to live with this risk, while preventing dikes from failing. The choice of the terminology **"overflow-resistant dike",** which is more reassuring than that of "overflowing dike", used previously, has made it possible to win the support of the population for development projects that allow the dikes to resist the passage of water over them without breaking.

"With overflow-resistant dikes, it's no longer a question of preventing flooding at all costs, but to manage it in a way that minimizes the risks to the population. »

Thibault Mallet

Symadrem, which is responsible for developing a coastal strategy for the Camargue, has proposed six options, broken down into 39 scenarios, ranging from the total fixing of the coastline to relocation, on which the union's elected representatives will have to vote in the summer of 2026.[11]

David Ferry, CNR Territorial Delegate for the Rhône-Mediterranean sector, shed light on the Rhône River, for which the Compagnie Nationale du Rhône (CNR) has been the concessionaire since 1930. The latter manages an area of 29,093 hectares, 45% of which is made up of water bodies. **Mr. Ferry pointed out the variability of the river's hydraulic regime, which makes its management complicated.** Past developments, particularly those intended for navigation, have led to sedimentation and bed incision problems, now requiring restoration programs in order to restore an ecological balance.

The salt corner, an intrusion of salt water into the river, represents a growing threat to the Camargue. How does this happen?

- When the flow of the Rhône is insufficient to repel seawater, especially during low water periods when the average flow can drop to 280 m^3/s (while it can rise to more than 14000 m^3/s during floods);
- When high tides, combined with a low flow of the river, accentuate the penetration of salt water;
- By the call of salt water from the bottom caused by the Mistral (north wind), which creates a surface current towards the sea.

[11] excerpt Article Le Monde, Audrey Garric, 15.02.25

In 2022, the salty wedge reached a record high, rising up to 35 km from the mouth of the Rhône for 56 days. This situation underlines the urgency of putting in place measures to limit this phenomenon and preserve agriculture and biodiversity in the Camargue.

The Water Agency is the public institution playing a central role in the implementation of water policy in France. Its Director of the Rhône-Mediterranean-Corsica zone explained how the challenges of water management had evolved over the years: it is a question of both preserving natural resources and economic activities and adapting to a change that is faster than anticipated, with more frequent winter floods and more severe summer low water levels.

Nicolas Mourlon, Director of the Rhône-Mediterranean-Corsica Water Agency, described **the Rhône as a river of capital importance for France**. It supplies drinking water to 11.5 million inhabitants and supports many uses: agricultural irrigation, navigation, industries (cooling of nuclear power plants, in particular) and energy production.

The impacts of climate change on the river are already noticeable with a drop in summer flows, linked to droughts, estimated at -13% between 1960 and 2020. Combined with the rise in temperatures (+1.8% over the same period), it will have a direct impact on these uses. N. Mourlon cited alarming projections: **The number of days when pumping will be impossible due to salinity is expected to increase from 1 day per year currently to 22 days per year by 2055.**

PART 3: What other components can be used to think differently about the territory and envisage new adaptation trajectories?

1.A collaborative and cultural approach to risk management

Emmanuelle Perrin, architect and urban planner and co-founder of the international association Risk and Architecture Workshop (RAW), presented her organization, which was born following the Fukushima disaster in Japan in 2011. The architect deplored the modern thinking that considers the city in its functionality without taking into account territorial and climatic particularities. She pleaded for a redefinition of the territory that takes into account natural risks and integrates the memory of climatic events.

The association, which brings together architects and researchers, offers international participatory workshops involving experts and local actors in order to co-construct spatial planning solutions. These workshops are based on specific tools, such as MAPITS, a "participatory mapping" that makes it possible to "collect information" and visualize perceptions of the territory and risks.

"We have disconnected physical geography from lived space."

Emmanuelle Perrin

The association offers spatial scenarios illustrating different development options. For example, in the Camargue, faced with the risk of marine submersion, E. Perrin presented two scenarios: an "archipelago" scenario that relocates the habitat to higher ground and accepts the flooding of certain areas, and a scenario of strengthening the dikes integrating functions such as aquaculture or energy production. She insisted that **land use planning should no longer be done in areas at risk and should take into account knowledge based on the stories and experience of the inhabitants.** The legend of Sara, a saint venerated by the Gypsies, and that of Tarasque, a mythological creature from Provence, are there to remind us of the risks.

RAW's Deltalab project aims to match deltas around the world by making them ambassadors of change. It is based on the fact that deltas, impermanent territories by nature, have historically learned to reorganize themselves and can inspire solutions to climate change and environmental degradation. The urban architect took the Camargue and the Bengal Delta as an example, exploring the spiritual, cultural and belief dimensions linked to these territories. It is the complexity of these ecosystems, with their history, culture, geography, human activities and weakened biodiversity, that must be considered in land use planning.

