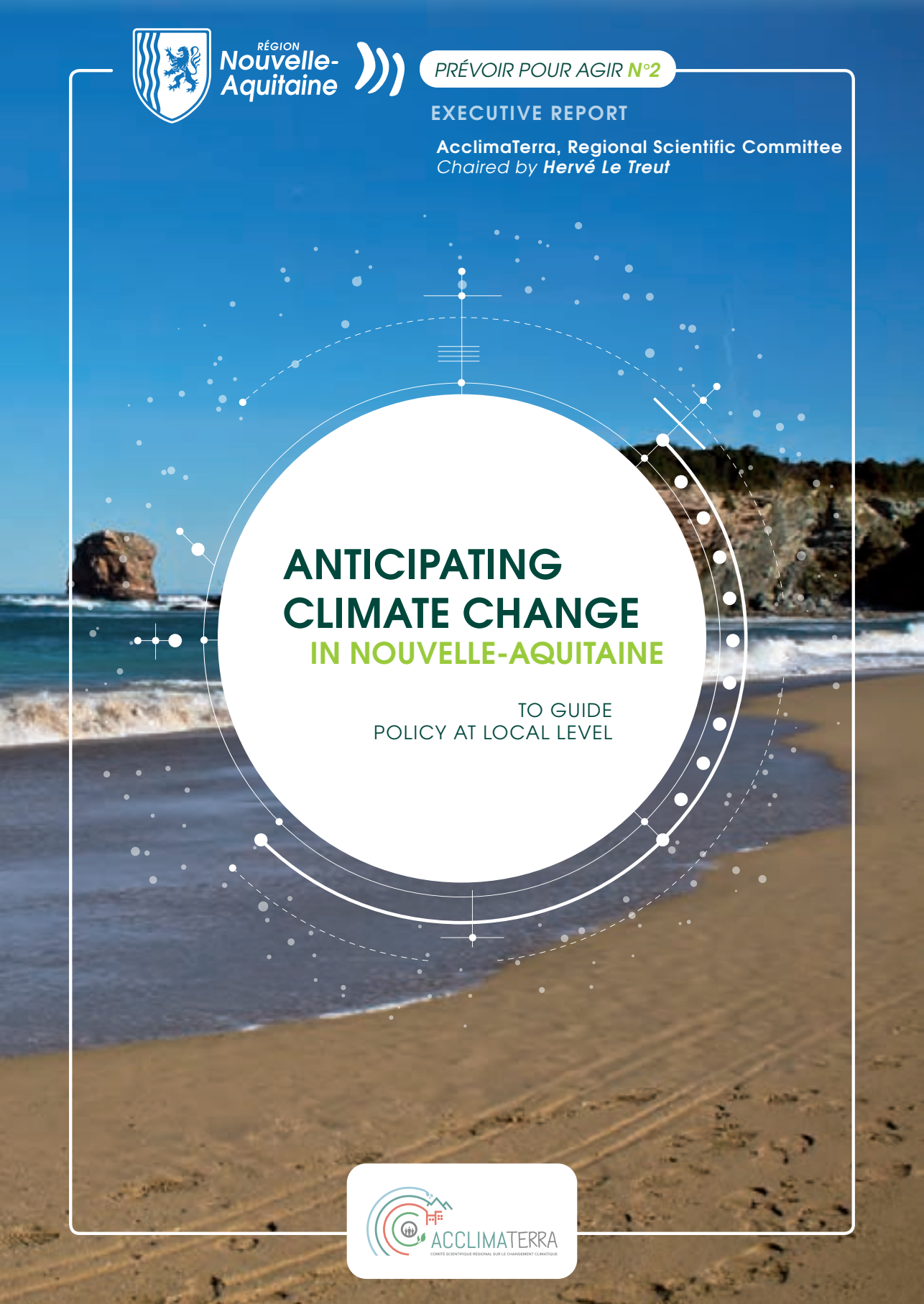
RÉGION Nouvelle-Aquitaine

PRÉVOIR POUR AGIR N°2

EXECUTIVE REPORT

AcclimaTerra, Regional Scientific Committee
Chaired by ***Hervé Le Treut***



ANTICIPATING CLIMATE CHANGE IN NOUVELLE-AQUITAINE

TO GUIDE
POLICY AT LOCAL LEVEL

ACCLIMATERRA
COMITÉ SCIENTIFIQUE RÉGIONAL SUR LE CHANGEMENT CLIMATIQUE

Editorial

For many years aware of the importance of climate change and the urgent need to tackle it, the Nouvelle-Aquitaine Region has undertaken an ambitious scientific endeavor with AcclimaTerra to broaden knowledge on climate change at regional level, and base public policy on scientific expertise.

This report provides indeed a unique assessment of climate change in a particular region, taking into account natural and socio-economic consequences of environmental degradation. It is therefore one of the building blocks our ecological and energy transition.

In order to support and deepen this transition, it is important first to design an integrated trajectory as all issues are interconnected. With the Néo Terra roadmap adopted in July 2019 the purpose of which is to hasten the transition through systemic policy action, the Nouvelle-Aquitaine Region, therefore, took up the challenge. Néo Terra is organized around 11 major ambitions, then itemized in specific objectives: citizen participation, agroecology, business transformation, energy transition, decarbonized transport, resilient urban development, waste treatment, biodiversity conservation, natural resources and water conservation, safeguarding of agricultural and forestry land. The Regional Council thus mobilizes across all its domains of intervention, and all the social actors in Nouvelle-Aquitaine, to converge towards a real ecological transformation and create a resilient, caring society and economy.

Alain ROUSSET
President of the Regional Council of Nouvelle-Aquitaine

Foreword

The present document is based on almost a decade of work in the Aquitaine region, a region which was extended in 2016 to the larger domain of Nouvelle-Aquitaine. This work was concluded by a report called 'Climate Change in Aquitaine' published in 2013, and by the report of a Working Group called AcclimaTerra, released in 2018. These reports have gathered the expertise of about 400 senior scientists, and have presented a comprehensive view of the environmental evolution of the region, in the past, the present and the future, for a wide range of disciplines, ranging from physical or biophysical diagnosis to societal issues.

The success of these documents, but also their intrinsic complexity, determined very early on the need for a more tractable version of the AcclimaTerra report, of a smaller size, focused on its main messages and recommendations.

This is the text, written in French for French decision-makers and citizens, which we now wish to bring to the English language.

The motivation for this translation derives mostly from the willingness to share what may be one of the most important results of our studies: the systemic character of regional evolution, and hence, the systemic diagnosis necessary to manage consistently the relevant territories. The regional system is complex: it brings about such different issues as the management of water resources, of vulnerable areas (urban, littoral, mountainous) of economic activities (agricultural or industrial), of biodiversity conservation, energy production, health, … It is indeed necessary to consider the different changes that can occur in a region like Nouvelle-Aquitaine in a global way, and to see how they overlap with each other to describe the climatic and environmental evolution of this region as that of a complex, heterogeneous but interdependent system.

This is of course a learning process, which is necessary in each region of the world – but will manifest itself differently in each case. We hope that the experience of Nouvelle-Aquitaine will be a useful reference for other studies. AcclimaTerra is continuing its activity and is widely open to cooperation with foreign partners.

Hervé Le Treut
Professor at Sorbonne University and École Polytechnique
Member of the Academy of Sciences

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Introduction
A local initiative: Climate Change in the Nouvelle-Aquitaine

The Nouvelle-Aquitaine region, located in southwestern France, became, after the territorial reorganization that took place in 2016, the biggest region in France with over 84,000 km^2. It houses almost 6 million inhabitants, has 720 km of coastlines and it is the first region in terms of agriculture and wood as well as photovoltaic production.

The president of the region, Alain Rousset, and the regional Council, have constantly emphasized the role of scientific information in decision-making. In 2011 considering the lack of information concerning the impacts of climate change at a local scale, the Council decided to create an Intergovernmental Panel on Climate Change (IPCC)-like committee'. The objective was to assess the available information that might help better understand the impacts of climate change in the region, and anticipate the associated adaptation needs. The task was entrusted to the IPCC member and climatologist Hervé Le Treut, and the C2A (which stands for Climate Change in Aquitaine) group was launched with a main objective: to produce a report that could concentrate and summarize the studies concerning climate change, while keeping a strong linkage with other issues, such as biodiversity, ecosystems, or economic activities. More than 170 senior researchers contributed to 15 themes, each having a dedicated coordinator. In 2013 the report 'The impacts of climate change in Aquitaine' was released and presented through public meetings to the society and territory's stakeholders. It is important to mention that this approach was the first of its kind in France.

As already mentioned, soon after that the region faced a major change: a three-region fusion to become Nouvelle-Aquitaine. New territories, new landscapes, new issues, new challenges that needed to be taken care of. So as to overcome them, the regional Council renewed its trust in this committee, which was renamed AcclimaTerra.

Even if at first these demands were originated by the regional Council, AcclimaTerra researchers saw right away the interest and the need that a work like this represented. In 2015 more than 240 senior researchers and contributors were willingly mobilized to produce another report that could harmonize the knowledge on climate change information for the entire region. In June 2018, the report 'Anticipating climate change in Nouvelle-Aquitaine. To guide policy at local level' was released. The aim of this work was to show how climate change will affect our territory and to provide both a diagnostic and recommendations which could help decision-making in a wide range of domains.

The Nouvelle-Aquitaine Council has made good use of these recommendations: together with a project call 'Écobiose' they helped define a roadmap called Néo Terra, which was approved in July 2019. It determined 11 ambitions, accompanied by quantified commitments and concrete actions aiming to support the transition effort in energy, ecological and agricultural terms by 2030.

For AcclimaTerra, the achievement of this second report does not imply any end to its actions. On the contrary, after the publishing of the report in 2018, AcclimaTerra launched two 'regional tours' in 2018 and 2019 in order to visit different cities so as to mesh the territory. The aim was to work side by side with the municipalities and the elected representatives, and to better understand the issues that each territory is facing in the context of climate change. This has, for example, taken the form of public conference that allows stakeholders to better assess the local challenges. Furthermore, AcclimaTerra has developed the capacity to present its work to associations, communities, enterprises, etc. AcclimaTerra also developed a specific interaction with a younger public, through presentations within schools, high schools, colleges and universities, and it is constantly active in updating its diagnosis and information. The growing ambition of AcclimaTerra is to provide a link between science and society at the heart of public decisions.

Coordination: **Valérie Barbier**

NOUVELLE-AQUITAINE :

12 DEPARTMENTS

THE VASTEST REGION IN FRANCE

84 000 km²

5,9 MILLION inhabitants

1/3 OF THE FORESTED REGIONAL TERRITORY

1st FRENCH & EUROPEAN REGION *for the value of its* **AGRICULTURAL PRODUCTION**

2nd METROPOLITAN REGION (excluding Île-de-France) *in terms of wealth production*

PIB **159,8 BILLIONS OF EUROS**

1 738
SURFACE
WATER MASSES

116
GROUNDWATER
M A S S E S

720 km
OF COASTS

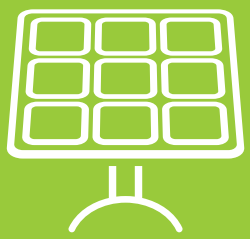
1.1 **MILLION ha**
of land still in
G R A S S

more than **52 000 ha**
of **PROTECTED** surfaces
b y r e g u l a t i o n

9.3 %
OF THE TERRITORY
ARTIFICIALIZED

182 719 GWh
CONSUMED

51 684 Kt CO_2e



36 529 GWh
RENEWABLE
E N E R G Y
PRODUCTION

1

Global climate, local climate: what dependence?

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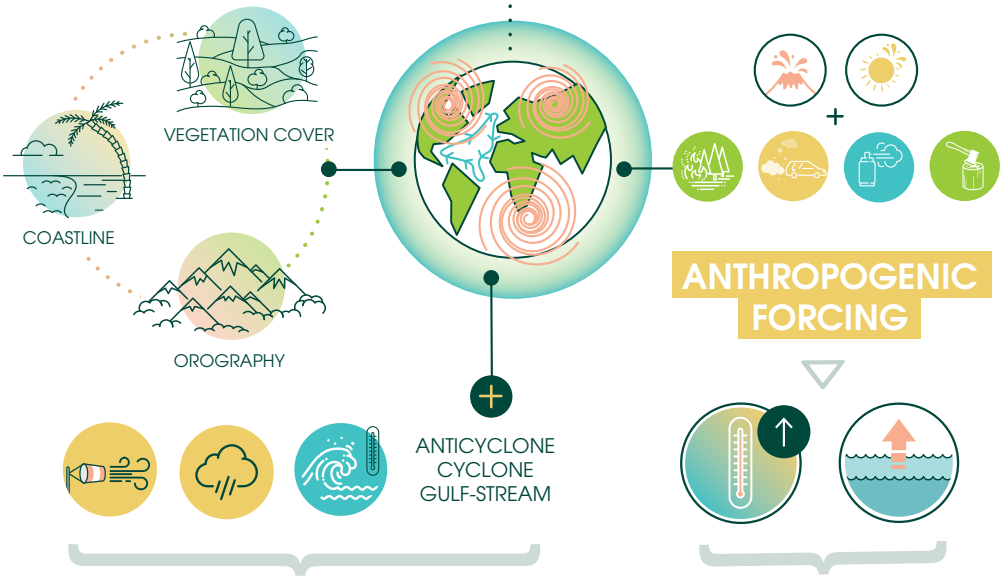
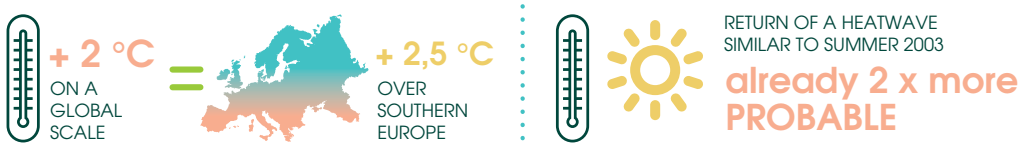
CLIMATE AT THE SCALE OF THE WHOLE PLANET



WEATHER BECOMES UNPREDICTABLE

BEYOND 10 DAYS

CLIMATE CHANGE IS PARTLY PREDICTABLE



RETURN OF A HEATWAVE SIMILAR TO SUMMER 2003

already 2 x more PROBABLE

THE LEVERS OF TERRITORIAL ADAPTATION

FUTURE RISKS OFTEN DESTRUCTIVE, GLOBALY INCREASING

APPREHENDING VULNERABILITIES TO PROTECT THE TERRITORIES

PROJECTIONS TO BETTER ANTICIPATE ACTIONS

Coordination: **Hervé Le Treut**

Authors: **Christophe Cassou, Hervé Le Treut, Serge Planton, Aurélien Ribes, Robert Vautard**

Contributors: **Laurent Li**

CONTEXT ELEMENTS

The Nouvelle-Aquitaine climate strongly depends on global climate. It is part of a meteorological landscape marked by major players such as the Azores high pressure and the Iceland depression, which have a major impact on the distribution of temperatures, winds or precipitation on the regional territory. There is also an oceanic landscape, marked by complex current regimes and by wave and swell regimes that can cross the Atlantic. All these big players are subject to fluctuations, which are independent of human activities and which are also impossible to predict precisely beyond a ten-day forecast at best for atmospheric processes.

The role of greenhouse gases emitted directly by human activities is also determining. Those gases play a major radiative role, because they remain for a very long time in the atmosphere, where they accumulate during periods ranging from several decades to several centuries. They are then mixed by the movements of the atmosphere on a global scale. In Nouvelle-Aquitaine as elsewhere, the greenhouse effect linked to human activities is therefore the result of gases emitted everywhere on the planet. Finally, global climate, by determining the weather regimes to which Nouvelle-Aquitaine is subject, also determines the different forms of how the regional climate responds and will respond to global warming: depending on the circumstances, the seasons, the years, the same region can thus be subjected to droughts, heatwaves, or, conversely, to floods.

Therefore, Nouvelle-Aquitaine does not have all the elements in hand to fight alone against the current changes.

But even if the warming that takes place in the region depends mainly on gases emitted from outside the regional territory, Nouvelle-Aquitaine must participate in international efforts to reduce greenhouse gas emissions, since the gases it emits will travel all over the planet. And it must also take into account the local climate consequences in their current manifestations, and, preventively, in terms of future climate changes. To summarize the region must find forms of synergy between actions to mitigate and adapt to climate change, in order to make the most of regional specificities (in terms of energy, regional planning, agriculture, etc.).

The main question is therefore: how do we assess the regional consequences of global warming? It is first necessary rely on global scenarios and models, and then to refine their results to get information at the regional level – which had been done for the two French models. In 2013, when the first report on climate change in the Aquitaine region was produced, it could also rely on the six scenarios for future greenhouse gas emissions established by the IPCC in the 'Special Report on Emission Scenarios', published in 2000. These scenarios were the result of a very important prospective work on the evolution of various factors: demography, energy resources, economy, financing capacity, governance… They showed that already the path to an overall climate, which would remain stabilized at the end of the century below a warming level of 2 °C (compared to a pre-industrial reference), was a very narrow and difficult path. In 2013/2014, in its fifth assessment report, the IPCC proposed different emission paths. Instead of asking 'here are the greenhouse gases that we are likely to emit, what will be the consequences?', the approach was: 'here are the types of consequences that we would like to avoid, what are the possible scenarios?' To this, most models showed that to stabilize the bar below 2 degrees of warming, the minimum objective of the Conference of Parties (COP) 21 in Paris, it would be necessary to go through a 'zero-emission' phase before the end of the century.

WHAT CAN WE SAY ABOUT RECENT CLIMATE CHANGE?

The available temperature records since the end of the nineteenth century indicate that Nouvelle-Aquitaine's climate has already warmed by around +1.4 °C during the 1959–2016 period. Computed over a longer period – for example, 1900–2016 – the estimate is not very different (+0.1 °C to +0.2 °C of additional warming); most of the warming has occurred in recent decades, mainly since the 1980s. This amount is clearly higher than the fluctuations expected due to the natural variability of the climate. Warming is more marked in spring and summer than in autumn and winter. It is also relatively uniform over the region, and very close to the average warming observed in France. It can be noted that this value of +1.4 °C is significantly higher than the global warming observed since the beginning of the twentieth century (around +1 °C), which is consistent with our understanding of the phenomenon, more marked on the continents, and confirms our anticipations for the future. The objective, mentioned in the Paris agreement, of global warming capped at +1.5 °C on average, would therefore not be achievable if it were limited to Nouvelle-Aquitaine only.

Since 1958, on the other hand, the annual and seasonal accumulations of precipitation have not shown any significant change. This is due both to the greater natural variability of the rain, which prevents a stable diagnosis, and to the fact that this variable is less directly impacted by the increase in the greenhouse effect. However, other variables linked to the water cycle are already showing signs of evolution, such as soil humidity (linked to the increase in temperatures, and therefore in evaporation). Many studies have described the evolution of the so-called 'extreme' weather events, such as heat or cold waves, droughts, storms, episodes of heavy precipitation, etc., due to the strong impact that these events have on our societies. From this point of view, the results obtained at the scale of France concerning the observed increase in heatwaves and the decrease in cold episodes are applicable to Nouvelle-Aquitaine (and consistent with average warming).

Another significant fact is the trend towards an increase in the extent of agricultural droughts across the country (due to the decrease of water quantity in the surface soil). This is also true for the Nouvelle-Aquitaine region, with an increase in [agricultural] droughts of 6 to 7 % since 1959.

The origine of these these changes has been the subject of numerous studies, which clearly indicate the preponderance of human influence in the current warming and its consequences. It is also established that in addition to the emission of greenhouse gases (GHGs), other human activities have impacted the climate of the last century. This is particularly the case for anthropogenic aerosol emissions, which partly masked the warming induced by GHGs: their atmospheric lifespan being much shorter, this masking effect should diminish in the future.

Numerous studies also seek to quantify the role of human influence on the occurrence of particular extreme events. For example, the heat heatwave of summer 2003, or the succession of storms in the 2013–2014 winter. Humans are never the only cause of these events, because the natural variability of the climate also contributes to determine their charateristics. Nor are humans responsible for their occurrence at a particular place or date. On the other hand, the probability of occurrence of these events has changed under the effect of anthropogenic disturbances. It has been estimated, for example, that the probability of a heatwave comparable to that of summer 2003 has more than doubled compared to that of a climate not affected by anthropogenic factors.

WHAT CAN WE SAY ABOUT REGIONAL SPECIFICATIONS OF FUTURE CLIMATE CHANGE?

Global climate models can anticipate future risks, but they are not sufficient to describe the regional characteristics of these changes. Regional models are needed, which provide more geographical details on a smaller aera, and use the global models to determine the conditions at the limit of this domain. Thus, it is possible to speak of 'regionalization of climatic simulations'.

Thanks to this technique, it is possible to better simulate atmospheric flows near the Pyrenees: for example, winds like Autan or Tramontane, whose direction and intensity are partly due to reliefs, or even events like Galerne, which periodically affect the south-west of France, can have significant impacts. Such simulations were carried out in a project involving several

dozens of European research institutes called the IMPACT2C project (see for example the atlas ***http://www.atlas.impact2c.eu***). This project showed that for a change of 2 degrees on a global scale, the south of Europe would undergo a more significant warming, of almost 2.5 degrees, especially in summer. This conclusion is valid for Nouvelle-Aquitaine.

Preventive adaptation to climate change can be built on these elements but it must also be done by taking into account climate evolution, which commits the long-term future, and will continue for several decades at least after the greenhouse gas emissions have been reduced or eliminated. This development is also accompanied by fundamental difficulties in determining the nature and intensity of risks, in particular in the most intense or extreme situations. Yet a lot of infrastructure needs to be built now, based on what can be expected from climate change in the coming decades. It will therefore be necessary to define a risk reduction policy that also takes into account those over which the region has no control. In this context, it must be borne in mind that whatever the origin of the phenomena which are more difficult to predict, climate change will very often increase their impact. The warming will thus make heatwaves more intense, the rise in sea level will be a factor of fragility for the coastal areas. It is of course the assessment of the vulnerability of the territories, societies and ecosystems thus threatened that can provide the basis for coherent political action.

2

A memory for a better adaptation to climate change?

