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ADAPTATION

I4CE
INSTITUTE FOR CLIMATE ECONOMICS
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Ensuring sufficient means to adapt to climate change consequences in France:

What are the costs?

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The Institute for Climate Economics is an expert association in economics and finance whose mission is to support action on climate change. Through its applied research, the Institute contributes to the climate policy debate. It also publicly publishes analyses to support the work of financial institutions, governments and local authorities.

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ABOUT QUANTI-ADAPT

Quanti-Adapt aims to consolidate and quantify the resource requirements for adaptation to climate change in France on the basis of relevant knowledge and experience. The aim is to structure an observatory of all adaptation costs on which to base the costs of different adaptation pathways and thus objectify the financing needs associated with roadmaps or strategies, including regional and sub-regional ones.

This first cross-cutting publication will be followed by thematic publications from autumn 2022 onwards, which will focus on the details of the specific needs of certain adaptation projects (forestry, construction, etc.).

For more information on the project and its developments, see: https://www.i4ce.org/en/projet/quanti-adapt-quantifying-the-needs-of-adaptation/

CONTEXT

This report, originally published in June 2022, is a contribution to the French public debate. It aims at supporting the acceleration and concretization of climate change adaptation initiatives in this country. Although France has had a National Adaptation Strategy since 2005 and a 2nd National Adaptation Plan (PNACC2) since 2017, concrete action in terms of anticipating the consequences of climate change remained limited up to now. However, since the publication of the volume II of the 6th IPCC report and especially in a context of increasing number of exceptional meteorological events (drought, succession of heat waves associated with major fires, episodes of intense precipitation, late frosts, etc.) formally attributed by scientists to climate change, the subject has started to take another dimension. National (ministries, member, or Parliament) and sub-national (local authorities) public decision-makers are now seeking to provide operational responses to address the issue. The current preparation of the future French Climate and Energy Strategy (SFEC), which for the first time should combine mitigation and adaptation to climate change in a common approach, should be one of the key moments of this evolution.

As a specialist in the economic and financial aspects of climate issues, the Institute for Climate Economics (I4CE) has sought to support this dynamic by focusing on the question of the resources to be mobilized for adaptation. Indeed, beyond the existing work on the costs of inaction, it is by raising the question of the costs of action in a very concrete way and by monitoring the resources actually allocated to different subjects that it is possible to move from words to action.

This study builds on the results of previous work (see the Finadapter project) which highlighted the need for public action to catalyze adaptation in France. It is indeed necessary today to sensitize and mobilize all the actors concerned, to create an environment enabling adaptation and to make sure that socially beneficial actions that do not have an immediate economic model are well funded.

We have therefore intended to show where these needs lie, to qualify their nature (investment needs, but also engineering and human resource needs) and to give an initial quantitative estimate of the amounts involved. The emphasis of the analysis is very clearly placed on the needs relating to the consideration of adaptation by and in public policies (the complementary part of the adaptation initiative coming from private actors is not addressed here).

This document thus presents 2 types of information:

- **A series of immediately operational proposals representing a total of 2.3 billion euros per year relating to actions that are often "no-regret" and already ready for deployment,** which could be carried out as of now at the national level to take the next steps towards adaptation. These actions have been formulated in the context of the new French government taking office, following the presidential election of 2022 and in the perspective of the first budget of this new five-year term. It seemed important to us to quickly put actionable proposals into the debate to ensure that adaptation would be taken care of in a structural way.

- **Thematic sheets bringing together the elements for assessing the costs associated with different options and different levels of ambition for the further construction and implementation of adaptation.** 2.3 billion euros per year will indeed not cover all of the country's adaptation needs. Nevertheless, in the absence of clearly established adaptation pathways for each subject that could have been translated into investment trajectories, we have chosen to summarize the state of the debate by public action area to help formulate the trade-offs to be considered and to document the debates with the available costing elements. The objective of these sheets is to help to structure real democratic debates on the choices to be made, taking into account their implications in terms of financing needs.

For reasons of clarity, the name of organizations, institutions and specific programmes have not been translated. A glossary is avalaible at the end of the report for a further understanding.

EXECUTIVE SUMMARY

Climate change consequences are already being felt, including in France, and these affects will be amplified until carbon neutrality is achieved at the global level *(IPCC 2022; Haut conseil pour le climat 2021)*. There is an urgent need to anticipate and prepare for these impacts by adapting to a changing climate in order to considerably reduce the social and economic costs, which are expected to be significant over the coming decades *(France Stratégie 2022)*. The consequences of climate change will not be the same everywhere or for all populations, and not all territories have the same resources with which to prepare. Adapting to climate change is also therefore a question of social equity and territorial solidarity, which is an issue the National governement must address.

To achieve this, a number of domains must be considered, such as adapting buildings to longer-lasting heatwaves, increasing the robustness of transport and energy infrastructure to ensure resilience in a context of greater climatic variability, transforming agricultural systems to cope with more frequent droughts, diversifying mountain economies in response to reduced snow cover, and managing coastlines to cope with rising sea levels *(I4CE and Ramboll 2020).* **Each of these challenges will require resources, both financial and human, to implement adaptation policies commensurate with the consequences of climate change *(I4CE 2021a)*.** Actions have already been launched by the State, local authorities and other actors, including the private sector, but they are not always equal to the challenges and many blind spots remain *(Haut conseil pour le climat 2021; Dantec and Roux 2019; IDDRI 2019).*

Whatever responses are to be undertaken in the various fields of action, the level of ambition in terms of adaptation, the sharing of costs, the speed of deployment and the types of adaptation pathways must be the subject of political discussions and decisions. Until these discussions have taken place and the decisions have been made, in one area after another, it will be impossible to precisely evaluate the needs in terms of the resources to be committed to adaptation. It is nevertheless possible to put a figure on the cost of a certain number of essential, proven, "no-regrets" measures that should be deployed now.

CLARIFYING THE TERMS:

Adaptation to climate change is often used as a catch-all term referring to different objective types. In all our work, we use the word "adaptation" to refer to anything that can be done to anticipate the negative impacts of climate change and to qualify the appropriate measures to prevent or minimize the damage that these impacts may cause. The "cost of adaptation" does not therefore refer to the cost of damage resulting from climate change, nor to the needs associated to the economic and social changes required by policies to combat greenhouse gas (GHG) emissions.

Maladaptation refers to actions that may ultimately increase the risk of adverse climate-related consequences by having a direct negative effect on risk or vulnerability or by exacerbating climate change.

Therefore, this study presents two complementary elements:

1. **a number of national budgetary decisions to make now that would complement existing actions;**
2. **cost elements to feed future discussions.**

The 18 measures detailed below are proposals for budgetary debate. They have been formulated and quantified on the basis of the shortfalls expressed by the actors concerned. These figures, particularly those relating to issues that have not yet been sufficiently discussed, will be refined in the coming months through consultations on each topic. However, the orders of magnitude shown are sufficiently robust to justify their immediate inclusion in public budgets.

At least an additional €2.3 billion per year that can be mobilized from the next Finance Bill

An initial set of 18 national budgetary measures can be taken now to formulate, strengthen or operationalize adaptation actions that have already been prepared. In terms of adaptation, it is most often through the combination of complementary actions that solutions can be found. These 18 proposals are intended to be part of a coherent set of measures that constitute a real adaptation policy. **The challenge is to ensure that resources are allocated to a range of action types that perform well together, rather than to concentrate resources on a few flagship proposals:**

1. FINANCING JOBS IN THE COORDINATION AND GUIDANCE OF ADAPTATION POLICY

To bring about the rapid improvement of the management and guidance of adaptation policy in France, in relation to the needs of cross-cutting governance and those of individual sector and public policy, human resources are especially needed. This requirement entails a relatively small amount of funding. Paradoxically, however, sufficient funds have not currently been allocated for this purpose, even though it is very often a prerequisite for adaptation policy implementation *(I4CE and Ramboll 2021)*.

2. SUSTAINING AND INCREASING THE RESOURCES OF POLICIES THAT ALREADY CONTRIBUTE TO ADAPTATION

Certain public policies – such as the protection of water resources, the prevention of natural risks, and improvements to public health or civil protection – already contribute to the management of climate risks. In the context of an increase in these risks, the resources allocated to these policies must be increased accordingly.

3. ALLOCATING DEDICATED BUDGETS FOR THE FUNDING OF ALREADY PROVEN NO-REGRETS INITIATIVES

In some territories and for some issues, advanced adaptation strategies and good practices already exist and could be extended immediately. These initiatives must be supported and financed today by setting up dedicated budgets or funds. However, this should not be the only type of action covered by budgetary measures.

These measures constitute the initial building blocks that should make it possible to respond to the risk identified, but also to ensure that subsequent decisions will integrate adaptation and that we are already starting to prepare for the deeper transformations that may be necessary:

- **Responding to known adaptation emergencies** (e.g. by addressing the well-known vulnerabilities of certain infrastructure) to ensure that we are no longer subject to every climate change impact and that we are able to anticipate its developments. Unexpected climate change impacts cost public finances dearly, while anticipation and prevention measures will ultimately enable expenditure to be reduced;

- **Ensure that future public investment decisions take climate change into account.** By giving ourselves the means to ask the right question at the right time, mainstreaming adaptation measures into investment flows planned in other fields (planning, economic development) is the most effective and inexpensive way of gradually strengthening territorial and economic resilience. In any case, this "adaptation reflex" will be less costly than having to modify infrastructure, buildings or industrial equipment at a later date specifically for climate change adaptation;

- **Preparing for more structural transformations.** In certain situations, climate change impacts will require more than just adjustments or incremental adaptations. Deeper transformations will sometimes need to be considered. For example, this could involve relocating infrastructure and housing in certain coastal areas or significantly reorienting the economy in some mountain areas. Most of these pathways have not yet been fully developed, but they must be the subject of Collective debats without delay. It is therefore necessary to equip ourselves with the means to inform and coordinate this work and to commit to the implementation of the initial stages, for example by obtaining any land needed as part of future restructuring.

It is also important to note that financing these measures is not the only lever to be

activated to accelerate adaptation in France, there remain other barriers to overcome. These barriers include the reluctance or inability of some local authorities to use debt to invest - for example, a reluctance to renew their water and sanitation networks more quickly when a doubling of the renovation rate would be desirable to limit water losses. Recruitment issues are another oft-cited obstacle, which occur due to the limitations of public sector employment and the difficulties associated with finding people trained in the challenges of adaptation.

The – potentially much higher – costs of other requirements will depend on the political decisions resulting from debates that must begin soon.

Adaptation costs will not be limited to the costs of these 18 measures. But the total sums to be committed will depend on the political decisions yet to be made, and therefore on the democratic debates ahead.

The issues at stake raise fundamental questions on the level of risk that we are collectively ready to accept when new development is planned; on the activities or territories that we wish to protect and those where transformation would be considered acceptable; on agricultural and tourism models that we wish to foster, and even on the level of solidarity between territories with different degrees of vulnerability.

Making progress in the construction and development of a social consensus is a necessary prerequisite for building the adaptation policy, and also therefore for evaluating the associated investment needs. At this stage, it is above all possible to establish milestones that will enable a better understanding of the types of needs associated with different alternatives.

There are specific requirements associated with each of these choices, that may increase the cost of achieving other public policy objectives. However, they will also serve as a guarantee that these objectives can be achieved in the long term, despite the impacts of climate change. The costs of adaptation are therefore no more and no less than the costs of adapted and resilient transition, transport, health, planning and tourism development policies.

FIGURE 1: GIVING OURSELVES THE MEANS TO ADAPT TO CLIMATE CHANGE CONSEQUENCES IN FRANCE: WHAT ARE THE COSTS?