2.Faced with the impermanence of the delta, the importance of a holistic and cultural approach

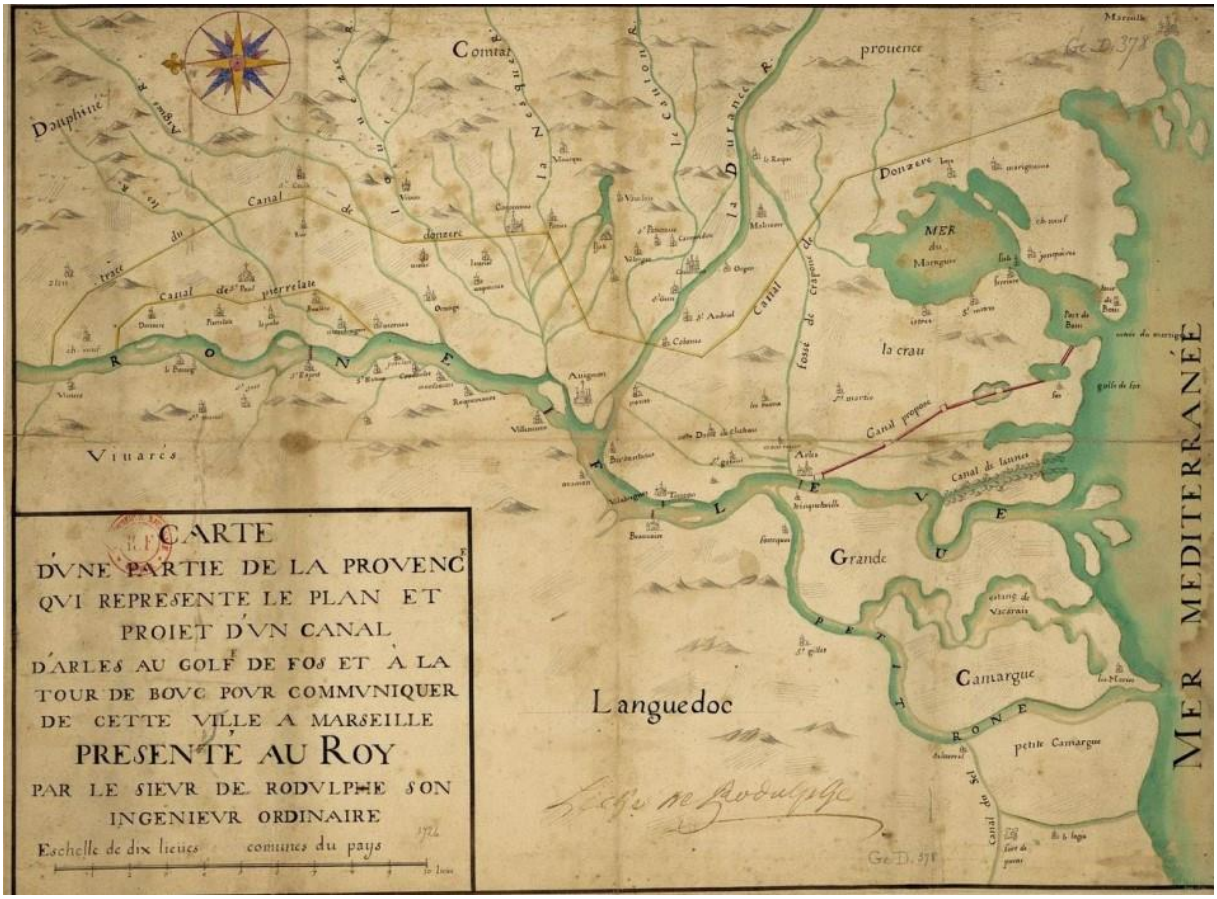


Figure 5Rodulfe 1726

It is in the heart of the delta, on the road to Saintes-Maries-de-la-Mer, that you can discover the Camargue Museum, on the site of the Mas du Pont de Rousty, which also houses the administrative centre of the Camargue Regional Natural Park (PNR). The presentation by Estelle Rouquette, Deputy Director of the PNR and curator of the museum, focused on the construction of the Camargue identity through history and literature.

Since the Middle Ages, the Camargue has been perceived as an exceptional, rich and fertile land: it is a source of envy and imagination. The cartographic representations show the evolution of land development, marked by the desire to control the Rhône and adapt it to the needs of navigation and trade: it was a question of taking advantage of the strategic geographical position of the delta.

This fascination for the Camargue has been perpetuated over the centuries, fuelling often idealised representations. The nineteenth-century manadier and writer Folco de Baroncelli helped create a mythology around local traditions, featuring the pink flamingo, the bull, the wild horses and the gardian as symbols of a wild and authentic Camargue. E. Rouquette highlighted the importance of **deconstructing clichés in order to reveal the complexity of the Camargue identity.** She relied in particular on the literary analysis of Jean Giono. The Provençal writer highlighted the violence of the sun, the corrosive salinity of the water, the telluric force of the river. His writing reveals a less picturesque but more realistic Camargue, marked by the struggle between Man and Nature.

"There are the marshes, the mud, the sands, the tangles of plant wrecks, this atrocious heat, this blinding light, these invisible gods."