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Historical data

+ measuring instruments

Transmitters of History

Profession

Welfare state

1572
1623
1647
1709
1719
1740
1769
1785
1924
1927
1934
1937
1999
2009
2010
2013
2014

37 Meteorological DISASTERS between 1700 & 1790

15 Landes forest STORMS between 1550 & 2009

-50 % FOREST STOCK of the Landes forest between 1999 & 2009

30 STORM SURGES of the Atlantic coastline between 1550 & 2010

RESILIENCE ADAPTATION ANCIENT SOCIETIES

Two or more storey house

Habitat removal

Fisheries

Wetlands

LESSON LEARNED FROM THE PAST REDUCTION OF CURRENT VULNERABILITY

collective awareness of a potential threat

preserved accessible administrative traces

Flooding Île de Ré 2010

list long-standing exposed territories

natural hazards visibles in the landscape

reference point Xynthia 2010

Coordination: **Emmanuel Garnier**
Author: **Emmanuel Garnier**
Contributors: **Bernard de Jéso, Frédéric Surville**

INTRODUCTION

Against all odds, the adaptation of our societies to climate change does not start today. De facto, if the historian digs deep into the archives, they will find an analysis of the impacts of climate on societies (risks, vulnerability) and their functioning, and indirectly discover the responses developed by our predecessors, responses that could qualify as adaptation strategies. Just as we need today, the necessary adaptations made by the old urban and rural communities in Nouvelle-Aquitaine resulted from an awareness of the harmful impact of fluctuations (long episodes) and climatic extremes (brief and severe weather events). While the adaptation to current climate change is often confined to its strictly economic, technological and physical aspects, the historical perspective highlights the facets that are more easily accessible to our contemporaries, such as the cultural, social, geographic and politico-institutional dimensions. More modestly, the historical perspective delivers concrete and practical experiences – and is therefore inexpensive for the taxpayer – of measures taken by our predecessors to limit the negative consequences of 'time disruptions', an expression that was used at the time.

TRANSMITTERS OF MEMORY

The word 'adaptation' implies a climatic threat perceived by those who face it. But who were those who spoke about it?

It is necessary to present these 'passers' of regional climate memory and understand what interests justified their scrupulous weather observations and how the knowledge they accumulated was shared for the benefit of the community. The vast majority of the available documentation consists of textual archives. Indeed, it was not until the middle of the nineteenth century that instrumental data (thermometric, hygrometric and barometric) finally appeared in the modern sense of the term. Among the witnesses there are prominent figures (nobles, bourgeois), Catholic and Protestant clergy under the Ancien Régime. Then, with the advent of the Republic, engineers (civil and military) and civil servants (teachers, staff of the prefectures, etc.) appeared. When it came to talking about the weather, these observers were very verbose for obvious reasons. The first is explained by their mastery of writing, a privilege that was not widespread until the end of the nineteenth century, before compulsory education was introduced by the Third Republic in 1882. Another advantage specific to these people was their financial ease, which allowed them to buy reliable measuring instruments from the eighteenth century onwards. How do we explain such a craze for climate facts? Against all expectations, it was less a sensitivity to the vagaries of meteorology than their more trivial economic consequences that motivated their attention. First of all, it was a financial interest that explains why the authors – often in contact with the rural world where they owned domains, or else were engaged in commercial affairs, particularly maritime business – were interested in the subject. In these conditions, being able to imagine, thanks to the equipment or to a series of observations recorded in a register, what the next harvests would be and the foreseeable impact on their 'people' (villagers, workers, etc.) was an indisputable strategic advantage in anticipating market mood swings and human disasters. After 1850, the work of civil servants was more in line with the creation of the welfare state, which claimed to protect its citizens from such vagaries.

THE 'MONSTROSITIES OF TIME' OR THE ETERNAL CYCLE

What were the climatic disasters that hit Nouvelle-Aquitaine? This is the challenge of the second part of the chapter through specific examples of disasters in the Dordogne, in the Landes, the Bordelais or even the Charente-Maritime, not forgetting the coastline of this large region. For example, in the eighteenth century alone, the current Dordogne department suffered no less than 37 floods, which was a hazard every three years or so! By way of comparison, the periods of reoccurrence put forward by the prefecture of the Dordogne in 2014 are between 10 and 75 years.

On the forest front, the Landes area is a textbook case. If Hurricane Klaus, in January 2009, is remembered as an absolute disaster for the wood industry and its inhabitants, the verdict of history, supported by the archives, reveals that between 1550 and 2009, 15 storms, which can be classified between levels 10 and 12 on the Beaufort scale, struck the local forest ecosystems. But it was not until the 1900s that these hazards caused real economic disasters. Why not before? Quite simply because the forest was completely different in the previous centuries. In the meantime, the Landes de Gascogne area has been the subject to a massive sanitation and reforestation, which have given rise to a completely artificial, mono-specific, and therefore not very resilient, forest. Maritime pine, a non-native species, is now supplanting better adapted species, such as local oak, beech and pine, which are much more resistant to winds.

LESSONS LEARNED AND RESILIENCE TOOLS

Another horizon, quite strategic for the future of the region's tourism sector, is the coastline that has experienced at least 30 proven storm surges between 1550 and 2010. Contrary to what one might think, the last 50 years have not been marked by a resurgence of this type of extreme event. The most catastrophic century corresponds to the eighteenth century, with nine storm surges. More surprisingly, in the last 100 years, six storm surges have struck the Bay of Biscay, the vast majority occurring between 1924 and 1957. In the 1930s, fears were such in public opinion and among elected officials that the newspaper La Petite Gironde did not hesitate to declare that the Pointe de Grave, just as happened to Atlantis, would probably soon disappear. The erosive process did not spare the coasts, as evidenced by the reports of engineers from the autonomous port of Bordeaux, who identified 23 storms as having caused sufficiently serious damage to be the subject of expert appraisals and expensive repair campaigns of dykes and other defensive works. On this erosive front of the interwar period, Soulac-sur-Mer was particularly vulnerable, as evidenced by the retreat of the dunes on the seafront, the collapsed or gutted dykes, as well as the buildings and dwellings that partially collapsed.

Climate risk, understood in its social dimension, was not experienced in the past as a fatality but rather as a state of expectation leading to the anticipation of a crisis. It involved a perception of danger, the expression of a fear that awakens the memory of a past catastrophe from which the collective consciousness emerges of a potential threat. This desire to better understand the risk required original forms of preparation for disaster, without neglecting any channel of information transmission. The communities therefore took care – through sometimes very imaginative ways – to adapt by developing disaster prevention and management actions. After each ordeal, our 'new Aquitaine' ancestors were able to keep the memory of extremes with the obvious aim of better guarding against them if they were to reoccur.

The administrative traces left by plagues of all kinds were thus preserved and accessible in such a way – and the municipal chronicles of the city of Bordeaux testify to this – that they could be consulted easily and at any time, by the 'decision-makers' of the past. The memory of natural

disasters was also the subject of a landscape inscription with its cartographic and 'memorial' versions. In the first case, the cadastral and urban map fixed by toponymy (place names) the territories exposed for a long time to the angers of nature, while the scales, the large plates or the votive offerings, small religious tableaux hanging in Catholic churches, all located in strategic places in terms of audience attendance (bridges, streets, shrines), recalled the danger and made possible an at least relative assessment of the threat by ordinary people. Finally, the social cohesion was, in a way, maintained, especially between generations, when it came to estimating exposure to risks by questioning the elders inhabitants in order to collect their memory. For the coastal populations, the coast was above all a nourishing space exploited in a sustainable way and according to an inescapable imperative: security. In this regard, the Lacanau site is emblematic, at the national level, of the process of deconstruction of a sustainable coastal landscape, which was accompanied, in contrast, by an aggravation of vulnerability from 1900.

CONCLUSION

Because the management of adaptation to climate change comes from a recent movement and remains largely unfinished when it comes to making it operational on a territorial scale, historical depth contributes in its own way to the preparation of vulnerable populations and their elected representatives. Knowledge of the adaptation trajectories of our predecessors can indeed favour a territorial consensus on objectives borrowed from old practices, therefore achieved (formerly) and again achievable at significantly lower expense than costly engineering work for the taxpayer and not environmentally sustainable. Finally, for decision-makers and scientists involved in this field of adaptation, the historical approach invites them to stay connected to the realities of the world and the field.

3

Legal instruments for climate change adaptation

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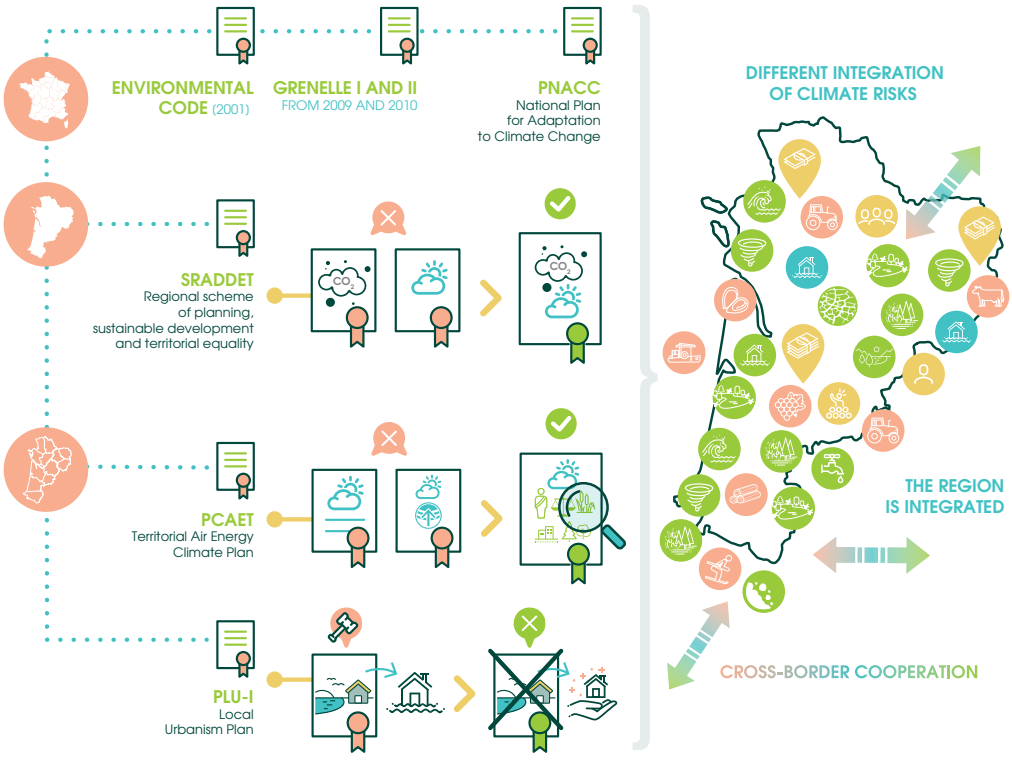
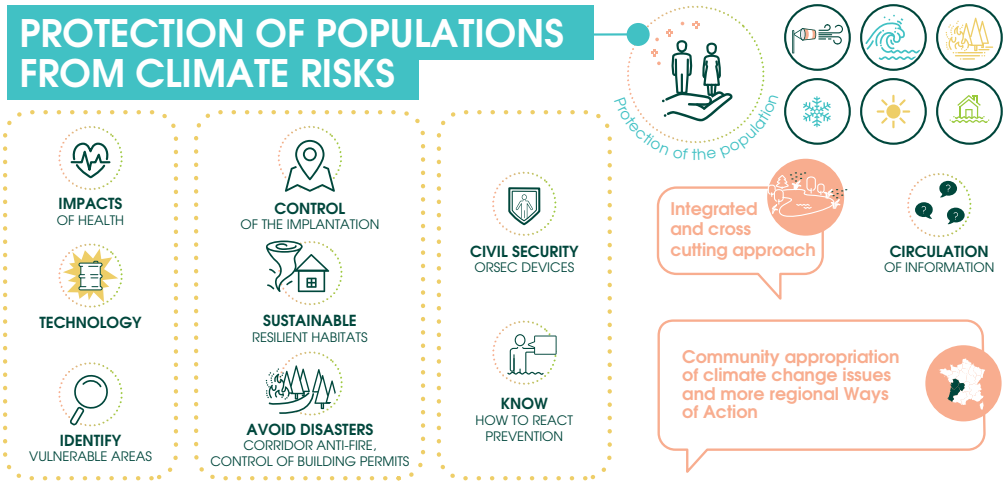
ADAPTATION OF TERRITORIES



TRANSFORMATION OF ECONOMIC ACTIVITIES

PROTECTION OF POPULATIONS FROM CLIMATE RISKS



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INTRODUCTION

Climate change adaptation in the Nouvelle-Aquitaine region must meet the international and European commitments concluded by France. At the national level, in the french Environmental Code 'the fight against the intensification of the greenhouse effect and the prevention of risks linked to global warming are recognized national priorities' since 2001.

The law has a certain number of legal instruments, which, even if they are not specifically dedicated to this objective, are intended to face the challenges of climate change adaptation. However, not all legal instruments, and more broadly, all public policies, have integrated these challenges in the same way and in the same spatial and temporal scales.

To approach the issue from a regional perspective, territorial planning tools have been used quite recently. Plans to limit greenhouse gas (GHG) emissions appeared as early as the 2000s, but it was not until 2004 that the climate plan included measures with a territorial vocation.

The objective of the PNACC (National Plan for Adaptation to Climate Change) is to support adaptation by allowing actors to become able to adapt to future climatic conditions that are still imperfectly known. During a second stage with the development of a new PNACC, recommendations are planned, in particular on the 'prevention and resilience' component. This is a question that deals with the operation of a progressive and structural transformation of the territories.

To translate these objectives at the regional level, planning instruments play a key role in setting objectives in various fields contributing to fighting global warming and preventing the harmful consequences of its effects. The challenge is above all to support changes in actors' practices and to develop territorial projects.

However, the legal instruments that can serve as a lever for adaptation are much more extensive than these plans and are found in different fields of intervention: regional planning, economic transformations and the protection of populations from climate risks.

THE TERRITORIAL APPROACH TO THE ADAPTATION TO CLIMATE CHANGE

Territories are not exposed to the climate risks and do not have identical financial, economic and human resources to prepare and implement the adaptation of their populations to climate change. The Nouvelle-Aquitaine Region Council is now the leader of the communities on its territory for the exercise of multiple skills related to the climate.

While it has been established that our GHG emissions are closely linked to land use planning methods, the corresponding policy is drawn up independently of the policy to fight climate change at national and territorial level.

Furthermore, climate change is the subject, in the texts in force, of rather general references, of very specific provisions or simple planning, whose obligatory and binding character are quite variable. The magnitude of the stakes should push the legislator to rethink the issue in a global way in order to give the regions the means of a real coherent policy to fight climate change.

In addition to the current Regional Climate Air Energy Scheme (SRCAE) and the Regional Ecological Coherence Scheme (SRCE), other tools for subregional application complete the system to fight climate change, such as the Territorial Air Energy Climate Plan (PCAET) and local planning documents.

However, it is essentially through the prism of the prevention of natural risks (in particular, flooding), that the law of urban planning apprehends (indirectly and partially) the fight against climate change, whether it is a question of planning the territory occupation or to reduce (by refusing building permits) the vulnerability of people and property. On a broader territorial scale, other legal instruments could be put in place to deal with climate change by developing cross-border cooperation. The Nouvelle-Aquitaine could encourage the conclusion of a tripartite agreement with Spain and Andorra for the protection of the Pyrenean ecosystem.

In terms of the protection of natural environments, environmental law makes support for adaptation possible by supporting water management planning and aquatic environments, by reducing GHGs and by protecting, to a certain extent, the coastline and the mountains. Adaptation concerns all species. Climate change has quickly become one of the main threats to biodiversity. To facilitate the adaptation of biodiversity to climate change at its scale, the Nouvelle-Aquitaine Region Council has the skills in the protection of natural spaces (Regional Natural Parks and especially Regional Natural Reserves) and the preservation of ecological continuity.

THE TRANSFORMATION OF ECONOMIC ACTIVITIES

Global warming also has impacts on economic activities and, conversely, business sectors produce disruptive effects on the climate. The law provides instruments to guide, encourage and constrain economic actors in terms of climate-responsible development, with more or less significant involvement at regional level. This is the case for agriculture, industry and transport. Agroecology is of crucial importance. The management of industrial pollution risks continues.

Efforts are being made to improve rail transport, to develop 'soft' modes (cycling, walking) and new uses for the car (car sharing).

Other sectors such as tourism and energy have legal means to implement at regional level. The tourism sector is strongly affected by all the events that modify the reception conditions for tourists. Therefore, adaptation to climate change is a real concern for those involved in this activity sector. The energy transition is relayed at the regional level by specific tools led by the regional Council (SRCAE PCAET, Local Plan of Urban Planning). Finally, corporate social responsibility (CSR) remains a powerful lever for mobilizing economic actors to achieve adaptation objectives. The environmental dimension of CSR, namely the consideration by companies of their environmental performance and their responsibility regarding the exploitation of natural resources, mainly refers to taking into account – throughout the production chain – pollution prevention and control practices, waste management and management of local pollution or the environmental impacts of transport.

The performance of a company now depends more and more on its CSR practices, which reflect its ability to think in the long term. If the region ranks among the most virtuous regions in terms of CSR approaches, other options can be considered to further promote CSR, such as financial incentives or strengthening of information and communication systems.

PROTECTING POPULATIONS FROM CLIMATE RISKS

Adaptation also involves preventing the risks that weigh on populations due to climate change: natural, technological and health risks. The law tries to give answers by regulations adapted mostly at a national level. This requires, in particular, layout and building control as well as the development of civil security systems.

The Nouvelle-Aquitaine region must make the most of these legal tools to prepare for adaptation in a context where the latest territorial reforms tend to centralize places of public decision-making in increasingly large territories (in particular new regions, on new inter-municipal scales), leading to potential difficulties in the circulation of information and physical representations of stakeholders and the public.

The region has developed tools to prevent health, natural and technological risks for populations in the territories. It also seeks to anticipate the socio-economic and health consequences for Nouvelle-Aquitaine.

In terms of preventing climate change risks to health, the regional Council can act by mobilizing its skills in local public policies in sectors such as transport and energy. It would also be important for the regional health and environment plans

to integrate all the dimensions of the impacts of climate change on health. In addition, certain regional skills allow Nouvelle-Aquitaine to get involved in order to reduce the vulnerability of the population against extreme weather phenomena generated by climate change. It will be able to identify exposed areas and anticipate vulnerability situations when the Regional Planning, Sustainable Development and Equality of Territories (SRADDET) scheme, provided for by NOTRe law, is implemented.

Facing climate risks, protecting populations depends on housing location and by taking action on the building itself, which will have to increase its resistance.

In addition, the emergence of environmental concerns has given a fundamental role to land issues in the management of renewable natural resources, particularly rich in the Aquitaine region. Land access regulation is indeed a question of primary importance in order to protect the environment and prevent possible conflicts. This regulation requires an establishment control and the implementation of land resources to manage the occupation of the territory. The specificity of the Nouvelle-Aquitaine coast, nature-oriented, also requires adequate land solutions.

Finally, civil security is especially sensitive for this region, which is particularly exposed to certain natural risks, whose frequency and magnitude could increase as a result of climate change.

Crisis management systems have been improved since the 2004 law on modernizing civil security. General provisions (ORSEC – Civil Security Response Organization) apply regardless of the origin of the crisis – the response is flexible depending on its magnitude. They are completed by specific provisions for certain risks previously identified (specific intervention plans, etc.).

These systems do not specifically and directly involve the region as a local authority.

CONCLUSION

Law, and in particular environmental law, has been widely mobilized across the Nouvelle-Aquitaine region to address the multiple challenges linked to climate change adaptation. However, it appears that a number of competences belong to the national level and it is therefore important that the communities take on problems in order to implement public policies that support adaptation at the local level, both in terms of transformation of economic activities and the evolution of public policies for preventing and fighting climate change.

New guidelines inspired by the new PNACC are currently under development and should allow the development of an integrated and transversal approach to adaptation with means suitable to the regional scale.

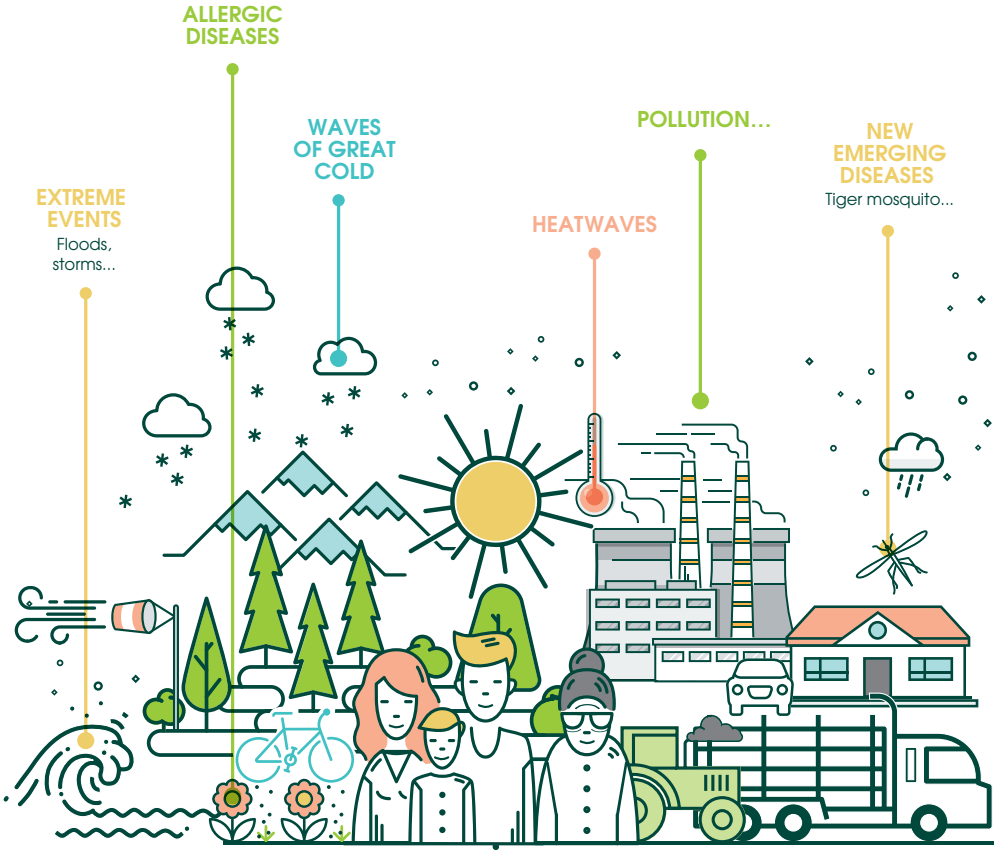
4

Environmental health

La Rochelle © Philip Lange

HEALTH A MAJOR LEVER

91% of Nouvelle-Aquitaine residents ARE INTERESTED IN **ENVIRONMENTAL HEALTH** (Health Environment Barometer 2015)



A ROLE ON FREQUENT DISEASES

CO-BENEFITS (salutogenesis)

- PROMOTING CONTACT WITH NATURE
- PROMOTING SOCIAL LINKS
- PROMOTING INTERSECTORIALITY AND INTERDISCIPLINARITY

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INTRODUCTION

Climate change is not only increasingly recognized as an extreme threat to health, but also as an opportunity to be seized to mobilize all stakeholders – decision-makers, researchers and public –to act responsibly. The Nouvelle-Aquitaine region has all the required strengths to grasp this issue: researchers, field workers and associations are weaving together actions in favour of environmental health, and almost all of the population has already appropriated the need to take this aspect on board. This text presents firstly the impact of climate change on health in Nouvelle-Aquitaine, and the implemented surveillance to anticipate health consequences. Secondly, the mechanisms by which climate change affects health are discussed, which leads to considering it as a determinant of health and a revealer of vulnerabilities within the regional population. Then, breaking with the classic paradigms both in health and in environment, the concept of environmental health is presented. The political decision is thus brought to renew itself, imbued with ethics and meaning. Finally, based on the Ottawa Charter and on salutogenesis, health appears as a relevant lever to drive changes that are struggling to emerge in our societies, and areas for reflection are offered.