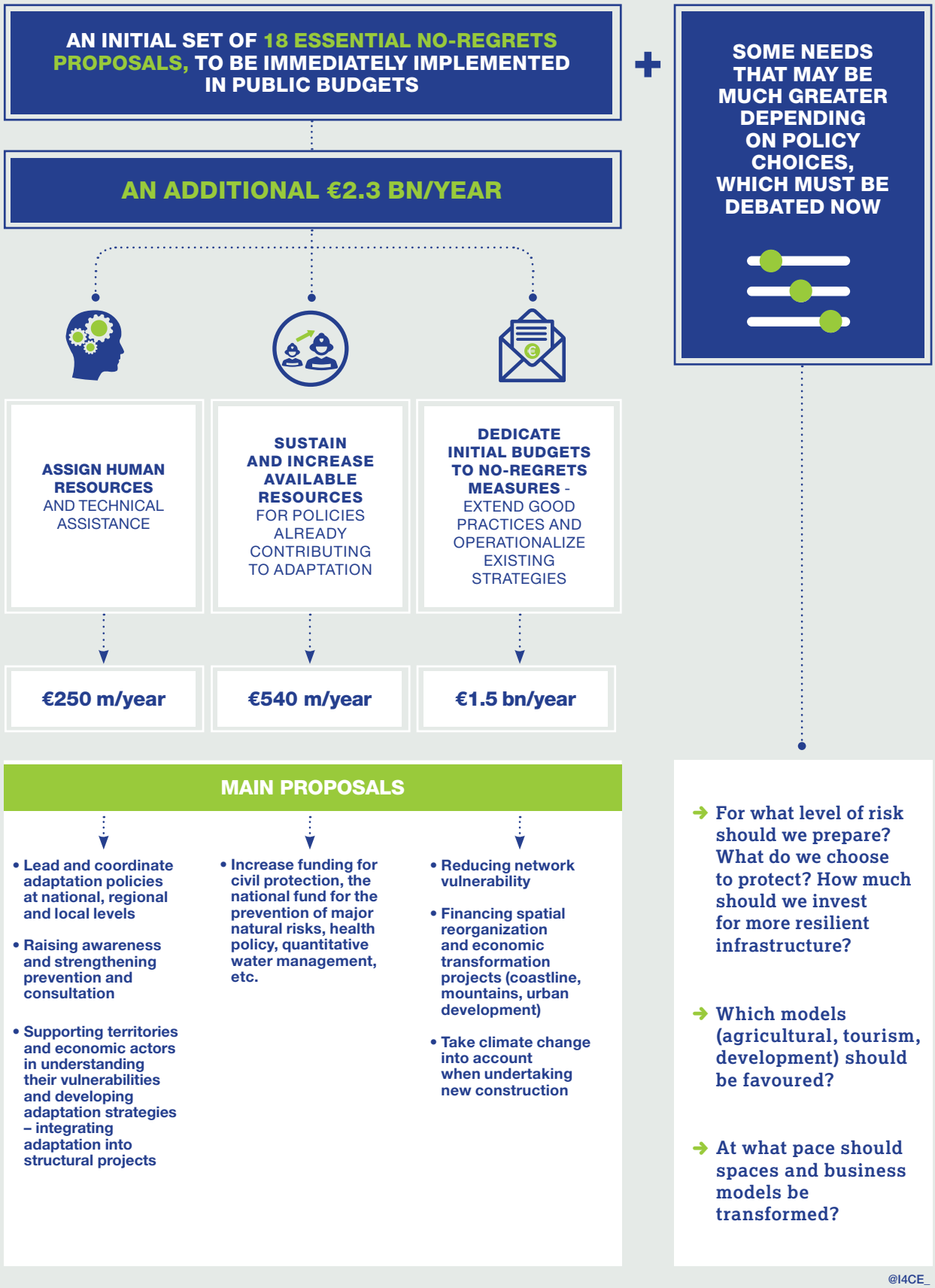


TABLE 1: 18 READY TO DEPLOY PROPOSALS FOR AN ANNUAL BUDGET OF AN ADDITIONAL €2.3 BILLION

PROPOSAL	REQUIRED BUDGET (€ M/YEAR)	RELEVANT ACTORS IDENTIFIED AT THIS STAGE
LEAD AND COORDINATE ADAPTATION POLICIES AT NATIONAL, REGIONAL AND LOCAL LEVELS		
1 — **Develop a real capacity to coordinate and lead adaptation** policies at national, regional and local levels	116	> State and its operators (ONERC, ADEME, DREAL...), regional authorities and regional actors, EPCI
2 — **Create a mechanism for combining resources** for the development and coordination of climate services	10	> State, Météo-France and research actors (IPSL, INRAE...)
PROTECT WATER RESOURCES SUSTAINABLY		
3 — **Increase and maintain for the long term the means** available to water agencies to support their work in protecting the global water cycle and biodiversity	300	> *Agences de l'eau* and stakeholders
ANTICIPATE AND PREVENT CLIMATE CHANGE IMPACTS ON HEALTH		
4 — **Fund a national investigative public health programme** to anticipate and prevent climate risks (research, prevention campaigns, improving health monitoring)	2,5	> State, *Santé Publique France*, health professionals, *Agences régionales de santé*
STRENGTHEN CIVIL PROTECTION POLICIES TO KEEP PACE WITH INCREASING RISKS		
5 — **Increase civil protection funding** to address the increasing risks of forest fires and wildfires – supporting the investment of the SDIS	115	> State, SDIS, ONF
MAINTAIN THE LEVEL OF NATURAL HAZARD PREVENTION IN A CHANGING CLIMATE		
6 — **Provide additional means** (budget for action and coordination capacities) to boost efforts to support flood risk prevention, to at least maintain the current level of risk despite climate change	125	> State, EPCI, risk prevention actors
REDESIGN CITIES TO TACKLE THE URBAN HEAT ISLAND EFFECT		
7 — **Provide technical assistance to existing urban renewal programmes** to enable them to integrate adaptation into the design of the operations they support	18	> ANCT, ANRU, *Banque des Territoires*
8 — **Maintain an annual support fund** for the extension of good adaptation practices in cities	500	> State, *Banque des territoires*, EPCI

* Although not addressed in this publication, other complementary actions that do not necessarily have a budgetary impact but facilitate better use of existing resources should also be implemented.

PROPOSAL	REQUIRED BUDGET (€ M/YEAR)	RELEVANT ACTORS IDENTIFIED AT THIS STAGE
ACCOUNT FOR THE FUTURE CLIMATE IN THE CONSTRUCTION AND RENOVATION OF BUILDINGS		
9 — **Strengthen resources for coordination,** awareness-raising and applied research on building adaptation, particularly relating to heatwaves	31	> State, ADEME, *Plan bâtiment durable* and *Réseau bâtiment durable*
10 — **Cover the additional costs of enhanced requirements** for sustainable and adapted to heat waves constructions in the building of educational and research facilities.	500	> State, local authorities
ENSURE THE RESILIENCE OF CRITICAL NETWORKS AND INFRASTRUCTURE: TRANSPORT, WATER, ENERGY		
11 — **Provide infrastructure managers and regulatory authorities** with the means to assess their vulnerabilities and to guide adaptation, particularly within the network asset management framework	15	> State, regional authorities and infrastructure managers
12 — **Establish and run a coordinating body** for infrastructure managers	1,7	> State, regional authorities and infrastructure operators
13 — **Provide an initial fund to finance targeted actions** to address critical vulnerability points on transport networks	325	> State, regional authorities and infrastructure managers
SUPPORT THE RESHAPING OF COASTAL AREAS TO COPE WITH RISING SEA LEVELS		
14 — **Provide communities with the means to objectify their vulnerabilities** and to develop and lead a coastal adaptation strategy	15	> State, EPCI
15 — **Create a fund** to support coastal reshaping	150	> State and local authorities
TAKE ACTION FOR RESILIENT FORESTS AND MAINTAIN THE SERVICES THEY PROVIDE		
16 — **Finance the implementation of the roadmap for the adaptation** of French forests to climate change (monitoring forest health, research-management interface, experimentation, coordination and consultation)	25	> State, ONF, CNPF, forestry and wood industry stakeholders
SUPPORT THE DIVERSIFICATION AND TRANSITION OF MOUNTAIN ECONOMIES		
17 — **Maintain the *Avenir Montagnes Ingénierie* fund and strengthen its coordination capacity** to meet the adaptation needs of mountain territories	16,7	> State, ANCT, *Banque des Territoires*
18 — **Maintain the State's share of the *Avenir Montagnes* investissement fund,** encourage regional authorities to do the same (to reach a total of €150 m/year) and direct investments towards projects contributing to adaptation	75	> State, ANCT, *Banque des Territoires*, regional authorities

CONTENTS

INTRODUCTION

Adapting to climate change: managing the inevitable and preparing for surprises

Climate change consequences are already evident, including in France, and these affects will continue to increase until carbon neutrality is achieved at the global level *(IPCC 2022; Haut conseil pour le climat 2021).* There is an urgent need to anticipate and prepare for these impacts by adapting to a changing climate to considerably reduce the social and economic costs, which are expected to be significant over the coming decades *(France Stratégie 2022)*. To achieve this, multiple topics must be addressed such as adapting buildings to cope with longer heatwaves, strengthening the robustness of transport and energy infrastructure to ensure resilience in a context of greater climatic variability, transforming agricultural systems to cope with more frequent droughts, diversifying mountain economies in response to reduced snow cover and the reshaping of coastlines to address rising sea levels *(I4CE and Ramboll 2020).* Each of these issues will require financial and human resources to implement adaptation policies that are up to the challenge of climate change *(I4CE 2021b)*.

11 CHALLENGES TO SUPPORT CLIMATE CHANGE ADAPTATION IN FRANCE

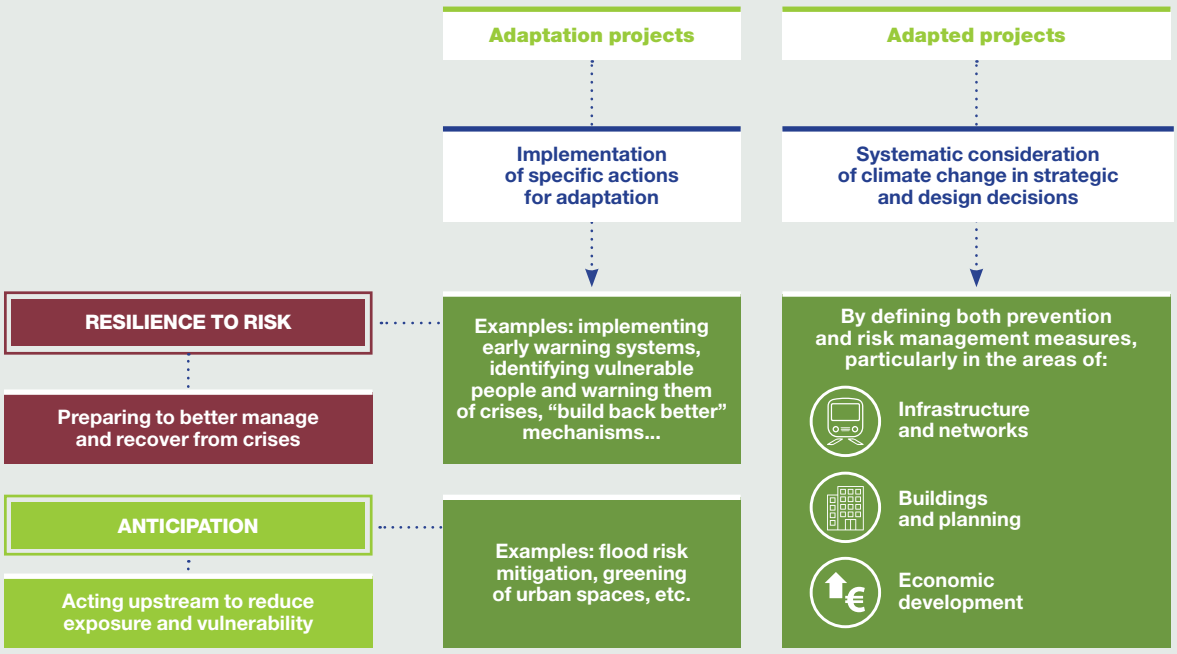
1. **LEAD AND COORDINATE** ADAPTATION POLICIES AT NATIONAL, REGIONAL AND LOCAL LEVELS
2. PROTECT **WATER** RESOURCES SUSTAINABLY
3. ANTICIPATE AND PREVENT CLIMATE CHANGE IMPACTS **ON HEALTH**
4. STRENGTHEN **CIVIL PROTECTION** POLICIES TO KEEP PACE WITH INCREASING RISKS
5. MAINTAIN THE LEVEL OF **NATURAL HAZARD PREVENTION** IN A CHANGING CLIMATE
6. REDESIGN **CITIES** TO TACKLE THE URBAN HEAT ISLAND EFFECT
7. ACCOUNT FOR THE FUTURE CLIMATE IN THE CONSTRUCTION AND RENOVATION OF **BUILDINGS**
8. ENSURE THE RESILIENCE OF CRITICAL **NETWORKS AND INFRASTRUCTURE:** TRANSPORT, WATER, ENERGY
9. SUPPORT **THE RESHAPING OF COASTAL AREAS** TO COPE WITH RISING SEA LEVELS
10. TAKE ACTION FOR RESILIENT **FORESTS** AND MAINTAIN THE SERVICES THEY PROVIDE
11. SUPPORT THE DIVERSIFICATION AND TRANSITION OF **MOUNTAIN ECONOMIES**

Adaptation to climate change is an element of territorial and national climate policies - and must be included in the various components of the next *Stratégie Française énergie climat*. But it also concerns several other areas of public action and therefore several programmes in the next Finance Bill. For example, adaptation must become a component of health, civil protection, risk prevention, planning, infrastructure modernization and economic and territorial development policies.

ADAPTATION BEYOND CERTAIN LEVELS OF CLIMATE CHANGE WILL NOT BE POSSIBLE

As the IPCC stated in its February 2022 report: beyond certain thresholds, which are not always well known, it will become humanly and economically far too costly to cope with the consequences of climate change *(IPCC 2022)*. It is therefore essential to manage the unavoidable adapting to climate change that we have been unable to avoid, and to avoid the unmanageable by making a successful transition to a carbon-neutral economy *(Dantec and Roux 2019)*. Therefore, the requirements described below are a supplement, rather than a substitute, for the needs to invest in the transition.