Jean Giono

Emmanuelle Perrin, in a post-session article, evoked [12]the land of mixing that is the Camargue, which for decades has mixed Gypsies, Italians, Spaniards, Greeks, Armenians and, long before that, Romans. She sees the contemporary folk identity as an atypical cross between the Spanish bullfight and the American shows of Buffalo Bill. If the population clings to it like a totem, it is because this protective belief makes it possible to claim a fixed identity. But identity is not culture. Know-how, know-how, and the ability to live together have nothing to do with identity: if we become too attached to nostalgia for the past, the architect warned, all this knowledge risks disappearing.

E. Rouquette recalled **that the Camargue identity is constantly evolving**, shaped by history, geography, literature and the evolution of the landscapes, the local fauna and flora as well as the human activities that take place there. The associative network contributes to keeping this identity alive. The CPIE Rhône-Pays d'Arles contributes to this through the organisation of events, workshops and educational projects. Its festival "Dans les bras du Rhône" invites you to (re)discover the river.

« Venir n'est rien, tout commence quand on revient.

Proverbe Malien qui vaut pour la Camargue, lieu de toutes les frontières, de tous les défis relevés ».
Erik Orsenna 30.VI.2016

The Festival of the Camargue and the Rhône Delta, initiated by the city of Port-Saint-Louis-du-Rhône, celebrates the natural and cultural richness of the delta every year by offering nature outings, conferences on environmental issues and photographic exhibitions. The PNR and the Museum are not to be outdone, which make it possible to create a dialogue between knowledge and to move away from representations opposing Man and Nature.

[12] Emmanuelle Perrin Back from the field: Plea for a Camargue guide plan. https://rawarchitectureworkshop.wordpress.com/

FOCUS: Kogi Ancestral Knowledge

To benefit from the ancestral knowledge on the relationship between Man and Nature of representatives of the Kogi people, the first Colombian people? This is the experience shared with us by Jean-Louis Michelot, geographer and naturalist, Director of the Centre-Est agency of the Ecosphère design office, and Gilles Mulhauser, Director of the Geneva Cantonal Water Office and IAGF member. During a study trip to the Rhône in 2023,[13] they were able to exchange their experiences and views with representatives of this indigenous people living in the Sierra Nevada de San Marta, in northern Colombia. Retired to the mountains, they live in connection with the elements and rely on uninterrupted oral transmission for 4,000 years.

While walking along the beach or sailing on the river, they systematically asked the question: **"What was it like here, before colonization?"** Their relationship with the territory is rooted in the history and memory of the place and invites reflection on the evolution of landscapes and human impact. Stones are part of this memory because the mineral is considered to be the foundation of life.

[13] Organized by the Tchendukua association

The river, too, is seen as alive: the Rhone glacier is the "brain", the mountain, the "skull", the confluence of the Ain and the Rhône, the "lung", and the delta, the "feet". **"If your feet are cut off, your head won't be fine," they say of the link between the sea and the mountains.** They insist on the importance of preserving glaciers, especially against the extractivism that is rampant in some countries. Their message calls for a profound paradigm shift based on a holistic vision of the delta at the scale of the watershed, respect for the living and gratitude for the nature that nourishes us.

"The delta must be in good shape if we want the river to be in good shape.

Kogi people

3.Innovations for adaptation

a. Sharing delta and river data

Modelling of the river and its port infrastructure to share scientific data and scenarios? This is what the Grand Port Maritime de Bordeaux (GPMB) offers with the Gironde estuary. Fabrice Klein, Innovation Officer at the GPMB, explained how this dynamic digital representation makes it possible to visualize the results made available on a collaborative platform[14] and to analyze the operation of the river in real time. This digital twin, operational since 2023, also facilitates the management of water resources and the anticipation of problems by simulating floods, through the integration of climate change-related data provided by the IPCC.