CLIMATE CHANGE AND HEALTH

The effects of climate change on health are numerous and concern frequent diseases (although it remains difficult to assess which parts are attributable to climate change): respiratory and cardiovascular diseases; allergies; mental illnesses; cancers, etc.

Direct effects linked to heatwaves, very cold waves or extreme events such as floods or storms are distinguished. These catastrophic situations are responsible for health problems most often immediately, even if longer-term effects can be observed, which are mostly psychological. Indirect effects can also occur by affecting the quality of living environments, or with the appearance and spread of emerging diseases linked to a change in the distribution of certain vectors (such as the Tiger mosquito), the increase in allergic diseases linked to the increase in allergenic elements in the environment through interactions between pollination and increased temperatures, or even by the long-term migration of certain allergenic plant species. Whether the effects are direct or indirect, the impacts will be more or less marked depending on the social dynamics involved. A better understanding of climate change impact on health requires a health and environmental monitoring system capable of anticipating the magnitude of the threat and the consequences for the population. This surveillance system is structured around two complementary approaches:

- systematic surveillance, based on health indicators or the active identification of cases by morbidity registers,
- surveillance alert, based on health and environmental events, using all official and informal communication methods.

These determinants influence not only the exposure to the risk linked to climate change and the prior sensitivity (vulnerability) of individuals to various hazards, but also the resources or the possibilities of preventing it. Health effects linked to climate change can also occur in the longer term, and in cumulative form, resulting from the effect of all the exposures that an individual can undergo over their entire life (exposome). This approach is consistent with the World Health Organization (WHO) definition of environmental health in 1994 which *'understands aspects of human health, including life quality, which are determined by physical, chemical, biological, social, psychosocial and aesthetics of our environment. It*

also concerns management of policy and practices, absorption, control and prevention of environmental factors likely to affect the health of present and future generations.'

The challenge is therefore to conceptualize environmental health in such a way that it becomes a tool for understanding and not just a definition. It brings solutions for the future, which our societies urgently need to face the challenges of the twenty-first century.

In environmental health, innovation is inevitably based on two principles: transdisciplinary work (interdisciplinary, at least), interprofessionality and intersectorality. Interdisciplinarity implies openness between disciplines, the interpenetration of knowledge leading to 'a community of points of view', even to hybridization. Research and decisions in the field of environmental health must necessarily be built by mobilizing all the sectors in which humans evolve (transport, housing, education ...) and go beyond the frameworks of ecology and health. Besides, this intersectorality already gave convincing results in the nineteenth century, notably in the construction of infrastructures linked to sanitation.

'Health is a value that can help identify common interests and stimulate a virtuous dynamic. It gives meaning to public action and is likely to motivate behavioral changes. The individual and collective health benefits will be quickly observed. Health thus constitutes a powerful lever to drive these changes, in partnership with other sectors'.[1]

Nouvelle-Aquitaine is particularly ready since 91 % of its inhabitants declare that they are interested in environmental health.

The health promotion model described in 1986 by WHO in the Ottawa Charter as well as the concept of salutogenesis is part of this holistic vision of environmental health.

CONCLUSION

Actions towards the population, which will not only be beneficial in the fight against climate change but also for the health of populations, called co-benefits, are examples of salutogenic actions. The complexity of the interrelations between the determinants of health does not allow an exhaustive and sectoral list of salutogenic actions, insofar as health crosses all the frameworks and the temporal standards of life of the population. The extended report proposes some principles of actions to be amplified in Nouvelle-Aquitaine:

- Foster social ties
- Foster contact with nature
- Foster inter-sectoriality to put health at the heart of societal challenges
- Foster interdisciplinarity

1• Marano, F., Pascal, M., Simons, J., Bard, D., Hubert, P., Pacteau, C. Recommandations issues du Congrès 2015 de la SFSE Changement climatique et santé : quels risques, quels remèdes ? Environ. Risques Santé, vol. 15, n° 3, 2016, p. 266–271.

5

Quality of environments

Limousin © Ilolab

WATER

GOOD ECOLOGICAL CONDITION

- 36 % WATERCOURSE
- 60 % UNDERGROUND WATER
- 15 % WATER BODIES
- 40 % DOWNGRADED DUE TO NITRATES
- 8 % TRANSITIONAL WATERS

INCREASE TEMPERATURE

→ In 40 years **+2 to 3 °C**

→ **-5 % dissolved oxygen**
→ Rivalry between species

WATER FLOW REDUCTION

→ **Less dilution** of pollution
→ **Pollutants** in sediments

INTENSE EXPLOITATION OF GROUNDWATER

→ Release of existing stock of parent molecules and metabolites

NEED TO...

...PROTECT WATER RESOURCES

Observation of climate change on water quality

Limit diffuse pollution

Optimize water extractions

Increase the level of collection and purification of discharges

Arrange waterways

Reorganize water governance

...SPECIFIC STUDIES

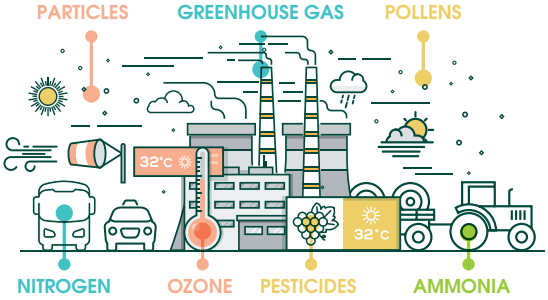
... APPLIED RESEARCH ON « THE FIELD »

TO BETTER UNDERSTAND THE EFFECTS OF CLIMATE CHANGE

and protect public health and biodiversity

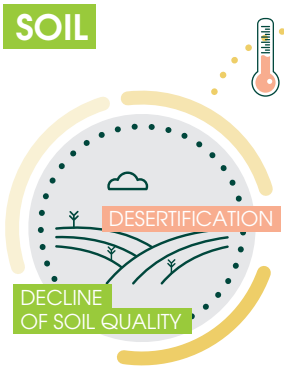
AIR

POLLUTION EPISODES: 8 DAYS PER YEAR



Deterioration of air quality in the coming decades.
Increases in aerosol contents, allergens

SOIL



INCREASE OF TEMPERATURE

CARBON LOSS = LESS FERTILIZED SOIL

Increase in biological activity
INCREASE IN MINERALIZATION
EFFECTS ON THE CYCLE OF NITROGEN

INCREASE BIOAVAILABILITY OF METALS

INCREASE OF CO_2
Lack of nutrients
NITROGEN and **PHOSPHORUS**

FUTURE CLIMATICS SCENARIOS
Affects microbial populations = less fertile

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INTRODUCTORY CONTEXT

The quality of an environment can be defined by the ability of its intrinsic characteristics to be able to meet the requirements of biocenosis, the protection of public health and the needs of anthropogenic uses. Visible and predictable changes, under the double impact of anthropogenic activities and climate change, the quality of the three environments 'water', 'air' and 'soil' are assessed in this text for the Nouvelle-Aquitaine region, based mainly on physico-chemical and sometimes biological parameters. The challenges are considerable in terms of public health (air pollution episodes, pollination, drinking and bathing water quality ...), of biocenosis (migration, development and reproduction, effect of invasive species ...), and many activities, such as agriculture (water stress, soil fertility, fight against the development of insects and moulds ...), aquaculture, fishing, tourism, etc. Despite these challenges, this impact of climate change on the quality and pollution of environments is often overlooked compared to other more publicized impacts, such as direct impacts on health, on extreme climatic and hydrological events, on the evolution of the coastline and on the availability of water resources. The waters and air of Nouvelle-Aquitaine, and to a lesser effect the soils, which are already significantly polluted, will nevertheless undergo several types of deterioration in the forecast climatic context.

WATER QUALITY AND CLIMATE CHANGE

The Nouvelle-Aquitaine region includes several types of freshwater, saltwater and brackish water resources, under a varied geographic distribution and unevenly distributed over the territory, thus creating very diverse aquatic environments. Exploited by man to meet his food, economic and recreational needs, these water resources are also vital for the natural environment.

The already bad state of surface water is highly likely to deteriorate, in particular under the increase in temperature and the decrease in flow rates.

According to the results of the 2015 SDAGE (Master Plan for Water Development and Management), only 36 %, 15 % and 8 % of Nouvelle-Aquitaine surface waters are in good ecological condition for the rivers, water bodies (e.g. reservoirs, lakes, pools) and transitional waters (estuaries in particular), respectively. The European objective of achieving total good condition in 2027 will not be easy to reach for these water, given the foreseeable impact of climate change. In addition, it should be noted that the analysis of many other chemical and biological indicators other than those of the WFD (Water Framework Directive) does not mitigate this finding.

In Nouvelle-Aquitaine, there has been a significant increase in the average temperature of surface waters over the past 40 years, with forecasts of it reaching +2 to +3 °C at the end of the century. The inevitable 'physical' consequence of this forecast will be a decrease of about 5 %, on average, in the dissolved oxygen content. The life of existing species will therefore be impacted, with changes in the distribution areas and rivalries between migrating species and those already present, especially in transitional waters with the additional effect of the increase in salinity. To this effect of ecosystems trajectory will be added increases in the number of invasive species, often thermophilic and opportunistic, and in the risks of diseases linked to endotoxins and parasitic microorganisms.

The significant foreseeable decrease in the flow rates of the Nouvelle-Aquitaine watercourses (e.g. large and small rivers, streams...) (as already partially observed), will inevitably have the effect of less dilution of pollution, with constant quality and quantity of anthropogenic discharges. This phenomenon, coupled with a probable remobilization of the pollutants already present in the sediments, under the effect of temperature and extreme hydrological events, will lead to an increase in organic and mineral macro- and micropollution.

The increased fragility of environments, the modification of trophic chains and more generally ecological networks, already subject to anthropic pressures, will therefore be aggravated by climate change at the level of all biological and ecological traits. The pollution excess coupled with the increase in temperature, salinity and organic matter content of freshwater, as well as the decrease in the pH of coastal waters, will be amplifiers of the 'engines' of abiotic and biotic reactions certainly modifying the mechanisms of toxicity.

Regarding water uses, the main question concerns drinking water quality, especially when this resource is the only one available. What are the treatment barriers to fight against the increasing 'raw water' problem of certain quality parameters (parasites, cyanotoxins, dissolved natural organic matter, proven and emerging micropollutants ...), and what are the costs and effects on the quality of the drinking water produced?

Groundwater quality should be less impacted with the exception of overexploitation events.

Sixty per cent of Nouvelle-Aquitaine's groundwater bodies are in good chemical condition, while the remaining 40 % are 'downgraded' by the nitrate and / or pesticide parameters. What will be the impact of climate change on this quality, knowing that soils that still hold significant proportions of fertilizers and phytosanitary products (and their metabolites) are meant to 'leak' into groundwater, and even more so under the effect of temperature increase and extreme hydrological phenomena? Faced with the decrease of surface water availability, the significant population increase (compared to the national average) near the coast and the increase in demand for drinking water per inhabitant, the shift to groundwater may appear to be a solution.

In terms of quality, the major risks of overexploitation will then be amplified by the transfer of pollutants to deeper aquifers and, more locally, likely increases in the salty bevel.

In addition to an essential mitigation policy, an adaptation plan becomes urgent.

Whether for surface water or groundwater, an adaptation plan will mainly consist of protecting water resources, increasing discharge collection and treatment level of wastewaters, limiting diffuse pollution and optimizing and adapting the levies to compensate the quantitative decline in resources. The most vulnerable areas of Nouvelle-Aquitaine should be targeted and some strategic observation sites be chosen, in order to monitor (by appropriate measures) climate change impacts on water quality on these areas, as well as the effects of adaptation measures.

AIR QUALITY AND CLIMATE CHANGE

Air quality deterioration is directly linked with demographic and economic development, but climate change, which is closely linked to air pollutant emissions, will probably contribute to accentuate this deterioration. However, despite the abundant scientific literature on the 'air quality / climate' relationship, the impacts of climate change on air pollutant emissions are still relatively uncertain, because of its geographic location dependence.

Quality objectives are often exceeded for certain pollutants, but average air pollution is globally stabilized.

At an average value per capita, atmospheric pollution in Nouvelle-Aquitaine is higher than the French average, particularly in terms of particles, nitrogen dioxide and ammonia. French quality objectives, and the WHO (World Health Organisation) guide values, are often exceeded in Nouvelle-Aquitaine with regard to parameters concerning particles and, above all, ozone. Most air pollutants show a decrease tendency over the past decade, except for ozone and volatile and semi-volatile organic compounds. Pesticides are present in the air at significant levels, especially near wine-growing areas, and the very likely resurgence of insect and mould invasions under the impact of climate change does not suggest a decrease in use of insecticides and fungicides. Greenhouse gas emissions (in CO_2 equivalent per capita) are identical to the French average, as well as their downward trend for almost 20 years. Conversely, the pollen index continues to increase.

Climate change will likely increase some air pollutants, nevertheless many uncertainties remain.

Despite the abundant international scientific literature on the 'air quality / climate' relationship, it is not fully accepted that solving air quality problems has a positive impact on climate change, and vice versa. However, published observations and scenarios suggest that air quality will deteriorate in the coming decades. For example, the average ozone concentration, known as 'hemispheric background', should increase by the second half of the twenty-first century in mid-latitudes, mainly due to the increase in episodes of drought and sunlight.

In Nouvelle-Aquitaine, as in all regions that will be particularly affected by climate change, the ozone contents, volatile (and semi-volatile) organic compounds, aerosols, allergens are the most likely to increase, as well are the most likely parameters to increase, as well as the contents of insecticides and fungicides especially for this agricultural region. It is important to note that there is a flagrant lack of specific regional studies in this area, and the elements cited above should therefore be used with caution, especially because they are based on transpositions of observations from a more global scale. Finally, it should be noted that the complex question of ultrafine particles, which are of considerable importance for public health, remains unresolved, particularly on the question of their evolution under the effect of climate change.

SOIL QUALITY AND CLIMATE CHANGE

In many parts of southern Europe, climate change is intensifying the pressure on soil resources by exacerbating the current decline in soil quality and possibly leading, in extreme cases, to desertification. This is why many European countries intend to assess the real contribution of soil protection to mitigate climate change, as well as, reciprocally, the effects of climate change on soil productivity.

The rise in temperature will lead to a greater carbon loss in soils with probable repercussions on their fertility.

The increase in biological activity as a result of temperature effect will in fact lead to an increase in organic matter mineralization in the soil, as well as probable effects on the nitrogen cycle.

In addition, the response of plants to an atmospheric CO_2 augmentation can lead to the risk of a lack of nutrients such as nitrogen and phosphorus.

Furthermore, future climate scenarios may also affect microbial populations in the soil, with many potential consequences, including loss of soil carbon, soil changes in greenhouse gas production and modifications at the soil–plant feedback level, with significant repercussions on soil fertility.

Does the greater release of pollutant 'stocks' in soil under the effect of climate change represent a major risk to the environment?

Although the objective of reducing the use of pesticides and societal demand should take place over a shorter period of time than climate change, drier periods over a part of the year may lead to more intense exploitation of groundwater resources. This would induce an acceleration of the release of the existing stock, parent molecules and metabolites.

For metals whose soils are accumulative environments, due to their complexation with mineral and organic materials, the effects of temperature on these materials may increase the bioavailability of metals, and therefore their toxicity. Increasing the frequency of extreme precipitation could also help increase their mobility.

FIELD STUDIES NEEDED FOR A BETTER PREDICTION

It is thanks to research in general, and to 'field' studies in particular, that the detection of pollution (up to ultratrace pollutant), its origin, the mechanisms of its evolution in the natural environment, its ecotoxic effects in nature and on human health, are now generally known. However, and unlike other more publicized areas, the evolution of the environments' quality under climate change impact is still too devoid of serious forecasting studies, despite the considerable challenges that arise from it (cf. Introductory context).

The authors of this chapter are indeed convinced that proven climate change will have impacts on the environment's quality. Nevertheless, their editorial approach may leave the general impression of advancement in an insufficiently known sector, as many of the modifications, linked to climate change, pollution (sources, types, natural and induced evolutions ...) and their effects (in particular toxic) are multiple and 'tangled'. This entanglement makes it difficult to put in place a coherent and relevant strategy to act effectively in favour of quality and can, moreover, fragment responsibilities, which is a source of inaction. In the absence of a global and systemic vision despite the significant regional research potential, the risk to avoid is not being able to answer the questions 'where is the enemy?' and 'where are the responsibilities?'.

In other words, a need for applied research of the Nouvelle-Aquitaine 'field' is essential to more clearly assess the impacts of climate change on the quality of environments, the adaptations to be recommended and the environmental and socio-economic challenges that will follow.

6

Water availability

Artesian well at Bontemps in Dordogne department © Hervé Chassain/Sud Ouest

UNIQUENESS OF THE RESOURCE

HYDROCLIMATIC PROBLEMS

74 000 km
of watercourses

1.5 billion m³
OF FRESH WATER
collected in 2015
in the Nouvelle-Aquitaine région

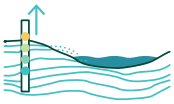
- **46 %** agriculture
- **34 %** drinking water
- **12 %** industry
- **8 %** energy

3 TYPES OF FRESHWATER IN THE WORLD

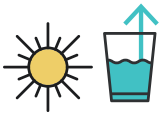
69,5 % | 30 % | 0,5 %

1 ▷ 

LOW-FLOW PERIODS + SEVERESTS + LONGESTS
↓↑
HYDROLOGICAL CYCLE disturbed

2 ▷ 

-20 % to -40 %
OF RIVER FLOWS
↓↑
OVEREXPLOITATION
of groundwater

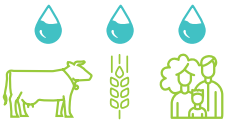
3 ▷ 

+1°C → +1,6 %
DRINKING WATER
consumption

WATER MIX

WATER FOR THE TERRITORIES AND THE ENVIRONMENTS

→ Expand the circle of participants



SOLIDARITY

Anticipation
of climate change

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INTRODUCTION

Freshwater withdrawals in Nouvelle-Aquitaine amounted to 1.5 billion m^3 in 2015. The share of volume for drinking water is 34 %. Agricultural uses represent 46 % of the withdrawn volumes. Irrigation withdrawals represent 65 % in groundwater (compared to around 35 % for France). The industrial sector takes 12 % of the total volume (nowadays decreasing). Energy production takes 8 % of the volume withdrawn.

WATER AVAILABILITY

The results of hydro-climatic expertise converge on the diagnosis of a tension concerning surface and groundwater availability in the Nouvelle-Aquitaine region under the impact of temperature rise (air and water), an increasing frequency of extreme events (including low water levels that are more severe in intensity and duration), an uncertain variation in annual rainfall, and an overall increase in evapotranspiration. Facing variation in flow rates (-20 to -50 % during low water periods), significant consequences are to be anticipated, such as regarding users satisfaction, on the evolution of aquatic biodiversity, and on plant growth. Beyond these trends, local specifics emerge: the Pyrenean rivers are experiencing an aggravation of low water levels and undergoing strong modifications of flows' global cyclicity linked to the variability of seasonal rainfall / snowfall ratios; the Dordogne regime is effectively supported by the management of its large upstream dams by EDF (French Electricity company), but in its upstream portion (Limousin), many small rivers contributing to low flows are suffering dreadful assaults; for the Charente, the complex measurement of flows evolution must take into account management requests and the hydrogeological functioning of underground complexes.

Developing towards a level of systematic hydro-climatic studies on all the rivers of the region, requires the identification of the typology of the sub-basins of the Nouvelle-Aquitaine according to a vulnerability index:

1. Rivers with low specific flows and subjected to strong anthropic pressures (including agricultural withdrawals) (Charente, Boutonne, Seudre, Dropt ...);
2. Rivers with moderate specific flows and subjected to strong anthropic pressures (including agricultural withdrawals) (Adour, Garonne, Isle, Dronne ...);
3. Rivers with rather strong specific flows and flows regulated by the management of EDF dams, but small upstream tributaries experiencing severe assault (Gaves, Dordogne, Nive ...).

For Nouvelle-Aquitaine groundwater facing climate change, the typology of the present aquifer systems, the analysis of their mode of operation and of the impacts of climate change, are prioritized for the territories of the ex-Limousin and ex-Poitou-Charentes (the ex-Aquitaine territory was covered in the 2013 report).

The territories of the western part of the Massif Central (Limousin), due to their essentially crystalline geological context, are naturally dependent on rainfall, in terms of quantity, frequency of precipitation episodes and the type of associated storage (surface reservoir or aquifer). Consequently, the low available reserve in basement aquifers induces a very rapidly marked low water level for surface sources and flows. This particular and complex functioning of basement aquifers means that providing management to each site should be considered.

In Poitou-Charentes, the large free and captive aquifers are particularly used by agriculture for which irrigation is necessary or represents a guarantee for securing crop yields. Thus, the impact

of climate change on water management represents a major challenge in order to secure both qualitatively and quantitatively this resource that supplies, in part, the central part of the Aquitaine sedimentary basin.