FIGURE 2: DIFFERENT FORMS AND MODALITIES OF ADAPTATION CONTRIBUTIONS



Adaptation policy in France: action is underway, but it remains largely insufficient given the scale of the challenges

We are not starting from scratch, risk prevention and management policies already exist in France and initial measures have been taken in recent years in response to climate change impacts in several sectors (during the *Assises de l'eau*, the *Assises de la forêt* and the *Loi Climat et Résilience*, etc). Nevertheless, many blind spots persist and there remains much work to be done, while the financial and human resources required for implementation are not always adequate for the ambition.

Until now, responses to developing climate risks have been mostly reactive - (intervening in the aftermath of extreme weather events for example), experimental (involving numerous calls for research projects), or partial through the proposal of legislative changes (*via* the identification of high-risk coastal areas for example) while lacking sufficient resources. Such approaches enable adjustments to marginal changes or the implementation of incremental changes, but it is clear that they do not initiate the operational implementation of adaptation actions commensurate with the challenges posed by the scale and speed of climate change *(Dantec and Roux 2019; Haut conseil pour le climat 2021; I4CE and Ramboll 2021; Comité 21 2020; IDDRI 2019).*

While capitalizing on the progress made, it is necessary to go much further by giving ourselves the means for more anticipative, ambitious and far-reaching action. Moreover, the most vulnerable populations, activities and territories are also often those with the least resources to invest in anticipation. Adaptation is also an issue of equity and solidarity. The collective response must therefore be better coordinated and associated with the clear programming of public resources. It is an issue of both public spending efficiency and social justice.

Composing an overview of adaptation needs in France and evaluating their costs is a prerequisite for ensuring that the resources deployed correspond to the issues

At the end of 2019, the French Senate noted that one obstacle to adaptation policy implementation in France is the lack of an estimation of adaptation needs, and even a lack of methodology for their quantification *(Dantec and Roux 2019).* Without this understanding of the needs, implementing a coordinated and effective policy is indeed difficult. It is also impossible to know whether the resources deployed correspond to the objectives. I4CE has therefore undertaken the work of identifying the needs for France to adapt to climate change and estimating the costs.

STUDY METHODOLOGY

The costs presented here relate to the implementation of adaptation – i.e. the implementation of anticipative action, prior to a particular climate change impact being experienced, in order to improve protection from or preparation for the impact. These costs should not be confused with the "costs of inaction" which represent the costs related to damage that has occurred (human or material losses, business losses, socio-economic losses, etc.) *(France Stratégie 2022; COACCH 2021; Feyen et al. 2020).* The aim of adaptation is specifically to mobilize upstream resources to avoid the costs of inaction downstream.

The analysis presented here was carried out in two stages: a qualitative definition of the adaptation resources needed, followed by a costing of these requirements.

The first stage of the analysis consisted in the qualitative definition of ten adaptation "challenges" in terms of the resources needed for adaptation: what resources, of what type, are required to implement what actions? This work was based on an analysis of the reference documents identified for each domain (parliamentary reports, roadmaps, etc.).

The second stage of the analysis was to move from a qualitative focus (which adaptation actions) to an estimate, in euros, of the associated resource requirements. To achieve this, we consolidated the various types of information based on the sources available:

- **Quantified results from previous thematic assessments** where available;
- **Extrapolated assumptions** based on local feedback;
- **Comparison** with other national or sectoral contexts;
- **Expert opinions.**

In translating actions into needs, we carefully accounted for the different types of resources required: financial resources, but also human resources (monetized on the basis of 1 Full Time Equivalent (FTE) = €60,000/year) for coordination, governance and technical assistance *(I4CE and Ramboll 2020).*

The main conclusion from this stage is that it is currently impossible to ascertain an overall figure for total adaptation needs in France. This impossibility stems not so much from a lack of information on adaptation action costs (even though some actions remain highly experimental) but more from a lack of clear consensus on the responses to be made to climate change consequences. Many adaptation decisions that will determine the extent of the requirements have yet to be taken at different levels (the subjects being very often regional but referring to issues of solidarity, cohesion and equity that are raised on a national scale):

- What level of risk is considered acceptable and, consequently, what level of effort are we collectively prepared to contribute to reduce the risk?
- What types of adaptation pathways are preferred when there are multiple possibilities on offer (to consider water for example, actions can be implemented on both supply and demand)?
- How can efforts be implemented over time, what is the pace of adaptation?

The answers to these questions will depend on the level of climate change actually experienced (and therefore on the greenhouse gas emission pathways adopted) but also, and above all, on the collectively adopted attitude towards these changes.

The primary aim of this publication is to provide input for the discussions that are urgently needed so that these decisions can be made, subject by subject. To help structure these debates, we propose two levels of analysis:

1. **Estimating the need for resources to implement an initial list of adaptation actions deemed essential and/or "no-regrets"** – i.e. measures that could be implemented right now and would be beneficial regardless of the level of climate change and future choices. This list is deliberately more subjective; it is based on our understanding of the specific issues at stake in each sector and is primarily intended to open up discussion and stimulate reaction.
2. **An overview, in the form of fact sheets, of all identified cost elements presented in their complexity.** The aim is to provide, as objectively and contextually as possible, reference points on the nature and the order of magnitude of needs according to the main parameters of choice.

This distinction is not a breakdown of what needs to be done in the short term and in the longer term. Some of the preliminary steps of structural transformation mentioned in the fact sheets should be discussed now. However, we did not include them in the initial list as we considered that consensus on these actions had not yet been demonstrated.

All of the assumptions that have enabled the calculation of costs are presented transparently and all are open to discussion.

➜ **For a more in-depth discussion of the methodological choices that guided this analysis, see:**
Dépoues. 2022. *"Changement climatique: passer des coûts de l'inaction aux besoins pour l'action".* Revue de l'OFCE, no. 176.15

Details on the scope of the list of measures ready to be deployed and their costing

- These measures correspond to the shortfalls expressed by certain actors concerned and/or documented in the literature. We have not therefore sought in this work to put an exhaustive figure on the expenditure contributing to adaptation, but have concentrated on calculating the costs of proposals that can be acted on immediately and that would enable progress to be made on the identified deficits.

- Some measures are directly inspired by proposals made by various actors, including parliamentarians, networks of local authorities or the General Inspector for the Public Administration, to make progress in this direction. When proposals are yet to be formulated, but unavoidable needs emerge from the analysis, we have proposed initial theoretical actions with the aim obtaining a complete quantification of the minimum resources to be mobilized immediately.

- Unless otherwise stated, all costs shown represent additional requirements on top of existing ones.

- Costings relate to budgetary measures that could be taken at the national level, including to support the implementation of local level action, in response to the budgetary constraints on local authorities.

- The analysis covers the whole of the French territory insofar as all of the regions share similar public policies. Overseas Departments and Regions are therefore considered in the same way as other local authorities. The specific and additional needs of these territories – potentially important in terms of adaptation given their exposure and particular vulnerabilities – have not been examined in depth.

- Proposals are formulated in the form of annual financial flows, as adaptation is mostly a long-term process. Unless otherwise specified, the proposed flows remain relevant for at least a five-year period.

I. 18 PROPOSALS REPRESENTING AN ADDITIONAL ANNUAL BUDGET OF €2.3 BILLION THAT THAT COULD BE PROVIDED FOR IN THE NEXT FINANCE BILL

An initial set of 18 national budgetary measures – representing a cumulative additional amount of at least €2.3 billion/year – can be taken now to prepare, strengthen or operationalize adaptation actions that have already been prepared.

Above all, this list is intended to open the discussion. The formulation of proposals is not intended to define the best courses of action, but simply to estimate the orders of magnitude of the means to be considered. Each proposal is based on an analysis, intended to be as objective as possible, of existing information on adaptation needs (see fact sheets). These figures, particularly those relating to issues that have not currently been sufficiently discussed, will be refined in the coming months through consultations for each topics. Nevertheless, the orders of magnitude provided are sufficiently robust to ensure their inclusion in public budgets without delay.

Three main types of measures

In terms of adaptation, solutions can most often be found through the combination of complementary actions. These 18 proposals are intended to be part of a coherent set of measures that constitute a real adaptation policy. **The challenge is therefore to ensure that resources are allocated to a range of action types that perform well together, rather than to concentrate resources on a few flagship proposals:**

1. FINANCING JOBS IN THE COORDINATION AND GUIDANCE OF ADAPTATION POLICY

The key issue is to rapidly improve the coordination and guidance of adaptation policy in France, with needs in cross-cutting governance as well as those more specifically of individual projects and public policy. This requires, in particular, human resources for coordination to guarantee a collective increase in skills, and a capacity to support and facilitate the issue wherever needed. This requirement entails a relatively small amount of funding. However, paradoxically, sufficient funds have not currently been allocated for this purpose even though it is very often a prerequisite for adaptation policy implementation *(I4CE and Ramboll 2021).*

2. SUSTAINING AND INCREASING THE RESOURCES OF POLICIES THAT ALREADY CONTRIBUTE TO ADAPTATION

Certain public policies – water resource protection, natural risk prevention, public health and civil protection – already contribute to the management of climate risks. In the context of an increase in these risks, the resources allocated to these policies must be adjusted accordingly.

3. COMMITING DEDICATED FUNDS FOR THE FINANCING OF NO-REGRETS INITIATIVES

In some areas and for some issues, there are already advanced adaptation strategies and good practices that can be immediately extended. These initiatives must be supported and financed in future by setting up dedicated budgets or funds. However, this should not be the only type of action covered by budgetary measures.

TABLE 1: 18 READY TO DEPLOY PROPOSALS FOR AN ANNUAL BUDGET OF AN ADDITIONAL €2.3 BILLION

PROPOSAL	REQUIRED BUDGET (€ M/YEAR)	RELEVANT ACTORS IDENTIFIED AT THIS STAGE
LEAD AND COORDINATE ADAPTATION POLICIES AT NATIONAL, REGIONAL AND LOCAL LEVELS		
1 — **Develop a real capacity to coordinate and lead adaptation** policies at national, regional and local levels	116	> State and its operators (ONERC, ADEME, DREAL...), regional authorities and regional actors, EPCI
2 — **Create a mechanism for combining resources** for the development and coordination of climate services	10	> State, Météo-France and research actors (IPSL, INRAE...)
PROTECT WATER RESOURCES SUSTAINABLY		
3 — **Increase and maintain for the long term the means** available to water agencies to support their work in protecting the global water cycle and biodiversity	300	> *Agences de l'eau* and stakeholders
ANTICIPATE AND PREVENT CLIMATE CHANGE IMPACTS ON HEALTH		
4 — **Fund a national investigative public health programme** to anticipate and prevent climate risks (research, prevention campaigns, improving health monitoring)	2,5	> State, *Santé Publique France*, health professionals, *Agences régionales de santé*
STRENGTHEN CIVIL PROTECTION POLICIES TO KEEP PACE WITH INCREASING RISKS		
5 — **Increase civil protection funding** to address the increasing risks of forest fires and wildfires – supporting the investment of the SDIS	115	> State, SDIS, ONF
MAINTAIN THE LEVEL OF NATURAL HAZARD PREVENTION IN A CHANGING CLIMATE		
6 — **Provide additional means** (budget for action and coordination capacities) to boost efforts to support flood risk prevention, to at least maintain the current level of risk despite climate change	125	> State, EPCI, risk prevention actors
REDESIGN CITIES TO TACKLE THE URBAN HEAT ISLAND EFFECT		
7 — **Provide technical assistance to existing urban renewal programmes** to enable them to integrate adaptation into the design of the operations they support	18	> ANCT, ANRU, *Banque des Territoires*
8 — **Maintain an annual support fund** for the extension of good adaptation practices in cities	500	> State, *Banque des territoires*, EPCI

* Although not addressed in this publication, other complementary actions that do not necessarily have a budgetary impact but facilitate better use of existing resources should also be implemented.