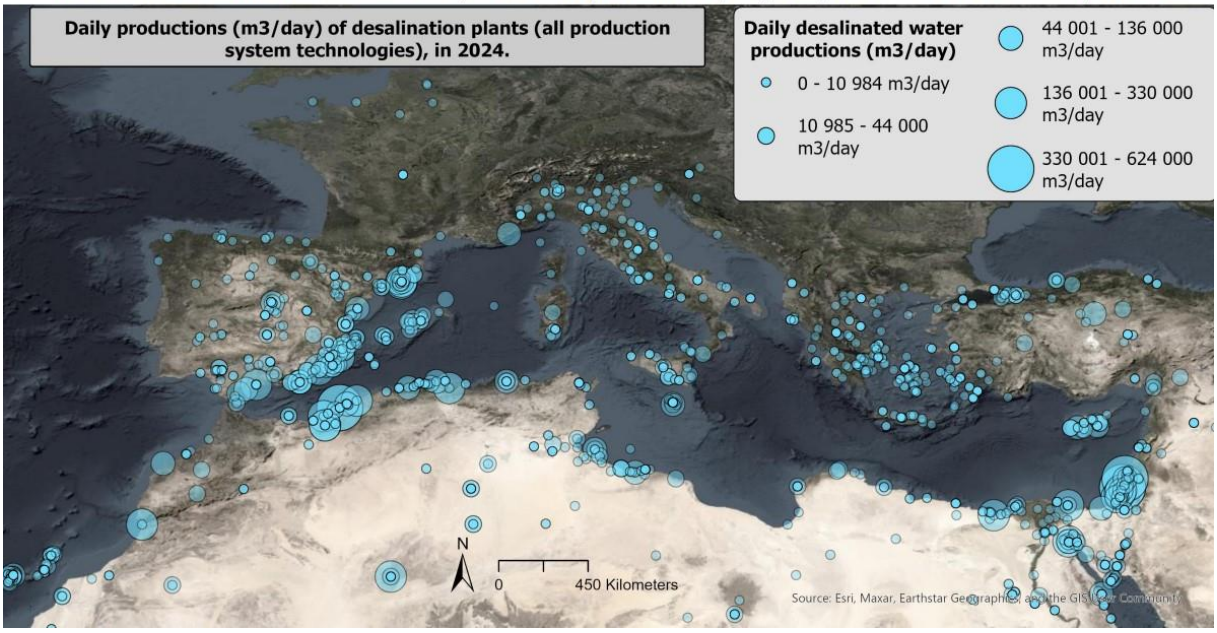
This tool is particularly valuable for local authorities, Klein said: it helps them in their choices in terms of wind turbine installation and measuring stations, plastic collection, dam water releases and wastewater treatment plant discharges. The fact that the information is open source democratizes knowledge and allows all the actors in the estuary to have the same level of information: this increases transparency and trust between them. The innovation manager praised the many other qualities of this awareness-raising tool: a more global, rapid and autonomous vision, reduced costs, improved sustainability and collaboration.

b. The development of certain non-conventional resources: desalination, reverse osmosis and wastewater reuse

Plan Bleu, based in Marseille, is one of the Regional Activity Centres of the United Nations Environment Programme's (UNEP) Mediterranean Action Plan (MAP), made available by France since 1977. Vigie de la Méditerranée, articulated around 24 States, it is **the first ecological planning tool for sustainable development on the scale of the Mediterranean basin.** It makes it possible to inform public policies by capitalizing on climate data.

[14] https://jumeaux-fleuve.naos-cluster.tech/fr/accueil/

Localisation des usines de dessalement productions journalières (m3/jours) d'eau dessalée associées, en 2024.

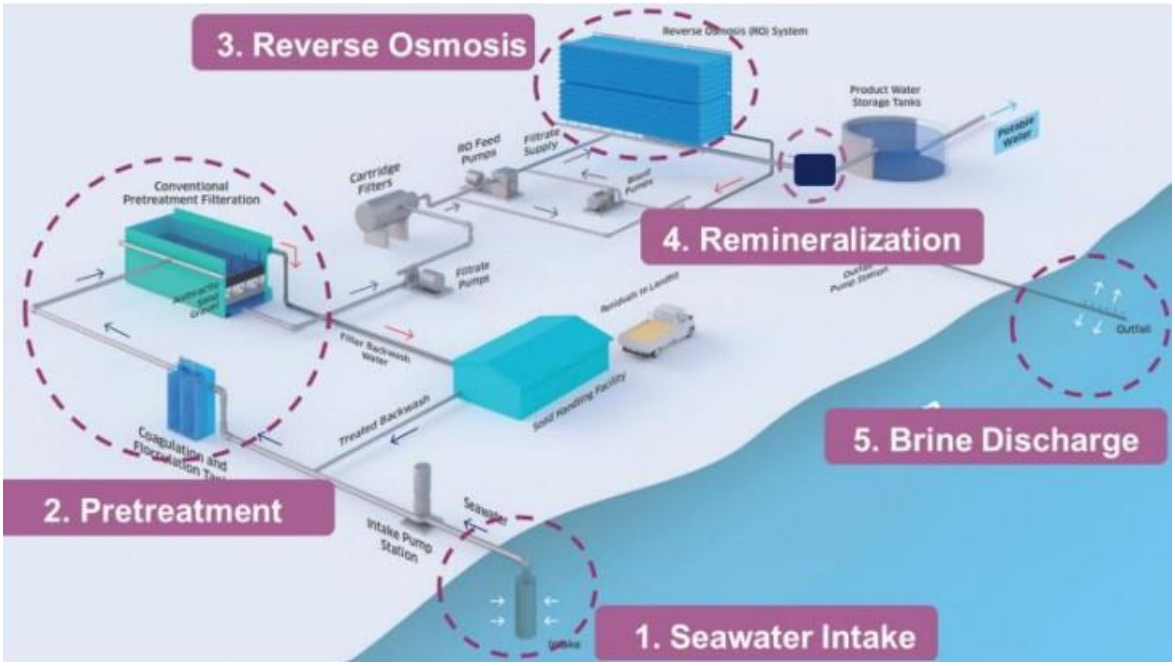


In the current context of water stress and scarcity of conventional water resources faced by Mediterranean countries, and in particular deltas, Samson Bellières, Project Manager for Green and Blue Transition within Plan Bleu, presented the **crucial role of non-conventional resources such as desalination and wastewater reuse.** More than 2,600 factories have been identified around the basin, demonstrating the scale of technological efforts made to meet the growing demand for drinking water.