For the aquifers in the centre of the Aquitaine basin, there is a global deficit in effective rain and, in particular, summer precipitation, which suggests a recourse to potentially greater withdrawals in groundwater and rivers during the driest summer periods. This deficit will have an impact on the recharging of surface systems and in particular the free water table of Sable des Landes. Predicting potential changes in recharge and the conditions (natural or artificial) in which it occurs will be essential in the future.

The question of groundwater availability has a double dimension since it can evolve either due to a variation in hydrological conditions (less resource *stricto sensu*); or of a greater pressure on the resource by an increase in demand and conflicts of use.

It is this second aspect that can be feared for deep aquifers, which could be concerned by the transfer of withdrawals from surface or subsurface waters (shallow aquifers) to groundwater. This temptation to transfer withdrawals to groundwater presents the risk of spontaneous and savage adaptation to climate change, which should be avoided by planned and organized governance and also by a reconfiguration of uses and techniques.

In terms of governance, a rapid diffusion of the adaptation to the climate change problem in sectoral and territorial policies for water management during the last decade can be witnessed. This trend is observed through prospective studies, expertise and management systems dedicated to each river (Climate change adaptation plan (Adour–Garonne), PGE Garonne–Ariège, Garonne 2050, PGE Adour, Adour 2050, Dordogne 2050, Charente 2050, prospective Adapt'eau…). These expertises propose a whole series of hydro-climatic scenarios, outlining the future of water in South-West France.

CONCLUSIONS

Nowadays, hydro-climatic conditions invite the adoption of certain principles to anticipate climate change. The following actions are recommended:

- to prepare collectively to live in a significantly different environment and therefore to define trajectories aimed at possible futures and future desires, articulating the scientific and technical expertise of managers, professional knowledge, users'-citizens' knowledge associated with stories of the future;
- to consider water resource as finite and unique, integrating the interdependence of surface / groundwater, territory (upstream-downstream), timing (seasons, annual, multiannual);
- to argue, in an indissociable and integrated way, the relationships between climate, hydrology, hydrogeology, uses and governance of water to develop a water mix at the scale of the territories;
- to use sustainable exploitation flow as a rule for aquifer management: preserve the stock while setting and respecting acceptable limits on the degradation of aquifer-dependent ecosystems;
- to restore natural conditions for supplying water systems (surface and underground) before authorizing the creation of storage facilities and the deployment of technical solutions that are often socially, ecologically and technologically complex;
- to favour territorial water management ('water for territories and environments') over sectoral water management ('water for users');
- to articulate storytelling and user knowledge, scientists' and experts' modelling, the image (...) to support the anticipation of climate change;
- to give better consideration to associative, professional and civic initiatives for the mitigation and adaptation to climate change in Nouvelle-Aquitaine;
- to assume the dissensus and submit to the choice of citizens and elected officials, contrasting and differentiated scenarios, knowing their consequences (adaptation adjustment scenario vs. adaptation transformation scenario ...).

7

Regional energy

Cestas solar plant ©Région Nouvelle-Aquitaine Francoise Roch

OBJECTIVE: « FACTOR 4 »
(EMISSIONS REDUCTION BY 4) FOR 2050

NOUVELLE-AQUITAINE

Energy consumption by final use
10.6 %
of national consumption
(AREC, 2017)

Fossil energies
(oil, gas, coal)
62 %

Electricity and renewable energy (including wood)
33 %

Petroleum products
73.9 %
of consumption
of the transport sector

Agriculture and fishing
10.1 %

Tertiary
6.9 %

Residential
5.6 %

Industry
3.5 %

+20 %
of GHG emissions
SIGNIFICANT INCREASE IN HEAVYWEIGHT TRAFFIC
between 1990 and 2015

INCREASE IN ENERGY CONSUMPTION
for personal transport

CONSUMPTION AND PRODUCTION

84 % of production
represents 104 % of consumption

+400 %
1960-2000

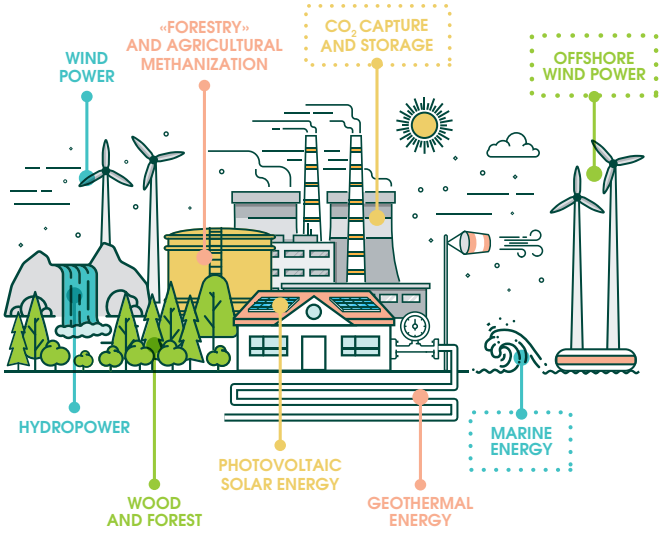
RT2020
Positive energy buildings standard

45 %

Technical Innovation

Training
of professionals

REGIONAL ENERGY MIX



LIVING BETTER CONSUMING LESS ENERGY AND SOURCE MATERIAL

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INTRODUCTION

This chapter is an innovation compared to the 2013 report. Energy being a cross-cutting theme with multiple activities, here it will be limited to the aspects that seem the most central. Furthermore, this chapter has sought to focus the analysis on regional energy levers despite the fact that this is a multi-scalar subject framed by national policies. The region was placed at the heart of the energy transition process and the fight against climate change by seeking to show the regional resources for the energy transition but also the constraints that the injunction to transition poses for these territories.

The chapter is organized around three objectives: to present the challenges of energy consumption; to provide an overview of sources of energy production; and to open avenues of investigation on the modalities of the transition in Nouvelle-Aquitaine.

ENERGY CONSUMPTION IN NOUVELLE-AQUITAINE

A work of synthesis of the existing documentation was carried out on the modes of energy consumption in the region. Studies conducted by AREC (Agence Régionale d'Évaluation environnement et Climat) highlight two trends in energy consumption in the region. On the one hand, the joint consumption of the transport and building sectors (residential and tertiary) represents 76 % of the energy used in Nouvelle-Aquitaine. This importance underlines interest in regional transport and housing policies, in particular due to the continuous growth of greenhouse gas (GHG) emissions in these sectors. On the other hand, petroleum products account for almost half of consumption due to the importance of transport, and particularly the high increase of freight transport traffic. This weight puts into perspective the actions undertaken in terms of carbon-neutral electricity production.

The importance of individual electricity consumption highlights the benefits of housing and energy efficiency policies. About 45 % of energy consumption in France is in buildings, individual residences and tertiary premises.

For these sectors, improvements in the buildings energy performance and changes in energy do not compensate for the large increase in built areas, particularly in the tertiary sector. Energy transition should therefore be considered not only through the promotion of the energy efficiency of buildings but also through their footprint and the regulation of urban expansion. Beyond the consumption centres' distribution according to energy types, it also seems necessary to question the weak integration of work on energy uses and users in the design of responses to the energy transition.

TYPES OF ENERGY PRODUCED IN NOUVELLE-AQUITAINE

The widest possible overview of the sources of energy production in the region has been developed. Renewable energy production in the region is increasing, apart from wind, and thus it covers 19.2 % of regional consumption. The different sectors are questioned about their contribution to GHG emissions reduction but also about their feasibility, their generalization and their territorial acceptance.

The chapter mentions the position of hydrocarbon production in the region, which is experiencing a slow decline. Next, the focus is on nuclear power generation at two power plants in the region to highlight that changes in water availability and surface water temperature directly affect the operation of nuclear power plants. The large part of the panorama is devoted to renewable energies, which are separated

between thermal and non-thermal renewable energy and between current capacities and those offered by the territory.

In Nouvelle-Aquitaine, the renewable thermal energy sector is marked by the significant weight of biomass (wood and biofuels), which represent 61 % of renewable energy. The upward trend in all renewable energies in the region shows, however, that the relative share of thermal renewable energy has tended to decrease, since the wood sector represented 82 % of renewable energy in 2005 and has now dropped to 61 %. The timber industry is an important regional lever in the fight against climate change, but the increase in timber removals should not reduce the forest stock at the risk of limiting the effects of the industry on GHG emissions.

The most dynamic renewable sectors are methanization and photovoltaics. At the end of 2016, 27 methanization units were active (14 sites are under construction and 66 projects in the advanced development phase), making the region one of the most dynamic in France in the methanization sector. The region also hosts 26 % of the national solar fields with more than 1,734 MW connected to the electrical network and Europe's largest photovoltaic field, in Cestas. However, if the installation of photovoltaic power plants on large 'useless' surfaces such as roofs and certain terraces does not represent a problem, other situations must be the subject of attention on the balance of benefit–cost in terms of forest reduction (and therefore CO_2 capture) and artificialization of cultivated land.

On the other hand, wind power has experienced mixed development. At the end of 2015, the wind energy sector represented only 3 % of energy production from renewable sources in Nouvelle-Aquitaine. The development of this sector is, in fact, fairly recent since the region's first wind farms were not put into service until 2004. The 50 neo-Aquitaine parks are mainly located in the former Poitou-Charentes region.

Geothermal energy and hydroelectricity are old renewable energies used in the region, with few new projects since 2000. Geothermal energy represents almost 7 % of renewable energies in Nouvelle-Aquitaine, while hydroelectricity production accounts for 9 %.

Nouvelle-Aquitaine has finally a development potential for renewable energies, which are still only at the development and prospective stage. Offshore wind farms produce more expensive electricity due to the distance to the coast, the depth of the water or the wind speed. However, electricity production is better in terms of wind and the landscape impact generates fewer conflicts than onshore wind turbines. Other types of energy can be produced from the sea, such as tidal power, wave power, tidal energy, osmotic energy, thermal energy or algal biomass. Although all these types of energy are known, not all of them have the same degree of technical, economic or industrial maturity. Tidal power is the most technically well-controlled energy sector today. For the other types of energy, the installed capacities are for the moment negligible compared to the quantity of energy produced.

The Nouvelle-Aquitaine region also hosts the CO_2 capture and storage pilot site on its territory. CO_2 capture and storage (CCS) are among the technological instruments put forward by the IPCC to mitigate global warming. The technique consists of capturing CO_2 emissions from polluting installations, such as coal plants, steelworks or cement plants, and injecting them into geological reservoirs. The Chapelle-de-Rousse pilot site (Pyrénées-Atlantiques) is for Total (oil and gas company) a demonstrator of the feasibility of this type of storage and its specific technology: oxy-fuel.

For each sector, the necessary balance to be maintained between the development of renewable energy, GHG emissions, ecological and social issues of territorial protection is emphasized.

CONCLUSION

Finally, transversely, the chapter aims to initiate reflections on local energy policies in Nouvelle-Aquitaine. In the introduction, it is recalled how regional and local actions are integrated into a national and international policy to fight global warming, but also into an energy market. Also, it concludes on the need to rethink the modes of governance of the energy transition in order to conceive a new energy model and not only to adapt the current system to the climatic dangers. The existence of contestation at the local level of certain energy transition projects highlights the need for reflection not only on the methods of appropriation by the territory of energy projects but also on their meaning for the territory actors and on the development model framing the transition. Indeed, energy transition implies a deeper society transformation as soon as it is included in the ecological transition. It implies a change of direction in taking into account environmental issues in the broad sense, including the energy transition as well as energy and material sobriety. Indeed, energy transition will not make it possible to face global challenges if the current development model is maintained.

8

Resources exploited by fishing and shellfish farming

Offshore Capbreton © Marie-Noëlle de Casamajor - Ifremer

1 100 shellfish companies

535 active fishing vessels

484 M€

4 600 direct jobs

2 200 ha of oyster concessions

270 km basket traps and mussel lines

ANNUAL PRODUCTION

43 000 t of oysters

13 000 t of mussels

1st PLACE FOR SPAT COLLECTION

NOUVELLE-AQUITAINE
1st French region
for oyster spat collection

ANNUAL PRODUCTION

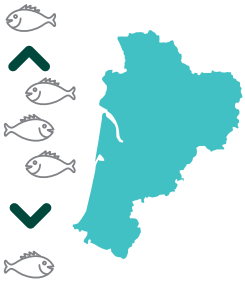
55 000 t of fishery products

Hake
Monkfish
Mackerel
Megrim
Cuttlefish
Sole
...

69 % consisting of 6 species

66 % subject to quotas

SEASONAL MIGRATIONS



DISTRIBUTION of species EXCEEDING THE REGION'S LIMITS

MODIFICATION OF THE LIVING ENVIRONMENTS

- WATER TEMPERATURE
- RIVER FLOW
- MARINE PRODUCTIVITY
- ANTHROPIC PRESSURES

- Displacement of species
- New species
- Modified phenology

ADAPT

- REGULATORY EVOLUTION
- FOOD CULTURE
- CHANGING METHODS AND BREEDING CYCLE
- WATER QUALITY
- DIVERSIFICATION

ACTIVITIES: ECOTOURISM
Tasting products
Fishing trips

FISHING
Target species
Fishing techniques

\+

ROLE OF SENTINEL OF FISHERMEN AND SHELLFISH FARMERS

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INTRODUCTION

The exploitation of resources by professional fishing and by shellfish farming generates an annual turnover of around 484 million euros, of which almost 80 % is made within the first 100 kilometres from the coast (estuaries and lagoons included). Nearly 535 vessels are active in fishing and nearly 1,100 shellfish farming businesses are active; the two of them together generate around 4,600 direct jobs.

IMPACTS OF CLIMATE CHANGE ON SPECIES EXPLOITED BY FISHING

The resources exploited by the fishermen of Nouvelle-Aquitaine are made up of populations present within vast distribution areas, far beyond the limits of the region, and living in various habitats. Coastal areas are often areas of juvenile concentrations while areas further offshore are used by adults. Significant seasonal migrations take place between the coast and the open sea or between north and south. Management must pay particular attention to these places of reproduction, feeding or growth of young specimens until sexual maturity, because these areas are often spatially limited, sensitive to changes (natural and anthropogenic) and have a key role within ecosystems.

Today, this effective consideration in management is still limited. The presence of these exploited resources in a determined place strongly depends on the physical, geochemical and biological properties of the water bodies. These properties, which condition the dynamics of the oceans (and in some cases also apply to continental waters), are modified by climate change but also by anthropogenic pressures. It is often very difficult to distinguish the role of each of these factors as well as their interactions, in particular because their impacts apply at distinct time steps; this is why the term 'global change' is often used. Changes can induce rapid modifications in the living environments of species and the relationships between them, in particular prey–predator relationships, and ultimately the functioning of ecosystems.

Studies dealing with the modifications that impact the stocks exploited by neo-Aquitaine vessels and seen through the prism of climate change, mainly concern temperature, then marine productivity, river flow regimes and, more incidentally, current and swell regimes. Among these modifications, the displacements of biogeographical limits towards the north are the best documented. Temperature greatly influences the spawning period and hatching speed (phenology) of certain species; it is also a source of physiological risks. Overall, climate change can affect population dynamics with contrasting effects depending on the species and, for the same species (or even population), depending on the geographic sector and its stage of development, with possible interactions between the stress sources. In this chapter, these changes are illustrated for 13 species of importance for Nouvelle-Aquitaine fishermen, but also for new or unusual species.

CONSEQUENCES FOR FISHERIES MANAGEMENT AND FOR SCIENCE

At present, the European Union is explicitly integrating climate change mitigation and adaptation objectives in the area of maritime spatial planning and integrated coastal zone management. The Common Fisheries Policy reaffirms the

obligations linked to these international commitments and strengthens the existing systems. It also highlights a more regional approach for optimizing the various systems with a view to achieving the Maximum Sustainable Yield in particular by 2020 at the latest, and ensuring the maintenance of biodiversity. The arrival of new predators raises the question of competition between species for prey and therefore the interest in carrying out a stock assessment using a multispecies approach. For example, a European hake population settles in the North Sea where it feeds on Norway pout at the expense of the saithe which is its 'local' predator.

The implementation of the ecosystem approach to promote the sustainability of fishing enterprises is recommended by several authors. However, today, the stock status indicators, which are the basis of the definition of total allowable catches (TACs) and quotas (themselves the keystone of fisheries management within the EU), are mono-specific. The International Council for the Exploration of the Sea (ICES), the main source of advice on management of the marine environments of the North-East Atlantic and adjacent seas, wishes to include information on the ecosystem in the assessment. But so far, the diagnoses relate to one or more species at the same time.

The challenge is therefore important for science and managers. The governance of resources, whose presence and abundance are and will be more variable inside and outside the exclusive economic zones of the EU, should evolve in particular in order to anticipate, facilitate and adapt the capacities and strategies of exploitation. Some authors propose an 'emergentist' vision, based on an adaptive approach calling on the permanent dialogue between the system and its environment, where any new organization of the system involves a modification of its environment, which in turn gives rise to an adjustment (impoverishment or enrichment) of the previous structure.

This 'emergentist' vision does not advocate any solution 'carved in stone', but supposes a permanent, evolving questioning and necessarily a reflection on the place that humans intend to take in the system.

IMPACTS OF CLIMATE CHANGE ON SHELLFISH SPECIES

Shellfish farming in Nouvelle-Aquitaine is mainly represented by the culture of the Pacific oyster and the mussel, and more incidentally by Eupean flat oyster, the Manila clam and the cockle. For the Pacific oyster and the mussel, spat collected from harvesting is one of the strengths of regional shellfish farming. For the past 20 years and for the oyster, this has been shared with the production of spat in hatcheries.

With regard to the traditional spat collection (Arcachon and Pertuis Charentais), the acidification of the oceans linked to the increase in the CO_2 concentration does not appear, to date, likely to significantly disturb spat production. The maturation of adult oysters is dependent on the temperature (for its speed) and the quantity of phytoplankton (for its intensity). This relationship to temperature has not changed over time in the Marennes-Oléron basin, but has evolved in the Arcachon bay, spawning occurring now about a month later than in the past. Changes in the phytoplankton population and / or the presence of contaminants in the environment could explain this situation. However, the development time and the survival rate of the larvae are always positively influenced by the water temperature.

Spat production capacities, from natural collection (mussel and oyster) or hatcheries (oyster), currently exceed production needs. However, the evolution of the oyster's distribution area towards the north (whether due to climate change and / or the invasive nature of the Pacific oyster *Crassostrea gigas* since 1970), demonstrates the capacity of certain sites (Vendée, South Brittany, Brest Harbour) to produce mature oysters and consequently a spat collection that can compete with the spat from Nouvelle-Aquitaine. In northern Europe, this spat collection is not seen as an opportunity, since this species is considered invasive, creating imbalances in the ecosystems of certain bays.

CONSEQUENCES FOR SHELLFISH ACTIVITY MANAGEMENT AND FOR SCIENCE

Neo-Aquitaine oyster farmers have largely relocated their farms to other sectors in France or in Europe, essentially to obtain better growth (in flesh and shell), or better survival rates (compared to sites subject to the effect of diseases). However, the spatial diversification of companies also corresponds to an economic adjustment to market constraints (seasonally adjusted product) and to a strategy aimed at reducing vulnerability (linked to shellfish mortalities) in an increasingly variable system (climatic accidents, diseases, dystrophic crises, etc.) of which climate change may be one of the key elements.

The genetic diversity of the Pacific oyster in France is significant and comparable to that observed in Japan. This significant genetic variability is an interesting reservoir of resistance to the various aggressions that oysters can undergo. Indeed, survival in the face of bacterial or viral infections is heritable, which allows for a natural or artificial selection of more resistant individuals to be considered, like that carried out by different French hatcheries. The effects of climate change, but also interactions with other biotic parameters, such as pathogens, which are themselves subject to climate change, can add to these adaptation factors and change the oyster's characteristics.

In these coastal ecosystems which are very variable by definition (interface zones between land and sea), research is struggling to identify clear and direct manifestations of the effect of climate change beyond the increase in temperature. In contrast, indirect effects such as temporal and spatial variations in salinity, which reflect the supply of fresh water to the littoral zone, are visible and have a direct impact on shellfish farming. The extreme dependence of shellfish and producers on variations in the coastal environment requires very close monitoring of the evolution of physical, biological and sociological elements by identifying potential ruptures. Technological and economic changes must be identified in order to analyse the risks for both production and marketing activity and for the preservation of ecosystem balances. Finally, the marketing of shellfish requires an ever greater health guarantee. Is the spatial proximity of sources of pollution and shellfish farming likely to change? The relocation of farms is an issue that also deserves to be addressed, since the traditional link between product, terroir and oyster farmer now seems to be supplemented by the search for a constant product quality (particularly the flesh rate and one that will satisfy more distant and less knowledgeable consumers.

CONCLUSION

The adaptability of fishing and shellfish farming companies in response to changes has a prospective dimension. It involves choices strongly linked to experience and knowledge, but also bets on a future depending on the state of the resource (including its habitats) and its development in the short and long terms, to which must be added the institutional and external constraints. The global changes encourage fishermen, shellfish farmers but also scientists and managers to think about, to perpetuate the fishing system and marine farming. Regarding 'seafarers', their situational analysis, constraints, management suggestions, as well as their perceptions of past and future adaptive capacity are important and should be considered. Shellfish farmers, by introducing new oyster species, changing their farming methods and sites, have managed to adapt to adverse conditions, even though the number of oyster farmers has decreased in some areas. For fishermen, the room for manoeuvre seems to have been more limited; the workforce of the French fleet has decreased by more than 50 % since the 1990s, even if this decrease is mainly due to overfishing and fleet exit plans. For scientists, improving species, interactions and the functioning of ecosystems knowledge is essential in order to adapt the tools used to assess fishery resources and aid management of present and future constraints. For managers, a longer-term, multi-year vision should be favoured in order to avoid crises or reduce their impacts; this probably involves changes and adaptations of public policies and regulations, which today are very focused on the management of a rent (quotas), which, by nature, is and will necessarily be more variable due to the effects of climate change.

9

New forests and new expectations?