PROPOSAL	REQUIRED BUDGET (€ M/YEAR)	RELEVANT ACTORS IDENTIFIED AT THIS STAGE
ACCOUNT FOR THE FUTURE CLIMATE IN THE CONSTRUCTION AND RENOVATION OF BUILDINGS		
9 — **Strengthen resources for coordination,** awareness-raising and applied research on building adaptation, particularly relating to heatwaves	31	> State, ADEME, *Plan bâtiment durable* and *Réseau bâtiment durable*
10 — **Cover the additional costs of enhanced requirements** for sustainable and adapted to heat waves constructions in the building of educational and research facilities.	500	> State, local authorities
ENSURE THE RESILIENCE OF CRITICAL NETWORKS AND INFRASTRUCTURE: TRANSPORT, WATER, ENERGY		
11 — **Provide infrastructure managers and regulatory authorities** with the means to assess their vulnerabilities and to guide adaptation, particularly within the network asset management framework	15	> State, regional authorities and infrastructure managers
12 — **Establish and run a coordinating body** for infrastructure managers	1,7	> State, regional authorities and infrastructure operators
13 — **Provide an initial fund to finance targeted actions** to address critical vulnerability points on transport networks	325	> State, regional authorities and infrastructure managers
SUPPORT THE RESHAPING OF COASTAL AREAS TO COPE WITH RISING SEA LEVELS		
14 — **Provide communities with the means to objectify their vulnerabilities** and to develop and lead a coastal adaptation strategy	15	> State, EPCI
15 — **Create a fund** to support coastal reshaping	150	> State and local authorities
TAKE ACTION FOR RESILIENT FORESTS AND MAINTAIN THE SERVICES THEY PROVIDE		
16 — **Finance the implementation of the roadmap for the adaptation** of French forests to climate change (monitoring forest health, research-management interface, experimentation, coordination and consultation)	25	> State, ONF, CNPF, forestry and wood industry stakeholders
SUPPORT THE DIVERSIFICATION AND TRANSITION OF MOUNTAIN ECONOMIES		
17 — **Maintain the *Avenir Montagnes Ingénierie* fund and strengthen its coordination capacity** to meet the adaptation needs of mountain territories	16,7	> State, ANCT, *Banque des Territoires*
18 — **Maintain the State's share of the *Avenir Montagnes investissement* fund,** encourage regional authorities to do the same (to reach a total of €150 m/year) and direct investments towards projects contributing to adaptation	75	> State, ANCT, *Banque des Territoires*, regional authorities

The issues at stake in the various domains, the proposed measures and the cost assumptions are detailed in the fact sheets for each project in the second part of this document.

Three immediate major objectives for climate change adaptation policy in France

These measures are the first building blocks that should enable a response to the risks already identified, while also ensuring that future decisions will include adaptation and that we are already beginning to prepare for the deeper transformations that may be necessary:

RESPOND TO URGENT ADAPTATION NEEDS THAT HAVE ALREADY BEEN IDENTIFIED

Climate change impacts are already being felt, including in France. Extreme weather events are becoming more frequent and more intense. Examples include the Roya Valley floods in October 2020, and the heatwave in June 2022. Until now, the response to the development of climate risks has very often been reactive, intervening for example in the aftermath of these extreme events. This reactive response has a significant cost, a cost that will increase as climate change impacts intensify. For example, in February 2022, the *Cour des comptes* expressed concern regarding the explosion of costs related to the phenomenon of shrinking and swelling clays. Recent works by insurers has predicted a 35% increase in natural disaster losses due to climate change by 2050 under an intense climate change scenario *(CCR 2018; FFA 2021)*. The resilience of French agriculture is also being undermined by an increase in extreme weather events and their intensity, requiring emergency public support measures such as the €1 billion released following the late frost episode in April 2021.[2]

Limiting public budgets to damage repair rather than funding adaptation measures is inefficient public spending. It is therefore important to switch from a reactive position where every impact is felt, to a more proactive stance. This firstly requires the reduction of accumulated adaptation deficits by reducing the most critical vulnerabilities as quickly as possible (e.g. if a section of infrastructure – for example, a railway – has become too old and only enables a reduced level of service every summer due to high temperatures, then there is an urgent need for it to be repaired because this type of vulnerability becomes unacceptable in a context of increasing heatwaves). This then requires the capacity to anticipate by adopting adaptive management strategies that take climate parameters fully into account.

ENSURE THAT PUBLIC INVESTMENT DECISIONS FROM NOW ON TAKE CLIMATE CHANGE INTO ACCOUNT

In recent years, major investment support programmes have been designed to accelerate the emergence or modernization of facilities and installations deemed particularly important for economic and territorial development. Among these programmes, several relate to long-term assets that will be directly exposed to changing climatic conditions. However, because they concern structural equipment and facilities, these programmes, which are intended for deployment and subsequent evolution in the coming years, must take adaptation to climate change into account. Integrating the new climate situation from the design stage of financed operations is in fact the most economical way of guaranteeing robust and resilient decisions. To omit this step, on the contrary, means running the risk of perpetuating or reinforcing vulnerabilities, while having to make investments again much sooner than expected. Given the sums involved, we cannot afford to invest twice (for example, to renovate the building stock twice).

Providing the means to integrate adaptation into these programmes may not meet all adaptation needs, but it is both an imperative to avoid maladaptation and an immediate opportunity to considerably strengthen the level of adaptation in France.

Ensuring the adaptation of existing infrastructure and equipment often represents a limited additional cost and is above all a question of good programme design. The challenge is therefore to ensure that managers and operators of these investments are encouraged and have sufficient time and technical expertise to integrate adaptation into the project design.

Since a considerable proportion of adaptation challenges relate to the territorial scale, the actions supported by local authorities also represent an important type of action that must be analysed from a climate change perspective. Discussions regarding contractual financing between the State and local authorities could be an opportunity to address this issue.

1. See https://www.ccomptes.fr/fr/publications/sols-argileux-et-catastrophes-naturelles - accessed on 17/06/2022
2. See Duplomb, Laurent. 2022. "Rapport fait au nom de la commission des affaires économiques sur le Projet de loi portant réforme des outils de gestion des risques climatiques en agriculture". French Senat

TABLE 2: A MULTITUDE OF INVESTMENT PROGRAMMES PLANNED ELSEWHERE WHICH MUST INTEGRATE ADAPTATION ISSUES

MAJOR INVESTMENT PROGRAMMES

Adaptation challenges in investment programmes:
- **Climate change must be integrated to avoid malinvestment in urban projects of new construction, retrofit and planning projects (heat in the city, flooding), in agricultural and forestry projects (drought), in mountain development (reduction in snow cover), in network infrastructure (flooding, heat, etc.), in coastal development (submersion, coastal erosion, etc.) ...**

- **Support (public and private) for the energy retrofit of private housing**
- **State investment for acquisition, building, structural works and the heavy maintenance of its building stock**
- ***Action Cœur de ville* – Phase 2 of the programme (announced)**
- **New National Urban Renewal Programme (NPNRU)**
- **France 2030: (at least) part of the plan that supports the third agricultural revolution, innovation and competitiveness of the wood-forest industry, sustainable city demonstrators**
- **Investment in transport network modernization (including from the State, local authorities, EU, *SNCF Réseau* and *Société du Grand Paris*)**
- **Investment in electricity networks (transport and distribution)**
- **Investment in the construction and renovation of social housing**
- **Maintenance expenditure by social landlords on their housing stock**

A PROFUSION OF SMALLER, SPECIFIC INVESTMENT PROGRAMMES

In addition to major programmes, numerous public sector investments present challenges in terms of adaptation. The challenge is to analyse all investments in terms of opportunities to take climate change into account and therefore to contribute to more adapted developments or infrastructure at national and regional levels. This analysis task has yet to be carried out.

- ***Plan Montagnes d'Occitanie Terres de vie* (2019-2025), *Plan littoral 21*, *Plan Montagne* (Auvergne-Rhône-Alpes), *Contrats stations* 2030 (Région Sud), *Plan de rénovation des écoles – Marseille, Engagement pour le renouveau du bassin minier du Nord et du Pas-de-Calais*...**

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PREPARE FOR MORE STRUCTURAL TRANSFORMATIONS

In some situations, climate change impacts will require more than simple adjustments or incremental adaptations. Deeper transformations will have to be envisaged in these cases. This may involve, for example, relocating facilities and housing in coastal areas, or significantly reorienting the economy in certain mountain regions.

Most of these pathways still need to be constructed, and they must be the focus of collective efforts from now on. It is therefore necessary to equip ourselves with the means to inform and lead this work.

Furthermore, some measures may need immediate implementation to keep open the maximum number of options. For example, given the time taken for trees to grow, it is not possible to experiment with new silvicultural forest strategies and to wait for the results, in the hope of using this knowledge to adapt future reforestation. In both cities and coastal areas, many transformational adaptation actions require land mobilization. The implementation of land use planning action today and mechanisms to seize opportunities to secure available land is a prerequisite for considering relocation or renaturation projects.

Finally, adaptation strategies are starting to be initiated at territorial and sectoral levels. The implementation of the first milestones of these strategies (e.g. relocating the most exposed buildings on the coast or supporting a new diversification project in the mountains) will be essential to demonstrate the credibility of proposed pathways and to ensure a solid starting point.

The initially available funds should be able to help with these first steps.

II. TOTAL REQUIREMENTS DEPENDING ON FUTURE DECISIONS

Adaptation cannot be limited to the 18 measures listed in the previous section. We must also consider complementary measures that are possibly more ambitious or even constitute radical transformations. Given that such actions may have a greater budgetary impact, and also because they may reflect different attitudes to climate risks, they must first be prioritized and politically debated. It is therefore a question of opening up democratic discussion: on subjects as fundamental as the level of risk that we are collectively prepared to accept when new developments are proposed; on activities and territories that we wish to preserve and those that we are willing to see transformed; and on the level of solidarity between territories with different exposure levels.

Achieving progress in the establishment and development of a social consensus is a prerequisite for assessing the associated investment needs. At this stage, it is possible to set out some milestones to better understand the types of needs associated with different alternatives.

At what point should we enhance our protection and prevention mechanisms in response to the increasing risks?

The initial actions listed above are aimed primarily at maintaining an equivalent level of protection and response capacity to address the increased climate risks that have already been observed. However, these risks have by no means been stabilized, and until carbon neutrality has been achieved, there is every reason to believe that pressures on economic and human systems will increase. Ensuring that our prevention and protection mechanisms maintain or even improve their effectiveness will therefore require their gradual strengthening over time. Each budgetary debate must be an opportunity to re-examine the scale (but also in some cases the type) of these policies:

TABLE 3: RETHINKING THE RESOURCES FOR EXISTING PREVENTION AND PROTECTION POLICIES

PUBLIC POLICIES MAIN BUDGET PROGRAMMES, MEASURES, EXPERTISE OR OPERATORS INVOLVED	EXISTING RESOURCES DIRECTLY CONTRIBUTING TO ADAPTATION	QUESTIONS TO RAISE
> PROTECTION OF WATER RESOURCES AND ECOSYSTEMS	Approximately **€1 billion/year** from the 11th Agences de l'eau programme	**— What quantitative management model should be applied in future:** proportion of sufficiency, storage, use of non-conventional resources?
> FLOOD RISK PREVENTION	Around **€300 m/year**	**— Expected 30% increase in claims due to climate change**: do we want to maintain/increase the level of prevention to maintain/decrease the level of risk?
> CIVIL PROTECTION	**€5.16 bn/year**	**—Risks are multiplying, extending to more departments, risk periods** (e.g. forest fires) are extending: what do emergency services need to maintain their ability to deal with these risks in the long term?
> PUBLIC HEALTH	Less than **€500,000/year** earmarked for heatwave risks, but broader health measures are essential in the context of climate risks	**— What are the new health risks linked to climate change, which populations are the most vulnerable** and what preventive actions are the most effective?

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What level of robustness should be sought?

To objectify and explicitly integrate the need for adaptation into the design of long-lived assets (infrastructure, buildings, facilities, etc.) should at least make it possible to ensure that already committed public investments do not increase vulnerability and enable the management of risks.

However, different options can be proposed that go even further, by turning these investments into opportunities to proactively reinforce the robustness of systems (power networks, transport systems, industrial facilities, etc.). This involves design choices (e.g. locations, routes) or technical choices (e.g. materials, technologies) that are effective in a wider range of climatic conditions and, for example, capable of withstanding higher temperatures or surviving more severe flooding. These choices may involve additional costs that need to be balanced against the issues at stake (e.g. the avoidance of operational losses they would enable or, in the case of public investments, the socio-economic damage they would minimize) and the level of risk deemed acceptable – which may vary greatly from one context to another and is a matter for debate. For example, while it is reasonable to ensure that a new nuclear power plant is resistant to all possible events, even the least likely, regardless of the associated additional costs, it may however be acceptable to allow the occasional closing of a transport route, if an alternative exists.

A precise estimate of these additional costs can only be made for each specific situation. However, it is possible to estimate ranges based on feedback from documented experiences.

TABLE 4: LEVELS OF AMBITION TO BE DEFINED FOR MORE ROBUST NETWORKS AND CONSTRUCTIONS

PROJECT	CURRENT FLOWS	QUESTIONS TO RAISE – COMPROMISES TO MAKE	POTENTIAL EXTRA COSTS
> **TRANSPORT INFRASTRUCTURE** AND NETWORKS	**€13 bn/year**	— **What amount of investment for what level of robustness?** What minimum level of service should be guaranteed, including in extreme situations? In what situations would weakened services be acceptable? Under what conditions?	**+ €78 to €650 m/year**
> **ELECTRICITY** NETWORKS	**€6 bn/year**		**+ €104 to €408 m/year**
> **WATER** NETWORKS	**> €6.5 bn/year**	— **What is a reasonable renovation** rate that could be a realistic aim?	**Up to + €2 bn/year to double the pace**
> **CONSTRUCTION** OF NEW BUILDINGS	**Total market of €125 bn in 2019** **€2.7 bn in State investment in its own housing stock in 2022** **€9.6 bn for social landlords**	— **What level of exemplarity** for which types of buildings, especially public buildings (schools, health services, etc.)? **What aims in terms of increasing** thermal regulation criteria?	**Currently a 10 - 15% increase, but with a potential learning effect**
> **RENOVATION** OF BUILDINGS	**€6.9 bn/year in public subsidies**	— **Should we prioritize fewer but higher quality** renovations annually by supporting deep renovations first? **Do we want to maintain the quantitative objective**s – with what level of ambition?	