Focus: Reverse osmosis desalination

Bellières took a nuanced approach by analysing the impacts of unconventional resources, highlighting environmental, economic and societal aspects. The brine discharged following desalination, which is warmer and saltier than seawater, disturbs the fragile balance of marine flora and fauna. In addition, the production of desalinated water requires large quantities of energy, often of fossil origin, and the investment and operating costs of the plants are considerable. Finally, he pointed out the imbalances in the allocation of resources between the different uses: a more equitable management, which takes into account the needs of all stakeholders, is desirable.

The blue economy expert promotes **the circular economy as a sustainable solution for integrated water management.** For example, it encourages the recovery of brine, which can be transformed from waste into a resource used in agriculture and salt marshes. It is a change in mentalities that must be carried out as much as an in-depth reflection on the uses and distribution of water in order to move towards more economical behaviour.



ENGIE Laborelec, ENGIE's research and development entity, is positioned as a major player in research and technical support for water-related projects, including desalination, which transforms seawater into drinking water. Thermal desalination, which consumes energy, is based on the evaporation and condensation of water: it leaves a saline residue. **Reverse osmosis is a more energy-efficient technology** : it forces seawater through a semi-permeable membrane under high pressure, separating the water from the salts. ENGIE, historically involved in thermal desalination thanks to the waste heat from its power plants, is now focusing on reverse osmosis due to its better performance.

Bart Ghysels, Water & Chemistry expert at Laborelec, described the different steps of reverse osmosis desalination:

- The water intake, carried out far from the coast to minimize the impact on marine ecosystems and guarantee resilience to climate change;
- Pre-treatment, which aims to protect the membranes from fouling and clogging and ensure the proper functioning of the installation;
- Reverse osmosis, i.e. the separation of water from salts using a semi-permeable membrane;
- Remineralization, which involves adding minerals to make the water drinkable and non-corrosive;
- The discharge of brine by mixing it with seawater to minimize the environmental impact.

ENGIE wants to innovate in order to develop a process that is as efficient as possible and has the least impact on the environment. Current research focuses on improving the chemical resistance of

membranes through the use of nanomaterials and energy efficiency. The current energy consumption of 2-3 kWh/m3 is approaching the thermodynamic limit (1.5 kWh/m3), limiting future progress.

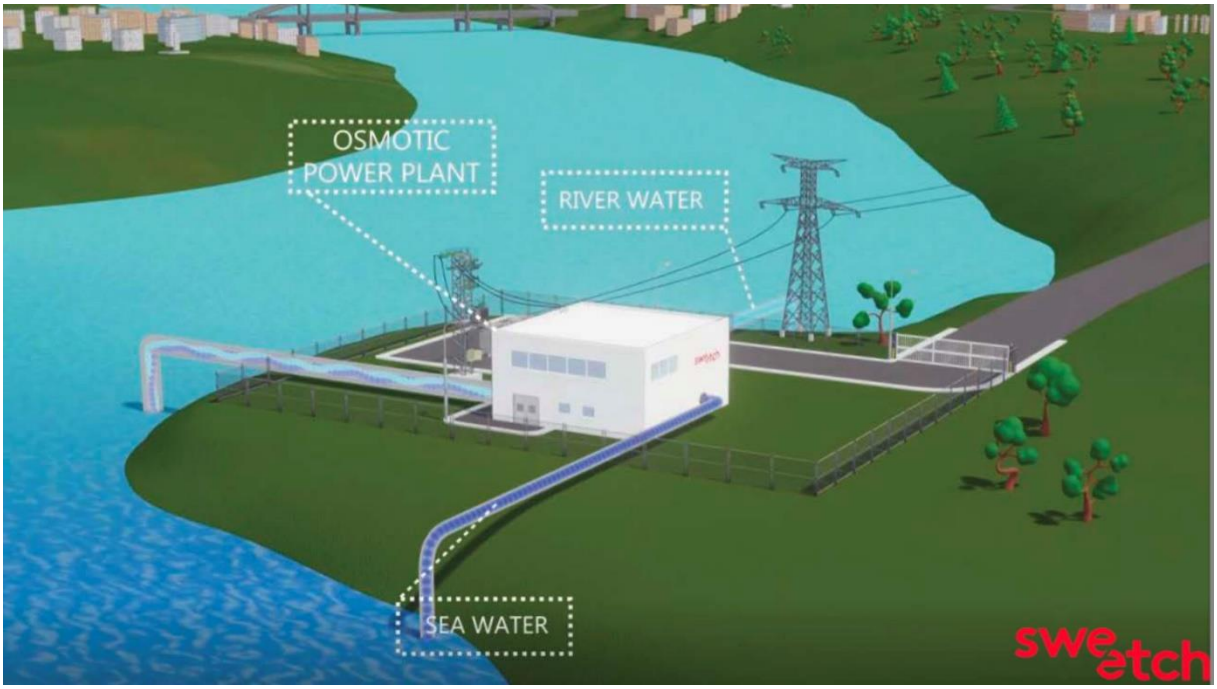
Finally, B. Ghysel insisted on the need to consider brine as a resource, and not as a waste. Currently, with 1,000 litres of seawater, 500 litres of drinking water and 500 litres of brine are produced, which is twice as salty as the water withdrawn and has a CO2 concentration 240 times higher than that of the air. **The impact of brine discharge is therefore destructive, especially in shallow seas.** ENGIE is looking for solutions to avoid this rejection. The idea would be to recover the brine in order to produce minerals and chemicals (soda by membrane electrolysis).