Mont Gargan, Limousin, France © Ivonne Wierink

DIVERSITY OF FORESTS

STRONG IMPACT OF FORESTS

2.8 millions d'ha OF FOREST

34 % of the surface NOUVELLE AQUITAINE REGION

1st FRENCH FORESTRY REGION

ADAPTATION TO CLIMATE CHANGE

CHOOSE MORE RESISTANT SPECIES

1

Shorter rotation

2

New species

3

Natural and / or Man Assisted Migration

ADAPTIVE MANAGEMENT

DIALOGUE
ORGANIZATION
COORDINATION

44 % OF FOREST OWNERS do not see climate change AS A PROBLEM

41 % OF FOREST OWNERS postpone the implementation of solutions for LATER

13 % OF FOREST OWNERS declare to ACT

CNPF 2014 survey, 592 forest owners in the Limousin and South of the Massif Central)

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INTRODUCTION

This contribution questions the future forests of Nouvelle-Aquitaine in the context of climate change, and the expectations of public authorities and forest owners: What species will populate our forests? Can we expect major changes in their composition? How can human action accompany this transition in composition? It emphasizes anthropogenic actions to maintain and renew indigenous species, and it questions the past and future introduction of exotic species to anticipate the adaptive requirements imposed by climate change. In a second part, the policies recommended by the European Union and France in the forest-wood domain are discussed, regarding their adaptation to climate change and their role in its mitigation. Finally, this second part also discusses the expectations of private forest owners facing climate change, following a survey carried out among them on this subject. This review follows the synthesis made in the book 'Impacts of climate change in Aquitaine', which reviewed the acquired knowledge on the already perceptible impacts, foreseeable short-term trends and on adaptation and mitigation measures that could be implemented. This review gives less space to the experimental results related to already visible impacts, but it is deliberately placed into a future perspective and at a more generic level.

CLIMATE CHANGE AND CURRENT AND FUTURE COMPOSITION OF FORESTS OF NEW AQUITAINE

This first part deals in a very general way with foreseeable changes in composition resulting from the joint action of local adaptation of species and migration, considering on the one hand native species and on the other, introduced species. It emphasizes anthropogenic actions to maintain and renew indigenous species, and it questions the past and future introduction of exotic species to anticipate the adaptive requirements imposed by climate change. At the interface between the temperate zone and the Mediterranean zone, the forests of Nouvelle-Aquitaine are dominated by species that are found at the limit of their range, and which would therefore, be particularly sensitive to climate change. The rise in altitude and latitude of the ecotone between the temperate and Mediterranean zones could be accompanied by an increase in Mediterranean species to the detriment of temperate species. In Nouvelle-Aquitaine, Mediterranean species, such as maritime pine, cork oak (*Quercus suber*), holm oak (*Quercus ilex*) and tauzin oak (*Quercus pyrenaica*), are at the northern limit of their range, while temperate species like beech (*Fagus sylvatica*) and sessile oak (*Quercus petraea*) are found at the southern limit.

In recent years, we have observed that Mediterranean woody species like cork oak and holm oak and sub-Mediterranean species like downy oak go up towards the north of Nouvelle-Aquitaine. These observations are corroborated

by current and past distribution models of species as a function of annual average daily temperatures, which clearly show a shift in the optimum of a presence towards higher temperatures for all species. There is a larger lag for Mediterranean or sub-Mediterranean species, such as *Quercus pubescens* (pubescent oak), *Quercus suber* (cork oak) or *Quercus pyrenaica* (tauzin oak). For maritime pine, the risk of poor adaptation of local stands, due to the difference between their current adaptive value and that expected in the future climate, is assessed, and could be compensated by a transfer of material (seeds) from more southern stands (assisted migration). Models based on IPCC scenarios suggest that this risk remains low in the medium term in the Landes context. The composition of the forests will also be modified by natural dynamics and the use by humans of different exotic species, some of which have already had some success in Nouvelle-Aquitaine (Douglas fir, Northern red oak, balck locust). However, the use of exotic species in the context of climate change remains a controversial subject. Supporters of its implementation refer to the enrichment of local diversity allowing selection for better adaptation to the conditions generated by climate change and the diversity of ecosystem services associated with forests. Opponents, on the other hand, highlight the exposure, in the context of climate change, to new risks much higher than those already incurred, such as the invasive potential of introduced species or increased vulnerability to new pathogens or fungi. These two points of view are treated in this synthesis for the most sensitive species (Northern red oak, Black locust, Tree of heaven (*Ailanthus altissima*) and Negundo maple). Regarding the demographic fate of these species, the use of simulation in different IPCC scenarios shows that the climatic conditions become very slightly unfavourable for Red Oak, but change little for the Robinia and the Negundo Maple.

ACTORS AND POLICIES FACING CLIMATE CHANGE IN THE FOREST

The second part of this chapter deals with the governance of public climate policies that interfere in the forest and wood sector, their consistency and effectiveness, and the attitude of private owners towards climate change. The policies developed and implemented in the forest-wood sector are today strongly influenced by climate issues at all levels of government. At the European Union level, the adaptation component is poorly developed: it only appears as part of a measure from the rural development support programme (EAFRD). On the other hand, the mitigation component is strongly present in the 'climate-energy 2020 package' where, for example, wood energy is supposed to contribute to more than 40 % of the renewable energy development objectives of the state members. As it happens, since the entry into force of this policy in 2009, the EU's strategy for the contribution of the forest to the reduction of GHG emissions is mainly focused on the substitution of fossil resources in the energy field, and not on carbon storage in forests or in wood products. In France, the recent National Forest Wood Programme is positioning itself in a relatively proactive but cautious manner with regard to adaptation issues. It proposes the adoption of an active adaptation strategy concomitant with the effort to increase forest renewal associated with ambitions to increase wood mobilization.

In this perspective, it is recommended to favour, in the coming years, the use of research and experimentation while encouraging the implementation of adaptive silvicultural management. This orientation is therefore strongly convergent with the mitigation policy, which provides a very significant forest resource contribution to the achievement of energy objectives.

In this multilevel configuration, the regional level tends to impose itself more and more as a framework for strategic adjustment and operational implementation of forest policy. In fact, an important part of the national provisions is eschewed in regional strategies in order to adapt to the territorial specificities but also and especially, to come into resonance with the competences of the communities, and very particularly of the regional councils. In Nouvelle-Aquitaine most of these instruments (Regional Forest and Wood Plans, SRADDET, Regional Biomass Scheme) are being developed and they must meet the challenge of the new regional scope. The Regional Forest and Wood Programme (PRFB) should, in principle, act as a framework for consistency between all the other regional documents by laying the foundations for the forestry strategy for the next ten years.

Although the issue of climate change has been on the scientific media and political agenda for three decades, forest owners, who own 90 % of Nouvelle-Aquitaine's forests, became aware

of this subject belatedly. This issue has in fact often been confused with the question of risks, which is more familiar to forest owners. A 2014 survey of a sample of 592 forest owners from Limousin and the South Massif Central, shows that forest owners are divided between denial, procrastination and engagement. The attitude of denial can be explained by scientific controversies, relayed by the media and which raise doubt among forest owners. They are not necessarily 'climatosceptic' but they think that the forest will be able to adapt alone to climate change. Landes forest owners thus interpret the succession of extreme climatic events (storm Martin in 1999, drought in 2003, storm Klaus in 2009) as tangible signs of climate change. Convinced that climate change is already a problem, they are much more cautious about the solutions to adopt. Despite this attitude, some of them declare that they have started to act. These adopt three types of strategy aimed at adapting forest management to climate change: some bet on more intensive production methods and opt for shortened production cycles; others, on the other hand, in a more extensive way promote the resilience of stands. Finally, others are making very gradual, piecemeal changes. But not all owners have the same financial, technical and cognitive means to implement these different silvicultural strategies. The risk is therefore not negligible that this diversity of routes will be reduced over time, the owners then opting for a single solution, simpler to implement and / or less expensive, more profitable, at least in the short term, and more in line with the normative discourse in force within the forest community.

These results highlight the limits of individual strategies and the need to propose collective solutions to support changes in practices, based on incentive policies.

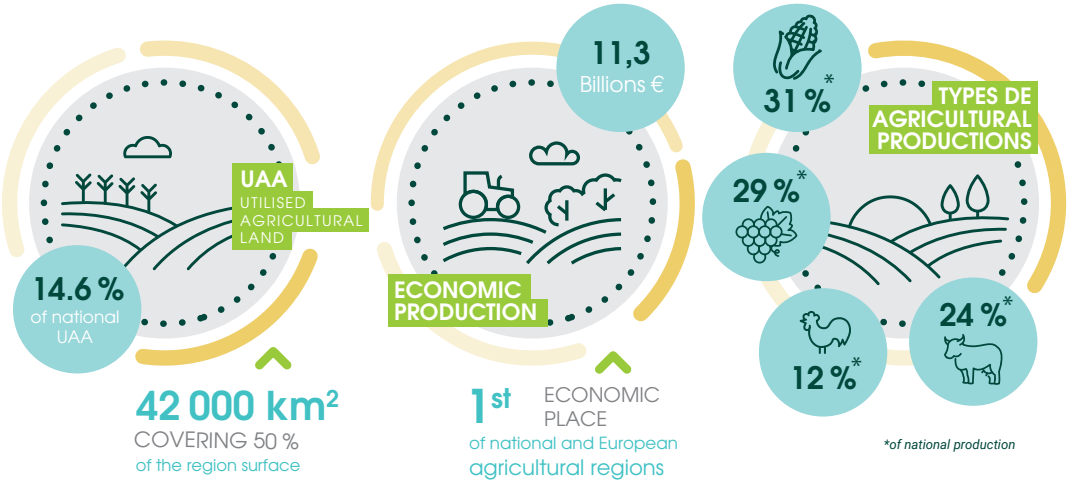
CONCLUSION

The forests of Nouvelle-Aquitaine contribute today to two levers. On the one hand, plantation forests (maritime pine, Douglas fir, poplars, i.e. one-third of the forest area) offer a resource and substitute products for other materials that produce more carbon. On the other hand, mixed deciduous forests (more than two-thirds of the surface) could rather be used to store carbon in the forest ecosystem, even if the aging of some of these forests would limit their carbon sink. These predictions are all based on the current state and composition of the forests, but do not take into account the species changes mentioned in the chapter, the effects of which will only be perceptible in the longer term. The most recent approaches, however, take into account extreme events (storm or fire), which could question one or other of the mitigation levers. Models including change of species, local adaptation and exposure to risks on the one hand and mitigation levers on the other remain to be built. It is the whole issue of current work to simultaneously take into account adaptive responses – natural or induced by humans – in mitigation models and scenarios.

10

What does the future hold for agriculture in Nouvelle-Aquitaine?

Agriculture in Limousin department, France.© Ivonne Wierink



3 AFFECTED ENVIRONMENTS

SOIL

CHANGE
increase intensity of rain

EROSION

WATER

REDUCED
rains

INCREASE
of evaporation

ESTIVAL WATER DEFICIT

THE LIVING

INCREASE
in insects, fungi ... pathogens, pests or beneficial

UNPREDICTABILITY

CONSEQUENCES OF CLIMATE CHANGE

PHENOLOGY • PERFORMANCE • QUALITY

VEGETAL
10 day in advance per additional Celsius degree

ANIMAL
-25 % milk from 32-38 °C

PRODUCTS
malformed fruit, altered wine quality

3 SYSTEMIC PRINCIPES
for climate risk management

1 DIVERSITY OF VARIETIES AND BREEDS

Water saving
Resilient at high temperatures
More rustic breeds, better adapted to the climate

2 ADAPTATION OF CULTURE AND LIVESTOCK TECHNIQUES

Advanced planting dates, adaptation of irrigation to water availability ...
Continuing the reduction of pesticides.

3 BUILDINGS AND LOCATION OF CROPS

Eco-designed livestock buildings, relocation of crops and vineyards

Coordination: **Nathalie Ollat, François Gastal, Sylvain Pellerin**

Authors: **Romain Barillot, Agnès Calonnec, Philippe Chéry, Jean-Louis Durand, Marie-Pierre Elliès, Inaki Garcia de Cortazar, Bénédicte Wenden, Magali Willaume**

Contributors: **Jean-Pascal Goutouly, Hervé Jacob Cornelis van Leeuwen**

INTRODUCTION

Agriculture is a major sector of activity in Nouvelle-Aquitaine, in terms of land use, production of economic value and generated jobs, both direct and indirect. The region is hosting very diverse agricultural systems with many emblematic productions, such as wine and cognac, corn and wheat and even fruits, and a diversified and high-quality livestock. All of these productions are highly exposed to the consequences of climate change because in Nouvelle-Aquitaine, temperature has increased to a larger extent than at the national level. In addition, this sector is using a lot of water, in a context where this resource is locally limited and where the risk of summer water deficit is increasing (cf. regional climate projections). Furthermore, because of its importance, the regional agricultural sector contributes to a quarter of direct greenhouse gas (GHG) emissions, in particular methane (CH_4), linked to livestock farming, and nitrous oxide (N_2O), linked to the use of synthetic nitrogen fertilizers. The effort to adapt agriculture to associated to an effort to reduce GHG emissions from this sector. Tensions linked to societal requirements in terms of food and respect for the environment, but also to the majority socio-economic model of agriculture, must be considered as additional factors of vulnerability in this sector, but will not be analysed in this document.

THE IMPACTS OF CLIMATE CHANGE ON RESOURCES MOBILIZED BY AGRICULTURAL ACTIVITY AND ITS ENVIRONMENT

Some effects of climate change will affect the entire sector, while others are specific to some productions. The erosive hazard could increase due to more frequent heavy rains, especially in winter. Soil fertility could be affected via the impacts of climate change on the biogeochemical cycles of carbon, nitrogen and phosphorus. Due to a higher evaporative demand and less rain in summer, water may become limiting in summer when crop yields largely depend on this factor. In addition, 20 % of the usable agricultural area is irrigated, mainly for the cultivation of corn, vegetable crops and orchards, which makes these crops vulnerable to the availability of water for irrigation. Climate change is likely to modify the biodiversity equilibrium associated with agricultural ecosystems therefore there is a growing uncertainty about pests and diseases for all crops. Thus, new pests and new strains for existing pests could spread quickly. Damage from certain fungal diseases, such as powdery mildew and mould, may be worsening.

More specifically, depending on the type of production, the consequences of climate change could be positive or neutral (yield of winter crops, fodder production and livestock farming in mountain areas), but in many other cases they could be rather negative in the more or less long term (corn yield, fodder production in summer for cattle, animal welfare and performance of above-ground farming, quality of the grapes and fruits). For plant production, one of the major impacts of the rise in temperatures will be the increased precocity and the shortening

of developmental cycles. Thus, grape harvests could take place 30 to 40 days earlier than it did at the end of the twentieth century. It may also be beneficial for earlier sowing of summer crops like corn, and thus avoid periods when water availability will be at its lowest in summer. But increased earliness could also increase the risk of spring frost. Lack of winter cold can also affect the dormancy-breaking process (which requires cold) for seed germination and budding of fruit species, with consequences on the budding rate and the number of flowers. The effects of the atmospheric increase in CO_2 and the general evolution of the climate on crop yields will depend on the cultivated species, with a priori positive impacts for winter and spring crops (wheat, rapeseed) and negative impacts on summer crops (corn, vine). The CO_2 effect will be beneficial for crops such as wheat and sunflowers by increasing photosynthetic activity, biomass production capacity and water efficiency (biomass produced per volume of water consumed). But due to the reduction in cycle length, the number of days that biomass will accumulate will decrease. In addition, crop yields will be negatively affected by increased heatwaves at sensitive crop stages (flowering and development of young fruits) and the risk of drought. The final yield will therefore depend on the combination of favourable and unfavourable impacts. For fodder systems, it is mainly the production seasonality that will change, with a productivity increase in winter and spring and a reduction in summer leading to difficulties to meet the demand, especially in summer. The floristic composition of the meadows may evolve with an increased contribution of Mediterranean species. The quality of the harvested products, as fruit species and vines is a major concern. In fruit species, the percentage of unmarketable odd-shaped or split fruits, could increase. Grapes will ripen in hotter conditions, with great impacts on sugar/acid balance and aromatic and phenolic composition. Consequently, quality and type of wines are likely to be greatly modified. Animal production will not be spared from climate change. Beyond the consequences on the availability of food, thermal regulation of animals will be the most worrying for welfare and productivity. Varying according to species and race, temperature increase will affect respiratory and food metabolism (reduction in the amount of food eaten and increase in water consumption), with impacts on growth, reproduction, lactation and health. Mountain beef production will therefore be less affected than plain milk production. Above-ground poultry farming is particularly sensitive.

CONCLUSION

By 2050, if climate changes remain within the limits of the simulations produced by IPCC, the magnitude and impacts on agricultural production will be significant and often negative, but will in most cases remain within the limits of existing technical levers for adaptation. From an agronomic point of view, three main modes of adaptation can be mobilized and combined. The first, and potentially the most decisive, strategy evolves **the choice of species, varieties and races that are better adapted and more resilient to face the new climatic conditions.** Earliness, cycle duration, adaptation to drought, lower sensitivity to thermal stress, resistance to diseases will be the traits to be favoured. The combination of species and varieties, such as cereal-legume mixtures in grasslands, or through agroforestry techniques, has been demonstrated as interesting. In vineyards, new grape varieties and rootstocks need to be considered. Sorghum, more resistant to drought, could replace corn in areas with low water availability. In addition to genetic lever modifications of cultivation and breeding techniques can be considered: advanced sowing dates; harvest delay; evolution of winemaking methods; reduction of tillage and mulch to save water; planting density and management of orchards; lengthening of the grazing period; modification of the composition of food rations; and air conditioning of livestock buildings, etc.

Irrigation will have to be planned in an enhanced way in order to reduce waste, find alternative techniques via better adapted plant material or cultivation conditions to reduce water needs (i.e. delay the cycle). If necessary, infrastructures which allow an increase of available resources and a better management of the resource distribution between the different uses of water should be considered. The third adaptation mode should **relates to the spatial distribution of crops.** There is indeed a large variability of environments at the local level, with varied climatic and agronomic potential. This variability can be used to consider a new crops' distribution according to their requirements and characteristics. Well

studied for the vine, this spatial lever could prove to be particularly effective in selecting fresher and late ripening plots, especially for early grape varieties like Merlot.

Finally, it is crucial that the adaptation of agriculture to climate change takes place while continuing the effort to reduce the negative impacts of agricultural activities on the environment (reduction in the use of pollutant inputs and GHG emissions, preservation of the environment and biodiversity). Several levers for adaptation to climate change are compatible with the reduction of GHG emissions and / or with the conservation of environments, such as the diversification of crops or the reduction of tillage. Several major levers to reduce GHG emissions from agriculture and increase carbon storage are compatible with adaptation to climate change – such as agroforestry, hedges, permanent soil cover – since these levers do not locally generate a risk of competition for water.

Overall, the combined mobilization of these different levers will have to be considered in systemic approaches, mobilizing the concepts of agroecology, leading to the establishment of new production systems at farm and sector levels, which will allow better adaptation to climate and environmental challenges. These approaches are already being tested in Nouvelle-Aquitaine for dairy farming and viticulture. Thus, faced with the increased risk of diseases and pests, it will also be necessary to mobilize methods of control that are both effective and compatible with the objectives of preserving the environment. Improved risk forecasting, diversification of rotations will help. Beyond the technical aspects, it is crucial to take into account the social dimensions linked to adaptation, that have to be evaluated in terms of capacity and acceptance of changes, both at the level of producers and consumers.

The research effort for adapting agriculture to climate change is significant in Nouvelle-Aquitaine, in particular for certain key sectors, such as viticulture, arboriculture and fodder production. Agricultural development, particularly within agriculture chambers and specific sectorial organizations, is also strongly mobilized. The challenge to succeed along with the necessary reduction in the use of chemical inputs, relays on the mobilization of all the essential biotechnical and socio-economic disciplines, as well as the whole stakeholders related to the agricultural sector, other business sectors and land management, especially in rural areas, without forgetting consumers, in order to take into account all of the environmental, economic and social issues at the crossroads of this sector of activity.

11

Urban areas and climate challenges

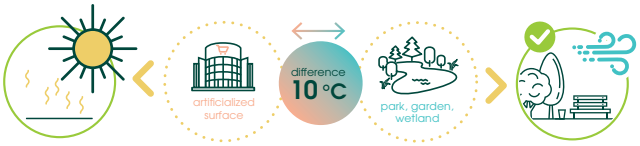
Pont de pierre, Bordeaux © Saranya33

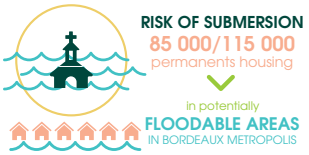
URBAN WAY OF LIFE

70 % CO_2 production in the world

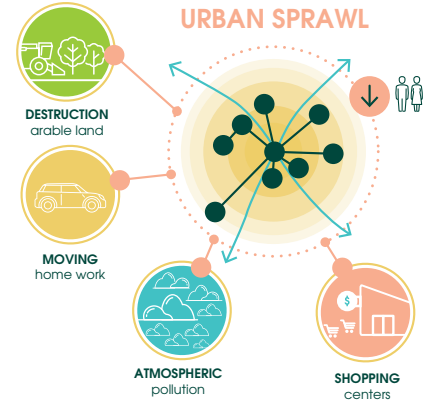
TRANSPORT	HEATING	BUILDINGS
CARS 195 g of CO_2 **km/person**	BUSES 107 g of CO_2 **km/person**	TRAMWAY 3 g of CO_2 **km/person**

IMPACTS OF CLIMATE CHANGE

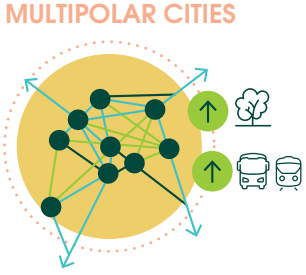


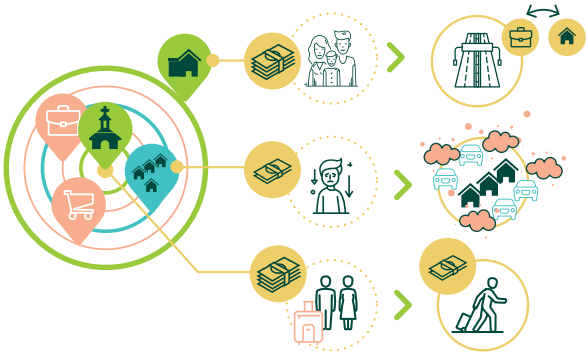


PROMOTING DENSE AND SUSTAINABLE CITIES ?