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Should deeper transformations be envisaged?

In some cases, marginal adjustments will be insufficient in the long term, and more profound transformations need to be considered. In many areas, there needs to be further discussion on adaptation to agree on the direction of the preferred adaptation pathways and the pace at which changes will be implemented.

These choices will depend as much on the level of anticipated climate change as on the attitude that we collectively choose to prioritize when addressing the risks: what do we choose to preserve, which sectors, which territories do we prefer to transform? These questions are very political and several alternatives are often possible. For example, it is possible to aim to temporarily maintain an irrigated crop if investments are made to increase the quantity of water available; while it is also possible to progressively favour other crops on the condition that such transitions can be supported.

These choices have specific needs that may increase the cost of achieving other public policy objectives. But they will also be the guarantee that these objectives can be achieved in the long term despite climate change impacts. The costs of adaptation are therefore no more and no less than the costs of adapted and resilient polices of transition, transport, health, planning and tourism development.

TABLE 5: POSSIBLE TRANSFORMATIONS THAT WILL REQUIRE DEDICATED INVESTMENTS THAT ARE NOT YET FULLY UNDERSTOOD

TRANSFORMATIONS TO SUPPORT	QUESTIONS TO RAISE
> **RESHAPING OF COASTAL TERRITORIES** DUE TO RISING SEA LEVELS	— **What are we protecting? What are we relocating?** What forms of community support exist among coastal and non-coastal territories?
> **DIVERSIFICATION AND TRANSFORMATION** OF MOUNTAIN ECONOMIES IN A CONTEXT OF REDUCED SNOW COVER AND INCREASED CLIMATIC RISKS	— **What climate change impacts will affect each territory?** What are the economic, agricultural and employment impacts? What possibilities exist for diversification? How can we rethink regions without a winter sports economy? Debates are needed involving all actors within each territory.
> **TRANSFORMATION OF URBAN SPACES** TO ENSURE THE HABITABILITY AND ATTRACTIVENESS OF CITIES	— **What are the specific vulnerabilities of each territory?** What risk levels are acceptable? Do some areas need to be completely redesigned? Do some activities need to be relocated?
> AGRICULTURAL SECTOR **TRANSFORMATION**	— **What irrigated crops do we want to maintain?** What changes in practices or even models (local environments, crops) are possible? How can the transition of farmers be supported?

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MAIN REFERENCES ON ADAPTATION TO CLIMATE CHANGE IN FRANCE

- CCR, Météo France. 2018. ***"RCP8.5 : conséquences du changement climatique sur le coût des catastrophes naturelles en france à horizon 2050".***
- COACCH. 2021. ***"The Economic Cost of Climate Change in Europe Synthesis Report on State of Knowledge and Key Research Gaps".***
- Comité 21. 2020. ***"S'adapter aux changements climatiques : propositions pour une transformation accélérée des territoires et des organisations".***
- Dantec, Ronan, et Jean-Yves Roux. 2019. ***"Rapport d'information fait au nom de la délégation sénatoriale à la prospective, sur l'adaptation de la France aux dérèglements climatiques à l'horizon 2050". French Sénat.***
- Feyen, L, J.C Ciscar, S Gosling, D Ibarreta, A Soria, European Commission, et Joint Research Centre. 2020. ***Climate Change Impacts and Adaptation in Europe: JRC PESETA IV Final Report.***
- FFA. 2021. ***"Impact du changement climatique sur l'assurance à l'horizon 2050".***
- France Stratégie. 2022 to be published.***"Impacts physiques et socio-économiques du changement climatique en France : synthèse de la littérature".***
- GIEC. 2022. ***"Climate Change 2022: Impacts, Adaptation and Vulnerability. The Working Group II contribution to the IPCC Sixth Assessment Report".***
- Haut Conseil pour le Climat. 2021. ***"Renforcer l'atténuation, engager l'adaptation".***
- I4CE. ***"No adaptation without operational requirements and human resources".***
- I4CE, et Ramboll. 2020. ***"Territoires : les chantiers de l'adaptation. Projet Finadapter."*** 2020.
- I4CE, et Ramboll. 2021. ***"Les défis économiques pour généraliser la prise en compte de l'adaptation au changement climatique dans les territoires français".***
- IDDRI. 2019. ***"Adaptation to climate change in France: focus on the national framework".***

_ CHALLENGES AND COSTS OF ADAPTATION BY DOMAIN

LEAD AND COORDINATE ADAPTATION POLICIES AT NATIONAL, REGIONAL AND LOCAL LEVELS

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW
A few people at the national level (<15), regional schemes often run on the basis of allocated time (sometimes on a voluntary basis) by people for whom this is not the main task.	1 Develop a real capacity to coordinate and lead adaptation policies at national, regional and local levels: **€116 m/year** 2 Create a mechanism for combining resources for the development and coordination of climate services: **10 m/year**

Resources to support this issue and to coordinate a multi-level governance

For as long as adaptation remains a secondary issue involving an insufficient number of people, it cannot be systematically taken into account. Our previous work has clearly shown that, more often than not, the obstacle to overcome is the difficulty of devoting enough time to the subject *(I4CE 2021; I4CE and Ramboll 2022)*.

The aim is to ensure that the questions raised in the first part of this report are asked at a sufficiently early stage, that adaptation pathways are designed on the basis of contextualized analyses of vulnerabilities and issues, that the available adaptation options are identified and discussed (particularly when they involve democratic compromise), and that the possible additional costs of adaptation can be financed and monitored over time:

AT THE NATIONAL LEVEL

The second French National Plan for Climate Change Adaptation identifies 12 ministries that are directly concerned by the implementation of adaptation. It would therefore seem consistent for each of these ministries to have at least one person dedicated to monitoring related action, in addition to the cross-cutting teams (particularly at ONERC or within ADEME), which could also be strengthened.

The strong territorial dimension of adaptation implies having contacts in the decentralized administrations, which are currently under pressure, making it difficult for them to carry out new tasks without increasing their resources *(Cour des Comptes 2022)*. Assuming that one adaptation manager per geographical department could be envisaged to enable the State to carry out its leadership and technical support roles as close to the regions as possible.

REGIONAL COORDINATION

At the regional level, we can observe the emergence of dynamics, in relatively varied forms. Most often these dynamics are structured around peer networks (e.g. *Plan climat-air-énergie territorial* – PCAET) project managers, water agencies, national park coordinators, etc.) facilitated (sometimes jointly) by organizations such as the *Conseil Régional*, ADEME or DREAL. Until now, this leadership has taken the form of relatively small part-time positions for project managers, sometimes accompanied by consultants.

These networks can also rely on various expert structures run by public bodies or associations such as regional obser-

vatories or the *Groupements régionaux d'expertise sur l'évolution du climat*. To catalyse and expand these dynamics, the mobilization of additional resources seems essential.

WITHIN THE PCAET

Since the 2015 *loi de transition énergétique pour la croissance verte*, 756 EPCI with more than 20,000 inhabitants must have a PCAET with an adaptation component. Apart from some rare exceptions, this aspect remains very underdeveloped within existing plans *(Intercommunalités de France 2022).*

As adaptation is a highly cross-cutting issue that concerns multiple departments within local authorities (e.g. water, urban planning, green spaces, social affairs, etc.) and local actors, developing a strategy and then implementing it requires considerable coordination and the mobilization of different professional know-how. Working across different fields and modifying design practices sufficiently far upstream to integrate climate change remains a challenge that local authorities are struggling to meet, apart from a few pilot projects (e.g. a specific urban development operation) *(I4CE and Ramboll 2022).*

While the tools exist (e.g. ADEME's TACCT approach), the ability to devote time to the development and management of a genuine local adaptation approach is a major obstacle. Overcoming this obstacle requires both a strong political will to prioritize this objective, along with the mobilization of dedicated resources.

The governance of adaptation is a subject that is currently being discussed in the framework of the preparatory working groups for the next *Stratégie Française Énergie-Climat.* The associated requirements, particularly the human resources, will depend on the organizational choices and the distribution of responsibilities that are actually adopted. Nevertheless, to provide an indicative estimate on the order of magnitude of these needs, we made calculations based on the hypothetical proposal below (assuming that these are mainly additional needs, as the current resources devoted to adaptation remain very low). The resulting sum required is **€116 m/year**.

TABLE: CROSS-CUTTING 1 – ESTIMATE OF THE RESOURCES NEEDED TO DEVELOP REAL CAPACITY TO LEAD AND COORDINATE ADAPTATION POLICY AT NATIONAL, REGIONAL AND LOCAL LEVELS

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IDENTIFICATION OF NEEDS	ESTIMATED ADDITIONAL COSTS
— Strengthening of cross-sectoral coordination and leadership staff within each State administration concerned: + 24 FTEs	**€1.4 m/year (State)**
— Fund one FTE post with responsibility for adaptation within each DREAL (x13) and DEAL (x5): +18 FTEs	**€1.1 m/year (State)**
— Fund one FTE post with responsibility for adaptation in the devolved administration at the level of each department (x101 – DDT or prefectures for example)	**€6.1 m/year (State)**
— Set up an adaptation unit within each regional administration (in the form of a dedicated team or a coordinated peer network distributed within sectoral departments): + 7 FTEs per region x18 regions For example, according to the following distribution: • 1 FTE for facilitation and coordination between the services involved in the regional administration • 1 FTE "observatory" for the compilation of data and the provision of relevant indicators • 1 FTE in charge of supporting sub-regional authorities • 1 FTE for the financing of adapted/adaptation projects • 3 FTEs equivalent to the time spent by staff within the different departments concerned with adaptation (economic development, vocational training and employment, tourism, agriculture and forestry, property and schools, planning, infrastructure and transport, natural areas, sea and/or mountain where applicable, etc.)	**€7.6 m/year (Regions)**
— Regional support earmarked for adaptation to local bodies supporting adaptation (local expertise groups on climate change, regional resource centres, etc.): €500,000/year x18 Regions	**€9 m/year**
— Fund an FTE with responsibility for adaptation within each EPCI that has to produce a PCAET (x756 obliged) and mobilize the time of staff from other departments in the relevant local authority (urban planning, green spaces, water, etc.): 2 FTEs per EPCI	**€90.7 m/year (EPCI)**

Public expertise

The operational implementation of adaptation must also rely on technical operators – including public operators such as ADEME, Météo-France, The *Office français de la biodiversité* (OFB), and the *Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement* (CEREMA) – which must also be able to mobilize resources on the subject *(I4CE 2020).*

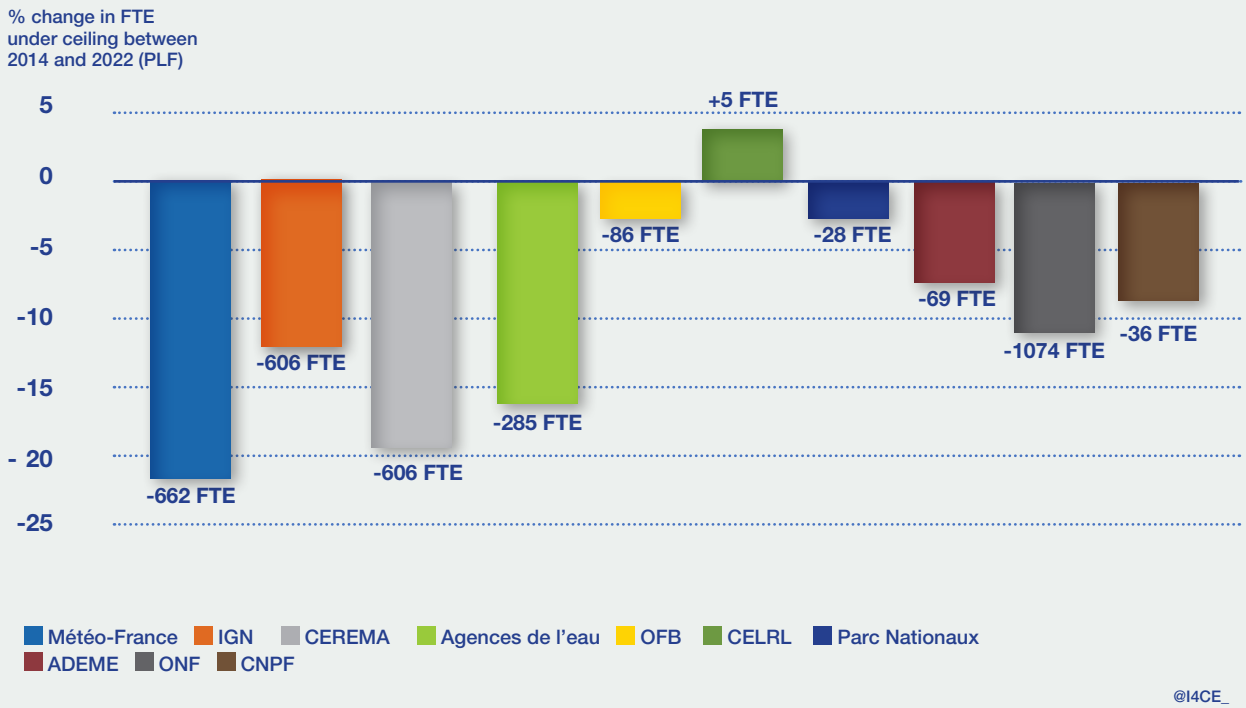
It is therefore evident that mobilizing the time and expertise needed to carry out the necessary action for climate change adaptation will have to be based on clear decisions and budgetary choices (resource reorientation, rule changes, recourse to external service providers, etc.). These trade-offs will have to take into account the characteristics of the tasks in question:

- Adaptation will happen over time – it is therefore an issue of enabling the implementation of long-term choices. For example, regarding forests, public actors have historically been the guardians of public interest. If other organization types were to be prioritized, a guarantee of long-term interest would need to be sought.