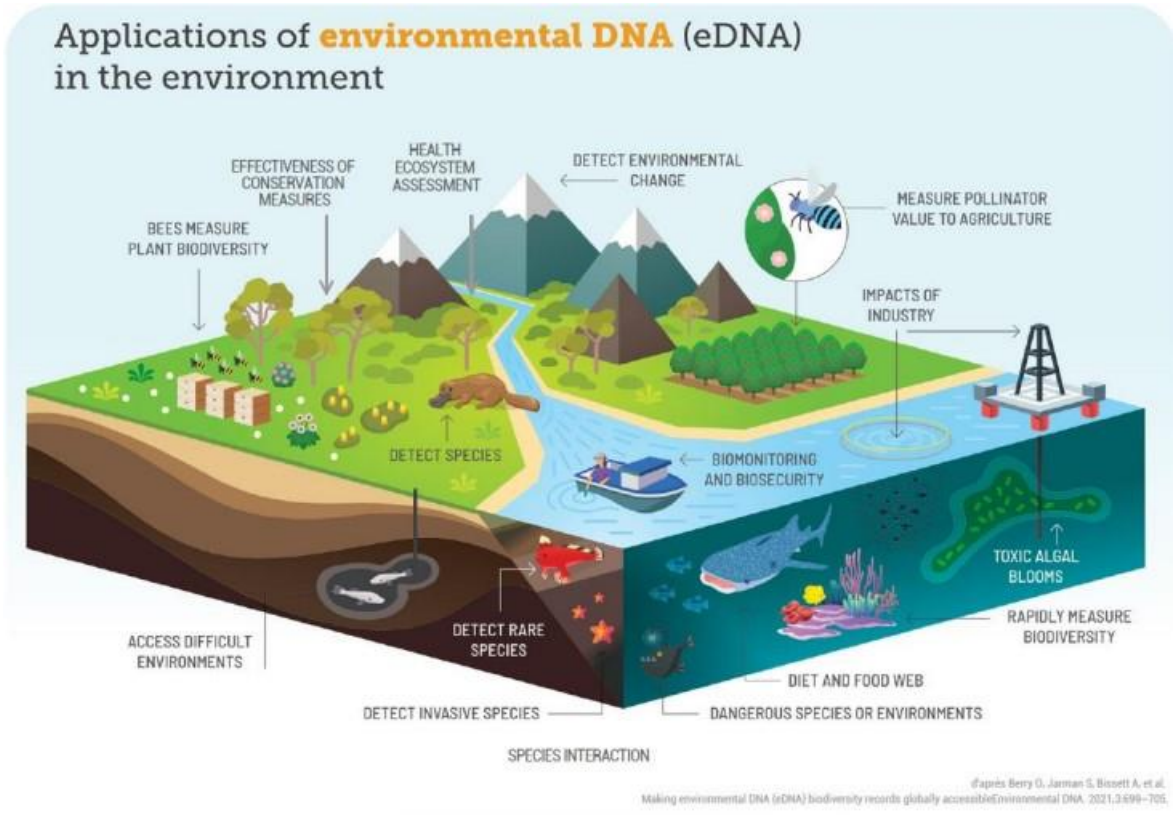
c. Osmotic energy production

IAGF had the chance to visit Sweetch Energy's osmotic generators, currently in the test phase, in the Rhône delta on the site of the Barcarin lock, managed by CNR. With eight patent families and an adaptable model (including a floating barge concept), Sweetch Energy and CNR aim to maximize the potential of this innovative technology for constant energy production with low environmental impact. Nano-osmotic diffusion energy generation uses special nanoscale membranes to control the movement of water and ions, generating pressure that can be converted into electricity. This process offers improved efficiency compared to traditional methods, exploiting differences in concentration to produce energy in a sustainable way.

Indeed, the discharge of brackish water after treatment recreates the initial composition of seawater without altering the ecosystem and the materials needed to manufacture the membranes are available locally.