CHANGE OF **LIFESTYLE**





Facilitating change

GREEN AREA
- QUALITY OF LIFE
- SALUTOGENIC ENVIRONMENT
- FIGHT AGAINST ICU

SUSTAINABLE AND RESILIENT HABITATS
- SANITARY QUALITY
- ENERGY SOBERITY
- LOW ENVIRONMENTAL IMPACTS

ECOMOBILITY
GOOD "MARKETABILITY" OF URBAN SPACE
(comfort of sidewalk use, noise level, public safety, cleanliness, density of traffic)

Coordination: **Daniel Compagnon**

Authors: **Francis Allard, Jean-François Berthoumieu, Régis Briday, Laura Cornelis, Laurent Couderchet, Julien Dellier, Alain François, Nathalie Gaussier, Patrice Godier, Florence Lerique, Étienne Lhomet, Sophie Moulard, Jean-Christophe Pereau, Julien Rebotier, Guy Tapie, Pascal Tozzi, Manon Vivière, Seghir Zerguini**

Contributors: **Antoine Delmas, Quentin Duval, Camille Hochedez, Benoît Leroux, Moulay-Driss El Jihad, François Mancebo, Daniel Peyrusaubes, Émilie Richard, Mohamed Taabni**

Often forgotten in assessments of climate change impact on our societies and our economy, urban areas, which contribute up to 70 % of the production of CO_2 emissions, will be strongly affected by the rise in temperatures and its consequences on natural balances. Now in this region, the metropolis of Bordeaux and the dozen urban areas of more than 100,000 inhabitants are faced with the double challenge of mitigation and adaptation.

Although local authorities' policy is framed by national policies and international agreements, there is room for manoeuvre and large cities like New York or Paris made brave and innovative decisions.

IMPACTS OF CLIMATE CHANGE IN URBAN AREAS

The risks associated with climate change in an urban environment are understood by crossing the various effects of global warming with the specific vulnerability of this space, depending on its physical and social characteristics (notably topography and proximity to a river or coastline, population density, income level and inequalities, nature of economic activities, etc.) but also the capacities of the local authorities to implement mitigation and adaptation measures. Among the many dimensions of urban life involved, some of which are discussed in other chapters, two were particularly analysed in this report.

Firstly, the phenomenon of heat islands has serious public health impacts. This concerns both the largest conurbations, like Bordeaux and Poitiers, as well as medium-sized cities like Agen. It depends on the meteorology but also on the morphology of the city and of its peri-urban space, and can be mitigated by a proactive policy of revegetation and protection of wetlands and natural areas threatened by rampant urbanization.

Secondly, the expected rise in sea level by 2100 –already very significant by 2050 – associated with the risk of river floods caused by exceptional and brutal rainfall, increases the probable intensity and frequency of the flooding hazard for certain urbanized areas in the Bordeaux metropolitan area. As illustrated by the 'marine submersion' map of the Flood Risk Territory (TRI) of the agglomeration, published in 2014 by the Regional Directorate for the Environment, Planning and Housing (DREAL), the urban planning project of national interest, Euratlantique, for example, is affected for part of its settlements. The risk of submersion, still underestimated by decision-makers and whose human and economic consequences in the metropolitan area would be very significant, calls for an evolution of town planning rules – and their real implementation – and an integrated strategy for managing this risk across the entire estuary.

COMPACT CITY AND SOFT TRANSPORT

Urban sprawl, which leads to the extension of networks, in particular of transport, the destruction of arable land or natural areas and the artificialization of soils on the periphery, but also strong dependence on the automobile, characterizes most of the agglomerations in the region, such as Limoges and Bordeaux studied in this report. Between 1960 and 1990, the urban area of Bordeaux doubled in size but lost in density, which hampers development, beyond the core centre, of an efficient and therefore attractive public transport network. Urban sprawl leads to longer journeys' between home and work, which generates growing traffic congestion and air pollution, especially during rush hour.

However, the densification of urban areas does not guarantee improved environmental performance, including from a climatic point of view: it all depends on the spatial distribution of economic; residential and recreational areas. A multipolar organization where the different districts are well connected by public transport and separated by parks and gardens has shown its effectiveness elsewhere. The policy adopted by the metropolis of Bordeaux of residential densification along the axes of the tramway and in new urbanized districts, should not lead to an even more mineral city, in particular with regard to the problem of heat islands mentioned above.

Despite the important development of the public transport offered in the Bordeaux metropolis and an expansion of soft modes of transport (biking, walking), whose co-benefits in terms of health and urban sociability are too underestimated, the share of the automobile remains far high, due not only to residential sprawl but also to the development of giant shopping centres on the outskirts of the city, with their parking lots. A medium-sized car (with air conditioning) emits 195 g CO_2 equivalent / km / person in urban areas, against 107 g CO_2 / km / person for a bus and 3 g CO_2 / km / person for public transport, such as RER, metro or tram. The automobile is responsible for a quarter of Bordeaux's total greenhouse gas (GHG) emissions.

A greater shift from individual cars to eco-mobility implies not only an absolute priority for public transport on the scale of the metropolitan area or even of the Département de Gironde, but also car-pooling. Reducing the use of motor vehicles is also a major public health issue. Although domestic and professional heating is also an important source of nitrogen dioxide, sulphur dioxide and fine particles, road traffic is the first identified cause in the Bordeaux metropolitan area. Advances in vehicle technological innovation are more than offset by increased traffic. If only to achieve the (modest) objective of the Bordeaux Metropolis Climate Plan to reduce the modal share of the automobile from 59 to 45 % by 2020, many more proactive measures will be needed. These orientations also apply to the other Nouvelle-Aquitaine agglomerations with + 100,000 inhabitants.

ECO-DISTRICTS, ENVIRONMENTAL INEQUALITIES AND SUSTAINABLE HOUSING

The emphasis placed on eco-districts since the 'Sustainable City' plan of 2008 and the so-called 'Grenelle 1' law of 2009, has led to several achievements in Nouvelle-Aquitaine. Presented nationally as innovation laboratories and 'pollinators' of urban transition, these showcases do not always have the desired ripple effect on the rest of the urban fabric. The climate issue is not always at the core of their elaboration, nor integrated in all their dimensions, beyond energy consumption. These operations can also have perverse effects, in particular by reinforcing or creating socio-spatial inequalities to the benefit of the wealthy middle classes, while the poorest are confined to the degraded housing of the downtown areas or rejected to the distant periphery. Typical of the growing aspiration to more 'ecological' lifestyles, the appeal of a house with a garden, however small it may be, endures and partly explains, in addition to the cost of land, the peri-urbanization in the Médoc, Entre-Deux-Mers and Blayais.

In addition the increase in movement of the centre-city dwellers to reach distant recreational areas partly erases the alleged benefits of the compact city model in terms of carbon footprint.

Inequalities linked to of urban environmental policies are little taken into account or only through the lack of access to energy services for poorest people. City-dwellers living near highways, especially near the ring roads and suburbs, suffer greater health risks than residents of peri-urban areas using these axes to get to work.

Inequalities are widening between the inhabitants of the most ecologically preserved territories and those of the peri-urban territories, where the sprawling suburban infrastructures, in particular roads and the contiguity of economic and commercial zones, quickly occupy the last spaces of nature. Taking into account the reduction of environmental inequalities in the context of the densification of housing would favour a more just, innovative and efficient sustainable urbanization policy.

With 42 % of final energy consumed in Europe and 35 % of total GHG emissions, the building sector remains today the key sector of environmental and energy policies. In the short term, the focus is on the thermal renovation of the existing buildings; but the sustainable construction policy cannot be reduced to the energy efficiency only. The concept of 'sustainable building' integrates construction safety, its resilience to climatic hazards, the sanitary quality and the living comfort, its energy sobriety in primary energy and its low environmental impacts throughout its life cycle. Treating the building sector as a stakeholder in its territorial environment makes it possible to envisage integrated solutions for the energy supply, the treatment of effluents and the reduction of urban heat islands, especially by the greening of buildings.

However, transforming the many experiments conducted in the region into an efficient public policy requires a large mobilization of public and private funds, in particular for the renovation of old buildings.

TERRITORIALIZED CLIMATE POLICIES AND THEIR INSTRUMENTS

Under the impetus of the national legislative framework, local authorities have become 'orchestrators' of territorialised climate policies, although they lack the administrative culture to design them and the material and human means to implement them. The cross-cutting nature of climate-energy themes is only slowly emerging. The injunction made to the local authorities to produce territorial climate plans and other schemes of ecological coherence has led to an ineffective stacking of planning documents, because they are poorly articulated among the different levels. These top-down approaches transpose practices that are thought of on an international and national scale to local scales, without regard to their suitability for the local context and without taking into account the electoral calendars which constrain any decision therein. This leads to a purely formal conformity, to a tendency to mimetic replication of local devices whose deep meaning, in particular from a climatic angle, is poorly understood. The great diversity of situations, however, requires a diagnosis and a specific treatment for each territory, in order to obtain the support of all local actors. For implementation, communities have three types of instruments (local regulations, economic instruments and communication / awareness) but only the latter is fully used, whereby the action taken is more directly perceptible and profitable politically.

12

Coastal physical modifications

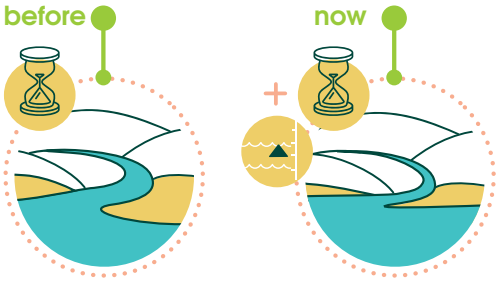
Atlantic Ocean at Truc Vert, Gironde department © Stéphane Bujan

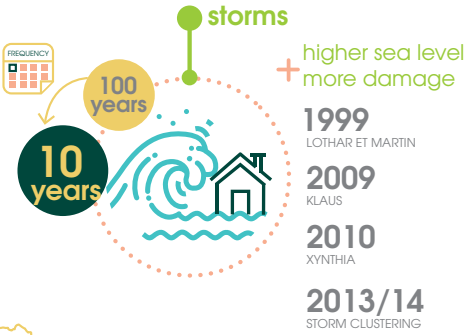
COASTLINE DIVERSITY

EROSION ABOUT **1 m/year** FOR **70 YEARS**

FLOODING BY 2100 BETWEEN **0.3 to 1.5 m more**

+ 3 mm/year Nouvelle-Aquitaine



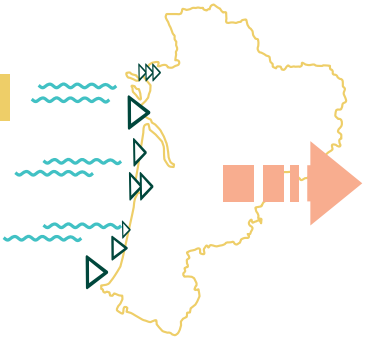


1 UNCERTAINTIERS

backwards and forwards

2050 ON MOST OF THE COAST LANDES/GIRONDE

− 65/100m

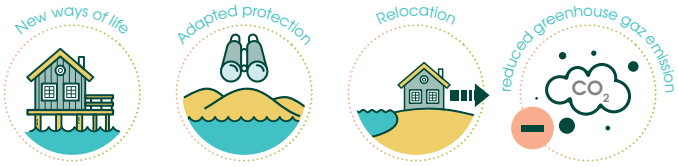


SIGNIFICANT TEMPORARY **SPATIAL HETEROGENEITY**

2 LIVING WITH RISK

New form of governance

CONSULTATION



3 CONTROLLED DYNAMIC MANAGEMENT

Ecosystem restoration and resilience

Coordination: **Bruno Castelle**

Authors: **Stéphane Abadie, Xavier Bertin, Bruno Castelle, Éric Chaumillon, Goneri Le Cozannet, Nathalie Long, Nicolas Rocle, Aldo Sottolichio**

Contributors: **Vincent Hanquiez, Vincent Marieu**

INTRODUCTION

The Nouvelle-Aquitaine region is characterized by an extremely diversified coastline, including rocky coasts, beaches and large sedimentary barriers, estuaries, tidal inlets, tidal bays and tidal flats, and vast coastal plains whose altitudes are located below the level of the highest seas. These diverse coastal morphologies exert major control over ecosystems and human activities. There is a large proportion of natural coastlines in Nouvelle-Aquitaine, but there is also a substantial proportion of coastlines artificialized by hard defence against mainly marine submersion and to a lesser extent coastal erosion. The coast of Nouvelle-Aquitaine is exposed to several hazards, the most worrying being erosion and marine submersion. Indeed, the recent history of Nouvelle-Aquitaine has been marked by major extreme events, such as the storms Lothar and Martin (1999), Klaus (2009), Xynthia (2010) and more recently severe storm clustering during the 2013 / 2014 winter. The latter made the coastline retreat in many areas well beyond earlier projections for 2040, and the Xynthia storm was a painful reminder that the low-lying coasts of Nouvelle-Aquitaine are particularly vulnerable to marine submersion. These hazards will be largely affected by climate change, which will have a profound impact on the physical drivers.

THE MAIN DRIVERS AND THEIR EVOLUTION IN THE FRAME OF CLIMATE CHANGE

At present, mean sea level rise is around 3 mm/year in Nouvelle-Aquitaine, and sea level will continue to rise over the next century. The magnitude of this phenomenon, roughly estimated to range between 0.3 m and 1.5 m by 2100, will strongly depend on efforts to reduce GHG emissions. By changing the characteristics of low-pressure system regimes across the North Atlantic, climate change will affect wave climatology as well as the intensity and frequency of extreme wave events. Simulations suggest that the Bay of Biscay will be relatively spared. However, these simulations are associated with uncertainties and the last winters do not follow the direction of these projections. In the context of climate change, the tide will be little affected overall. However, sea level rise could locally impact the tide, with an increase in spring tide ranges of less than 2 % in Nouvelle-Aquitaine. Much larger changes could be observed inside estuaries due to morphological changes. The surges, which are crucial to the risk of submersion, are by definition directly impacted by climate change through mean sea level rise and the evolution of storm regimes.

Finally, projections on the hydrology of France by 2100 indicate a sharp decrease in precipitation in the watersheds, implying a reduction in river flows, which amplitude varies according to the considered scenario. This will profoundly affect estuarine environments and the supply of sediment to the coast.

EROSION HAZARD IN NOUVELLE-AQUITAINE

In the last 70 years, overall erosion has been the most intense (1) along sandy coasts, (2) in the north of the region and (3) at the beaches adjacent to the mouths of Maumusson and Arcachon, as well as those adjacent to the Gironde estuary. The erosion rates of the sandy sectors are far from being constant over time. For example, erosion has been relatively constant at Pointe de la Négade since at least 1950 (~ 4.6 m/year) while other sites, such as the coast of the Arvert peninsula, largely eroded until 1970, but have remained relatively stable for the past 40 years. Certain areas, such as the sand spits (Pointe de Grave, Pointe de Bellevue, Pointe de la Coubre), have been significantly accreting for several decades. This spatial and temporal variability of the evolutions shows that other natural phenomena drive these changes, such as the gradients of longshore drift, the availability of sediment stocks on the continental shelf or even the cyclical migration of the passes or the connection of the banks of the ebb deltas on adjacent coasts.

These changes are also impacted by extreme events, such as those of the winter of 2013/2014, which was the most energetic in Nouvelle-Aquitaine for at least 70 years and eroded sectors that had been stable in recent decades, or accelerated erosion in others (e.g. 60 m in one winter at Pointe de Gatseau). The rocky areas evolve according to localized land movements of continental and / or marine origin. Average retreats of around 0.6–0.8 m/year at Anglet, 0.15–0.3 m/year between Biarritz and Bidart, and very stable and homogeneous erosion of around 0.15 m/year south of Bidart (Guétary – Hendaye) are observed. Similar orders of magnitude are measured further north at Pointe du Chay (Angoulin sur mer) or Chef de Baie (La Rochelle). Quantifying the impacts of climate change on erosion is a real scientific challenge and there is no generic approach to work on this problem. The rise in mean sea level, the decrease in river flows and sediments carried to the coastlines, and the possible increase in the intensity and frequency of extreme events will all aggravate current trends. Even if, locally, we could observe erosion trends reversing towards accretion on short timescales (a few years), in particular on the coasts adjacent to estuary mouths, chronic erosion will continue and will be accelerated. Simulations suggest that sea level rise will explain the widespread increase in erosion of sandy coasts towards the end of the century, whereas in the next decades shoreline variability will be mainly controlled by the processes explained above. By 2050, an average shoreline retreat at the sandy coasts of the Landes / Gironde is estimated to 65 m and several hundred metres along the sectors that are already the most mobile. By 2025 and 2050, the mean retreat values on the rocky areas will be around 10 m and 27 m, respectively. These estimates remain extremely uncertain, and in reality, it is necessary to keep in mind only the orders of magnitude.

MARINE SUBMERSION IN NOUVELLE-AQUITAINE

Marine submersion is a hazard that mainly affects the coasts dominated by tides due to the presence of vast low-lying areas and the absence of developed sedimentary barriers. They are mainly located within the pertuis Charentais, within the Gironde estuary, within the Arcachon basin and in the estuaries and bays of the Basque Country.

Marine submersion risk along sectors exposed to ocean waves are generally more localized (e.g. Mimizan, Capbreton, St-Jean-de-Luz, Hendaye) but potentially with high flow speed within breaches, cutting the sedimentary barriers and dunes. Phenomena like Xynthia are in fact not exceptional: for example, five other events caused marine submersions of comparable extent in the central part of the Bay of Biscay during the past century (1924, 1940, 1941, 1957 and 1999), even if very different meteorological-oceanic configurations caused them. In the future, even if the weather patterns do not change much, sea level rise will mechanically lead to an increase in the frequency and intensity of marine submersions.

It can be noted, for example, that differences currently observed between water levels reached by centennial and decennial storms are of the order of half a metre at La Rochelle. However, sea level rise is expected to be at least 30 cm by the end of the century, regardless of the scenario of greenhouse gas emissions. Many uncertainties exist as to the future impacts of submersion. For example, many polders find themselves isolated today from marine and continental waters by dykes and levees, and are deprived of sediment supplies. Their morphology is therefore fixed and they can no longer adapt to the rise in sea level by aggradation. In contrast, in semi-closed 'natural' environments that are not dammed or

non-polderized, if the sediment supply is sufficient, the sedimentation rate could compensate for the sea level rise and the marshes would thus be preserved in the long term. Sedimentation in semi-enclosed environments can also lead to a decrease in their wet sections, causing changes in tidal wave propagation. In addition to these uncertainties, which are already numerous, there are those linked to human activities, such as dams and dredging, which modify hydrodynamic flows and sediment supplies. Similarly, protective dykes, depending on whether they are maintained, moved or removed, will have a strong influence on the lateral expansion of the tidal wave and floods.

ADAPTATION

Hard protection is no longer the only strategy to adapt to the impacts of global change; nowadays it is about considering living with risk. There are three types of adaptation: (1) protection, (2) relocation or strategic retreat, (3) mitigation. The idea here is to have a time-phased approach and to define when the risk is no longer acceptable to society and the community. It is necessary to think of a gradual implementation of an adaptation project, with a consultation and awareness component. To achieve this, adaptation must, among other things, go through the establishment of new forms of governance, where the participative must have a major place, because it allows the unblocking of certain people who refuse to accept the occurrence of major natural risk to their living territory. This concertation conditions the adhesion of people to the projects and thus facilitates their concretization, beyond the financial and regulatory conditions.

Choosing the best adaptation to climate change remains complex and depends on the timescales covered (cf. Local Strategy for the Management of the Lacanau Coastal Strip) but also deeply on the object and the hazard of interest. For example, along the open coasts of ancient Aquitaine, where the stakes remain localized and beach nourishments not sustainable, the balanced management of dune systems by the National Forest Office (ONF) must be continued. At the other end of the spectrum, in the presence of numerous stakes – for example, certain pocket beaches in the Basque Country – a multicriteria analysis shows that coastal developments should be reinforced in order to durably fix the coastline and continue or even accelerate its nourishment to maintain sufficiently wide areas and/or to stabilize the base of the structures. More specifically for the flooding hazard, the systematic rising of the dykes is not the only solution. Lowering the dykes and letting areas with low stakes flood could significantly reduce water levels and reduce submersion in the nearby areas with high stakes. The establishment of large flood plains with second-row dykes could therefore be considered. More broadly, sanctuarizing areas with low stakes in order to leave them in free evolution will allow a better understanding of the natural resilience of these systems to climate change. It will then be necessary to explore to what extent this management of controlled dynamics can improve the system resilience while promoting greater biodiversity and improving ecosystem services.

CONCLUSIONS

Overall, the costs of maintaining and reinforcing coastal defences are very high compared to the financing capacity of the public authorities, which in future decades and under the effects of climate change will result in an inevitable choice between maintaining coastal defences and strengthening them, more flexible adaptation, or even abandonment in the event of a significant sea level rise or an increase in extremes. It is now necessary to consider alternative defences and adaptations, based on in-depth research and a better understanding of the processes involved.