- Adaptation requires an expert knowledge of the situation and the areas, the monitoring of changes over time, and the utilization of experience and scientific knowledge. The successful implementation of an adaptive management process therefore also depends on the continuity of job roles and their sustainability over time.

- The context of climate change is one of variability and therefore of increased uncertainty. Systems, particularly human resources, can no longer be tailored for a nominal situation and must include a certain amount of leeway to cope with deteriorating conditions or even recurring crises.

FIGURE: CROSS-CUTTING 2 – CUMULATIVE CHANGES BETWEEN 2014 AND 2022 TO THE TOTAL WORKFORCE OF THE MAIN NATIONAL PUBLIC OPERATORS CONTRIBUTING TO ADAPTATION



Climate services

Adapting to climate change means no longer planning, designing and building on the basis of historical climate data, but also taking future climate projections into account in decision-making. This may be relatively straightforward for organizations that are used to working with variables such as temperature, precipitation volumes or drought indicators. But this is more challenging when climate dependencies are implicit or unquantified.

For all subjects, there is therefore a need for transparent climate data and information at the right scales, but also for support in using them or, in other words, the need for 'climate services' *(ONERC 2022, 65; European Commission 2019; AllEnvi 2016; CGDD 2019).*

This need may be encountered by infrastructure operators, local authorities, economic actors, and also government services. Some of these actors have the means to internalize some of the expertise, but this is far from the case for all.

UPSTREAM RESEARCH

The development of climate services adapted to different functions is only possible with the support of major upstream research efforts. France and the European Union are fortunate in being able to rely on solid research centres that have been working on these issues for many years. Nevertheless, the scale and complexity of the phenomena involved are generating new questions that must be studied. Although requirements in terms of new research have not been quantified in the framework of this analysis, it is important to note that they remain significant and that giving ourselves the means to meet the challenges of adaptation also means maintaining ambitious research capacities.

Recently, some projects supported by the French National Research Agency (*Agence nationale de la recherche – ANR*), namely the "Priority Exploratory Research Programmes and Equipment" (*Programmes et équipements prioritaires de recherche exploratoire – PEPRs*) have made contributing to adaptation one of their main objectives, such as the PEPR FORESTT[1] (€74 m over 5 years), the PEPR OneWater (€53 m over 10 years).

Most adaptation topics analysed (for forests, cities, coasts, mountains, etc.) have identified the need to develop or enhance thematic climate services. They concern the provision of data and the development of indicators, but also the design and coordination of interfaces, of which web portals are only one component. The development, testing and long-term management of support services - based on skills that are complementary to research expertise on climate and its impacts - are also essential. The work of developing and updating information must therefore be complemented by the maintenance and long-term management of technical infrastructure (including IT) and partnerships to disseminate and maintain service provision *(Kageyama and Morin 2022; Vautard et al. 2022).*

Given that each of these components has a cost, the coordination of activities (for example, the better reuse in different contexts of modules developed to meet particular demands) and the sharing of certain resources (for example, IT infrastructure and teams, administrative management resources, coordination capacities) would be well worth consideration. The aim would be to ensure that appropriate services are available to the various stakeholders at a reasonable cost and within a reasonable timeframe.

The establishment of a key contact for public actors or those involved in public service objectives could also be envisaged. To function properly, such a scheme should be complemented by contacts, within the various user structures (e.g. DREAL, ministries, infrastructure operators, etc.), that would have the necessary skills to facilitate dialogue between service producers and users.

By way of illustration, we can cite mechanisms that exist or have existed in other countries to support and organize the development and deployment of climate services:

- In the UK, the Engineering and Physical Sciences Research Council (EPSRC) programme funded the Adaptation and Resilience to a Changing Climate (ARCC[2]) network from 2014 to 2017, which was managed by the UK Climate Impacts Programme (UKCIP) and hosted by Oxford University. This network supported the creation of an enabling environment for adaptation by strengthening cohesion between research actors and stakeholders involved in climate change adaptation; facilitating the flow and use of knowledge and the accessibility of the latest research results. Up to 9 people worked full time on this network which, in 2014 for example, had an annual funding of **£1 m.**
- In Quebec, the Ouranos[3] group – "a non-profit organization that develops and coordinates projects by tap-

1. Which was finally not taken
2. See https://www.arcc-network.org.uk/about-us/ - accessed on 13/06/2022
3. See https://www.ouranos.ca/ouranos/- accessed on 13/06/2022

ping into a network of approximately 450 researchers, experts, practitioners and policy-makers from a variety of disciplines" – employs 50 people across eight priority areas and coordinates more than 100 projects. In 2020-2021, the total budget for Ouranos' scientific programming amounted to $54.7 m (including around **$13 m** of its own resources). During the same year, Ouranos was able to contribute to the development of three plans for three levels of government: the Federal Climate Strategy, Quebec's Plan for a Green Economy, and Montreal's Climate Plan *(Ouranos 2021)*. Ouranos' regular members include the province of Quebec, Hydro-Québec, the *Institut national de la recherche scientifique*, UQAM, McGill and Laval universities, and the Environment and Climate Change Canada agency.

- In France, the GICC program supported by the Ministry of the Environment and ADEME and led by GIP Ecofor was able to coordinate calls for research projects from 1999 to 2016, as well as the community of actors involved. Dozens of projects have thus received several hundred thousand euros in funding, enabling the construction of numerous building blocks for existing climate services. A fund to launch a new call for projects should have been released within the French National Climate Change Adaptation Plan (PNACC-2) framework, but this did not take place due to the lack of an available budget line. Subsequently, a three-year "Climate Services Agreement" was signed in 2017 between the Ministry of Ecology and the *Centre national de recherche scientifique* to provide the "open access dissemination of a data set, methods and training materials to enable decision-makers and industry to interpret climate projections, extreme events and national contributions to emission reductions". This agreement, which ended in 2021, notably allowed for the enhancement of the DRIAS[4] portal. The mid-term review of the PNACC-2 indicated that just over **€1 m** was committed to sub-measures relating to the Climate Services Convention *(MTE 2021, 100)*.

The various needs expressed converge on the usefulness of recreating a permanent mechanism capable of supporting and maintaining such a dynamic by sharing resources (technical infrastructure, HR) and by proposing a regular call for projects. This funding should be in the order of **€10 m/year**, at least partially State-supported and to which various partners, including companies, could contribute. Different support methods could be explored by linking researchers and public actors.

This type of structure could both rely on and support local level work (e.g. work by local climate change experts groups) and work at the European scale, for example in the framework of the ClimatEurope network *(European Commission 2019).*

It could also meet the needs for coordination and knowledge-sharing among infrastructure operators, as mentioned above in the network section.

Main references

- AllEnvi. 2016. **"Services climatiques pour l'adaptation au changement climatique."**
- CGDD. 2019. **"Théma - L'évaluation socio-économique des projets de prévention des inondations en France."**
- European Commission. 2019. **"A European research and innovation roadmap for climate services."**
- Cour des comptes. 2022. **"Les effectifs de l'administration territoriale de l'État. Exercices 2010-2021."**
- I4CE. 2020. **"Adaptation in the state budget."**
- I4CE, Ramboll. 2021. **"Défis économiques pour généraliser l'adaptation au changement climatique dans les territoires."**
- I4CE, et Ramboll. 2022. **"Challenges to implementing adaptation on the ground- 5 case-studies in France."**
- Intercommunalités de France. 2022. **"Changement climatique : la nécessité de l'adaptation de l'action publique locale."** Focus Environnement.
- Kageyama, Masa, et Samuel Morin. 2022. **"Investir dans la modélisation du climat pour une action climatique efficace."** CNRS Le journal, 1er avril 2022.
- MTE. 2021. **"Évaluation à mi-parcours du PNACC-2."**
- ONERC. 2022. **"La Prospective au service de l'adaptation au changement climatique."**
- Ouranos. 2021. **"Consortium sur la climatologie régionale et l'adaptation aux changements climatiques : rapport annuel d'activités. 2021/2021."**
- Vautard, Robert, Jean-Michel Soubeyroux, Nathalie de Noblet-Ducoudré, Maryvonne Kerdoncuff, David Salas-y-Melia, et Benjamin Sultan. 2022. **"Les services climatiques."** In La Prospective au service de l'adaptation au changement climatique, 65-85.

4. See https://convention-services-climatiques.lsce.ipsl.fr/ - accessed on 13/06/2022

PROTECT WATER RESOURCES SUSTAINABLY

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
11th *Agences de l'eau* Programme: €2.5 bn/year of which approximately €1 bn/year contributes to adaptation Specific measures (e.g. the *France 2030* Call for Proposals, research projects such as Explore2)	3 Increase and maintain for the long term the means available to water agencies to support their work in protecting the global water cycle and biodiversity: **+ €300 m/year** by ensuring that resources are mobilized for consultation and the development of territorial programmes for water management	More significant actions concerning the resource (e.g. development of storage capacity) but also and above all on the moderation of usage (e.g. change of crops) will be necessary and have not yet been quantified.	Drought has already caused nearly €100 m/year of damage to agricultural production on average in recent years[1] + costs on other water uses (CGAAER 2017, 34) In the complete absence of adaptation, up to €14 m/year of lost agricultural income and €75 m/year for the agri-food industry[2]

Extend and strengthen the dynamics of resource protection

Given the increased risk of drought that will affect a wide range of water uses and could have knock-on effects on ecosystems and biodiversity, the protection of water resources is a major challenge, even more so than in the past *(Tuffnell 2020).*

The subject was addressed during the second phase of the 2019 *Assises de l'eau*, resulting in a pact to face climate change that will guide the 11th intervention programme of the water agencies (2019-2024). This programme should enable agencies to "financially support territorial projects in favour of adaptation to climate change, the preservation and restoration of aquatic environments and the reduction of water pollution with a fund of **€5.1 billion** " (out of a total €12.5 billion in the programme).[3]

In particular, action relating to quantitative resource management and investment in water-saving measures in agriculture, where the quantitative imbalances are the greatest, is considered to have "the best cost/effectiveness ratio" *(IGF and CGEDD 2018)*. Such action represents €4.9 billion in the 11th programme. Expertise, planning and environmental education actions are most often also beneficial for adaptation (€0.85 bn).

Nevertheless, following the *Assises de l'eau*, many questions remained regarding the future of water policy funding, particularly due to the existence of a ceiling on agency expenditure and the development of their objectives towards biodiversity policy *(Launay 2019).*

These issues must be addressed in the context of climate change when the 11th *Agences de l'eau* program is reviewed in 2022 and the subsequent period is prepared. An additional alarm was sounded in 2022 when the government

1. The cost of agricultural disasters due to climatic causes has averaged €173 million per year in recent years, which represents production losses of around €600 million per year. Drought is the main cause (accounting for 55% of damage and compensation) and it is grassland systems and livestock farmers who are most affected.
2. In a status quo scenario for agriculture characterized by no creation of reservoirs or transfers of water from areas with excess to areas with deficits, the slow continuation of water efficiency gains without any qualitative leap or other transformation *(ibid)*
3. The mid-term evaluation of the second French National Climate Change Adaptation Plan estimated that 52% of the water agencies' programme would be dedicated to adaptation in 2020.

had to announce in spring that the water agencies would be exceptionally permitted to spend an additional **€100 million** in response to the significant risk of drought in the summer of 2022 [4].

In a 2018 report on the future of water and biodiversity operators, the Inspection générale des finances and the *Commissariat général au développement durable* recommended a refocusing of agency action, while noting that the need for quantitative management will remain or even increase. Efforts should therefore increasingly focus on the global water cycle and the many associated objectives (restoration and preservation of aquatic environments and biodiversity, pollution control, restoration of the quantitative balance of water resources), including climate change adaptation.