This clean, renewable technology is revolutionary and makes osmotic energy cost-effective to generate electricity where salt water and fresh water meet, i.e. in estuaries and deltas. Every year, 30,000 TWh of energy is naturally dissipated in deltas around the world via the salinity gradient. On the Rhône, this potential could reach up to 500 MW, the equivalent of the consumption of 1.5 million people.


OSMOTIC POWER PLANT
RIVER WATER
SEA WATER
sweetch


Applications of environmental DNA (eDNA) in the environment
EFFECTIVENESS OF CONSERVATION MEASURES
HEALTH ECOSYSTEM ASSESSMENT
DETECT ENVIRONMENTAL CHANGE
MEASURE POLLINATOR VALUE TO AGRICULTURE
BEES MEASURE PLANT BIODIVERSITY
IMPACTS OF INDUSTRY
DETECT SPECIES
BIOMONITORING AND BIOSECURITY
TOXIC ALGAL BLOOMS
RAPIDLY MEASURE BIODIVERSITY
ACCESS DIFFICULT ENVIRONMENTS
DETECT RARE SPECIES
DIET AND FOOD WEB
DETECT INVASIVE SPECIES
DANGEROUS SPECIES OR ENVIRONMENTS
SPECIES INTERACTION
d'après Berry O, Jarman S, Bissett A, et al.
Making environmental DNA (eDNA) biodiversity records globally accessibleEnvironmental DNA. 2021;3:699–705.

D. Environmental DNA

Franck Pressiat, Head of the Environment Department of the Compagnie Nationale du Rhône (CNR), presented the concept of eDNA, or environmental DNA, which consists of taking water samples, filtering them and comparing the DNA present in these filters with databases. This makes it possible to **detect rare, cryptic or difficult-to-observe species by traditional methods.**

This method has a significant number of advantages:

- Efficiency and speed: an eDNA campaign on the Rhône has made it possible to obtain as much information on biodiversity in a few weeks as ten years of electric fishing;
- The discovery of rare or extinct species: the thick mussel, a freshwater mussel considered to have disappeared from the Rhône for 40 years, has been found;
- Monitoring invasive species such as quagga mussels;
- Monitoring long-term biodiversity trends;
- The evaluation of ecological restoration projects, such as the one carried out on the Rhône with a consortium of 18 research laboratories;
- Decision support for managers (water agencies, river syndicates, etc.) in terms of biodiversity protection and development.

However, there are some limitations to the use of eDNA, such as the inability to accurately quantify the population of a species, the risk of contamination of samples if strict protocols are not followed, and the difficulty of interpreting the data. DNA is stored for 15 days in water in our latitudes, so it is important to consider the context and other sources of information when interpreting eDNA results.

eDNA experts (Spygen, Alchios, Naturalia, etc.) and research organizations (University of Grenoble, CNRS, etc.) have joined forces to form the Vigilife alliance, a global network for monitoring life and biodiversity, particularly on the Rhône and other sentinel rivers. Their ambition is to make the Rhône the first river in the world to have a complete monitoring of its biodiversity, from the glacier to the sea, thanks to eDNA. 40 stations will be needed for this monitoring.

"eDNA is a complementary tool that allows long-term and long-distance monitoring."

F. Pressiat insisted that eDNA should not replace traditional methods of studying biodiversity but, on the contrary, should be combined with other techniques such as electrofishing and eco-surveys to obtain a more complete view of biodiversity. This approach is a source of hope for the protection of aquatic ecosystems.

All these innovations remain avenues in development that the territory could seize in response to certain issues such as water stress and soil salinization (desalination, REUSE, brine recovery), the erosion of biodiversity and disturbance of aquatic ecosystems (eDNA + classical method), sustainable and local energy production (osmotic energy), the integrated and concerted management of water resources (digital twin, collaborative platforms)

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Conclusion and perspective

During the conference organised on 18 October 2024 entitled "*The future of rivers and deltas: Crossed views of the Rhône deltas, the deltas of the world",* the IAGF experts concluded their session in the Camargue by presenting what they had learned in contact with the various stakeholders of the territory, while putting it into perspective with other deltas of the world.

Climate challenges: a shared reality

Deltas, whether in the Camargue, Bangladesh or Senegal, are suffering the full force of the effects of climate change and share similar problems: rising sea levels, salinization, changes in river flows, drought and flooding.

Fawzi Bedredine, project coordinator of the OMVS (Organisation for the Development of the Senegal River), warns of the importance of the fight against salinisation: "Salt is the most dangerous enemy of agriculture." He shares the Senegalese experience of an anti-salt dam that has made it possible to quadruple the available agricultural land and stresses the need to anticipate these phenomena.

Katherine Daniel, Director of the School of Cybernetics in Australia, describes the Australian reality: "For 30 years, we have been experiencing increasingly intense droughts, floods and fires." She warns of the acceleration of climate crises and pleads for stronger anticipatory policies: "We have to see elsewhere in the world what is happening to be ready. You have to anticipate in order to be able to anticipate. »

At the same time, Pascal Bourdeaux, a historian specialising in Southeast Asian religions, links climate impacts to cultural and religious perceptions. By studying the Mekong Delta, he explored how Buddhist beliefs, marked by a cyclical conception of time, influence the way local communities view climate change.