13

Wetlands: rich but threatened ecosystems

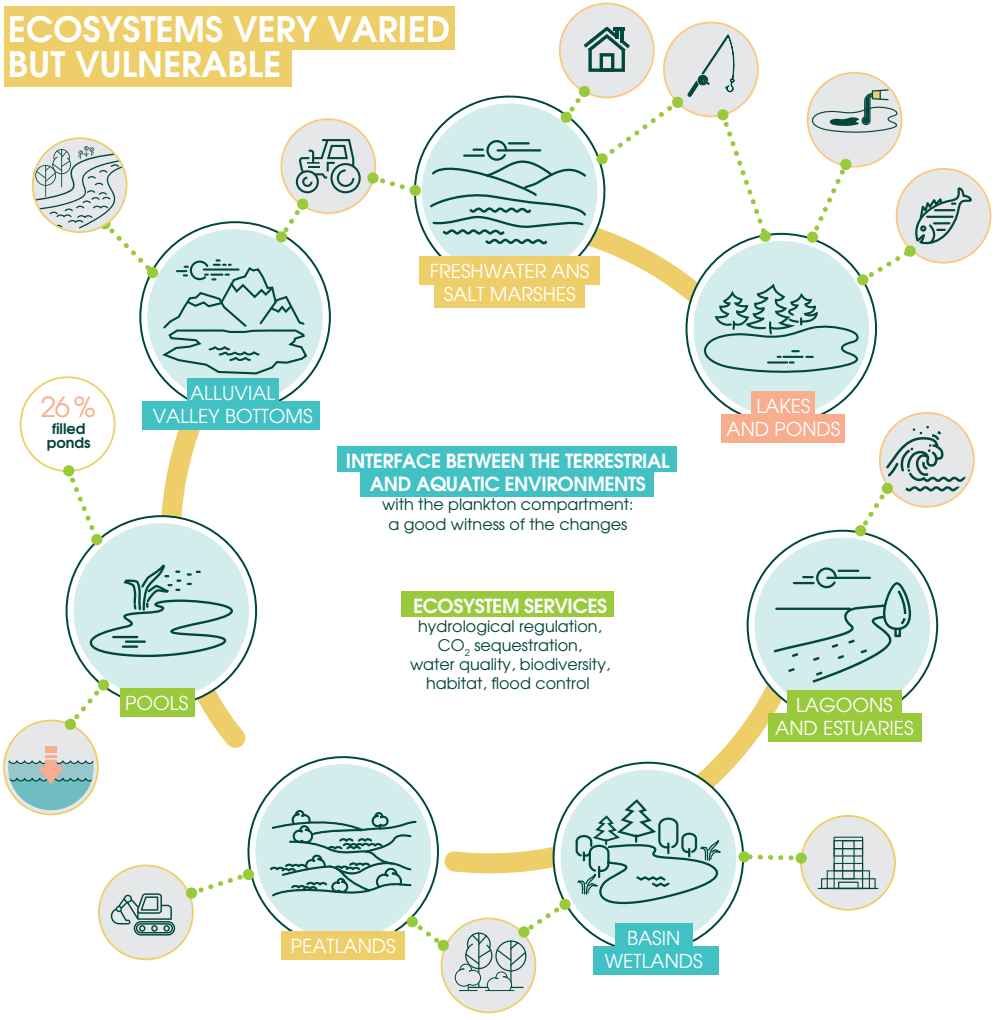
Limousin © Chrislofotos

WARMING AVERAGE temperature of Earth AND SURFACE WATER

SEA LEVEL **ELEVATION**

MAJOR weather events
wind, rain, floods, submersions

ECOSYSTEMS VERY VARIED BUT VULNERABLE



ACQUIRE
KNOWLEDGE
descriptors, indicators

+

SUSTAINABLE
HUMAN ACTIVITIES
in harmony with the territory

=

RESILIENCE
OF SOCIO-ECOSYSTEMS

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Nouvelle-Aquitaine's wetlands are very diverse ecosystems and produce many ecological services (hydrological regulation, CO_2 sequestration, water quality, biodiversity, flood control ...) to society. Following the classification of the Millennium Ecosystems Assessment (MEA), 2005, three main types of services have been identified, namely production, regulatory, and cultural services and linked to three main ecological functions (hydrological, biogeochemical and habitat). However, their vulnerability depends very much on their location and the uses that have developed over their history. The functional approach is essential to understand how wetlands can adapt, in particular to the effects of climate change – modification of biological and physical characteristics as well as the relationships that are established between the different compartments (living and dead matter). At the interface between the terrestrial and aquatic environments, the proposed approach made it possible to identify six types of wetlands: retro-littoral marshes; alluvial valley bottoms; lakes and ponds; ponds, lagoons and estuaries; head basin wetlands; and peatlands.

However, the functional dynamics of wetlands are gradually threatened by climate change, which means reconsidering their role in the development of the territory in the future. Using a typology expressed in terms of state and pressures, Nouvelle-Aquitaine's wetlands are analysed to account for the main factors likely to impact their profile and their long-term evolution in terms of functions and associated services.

Concerning the retro-littoral marshes, their condition has evolved mainly under the effect of agricultural orientations and developments (notably land consolidation). The current pressure factors are at the same time intensive agricultural activity, urban development, and activities linked to outdoor leisure. The alluvial bottom valleys are marked by the development of rivers to cope with the risk of flooding, while agricultural pressure may have gradually led to a lowering of groundwater levels. Lakes and ponds are mostly artificial water features used for fish farming or energy supply. The pressures they face come from the demand for leisure activities. Regarding the ponds, we do not have an inventory for the whole of Nouvelle-Aquitaine, but they are characterized by high biological productivity. Very reactive to weather variations, these small wetlands have low short-term resilience. The study of lagoons and estuaries focuses mainly on the coastal wetlands of the Gironde estuary. Their situation has changed over the course of anthropogenic (hydraulic, infrastructure, etc.) and natural (particularly de-polderization) transformations.

The pressures that estuaries face are geochemical, ecological and socio-economic. As for the wetlands at the head of the watershed, they are characterized by biogeographical diversity and are subject to pressures linked to agricultural and urban activities. Finally, the state of the peatlands presents a wide variety of typologies in the territory and is mainly affected by human activities (drainage, use of water resource, filling ...).

In this context, climate change intervention is causing a change in the balances of a certain number of structuring factors for the functioning of wetlands. The main forcing factors involved are the warming of the earth's average temperature and surface waters, the sea level rise, and the increase in the frequency of exceptional climatic events occurrence (wind, rain, floods and marine submersions).

These factors can have a direct impact on the wetland functioning but also indirectly through the impact on services and uses. Conversely, wetlands can play a role in limiting global warming.

Indeed, these ecosystems, acting as carbon sinks, have a buffer role, and could help to reduce this trend to a certain extent. In addition, through their hydrological regulation capacity, wetlands will help to mitigate the incidence of acute climatic events, which will multiply.

For all these reasons, their increasing degradation could be very harmful and their better consideration is essential in the definition of an action policy in response to climate

change. The impact of climate change has been estimated from an assessment considering the response of the aquatic compartment. The plankton compartment study appeared relevant due to it being a biological compartment that is very reactive to fast changes in the hydrosystem.

Climate change will affect the functioning of planktonic communities in the retro-littoral marshes and their associated functions/services. These modifications will be modulated by the management choices in response to this change phenomenon. The increase in earth average temperature and surface waters will modify biodiversity, the dynamics and the functioning of planktonic food webs. Low-water periods will increase and natural or artificial marshes' replenishment will decrease. Marshes' water levels will be falling despite an ever-present need for water resources for their uses (link with the Water availability chapter). Marine submersion and the frequency of extreme weather events (storms) will tend to increase. But if the frequency of these events increases, the resilience time question of these environments remains to this day unanswered due to the lack of fundamental knowledge on the subject. In all cases, plankton communities will be very reactive to climate change.

Even if the apparent resilience of aquatic environments may seem high with regard to limited stresses in space (cleaning up a marsh) or over time (temporary marine submersion), it can be modified by reducing water replenishments and by the intensification of stressful practices for the environment (agricultural pressures and town planning). It is therefore necessary to acquire knowledge on marshes' resilience and to acquire good state of the environment indicators in order to highlight the modifications of this 'good state', and ultimately establish the link with the causes (nature and intensity of pressures on the environment). On this point, a realistic lever of action to build a strategy that aims, for the planktonic compartment, to limit the incidence of global warming, or even to act on it, is represented by the hydraulic factor. This lever could be divided into two management axes: firstly, with the increase in the water body renewal by a global work on the resource; and secondly, the maintenance of the buffer volume offered by the water blade height thanks to a regular maintenance of the marsh canal network.

A prospective exercise carried out has enabled an understanding of the influence of climate change impacts on wetlands. The dynamic of these ecosystems is determined by both natural factors – change in planktonic communities, marine submersion ... – and by socio-economic factors, such as the role of ecosystem services, planning, integrated water resources management. In this context, from the relative trends of low-water period lengthening and of water deficit, to the orientation of the common agricultural policy favouring the subsidization of intensive cereal crops to the detriment of livestock, and to taking into account the hazard of marine submersion, two cases of trend evolution were studied: one with the *status quo* on the use of water combined with an infrequent submersion hazard, the other with the *status quo* on the use of water combined with a frequent risk of submersion.

Finally, it seems essential to have the tools to identify the wetland transformations and their uses, and to undertake the evaluation of these particular socio-ecosystems, both in terms of biological heritage and services delivered to society. The characterization of wetland ecosystem functions is recent, particularly with

regards to the aquatic compartment. Thus, a better description of ecosystem functions would first allow the identification of the levers of action on which the various intervention strategies will be built, but also the anticipation of the overall impact of these policies. To use the example of the plankton compartment, functional descriptors development would make it possible to specify the resilience of the water body according to the different water management scenarios and thus assess their impact on the biogeochemical functions (purification) and habitat (biodiversity) of the aquatic compartment.

Similarly, the trophic quality assessment indicator for aquatic environments could play a relevant role in acquiring functional knowledge (aquatic ecology) and in revealing the changing world (climate pressure and links between habitats and use).

In a context of climate change, wetland preservation is a major challenge for the territories of Nouvelle-Aquitaine. To achieve this, it becomes urgent to define wetland sustainable management from a conceptual and operational grid on a global scale. In this perspective, an approach in terms of ecological limits applied to wetlands could indicate the thresholds within which it would be possible to develop human and economic activities without prejudicing the functioning of the considered wetlands. In doing so, it would help to understand the resilience of socio-ecosystems by focusing on the functionality–services interface.

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Mountains

The village and the circus of Lescun © Lavigne

LOCAL SCALE
not integrated in
CLIMATE
MODELS

1950→2013
+0.2 °C
to +0.3 °C
BY DECADE

-2 to 3
DAYS OF SNOW
BY DECADE
between December
and April since 1980

BIODIVERSITY
before
After
- GENETIC DIVERSITY AND POPULATION INSULATION

CONSTANT
RECOMPOSITION

IMPACT ON ECOSYSTEMS
and the benefits
HUMAN SOCIETIES
DERIVE FROM

PYRENEES

VERY VULNERABLE
TO ENVIRONMENTAL
CHANGES

Forest

Prairies and Pyrenean
agro-pastoral ecosystem

LIMOUSIN

AT THE HEAD OF THE WATERSHED

THERMIC
SIEVES

LOW
DENSITY

DYNAMIC LANDSCAPES

KNOW AND
UNDERSTAND

CLIMATE ISSUE
AND ASSOCIATED
NATURAL RISKS

AGROPASTORAL
SYSTEMS

INFORM, CREATE AWARENESS
OF MIGRATION
AND ADAPTATION
PRACTICES

PERCEPTIONS AND REPRESENTATIONS
OF CLIMATE CHANGE
BY THE «MOUNTAINEER»
TO EVOLVE PRACTICES

ADAPTING MOBILITIES
AND HOUSING

THE PYRENEES

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massif central
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THE PYRENEES

Mountains are particularly vulnerable to climate change. Yet an understanding of its implications remains limited, due to a lack of high-altitude observations and a still relatively crude representation of mountain topography in climate models.

This chapter provides a first analysis on the paleoclimatic evolutions of the Nouvelle-Aquitaine's mountainous areas, essential to take measure of the rupture that they introduce by their trajectories, initiated during the last millennia. The general trends recorded over the last 16 millennia in the Pyrénées-Atlantiques demonstrate the sensitivity of the mountain environment and the very high reactivity of the upland plant landscapes to climate change, including in the context of abrupt events characterized by temperature variations of a few degrees.

New to this territorial scale, the analysis of homogenized temperature timeseries over the period spanning from 1950–2013 indicates that temperatures (both minimum and maximum) increased from +0.2 °C to +0.3 °C per decade.

Climate projections show, on the Pyrénées-Atlantiques, a continued annual warming until 2050, whatever the scenario. Beyond, over the second half of the twenty-first century, the evolution of the annual average temperature differs significantly depending on the considered scenario: the only one that stabilizes global warming is the scenario that incorporates a climate policy aimed at lowering CO_2 concentrations (RCP - Representative Concentration Pathway 2.6); according to the scenario without climate policy (RCP 8.5), global warming could reach 4 °C by 2071–2100. In terms of snow cover, despite high interannual variability and a more marked trend at low altitude, the number of days with snow-covered ground has decreased significantly over the December–April period since the early 1980s, with a loss of 2 to 3 days of snowfall per decade. Future projections point to a slight drop in snow depth to 1,800 m over the Aspe-Ossau massif until the 2030s and then a marked acceleration from the 2050s; according to the most pessimistic scenario (RCP 8.5) at this altitude, snow could even become scarce by the end of the century.

In terms of new knowledge acquired concerning biodiversity, it should be pointed out that the convergence of research results confirm a significant reduction in the distribution of the populations of the studied species and thus suggests a significant loss of genetic diversity and population isolation in the future, which in turn suggests increased vulnerability of species to climate change. Far more complex than a 'simple pyramid' that populations of animal and plant species would simply climb in an 'escape to the top' goaded by the rise in temperatures (the 'escalator' effect), the mountain is a place of constant recomposition. However, the observation made in 2013 still prevails: the effects of climate change on the biodiversity structure of regional mountains remain mostly unknown.

These structural changes are not without impact on the ecosystems' functioning and, on the benefits derived from them by human societies (ecological services). Two examples are developed in the chapter: that of the Pyrénées-Atlantiques forests, which, thanks to the richness and complexity of their ecosystems, provide several functions (wood production, soil protection, water regime regulation, leisure, landscape, etc.) and that of agro-pastoral activity, which contributes to the maintenance of an original Pyrenean agro-pastoral ecosystem, recognized for its biodiversity and more generally for a set of ecological services. For forests, several indicators make it possible to assess the impact of climate change, including the leaf deficit, which, when it increases, is a sign that the trees' health is deteriorating. Recent research indicates a trend towards an increase in this leaf deficit over the years on the French side of the Pyrenees – however, with large spatial disparities: in this region (under Atlantic influence), the plots studied seem for the moment relatively spared, as opposed to the Mediterranean plots, which have been more affected with a continuous increase since 1997. It also hides a certain temporal complexity: before 2003 the plots located in the Pyrénées-Atlantiques had a leaf deficit of 0 to 20 %, while since 2004 it is noted that these same plots now have a leaf deficit of 20 to 40 % (except in 2011). Given the climate projections (possible increase in temperatures and reduction in water availability), it is to be feared that the trend observed east of the Pyrenean chain (Mediterranean) will gradually transfer to the west (Atlantic). For agro-pastoral systems, several actions are being undertaken, sometimes relating to study, sometimes for support or funding; some seek to characterize, understand or assess the situation or prospects (GHG emissions, ecosystem services rendered by agricultural holdings) while others aim to inform, raise awareness or even encourage farmers to engage in mitigation and/or adaptation practices.

Evidence suggests that climate change will also have a major economic and social impact on winter activities, particularly the ski industry, whose sustainability in its current form appears to be compromised. Among the Pyrenean ski resorts, those in the Pyrénées-Atlantiques (Gourette, Artouste, La Pierre Saint-Martin) have been classified as having medium to high vulnerability, Gourette being the most resilient of them. At the moment, despite the low altitude of a significant part of the ski areas (especially Artouste and La Pierre Saint-Martin), the influence of a rather oceanic climatology ensures sufficient snow cover, although irregular, year on year; however, it will be increasingly difficult to ensure a sufficient layer of snow at the start of the operating season, thereby greatly compromising skiability. In the short term, under a moderate climate change scenario (with an anomaly of +2 °C of dry winter average temperature compared to precipitation), certain technical adaptation measures (slope grooming, artificial snow ...) might be enough to guarantee the skiability of most seasons, especially in Gourette. But with a more severe scenario (with an anomaly of +4 °C of dry winter average temperature compared to precipitation), the skiability of these three stations will be compromised. Under the more likely scenario of +4 °C, a diversification of the areas' tourist offerings will be more than necessary in order to guarantee the sustainability of these ski resorts, by considering what is called an 'all-year mountain resort' capable of guaranteeing economic activity out of season.

A component not treated in the previous report, that of social perceptions and representations of climate change and the associated risks, is particularly fundamental in order to grasp the brakes and potential levers for the mitigation and adaptation of local mountain societies. The mountains, due to the low density of the road network, the small size of the municipalities and their lack of means, appear very vulnerable. The reality of environmental change is an established fact for pastoralists and elected officials from communities. But, rather than talking about climate change in the strict sense, they instead report a series of visible-to-the-eye indicators, which testify to environmental changes in the broad sense (a shortening of the snow cover period or even an increase in thunderstorm episodes ...) and are considered as simple hazards that can impact production on time, of course, but which the profession has always had to deal with. In terms of action, the initiatives remain modest and most often fall under national regulatory changes, imposed and linked to mitigation and adaptation policies, particularly in energy.

Elected representatives and breeders' opinions highlight that climate change challenges, in the strict sense of the term, seem difficult to grasp because they are distant and marked by uncertainty. Finally, the immediate or next

concrete constraints imposed by regulatory or economic changes are of much concern to local stakeholders and the supervisory structures. Scientific uncertainty and lack of perception of changes could therefore justify doing nothing at the operational level, but in addition to the hazards themselves, the impact of climate change can contribute to increasing local society vulnerability and weaken management and control measures. Collective action and public policies in the field of climate change are so far, for the most part, held by the government, which has little incentive for local authorities to act; local initiatives therefore remain rare and often come from higher levels or from other bodies such as the Pyrenees National Park, the Pyrénées-Atlantiques Department or the Basque Country Council (at the origin of the only climate plans of the Aquitaine part of the chain).

By seeking better climate resilience and more sustainable planning for the entire current economic model, anticipation and adaptation are the major challenges that the various mountain regions will have to face. This necessarily requires increased knowledge of the climate issue and the associated natural risks, far beyond that provided by the general media. Understanding the interactions between environmental and social processes in mountain areas, placing climate change perceptions and representation questions at the center of the situation, remains another essential aspect to grasping the brakes and potential levers for local societies' mitigation and adaptation. Furthermore, understanding the legacies of past use of the elements (soil, water ...) is useful to support the necessary changes, such as those of the ecological transition. Even if climate change is today a little uncontested reality, the appropriation of this subject on the different territorial scales discussed in this chapter and its concrete translation remain difficult. There are, in fact, several brakes that are still very powerful and that delay action, such as, for example, the gap between the elective time and the expected effects of a decision, the dominance in the debate of the economic crisis repercussions, the lack of hindsight and studies on the real effects in the mountains, work habits, representations and perceptions, etc.

THE MASSIF CENTRAL

The Limousin Mountain represents an area at stake because of its position at the head of the watershed. The conditions for managing its water resources but also the catchment areas as a whole (summits, slopes, valley bottoms, wetlands, i.e. the territory at the head of the basin), in terms of quantity and even more, quality perhaps, are decisive for the proper functioning of the watershed as a whole. Basin heads are often associated with low population density areas, isolated from industrial and economic developments and mainly occupied by forest land. It is therefore very important for the Limousin Mountain to consider the societal and ecological issue facing climate change, given the impact that one may have on the other.

This territory is known for some of its subregions: Millevaches plateau and Monédières. Like the rest of the Massif Central and other mountain regions, its landscapes have undergone profound upheavals since the fifth century before our era (highlighted by palynological studies) but also during the twentieth century. During this period the moors (dry and wet) and peat bogs associated with the pastoral model, have led with the rural exodus and the plantation policies, to the present constitution of a very wooded massif, mixing resinous and more rarely leafy plantations, with a dynamic of abandoned land.

The wetlands sheltered in the Limousin mountains play a very important role in species conservation. The Limousin Mountain is a refuge for ectotherms (insects, reptiles, fish ...), which find quality habitats in peaty and humid environments.

Water availability in particular will have a very important role in the future because it will condition the maintenance and stability of the wetlands. Agricultural, forestry and animal husbandry practices will have to adapt to increasing droughts. In addition, the low density of the population, which often requires motorized trips, and also the consequent propensity of mostly old buildings in the area, constitute the major challenges of the adaptation and spatial planning of the Limousin Mountain.limousine.

CONCLUSIONS

Confirming the recommendations formulated in the previous edition (Le Treut 2013), this chapter reiterates the importance of acting quickly, and failure to do so risks allowing essential ecological services to change and consequently impact the activities and well-being of part of the population depending on high- and medium-altitude resources

15

Local participation and citizen ownership

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INCLUSIVE INVOLVEMENT

SOCIAL ACCEPTABILITY

LEGITIMISE PUBLIC POLICIES

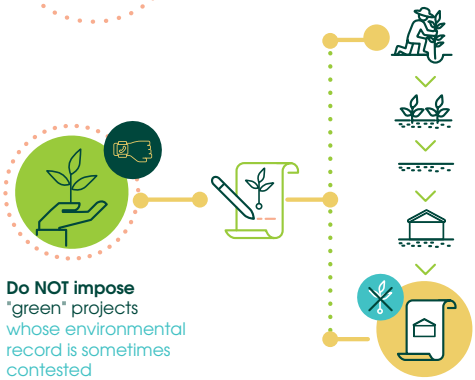
PROMOTING PEOPLE'S OWNERSHIP

LISTENING TO THE OPPOSITION TO THE GENERAL INTEREST

DISSEMINATE CLIMATE POLICIES

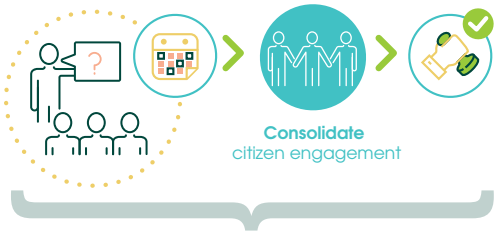
ADJUSTEMENT ADAPTATION

Do not exclude citizen debates

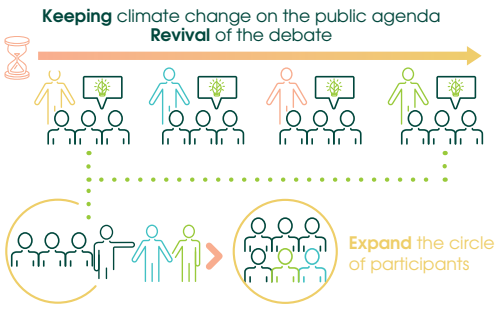


Do NOT impose "green" projects whose environmental record is sometimes contested

TRANSFORMATIONAL ADAPTATION



Consolidate citizen engagement



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The participation of the various stakeholder groups affected by the policies implemented to face climate change, if it matters at all socio-political organization levels, is particularly crucial at regional and local territorial scales.

Increasing the involvement of the larger public requires first sharing knowledge, not only in the climate sciences, but also in matters of public policy effectively implemented hence the need for observatories on climate policies, such as the one established by the former Poitou-Charentes region. In addition, beyond expert knowledge, public policy must also be able to rely on lay people knowledge – outside the academic and technocratic world – to complement the stock of relevant data and involve the public before any decision is made.

CITIZEN PARTICIPATION IN POLICY DESIGN AND CLIMATE CHANGE AWARENESS

Public participation in decision-making and public policy is essential for the success of local environmental policies, particularly on climate. It makes it possible to move from an 'adjustment-adaptation' to a 'transformational adaptation', that is to say, aiming at a transition towards a sustainable socioecological system.