Several analyses have sought to estimate the additional needs for these policies. Based on the conclusions of a 2016 *Conseil général de l'Environnement et du Développement durable report, the Comité pour l'économie verte (CGEDD 2016; Comité pour l'économie verte 2022)* considered an additional need of **€400 m/year** year to be a conservative estimate.[5] The authors stated that the revenue ceiling for water agencies should be raised by **€150 m from 2023 and eventually by €300 m** to help meet this requirement.

"Reinforcing the legitimacy of intervention by water agencies in the global water cycle and in climate change adaptation, a field in which they are expected to play a role, by extending their charges to cover damage to biodiversity" appears to be the second most important argument for justifying this need *(Comité pour l'économie verte 2022, 10)*. Nevertheless, it is very difficult and probably not relevant to single out the proportion of funds needed specifically for adaptation.

Adaptation therefore appears, as it should, to be a structuring factor (a motivation and an objective) in discussions on the future funding of water and biodiversity policy. Investments in the global water cycle are economically justified by taking into account the multiple benefits they generate, including the resilience of ecosystems and the protection of the quality and quantity of the resource during periods of climate stress[6]. Several recent reports shed light on adaptation actions to be implemented in line with these policies *(Tuffnell 2020; CGEDD 2019; OPECST 2022).*

Agricultural transformation

Agriculture is the main water consumer, accounting for 45% of the total volume, 80% of which is used for irrigation[7]. Farmers are therefore both the first to be affected by droughts as well as key actors in the debates on quantitative resource management and the reconciliation of water uses.

By initiating the *Varenne agricole de l'eau et de l'adaptation au changement climatique* plan in 2021, the government has sought to involve all stakeholders (farmers, NGOs, elected officials, State services and operators, etc.) in the identification of solutions that will enable farmers to adapt and protect themselves in the face of climate change[8].

At the end of this consultation, various actions were announced with significant budgets, according to three themes *(MAA and MTE 2022)*:

- Anticipation and protection: including improved preventive crisis management, an update of the Explore 2 study on future climate change impacts and a reform of agricultural insurance which should mobilize a budget of **€600 m/year** i.e. an increase of €300 million;
- Strengthening resilience: particularly through the implementation of State/Regional partnerships to support agricultural transition[9] as well as **€680 million** (as part of the France Recovery and France 2030 plans) to support the adaptation of agriculture *via* various calls for proposals concerning, for example, the purchase of innovative equipment, the optimization of irrigation systems and the creation of hydraulic infrastructure;
- Resources that can be mobilized for agriculture in the long term: focused on a better understanding of needs and available resources, adaptation of regulations, innovation and experimentation (e.g. regarding wastewater reuse).

4. See https://www.banquedesterritoires.fr/risque-de-secheresse-les-agences-de-leau-autorisees-depenser-100-millions-deuros-supplementaires - accessed on 20/05/2022
5. On the basis of the needs for the global water cycle of around €250 m per year to ensure compliance with the objectives set by the Water Framework Directive, and the needs for biodiversity restoration estimated at €200 m per year by the 2016 CGEDD report.
6. It should also be noted that the resources available to water agencies could also contribute to other adaptation topics discussed elsewhere in this report, particularly those relating to the renaturation of coastal areas and nature in cities.
7. https://www.statistiques.developpement-durable.gouv.fr/leau-en-france-ressource-et-utilisation-synthese-des-connaissances-en-2021 - accessed on 24/05/2022. This is followed by power plant cooling (31%), drinking water (21%) and industrial uses (4%).
8. https://www.ecologie.gouv.fr/point-detape-du-varenne-agricole-leau-et-ladaptation-au-changement-climatique - accessed on 26/05/2022
9. The example cited is that of the GIP Occitanie with the secondment of 2 FTEs from the Ministry of Agriculture in 2022 and €300,000 in financial aid.

While these orientations have been welcomed by some in the agricultural world, they have also given rise to a certain number of criticisms concerning, in particular, the concentration of efforts on measures to optimize usage (for example via the efficiency of irrigation or genetic selection) and water storage, to the detriment of efforts to reduce demand *(OPECST 2022)*[10]. In other words, current pathways aim to preserve the existing agricultural model without questioning the possibility of more structural transformations (e.g. stopping the use of certain irrigated crops in territories where the water deficit is becoming too severe, developing new sectors or relocating production) in a climate change context.

Optimization efforts could, however, prove insufficient in scenarios of more intense climate change. Nevertheless, there is no consensus on what would constitute a more ambitious adaptation pathway in the medium term *(CGAAER 2017, 10).*

Some proposals are targeted towards a significant increase in water storage and transfer capacities. While there doesn't seem to be much leeway for building new large infrastructure, the development of multiple hillside or substitution reservoirs is being seriously considered by certain actors. This would require significant investment. Assuming average construction costs of €3/m^3 [11],in 2015, the *Conseil général de l'alimentation, de l'agriculture et des espaces ruraux* (CGAAER) evaluated an investment need of about **€900 m over 10 years (i.e. €90 m/year)** to create storage of 300 million cubic metres. Such an expense could be borne partly by the irrigators themselves but would also require a certain amount of public support *(CGAAER 2015, 32).*

The Spanish example provides an interesting point of comparison. For several decades the country has been committed to an irrigation-based model that relies on the storage and transfer of large volumes of water and on significant investment[12]. As noted by the Scientific Council of the Rhône-Mediterranean basin, "the Spanish model only holds up if an adequate amount of water is available to allow the reservoirs to be sufficiently filled" and "it seems that these physical limitations are close at hand. The average filling rate of the reservoirs, which has been decreasing in recent years, is a characteristic sign. […] The climatic changes underway, that will continue in the coming decades, will accentuate the risk of failures, the seriousness of which may also be due to the limited options for adaptation or reversal for a system based on the development of major infrastructure." *(Conseil scientifique du bassin Rhône-Méditerranée 2020, 31)*

This type of pathway, aimed mainly at maximizing the available water supply, nevertheless remains highly controversial, as evidenced by several local conflicts including the Caussade dam and other projects in the Deux-Sèvres region[13]. Opponents to the construction of new storage capacities denounce the privatization of water resources and the environmental impact of such infrastructure. They also highlight the unsatisfactory nature of these projects in the climate change context, claiming that these solutions lack long-term viability and take much-needed attention away from the more structural transformation of agricultural models *(Aspar and Feuillette 2019; ADEME 2022a; 2019).*

Such transformations of agricultural models would also generate **costs that remain difficult to quantify**. Indeed, transformational adaptation pathways in agriculture remain poorly documented and their linkage with the dynamics of agricultural transition in progress is not always made clear. It can nevertheless be assumed that this would require substantial resources both to accompany the gradual withdrawal from certain productions and to invest in new areas/new crops.

In this publication we have only addressed the needs for agricultural transformation from a water resource perspective. To progress towards an overall estimate of the transformational needs of agriculture with a view to adapting to all climate change consequences, there remains much work to be done, taking into account the other direct impacts on production, but also on all the agricultural value chains (ADEME 2022b; 2022a; 2019).

THE IMPORTANCE OF CONSULTATION AND ESTABLISHING SHARED VISIONS AT THE TERRITORIAL LEVEL

The still emerging and potentially highly conflictual nature of this issue therefore calls for particular emphasis to be placed on the mobilization of the necessary means to implement approaches with a local outlook, on the scale of each sub-catchment area, and to coordinate the dialogue among water stakeholders.

The objective expressed during the *Assises de l'eau* to draw up some fifty Territorial Project for Water Management (PTGE) by 2022, then to reach 100 projects by 2027, may constitute a good basis for progress in this direction.

10. The literature highlights several groups of complementary actions to reduce pressure on water resources. Firstly, some actions aim at reducing demand: by optimizing consumption efficiency (i.e. by reducing losses) or by seeking to reduce demand (i.e. by promoting activities that consume less). Secondly, other actions aim to increase the available supply: by importing and/or storing water or by resorting to so-called "non-conventional" resources, for example by developing wastewater reuse or sea water desalination.
11. A 2005 analysis by the Rhône-Méditerranée-Corse Water Agency that studied 47 projects arrived at similar costs of €3 to €4/m3.
12. By encouraging certain territories (e.g. Boutonne) to develop storage capacities of 4% of winter surpluses, the CGAAER noted that such a rate (4%) would remain "low compared to the rates observed in Spain (Ebro: 50%) or Morocco (Oum er Rbia: 200%)" (CGAAER 2015, 8).
13. See for example https://www.actu-environnement.com/ae/news/retenues-substitution-discorde-38731.php4 - accessed on 9/6/2022

On the basis of feedback[14], we can consider that formulating a PTGE requires €150,000 - this equates to a total need of **€15 m**. According to the PNACC2 mid-term review, 63 PTGEs existed in 2020 *(MTE 2021, 63).*

Main references

- ADEME. 2019. ***"Comment développer sa stratégie d'adaptation au changement climatique à l'échelle d'une filière agroalimentaire ?"***
- ———. 2022a. ***"Démarches d'adaptation au changement climatique dans les secteurs agricole et forestier et leurs filières".***
- ———. 2022b. ***"Feuilleton adaptation au changement climatique, transition 2050".***
- Aspar, Juliette, et Sarah Feuillette. 2019. ***"Pratiques et systèmes agricoles résilients en condition de sécheresse."*** AgroParistech - Agence de l'eau Seine Normandie.
- CGAER. 2015. ***"Synthèse Eau et Agriculture. Tome 1 : Aspects quantitatifs."***
- ———. 2017. ***"Eau, agriculture et changement climatique : Statu quo ou anticipation ?"***
- CGEDD. 2016. ***"Proposition de scénarios de financement des politiques publiques de préservation des ressources en eau, de la biodiversité et des milieux marins."***
- ———. 2019. ***"Retour d'expérience sur la gestion de la sécheresse 2019 dans le domaine de l'eau."***
- Comité pour l'économie verte. 2022. ***"Pour élargir à la biodiversité la fiscalité des agences de l'eau."***
- Conseil scientifique du bassin Rhône-Méditerranée. 2020. ***"Avis et recommandations sur l'intérêt économique à Moyen et Long terme de la substitution des prélèvements par stockage ou par transfert de l'eau."***
- IGF, et CGEDD. 2018. ***"L'avenir des opérateurs de l'eau et de la biodiversité."***
- Launay, Jean. 2019. ***"Assises de l'eau, phase 2 : Rapport de Jean LAUNAY à Madame Emmanuelle WARGON."***
- MAA, et MTE. 2022. ***"Conclusions du Varenne agricole de l'eau et de l'adaptation au changement climatique."*** Dossier de presse.
- MTE. 2021. ***"Évaluation à mi-parcours du PNACC-2."***
- OPECST. 2022. ***"Les aspects scientifiques et technologiques de la gestion quantitative de l'eau."***
- Tuffnell, Frédérique. 2020. ***"Rapport d'information sur la gestion des conflits d'usage en situation de pénurie d'eau."*** Rapport d'information au nom de la commission de l'aménagement du territoire et du développement durable. Assemblée Nationale.

14. See for example
- https://www.vie-jaunay.com/uploads/PTGE/Feuille%20de%20route%20PTGE%20Vie%20Jaunay%20et%20annexes.pdf and
- https://sf12fbb23ccbb0bcd.jimcontent.com/download/version/1607696572/module/9042204620/name/20201209%20 Pr%C3%A9sentation%20CS.pdf - accessed on 02/06/2022

ANTICIPATE AND PREVENT CLIMATE CHANGE IMPACTS ON HEALTH

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
National Heatwave Plan and dedicated monitoring and warning system < €500,000/year	4 Fund a national investigative public health programme to anticipate and prevent climate risks (research, prevention campaigns, improving health monitoring): at least **€2.5 m/year**	Up to 1% of deaths attributable to rising temperatures in a high warming scenario in 2050 Potentially much higher prevention and care needs	E.g. financial cost of heatwaves in France between 2015 and 2020: [€22-37 billion] *(Santé publique France 2021).*

The effects of climate change on human health could be significant *(Romanello et al. 2021)*. Today, in France, this aspect is mainly considered from the point of view of the risks associated with heatwaves, particularly through the National Heatwave Plan *(Plan National Canicule)*. However, the first maps of the issues indicate that heatwaves may only represent one aspect of the health impacts to be addressed, alongside possible developments of certain risks such as infectious diseases, issues related to water quality or even the increased risks following extreme climatic events.

Different types of actions are to be envisaged in terms of *(IANPHI 2021)*:

- **Awareness raising and prevention:** for example in terms of staff training, support for public decision-makers in integrating these issues into planning (e.g. urban planning and health), information for the general public; dissemination of good practices but also preventive adaptation of health infrastructure and buildings housing vulnerable populations (e.g. *(HCSP 2020)*). Some especially vulnerable groups (such as children, the elderly and construction workers) can be targeted as a priority;

- **Health surveillance and monitoring:** to monitor climate risks and health impacts and to evaluate the effectiveness of different adaptation measures;

- **Crisis management:** to be better prepared to respond to emergency situations during extreme events or new epidemic crises and to ensure better post-event follow-up.