Deltas and their watersheds, a complex interaction

Deltas are not simple fluvial terminations. They embody the complex interactions between watersheds and their populations. It is therefore urgent to reconnect the Camargue to its river.

Erik Orsenna evokes the Camargue and its delta, as "an island" cut off from its nourishing river, the Rhône. Echoing the famous phrase from Visconti's film The Leopard, he challenges us: "What must be changed for the essential to remain? The threat is no longer Garibaldi's army, but climate change. This metaphor underlines the urgency of a profound transformation to avoid immobility and nostalgia.

Gilles Mulhauser, Director General of the Cantonal Water Office in Geneva, underlines this essential relationship: "The glacier is the brain, and the Camargue the feet of the Rhône." This image, inspired by the Kogi Indians of Colombia, illustrates how the deltas downstream reflect the hydrological, climatic and human dynamics upstream of the watershed.

Jean Jalbert, Director of the Tour du Valat, reminds us that "deltas are integrators of everything that happens in the basin", highlighting their role as buffer zones between rivers and seas. He warns that the development of deltas often disconnects them from their watershed, ignoring the importance of the "great water cycle" in their functioning. He calls for a rethink of "livability", i.e. the way of living in harmony with these dynamic spaces. Based on the example of Bangladesh, he asks: "How can we re-establish a form of mobility and live well in these changing spaces?"

Tangible and intangible heritage: an essential component of any development project in deltas

The cultural dimensions of the tangible and intangible heritage of the deltas are essential in order to understand the realities of the delta in a holistic way. Pascal Bourdeaux presents the Mekong Delta as an "active character": an entity in permanent interaction with the populations and their spirituality. He insists on the integration of local knowledge and beliefs in development projects: "If a tree is sacred to a community, this symbolic value must be understood and respected."

Cooperation and Sharing: collaborative governance for a common territorial project

For sustainable integrated water resource management, deltas require collaborative governance processes and transboundary cooperation.

Fawzi Bedredine recalled a Malian proverb: "When we share water, we can share everything." He then referredto the fact that " cooperation between the different actors is essential, even if the interests may be contradictory ". The example of the Renaissance Dam in Ethiopia, a source of strong tensions between Egypt and Ethiopia, illustrates the consequences of a lack of upstream consultation.

Governance is a crucial point, a common denominator for all deltas and a major challenge for the Camargue. How can the divergent interests of local actors be reconciled and a coherent and sustainable territorial project can be built? The problems of consultation and dialogue are real obstacles to action.

Like the OMVS, the Compagnie Nationale du Rhône (CNR) can be a source of inspiration in this sense, as Erik Orsenna cites. This structure, which brings together actors with sometimes different political visions, has been able to create a collaborative governance around a common objective: the integrated management of the river.

Gilles Mulhauser stresses the need to align with a vision, thanks to a unifying project: "A project is difficult to achieve if you don't have a common vision. He also advocates for consultation and observation tools combining science, culture and economics.

The need to strengthen dialogue between deltas was confirmed by Katherine Daniel: "By working together, by sharing data and knowledge, we can build collective futures that make sense."

Anticipation, Innovation, Tradition: prerequisites for adapting to the impermanence of deltas

Anticipation is one of the key conditions for a sustainable future. Katherine Daniel insists on the importance of anticipating. It is not just a question of reacting to events, but of projecting oneself into the future, imagining possible scenarios and preparing in advance.

Innovation (technological, organizational, methodological, agronomic, etc.) is a powerful lever for responding to challenges and must be thought of in an interdisciplinary manner. Following the example of tools combining interdisciplinarity for governance processes, Gilles Mulhauser encourages the development of interdisciplinary observatories "mixing scientific data, cubic metres, hydraulic data with social and economic data".

Deltas in the face of crises are also spaces where innovation must be inspired by local traditional know-how. Jean Jalbert evokes constructive adaptive solutions in Bangladesh, where mobile villages adjust to the floods of the Brahmaputra in order to manage risks with sobriety and robustness: "This impermanence is a characteristic of deltas, and it must be integrated into our reflections."

Katherine Daniel highlights the role of technology in crisis management, while recalling the importance of cultural and human approaches: "In Australia, our water systems are old, but they remain examples of resilience in the face of a changing environment."

Deltas, while exposed to multiple challenges, can be vanguards of a desirable future.
In the face of change, these nourishing lands are cradles of deep attachment for their populations.
The Rhône delta in the Camargue is a treasure. A treasure trove of riches, challenges and also hope.

Its development projections must be thought of as interconnected with the entire basin and its upstream source, and in deep connection with its history, its identities, secular reflections of multiple adaptations.

Deltas must be able to embody the interconnection between science, culture, history, economics, politics, thus paving the way for new innovative and inclusive development projects.

"Deltas must remain spaces of life, memory and the future."[15]

[15] Jean Jalbert