If the introduction of participatory mechanisms in environmental policies has had beneficial effects (decompartmentalization of projects, integrating long term perspectives and non-monetary values), there are many criticisms of the limits of these processes. They do not help to overcome conflicts around development projects, address only small variations within the projects and seek to deliver formal compliance with the legislation in force, leaving aside issues of relevance and social utility. These limits also apply to participation in the context of the transition towards a sustainable city better prepared for climate change (e.g. eco-districts). An unfortunate but necessary hindrance to legitimise public policies from the viewpoint of project promotors, these mechanisms are only a 'smokescreen' or, at best, an exercise in public relations in the eyes of opponents.

When willing to promote social acceptability of climate policies in Nouvelle-Aquitaine, and facilitate their real appropriation by the people, it is imperative to restore confidence in public participation by innovative forms of consultation whose conclusions would cease to be ignored by decision-makers. It is necessary to break resolutely with a vision of participation as a technique for manipulating public opinion. The local level is particularly suitable for this new approach and there are already many experiments under way.

Participation is also a source of enhancement for public debate and therefore a factor in improving policies. By keeping the issue of climate change on the participating actor's public agenda, it contributes to maintaining a collective mobilization at the level of the climate change stakes.

The challenge remains, however, to widen the circle of participants beyond already mobilized citizens, due to their functions (e.g. elected officials) or their militant commitments. This is why participatory mechanisms must include a public education component to be fully successful.

Popular education experiments on climate change, often carried out by civic groups, must be amplified and better supported by public authorities.

CITIZEN PARTICIPATION IN THE IMPLEMENTATION OF PROJECTS AT DIFFERENT TERRITORIAL SCALES

The participation of the relevant stakeholders at the appropriate level often makes it possible to make policies with strong negative externalities more acceptable; for example the construction of various energy plants. In this regard, the wind turbines and photovoltaic parks development plan for the ex-Aquitaine is a textbook case of imposition from above, favouring a technical and sectoral vision by opposition to an environment global approach, treating the affected local people as negligible. Decision-makers' tendency to stigmatize local opposition is the same in other country planning schemes and ignores the contribution of NGOs to the defence of a higher general interest

This is more damaging since France, and this region in particular, have fallen behind in the development of renewable energies. However, the cause of climate change does not justify coercively imposing projects, the environmental assessment of which turns out, on close examination, to be most problematic. The role of participation must therefore be rethought to allow the flourishing of policy instruments such as the 'positive energy territories' (TEPOS more recent TEPCV) that the Region is determined to support.

Finally, participation, far from being limited to a one-off consultation, must be committed over time to consolidate citizen engagement and work to transform behaviour. It can relate to the evaluation of the policies implemented as well as their initial design, with the aim of reinforcing their relevance. To be effective, however, participation must lead to the re-politicization of the climate issue as a choice of a collective destiny, contrary to the dominant framework, which overtechnicalizes choices and excludes most of the people through the use of expert jargon.

Another concern in appropriation of the climatic policies is their territorialization and how they are translated at the various levels of the local territory. There is still a wide gap between technocratic planning documents and top-down regulations from the capital city and their effective implementation by local stakeholders.

Climate emergency discourses hammered into people and technocratic injunctions come up against other priorities and logics of action that are just as decisive at the local level. This multilevel territorial divide can only be overcome by stimulating debate over the real priorities for public policy at different levels.

CONCLUSION

The context in which climate policies intervene is therefore a domain of knowledge as important to develop as the types of recommendations or public policy instruments to be implemented. Contrary to a one-size-fits-all policy approach the challend is to reinvent our democratic practice through citizen involvement.

Conclusion

SOME ELEMENTS OF CONTEXT

Rarely will an environmental problem evolve as fast as that of climate change: temperature records that are now beaten annually, or almost, bring us gradually to climatic situations that planet Earth has not known for tens of thousands of years. And this situation can only get worse: as long as the global introduction of greenhouse gases into the atmosphere continues at a rate much higher than what nature can intake, global warming will also continue. As greenhouse gases remain in the atmosphere for decades, or centuries, it is a process that now commits our future to these same losses. It may take the whole of this century and beyond for temperatures to stabilize, and they will do so at a level that will be significantly higher than today.

Nouvelle-Aquitaine territory, like all territories on the planet, must drastically reduce its greenhouse gas emissions, until they disappear completely. From this point of view, it is one actor among others, in a situation that is first negotiated on a global scale.

But this role of actor must be kept by the Regional Committee in a committed way, because it is very often at its level that the challenges and the impacts of global warming are felt in the most measurable and sensitive way. Adapting to climate change manifestations is therefore conceived above all at a regional scale, and the region is also the place par excellence where synergies can be determined between actions to mitigate climate change – and therefore decrease greenhouse gas emissions – and those of adaptation to the inevitable share of future climate change. Indeed, mitigation and adaptation are often defined with reference to the same target areas (transport, heating, agriculture, housing ...), and they can be based on the same regional specificities. These perspectives of 'co-benefits' prompted the devotion of a chapter to the used energy resources panorama at the regional level, with of course a more particular emphasis on those more specific to Nouvelle-Aquitaine.

To start working on these issues, several important contextual elements must be dealt with. The first is undoubtedly the problem of passing time, the notion of urgency, which is now becoming a dimensioning element of all climate policies. It is now no longer just a question of reacting to already occurred climate changes, to the most visible recent weather events, but also of anticipating what may happen in the coming decades, whether these are fairly precisely defined risks or more random situations. To this is added another important constraint: that of the complexity of the choices to come. The necessary simplicity of climate change warning speeches is not enough to determine an action agenda that takes into account the complexity of the real-world socio-eco-climatic systems. In this respect, the region is a remarkable place to learn about this complexity, because many decisions need to be taken in a concrete, precise and often rapid manner.

WHAT BENEFIT CAN ADAPTATION TO CLIMATE CHANGE TAKE FROM A REGIONAL APPROACH?

The regional scale brings a systemic dimension to the definition of actions to adapt to climate change. Adapting does not mean 'tinkering' with occasional blockages, in response to problems encountered one by one, but on the contrary, it is inventing a different future. At the scale of the Nouvelle-Aquitaine region, current or future changes have, or will indeed, often have a systemic nature: all the envisaged impacts are linked by physical (mainly air and water), chemical (environmental pollution), ecological (invasive species, environmental pollution) or even socio-economic vectors. They must be studied together.

The notion of climate justice is important: at the Nouvelle-Aquitaine scale: all the territories are vulnerable but often at different levels, which means implementing plural and differentiated actions, with a time frame adapted to inequalities, which are often well identified. Certain territories therefore require special attention.

Inventing this future can of course only be done with a certain idea of the links between humans and their environment. This need is strongly developed in the chapter Environmental Health. But this concern is found in a different way every time it comes to managing complex communities: urban areas, mountains... The role of history is interesting to emphasize in this context. Historical knowledge contributes, in its own way, to preparing vulnerable populations and their elected representatives. The knowledge of our predecessors' adaptation trajectories

can, for example, foster a consensus to borrow old practices at significantly lower costs than new engineering works, which risk being unsustainable at an environmental level.

THE NEED FOR NEW GOVERNANCE?

Governance and law were new subjects (and chapters) treated in this report. Significant space has been devoted both to the diversity of structures that frame the climate problem in its regional dimension, and to regulation, which is often a major point of support for all public action. The report highlights the complexity of the mechanisms that govern interactions between citizens, advice places and decision places. This complexity calls for the simplification and consistency of mechanisms. Nor should it prevent participation and even citizen ownership of the decision-making and implementation of public action, which is crucial for the future.

The choice of consultation methods is a key element in this context. The directions that will be chosen – just like those that will not be – will profoundly affect everyone's lifestyle. Recent events have shown that public support for these changes is an achievement factor that is absolutely essential for the success of climate change policies.

The problem of adapting to climate change offers a little more time for citizens' debates, because the impacts of climate change come with a delay in greenhouse gas emissions, which often takes a few decades. The AcclimaTerra Committee wants to play a role in this process by creating, among others, mediation actions.
www.acclimaterra.fr

A NEED FOR SCIENTIFIC RESEARCH

Confronted with a fast-evolving problem like the climate problem, there is a very strong need for surveillance, for vigilance in the face of poorly established risks. This need overlaps with a requirement to better understand the systemic and therefore interdisciplinary dimension of current changes. A region the size of Nouvelle-Aquitaine constitutes a heterogeneous environment: wanting to follow its evolution means asking many questions, which today are unanswered. For example: droughts have multiplied in recent decades in Nouvelle-Aquitaine. Do all these episodes have the same consequences on the fauna, the flora, the water reserves? The answers depend on more easily interconnected databases, on the definition of indicators, which allow better visibility and better understanding of the multiple dynamics associated with regional climate change. It is necessary to better estimate the vulnerability of the territories, by using modelling, imagery (maps, videos, diagrams), as well as a narration of this information going as far as user knowledge. Here too, AcclimaTerra wishes to provide assistance in the future to these essential scientific dynamics. But they will require a mobilization that goes far beyond what a committee of volunteer scientists can do.

NECESSARY ACTIONS

Water, its management and sharing is a central element of adaptation policies. The temperature rise (air and water), the modification of the melting conditions of mountains' snowpack, the increasing frequency of extreme events (floods, low water levels, heatwaves), the uncertain variation in the rainfall, the certain increase – evapotranspiration, variation in river flows that all these factors will cause over the next decades (-20 % to -50 % during llow-water periods) will create a pressure on surface and groundwater availability. The water quality, already in a very average state, will also undergo notable effects, such as an increase in temperature, a decrease in dilution, or the release of part of the stocks of pollutants from the soil and sediments, with impacts on biodiversity and public health. Significant consequences are also to be expected on the satisfaction of users, on the evolution of aquatic biodiversity, on plant growth. Anticipating these difficulties is essential. The 'hydroclimatic' policy to be implemented must respect the inevitably increasing nature of future hazards, and offer sustainable management of this development, rather than management of specific crises, which offers no foresight on the future. It is a question of defining possible and desirable futures by articulating the managers' scientific and technical expertise, professional knowledge, but also the user-citizens knowledge. Imagining the 'water mix' of tomorrow involves exploring in more detail multiple problems.

The evolution of agriculture, a central activity for the economy of the region, is strongly linked to the constraints of water management. The already noted increase in certain climatic hazards (e.g. summer droughts, heatwaves, but also spring frosts), a situation which can only increase in the future, is indicative of the agriculture and livestock future problems. There may be positive impacts, such as more complete ripening of fruits and higher yields of some crops, due to the fertilizing role of CO_2 in the atmosphere and longer cycles. But the negative impacts will remain *a priori* greater, especially with regard to the availability of water and the increase in temperature for livestock.

Important choices in terms of production systems must be made. All of the issues must be taken into account, in particular the economic sustainability of farms in their diversity, and changes in eating habits. A more water efficient agriculture as well as in inputs must already be considered. It is very important to assess now their environmental impact in terms of CO_2 emissions and water consumption. We must take advantage of current questions about the agricultural production model, particularly with regard to phytosanitary inputs, to redesign production systems now that integrate all of these challenges, including the climate issue. In 10 years, it will be too late.

Urban areas, which contribute up to 70 % of the production of CO_2 emissions, and which are the main sites of episodes of air pollution, such as particles and ozone, will be strongly affected by the temperature rise and its consequences. The metropolis of Bordeaux and the dozen urban areas of more than 100,000 inhabitants are already faced with the double challenge of mitigation and adaptation. The latter manifesting itself in particular as heat islands during heatwaves and the risk of flooding, even submersion, in the Garonne valley. The agglomeration is an appropriate level for implementing climate policies, but the proliferation of non-binding, redundant territorial planning documents that are not translated into reality is not enough. Efforts can be made or intensified in very concrete areas: the adjustment, but also the real application of the rules of town planning (in particular in flood zones), the increased vegetation of the city and the absolute respect for wetlands and existing green ones. The densification of housing, necessary to cope with urban sprawl, especially on the outskirts of agglomerations, as well as necessary to optimize public transport networks, should not, however, lead to an even more mineral city, to the detriment of green spaces, public or private. The integration of climate issues into urban policies, in particular adaptation, long ignored, must become a priority. In this context, the accelerated reduction of the place of the automobile in favour of collective and non-polluting modes is essential. This consideration of the dimension of climate change is urgent, because the urban morphology is changing slowly and the heavy investments that are required will have consequences for several decades.

Nouvelle-Aquitaine's coastline is particularly vulnerable to the hazards of erosion and marine submersion. These are partly of natural origin, and it remains difficult to separate the share of natural changes from those linked to anthropogenic activities. The impossibility of producing exact forecasts constitutes an element of unavoidable difficulty in the management of coasts.

Part of the future developments depends not only

on future greenhouse gas emissions, but also on the specific variability of the climate, or even on the random action of the most violent events (which hit the coast of Nouvelle- Aquitaine well before climate change manifestations).

These rare events can leave a deep mark, especially when they coincide with high coefficient high tides. Even if meteorological storm regimes are difficult to predict, the rise in sea level is an inevitable phenomenon, of which only the precise magnitude raises questions. A significant increase in the risk of erosion by the sea level rise could thus occur later, in the second half of the twenty-first century. On the other hand, in the coming decades, the increase in the average sea level will mechanically lead to an increase in the frequency and intensity of marine submersions in the lower coastal areas. The improvement of models and the work of understanding the natural mechanisms that come into play can reduce the uncertainties around the forecast of future evolutions, but not remove them entirely due to their intrinsic character.

In this context, defining coastal management strategies is both necessary and delicate, particularly with regard to the cost of increasingly high defences and the limited capacity to finance public authorities. Crossing social and economic issues with physical risks will allow action strategies to be determined at different scales. On the coastal sectors, among the options that will eventually become unavoidable is relocation, involving giving back spaces to the sea and relocating activities and goods behind the coast; in places, this may lead to a recomposition of uses on the territories and will invite new approaches to coastal planning and management.

Mountains are also a particularly vulnerable area. This is both an area where all economic activities are articulated with natural resources, and an unparalleled reserve of biodiversity, living at altitude and directly threatened by global warming. It is also an area where the shaped landscapes by millennia of pastoralism tend to disappear. Finally, it is an environment where the climate change synergy adaptation/mitigation must be confronted with a striking presence: hydroelectricity.

The challenges are different depending on the massifs. For the Limousin mountains, the report highlights environmental and societal vulnerabilities, to which climate change adaptation policies and their consequences will have to pay particular attention.

In the previous report, the Pyrenean mountains were the subject of in-depth work on the evolution of ecosystems facing climate change and the rapidly changing socio-economic framework. This report reiterates the importance of strongly reacting, and that not doing so risks allowing essential ecological services to change and consequently impacting the activities and well-being of a part of the population that depends on high-altitude resources. Mountain knowledge is still too incomplete and the lack of reliable scenarios at the local level is still palpable and penalizing. This justifies the need to build long-term experimental projects in diversified socio-ecosystem contexts, and invites the promotion of concerted research, based on field observations, complementary to modelling work, in particular within the framework of observatories (actions are carried out, for example, within the Pyrenees Climate Change Observatory (OPCC – between France, Spain and Andorra).

That the possible effects of climate change may be very dependent on local situations, that the scenarios on these scales are lacking, that there exists in parallel a certain scientific uncertainty, should not be used to excuse or even to argue for timidity of action, but should on the contrary lead to strengthening studies on all these themes. At this point, the insistent reminder for the need to rethink governance or to 'think differently with real responsiveness', as was done in the previous report, has not yet produced the expected results.

The forest. Encouraged by the already perceptible climate change impacts on the functioning of trees and forests, adaptive management policies based on more dynamic and diversified silviculture are gradually being implemented. The concern of the public authorities has shifted

mainly to the role that the forest and more generally the forest-wood sector could play in a more low-carbon economy. In Nouvelle-Aquitaine, the contribution of the forest is defined along an 'extensification versus intensification' contrast. On the one hand, forests subject to intensive silviculture (maritime pine, Douglas fir, poplars, i.e. one-third of the forest area) offer a resource and substitute products for other materials that produce more carbon. On the other hand, mixed deciduous forests (more than two-thirds of the surface), responding to more extensive silviculture, would rather be used to store carbon in the forest ecosystem. The National Forest Wood Programme broadly supports this dynamic, by encouraging first an adaptive management of the forest, and second very strongly encouraging the use of wood resources to reinforce mitigation policies. This support is reflected in public actions aimed at more energetic forest management and the promotion of timber construction, or even the sinking of carbon finance. It now remains to strengthen these systems and initiatives across Nouvelle-Aquitaine and to roll them out locally as part of the Regional Forest and Wood Programme. However, these devices remain very fragile with regard to the impact of extreme events (storms, fires, parasite attacks), which could call into question their ability to contribute to the mitigation of climate change.

Nouvelle-Aquitaine's wetlands are very diverse ecosystems that provide society with many ecological services: hydrological regulation, CO_2 sequestration, water quality, biodiversity, flood control ... The first problem lies in preserving their territorial grip, meeting the needs of urban or agricultural development, but also concerns the threats of drying up as a result of climate change itself. An associated problem is how best to preserve the ecological wetland functions in terms of climate change growth. It is seen that the functional dynamics of wetlands are gradually threatened, which implies reconsidering their role in the development of the territory in the future. The study of the planktonic compartment, very reactive to rapid changes, provides an instructive example of climate change impact by affecting the functioning of planktonic communities of the littoral marshes as well as their associated functions and services.

In general, scientific tools must be built to better identify the transformation of wetlands and their uses, and undertake the evaluation of these particular socio-ecosystems, both in terms of biological heritage and of services delivered to society. A better description would identify the levers of action on which to build the different intervention strategies, and anticipate their success.

Shellfish farming – essentially oyster and mussel culture in Nouvelle-Aquitaine – is an example of the exploitation of regional resources, which provide economic resources and participate biodiversity. They are vulnerable to the impact of global change and its effects, which increase the already strong variability of the coastal environment. Shellfish, and in particular the oyster, see their distribution areas and their reproduction conditions change, putting the juveniles' supply, which until now was a speciality of companies in the Nouvelle-Aquitaine region, in competition.

Shellfish farmers in the Nouvelle-Aquitaine region, in line with the great variability of the ecosystems of which they are part, have long adopted an ability to evolve and adapt. The future of shellfish farming in the Nouvelle-Aquitaine region will depend on these terms:

1. The provision of production sites in the Nouvelle-Aquitaine region with coastal water quality that includes *ad hoc* salt conditions and the drastic reduction of current and emerging pollution.
2. Whatever the breeding site, supporting the maintenance of businesses and their marketing in the Nouvelle-Aquitaine region.
3. On land as at sea, developing a dynamic and secure land policy (regime concessions at sea)(availability of land on the coast), in an increasingly competitive context between uses.

Fishing is also an important economic activity in the Nouvelle-Aquitaine region, which is under the influence of climate change in the open sea as in estuarine areas or in the Arcachon bay.

The biogeographical limits of the species exploited by fishing have been displaced to the north, which currently do not seem to be compensated by the arrival of new species in sufficient quantity for exploitation in the Bay of Biscay. Neo-Aquitaine vessels are largely small to medium in size. If vessels are no longer able to 'follow the resource' or exploit it when it is present along the coasts of Nouvelle-Aquitaine, the risk in the medium/long term is that their local exploitation will stop and that this resource will be exploited elsewhere by investors outside the region, with an associated risk of loss of wealth or 'economic and cultural heritage'.

It is important to maintain the link between fishing activity and the territory. The adaptation of fishing companies in the context of climate change calls for changes to be made to fishing regulations and management at European level, so that access rights to the resource integrate into the spatial distribution of these rights the modifications in the dynamics of different species, induced by climate change. This adaptive management is necessary to preserve fishing activity. These readjustments must also take into account the necessary protection of species weakened by climate change.

This also requires the development of a food culture that allows the species caught to be diversified. This diversification of activity can also come from operating systems based on multi-activity (intra-fishing with multispecies fisheries, tourism ...). In addition, fishing plays a 'sentinel' role facing climate change. The fisherman's role is also to help collect data on the arrival of species with a more 'southern' affinity.

Local participation and citizen ownership.
The significant changes in territorial public policies, which the report has shown to be necessary in many areas, is a reminder that, in the end, nothing can be done without strong support from citizens.

These are affected by both climate change and by the measures supposed to remedy it, which can be accompanied by unwanted side effects. The legitimacy of local decision-makers and elected officials provides only a partial response to this challenge, and the controversial question of participation is at the heart of this need for citizens' ownership of change.

If promising experiments are carried out in the territories, as illustrated by the chapter on water availability, in many other cases the mechanisms for consultation and participation – often more legislative and regulatory – show their limits. Renewing practices enabling the concerned populations to be involved in the decision as close as possible to the field, and promoting a broad public debate taking into account citizen expertise, brought in particular by the associative world, seem essential to the social acceptance of the choices for public action (for example, in the field of new energies). Participatory democracy can become the engine of a successful ecological transition.

Acronyms

ADEME: Agence de l'environnement et de la maîtrise de l'énergie - *Regional Environment Climate Assessment Agency*

AREC: Agence Régionale d'Évaluation environnement Climat - *Regional Environment Climate Assessment Agency*

CERFACS: Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique - *European Center for Research and Advanced Training in Scientific Computing*

CNPF: Centre National de la Propriété Forestière - *National Center of Forest Owners*

DREAL: Direction régionale de l'environnement, de l'aménagement et du logement - *Regional Directorate for the Environment, Planning and Housing*

EPTB: Établissement Public Territorial de Bassin - *Public Territorial Basin Establishment*

Grenelle I and II: *"Grenelle Laws" are two laws resulting from the Grenelle Environment Forum and which have made significant changes to environmental law, following a democratic process based on the principle of "Five-party governance".*

GIP: Groupe d'Intérêt Public - *Public Interest Group*

IPCC: *Intergovernmental Panel on Climate Change. www.ipcc.ch*

PCAET: Plan Climat Air Énergie Territorial - *Territorial Air Energy Climate Plan*

PNACC: Plan National d'Adaptation au Changement Climatique - *National Plan for Adaptation to Climate Change*

PRFB : Programme Régional Forêt Bois - *The Regional Forest and Wood Programme*

SDAGE: Schéma Directeur d'Aménagement et de Gestion des Eaux - *Master Plan for Water Development and Management*

SRADDET: Schéma Régional d'Aménagement, de Développement Durable et d'Égalité des Territoires - *Regional scheme of planning, sustainable development and territorial equality*

SRCAE: Schéma Régional Climat Air Énergie - *Regional Climate Air Energy Scheme*

TEPCV: Territoires à Énergie Positive pour la Croissance Verte - *Positive Energy Territories for Green Growth*

TEPOS: TErritoire à Énergie Positive - *Positive Energy Territories*

UMR: Unité Mixte de Recherche - *Joint Research Unit*

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