At present, the entire budgetary programme 204 relating to "Prevention, health security and health care provision" represents a sum of €200 m/year *(PLF 2022),* of which €1.54 m is dedicated to health monitoring and €26 m to the prevention of environmental and food-related risks. Among this expenditure, the national policy for the "prevention of seasonal risks", which covers the risks of heatwaves, extreme cold and "summer risks", mobilizes **€478,000** *(Government 2021)*. If risks linked to climate change were to be better accounted for in the area of preventative health, the respective budgets would have to be gradually increased.

It should also be based on the capacities of actors in the field (health professionals, first and foremost) to ensure they have the means to dedicate time to vigilance and the adaptation of intervention principles. In this respect, in terms of resources to strengthen the capacity of the health system to adapt to the development of climate risks, the most important requirement is not specific to these risks: it involves **ensuring sufficient leeway to enable responses to situations of new pressures.**

It is also worth noting the important interaction of health measures with other projects and adaptation levers: the reconfiguration of urban spaces (the presence of green spaces and the control of heat island effects which have direct impacts on health), the design of buildings or even coordination with civil protection during crises.

The extent of the specific needs has not been precisely evaluated to date, but several actions that would enable the first building blocks to be laid for a better integration of climate-related issues in prevention and environmental health policies can however be identified and the needs for their implementation estimated:

TABLE: HEALTH 1 – ESTIMATE OF THE MEANS NECESSARY FOR THE IMPLEMENTATION OF ACTIONS THAT COULD CONSTITUTE A NATIONAL EXPLORATORY PROGRAMME TO ANTICIPATE AND PREVENT CLIMATE HEALTH RISKS[1]

ACTIONS	ESTIMATION OF ASSOCIATED NEEDS AND POSSIBLE FORMS
— Planning of projects to explore and deepen knowledge on the links between climate change and health for the better calibration of changes (targeting of information campaigns, adaptation of principles, changes in standards, equipment, etc.) At this stage, many avenues to be explored have been identified but not yet prioritized: e.g. heatwave-related risks to pregnant women and perinatal care; heatwave impacts on health at work; effect of climatic events on mental health; non-heat-related climatic risks and health; climate-health-food nexus; changes in behaviour with temperature (e.g. sport and leisure activities) and health impacts; capacity of emergency and health care systems to respond to the combination of crises (e.g. heatwaves and epidemic waves); climate-health-social inequality interactions	**— Launching and coordinating a multiannual call for proposals** aimed at exploratory projects carried out in partnerships involving research teams and field staff, enabling the identification of issues and requirements and guiding the necessary in-depth studies: €1.2 m/year (assuming 1 FTE to coordinate the call for proposals and 5 to 6 annual projects of €150,000 to €200,000)
— Collection and evaluation of good practices and support for their deployment with expert actors (e.g. support for climate and health measures in the PCAETs; in urban planning; awareness-raising with associative actors; advice to elected officials on managing crisis episodes).	**— One person in charge of coordinating these tasks at the national level** and a dedicated contact within each regional cell of *Santé Publique France* - i.e. approximately 17 FTEs - €1 m/year
— Improving the consideration of climate-related effects within existing monitoring and surveillance systems (e.g. syndromic surveillance, monitoring of vector-borne diseases such as those transmitted by the tiger mosquito).	**— Initial time for study and preparation for implementation within *Santé Publique France*** (e.g. automation procedures for data collection, documentation, analysis procedures, impact on principles). Then awareness-raising and coordination of user networks. Mainly human resources: €120,000/year (assuming 2 FTEs).
— Extension of feedback in the aftermath of extreme climatic events and adjustment of responses.	**— Mainly human resources:** €120,000/year (assuming 2 FTEs).

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1. In the absence of a pre-established roadmap or strategy, these proposals (which do not constitute an exhaustive list of things to do) have been formulated on the basis of the analysis and interviews that the authors were able to conduct.

In total, these initial actions would represent a budget of around **€2,5 m/year** which would gradually increase as the issues are identified and progress is made on the responses to implement. It could thus become much more substantial at the more operational phases, which must be decided upon.

A significant part of this sum concerns human needs. For example, four people currently dedicate part of their time to considering how to better integrate climate change risks into public health systems within *Santé Publique France (source: interviews)*. In comparison, the UK Health Security Agency (the British counterpart) has a team of more than 10 people dedicated to these issues.

These sums should be put into perspective with the economic effects of extreme weather events: including direct effects on the healthcare system, health insurance and socio-economic impacts. By calculating the impacts of excess mortality, *Santé Publique France* evaluated the health effects of heatwaves in France, between 2015 and 2020, to be €22 to €37 billion *(Santé publique France 2021; France Stratégie 2022).*

Main references

- France Stratégie. 2022. ***"Impacts physiques et socio-économiques du changement climatique en France : synthèse de la littérature".***
- Gouvernement. 2021. ***"PLF 2022 - Prévention en santé."***
- HCSP. 2020. ***"Avis relatif à la fiche d'aide à la décision "Fermeture des écoles primaires" en vigilance canicule rouge."***
- IANPHI. 2021. ***"Feuille de route de l'IANPHI pour l'action sur la santé et le changement climatique."***
- Romanello, Marina, Alice McGushin, Claudia Di Napoli, Paul Drummond, Nick Hughes, Louis Jamart, Harry Kennard, et al. 2021. ***"The 2021 Report of the Lancet Countdown on Health and Climate Change: Code Red for a Healthy Future."*** The Lancet 398 (10311): 1619-62.
- Santé Publique France. 2021. ***"Évaluation monétaire des effets sanitaires des canicules en France métropolitaine entre 2015 et 2020."***

STRENGTHEN CIVIL PROTECTION POLICIES TO KEEP PACE WITH INCREASING RISKS

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
Annual budget for civil protection: > €5.16 billion (including €1.3 billion from the State). Approximately €575 m of which for forest fire prevention and control policies.	5 Increase civil protection funding to address the increasing risks of forest fires and wildfires – supporting the investment of the SDIS: **€115 m/year**	Broader civil protection issues (epidemic crises, extreme weather events, etc.) to cope with the increase of risks in terms of frequency and area. Changes in principles, resources and equipment to be envisaged.	Increased costs of damage (human, economic and ecosystem) arising from the geographical extension and duration of the forest fire season. Additional costs related to the management of crises in the absence of preparedness.

Increased climate variability may also mean more extreme events and possible crisis situations to address. Although initial efforts must involve prevention, it is also essential to question crisis management methods in order to develop (or in some cases even transform) intervention strategies and principles and/or, if necessary, to review the size of the material and human resources that can be mobilized. This will have a budgetary impact but will also concern human resources with important issues at stake in terms of employment pathways.

At present, the State's civil protection budget (a cross-cutting policy to which 10 budgetary programmes contribute, including programme 161, which accounts for 44% *(Government 2021; Dumont 2021)*) is **€1,3 bn/year** *(PLF 2022).* However, as the Senate's 2022 information report notes, "the financing of public protection is essentially based on local expenditure [...] The consolidated budget of the *Service Départemental d'Incendie et de Secours* (SDIS), financed by the local authorities, amounted to **€5.16 bn** for the year 2020", with "marginal" financial support from the State. The expected increase in needs should be gradual, with systems being reinforced in stages.

Deliberations have already begun at the French *(Mondon et al. 2022)* and European levels[1]. The results of this work will soon be made public and will provide precise information on the additional needs to be met in the coming years. In the meantime, we can illustrate the type of developments to be expected using forest fires and wildfires as an example.

Case study: forest fires and wildfires

Climate change is reflected in an extension of the geographical areas affected by forest fires and wildfires, a lengthening of the fire season and an increase in fire intensity – even the appearance of new categories of fires (e.g. megafires). Météo-France has already extended the warning system to the whole of mainland France, while current prevention and defence policies, that were designed and sized for a certain level of risk, are gradually becoming obsolete.

The challenge in terms of public policy is firstly to preserve the current methods of prevention and defence policies, and then to prepare to adapt the scale of the capacity in line with increasing risks. To make preparations for these changes, a necessary first step, which is currently underway, is the drawing up of a complete risk map that takes climate projections into account *(CGEDD, IGA, and CGAAER 2016; Government 2022).*

It is only when this work has been completed that we can have a precise knowledge of the costs to be incurred. Nevertheless, previous estimates anticipate an increase

1. See https://www.consilium.europa.eu/en/press/press-releases/2022/03/03/making-civil-protection-ready-for-climate-change-council-adopts-conclusions/ - accessed on 19/05/2022

of at least 20% in the resources of these policies, i.e. + **€100 m/year** (*CGAAER and IGA 2010, 67).* The many reports that have addressed the subject in recent years have made numerous recommendations to strengthen and extend action for prevention *(Perea and Lambert 2022; Cattelot 2020; Vogel 2019; CGEDD, IGA, and CGAAER 2016).* The implications of these recommendations in terms of resources have not been systematically assessed. There are prevention and awareness-raising actions in newly affected departments that could, for example, replicate an *Entente Valabre*-type model (budget **€1.5 m/year**) or the creation of a support fund for forest fire investment projects within the SDIS structural investment support allocation (**€15 m/year**). As a first estimate, and keeping in mind that very significant cost increases are to be expected, possibly well above the aforementioned 20% from the 2010 report, an initial resource increase projection of around **€115 m/year** for these policies can be assumed.

AERIAL FIREFIGHTING

Among the important actions already undertaken that will require the mobilization of significant resources, there is the renewal of the civil firefighting air fleet. A 2018 order for six new Dash 8-Q400 MR air tankers amounts to **€370 m** within the 161 budget programme.

Beyond the renewal of ageing aircraft, the issue of adapting the fleet to the changing fire risk has been raised. In 2016 the CGEDD noted that in the medium term, adapting to climate change effects would require an increase and evolution of operational air capacities, estimating at the time that France did not have "the operational capacity to respond to the foreseeable extension of the risk in metropolitan France, while guaranteeing the maintenance of the operational response in the South and South-West zones." *(CGEDD, IGA, and CGAAER 2016, 109).*

The choice of the Dash as a replacement for the Tracker S-2FT aerial firefighter is a component of the response because it broadens the fleet's operational capacities: the Dash is cited as being equivalent to two Trackers due to its speed and greater load capacity, as well as the larger geographical area it is able to cover, "a capacity which is essential given the geographical extension of the forest fires risk" *(Vogel 2020, 31).*

There has also been a commitment to bolster the helicopter fleet by more than **€30 m** of payment appropriations included in the PLF 2022 *(Vogel 2021, 30).*

Another element of the response comes from the co-financing possibilities enabled by the European Union's RescEU mechanism. With funding of **€1,9 bn** under the European Recovery Plan, this mechanism aims to contribute to the emergence of a joint European aircraft fleet, the acquisition of which is co-financed by the European Commission and Member States. The 2021 Senate budget report states that "France will be the forerunner of this new force and will acquire two Canadair amphibious water bomber aircraft. This order will thus be co-financed by the European Union, up to 90% of the investment and operating costs, for a total estimated amount of around €90 m" *(Vogel 2021, 31).* The acquisition of a heavy-lift helicopter is also envisaged as part of this plan, in conjunction with Germany.

These prospects therefore suggest that the civil protection investment budget will be maintained at a relatively high level, justified in particular by the need to adapt the response mechanism to match the development of risk in a climate change context.

Main references

- Cattelot, Anne-Laure. 2020. ***"La forêt et la filière bois à la croisée des chemins : l'arbre des possibles."***
- CGAER, et IGA. 2010. ***"Rapport de la mission interministérielle Changement climatique et extension des zones sensibles aux feux de forêts".***
- CGEDD, IGA, et CGAAER. 2016. ***"Mission d'évaluation relative à la défense de la forêt contre l'incendie."***
- Dumont, Françoise. 2021. ***"Rapport d'information sur la sécurité civile".*** Sénat.
- Gouvernement. 2021. ***"Document de politique transversale, projet de Loi de finances pour 2022. Sécurité Civile."***
- ———. 2022. ***"Clôture des Assises de la forêt et du bois : Dossier de Presse".***
- Mondon, Sylvain, Laurent Franchistéguy, Laurent Paul, et Charles Colin,. 2022. ***"Adaptation des activités de sécurité civile au changement climatique".*** In La Prospective au service de l'adaptation au changement climatique, 101-17.
- ***Perea, Alain, et Jean-Michel Lambert. 2022. "Mission "flash"sur la prévention des incendies de forêt et de végétation".*** Assemblée Nationale.
- Vogel, Jean-Pierre. 2019. ***"Rapport d'information sur la lutte contre les feux de forêts".*** Sénat.
- ———. 2020. ***"Rapport général fait au nom de la commission des finances (1) sur le projet de Loi de finances, adopté par l'Assemblée nationale, pour 2021. ANNEXE N° 29b - SÉCURITÉS (Programme 161 "Sécurité civile")".*** Sénat.
- ———. 2021. ***"Rapport général fait au nom de la commission des finances (1) sur le projet de Loi de finances, adopté par l'Assemblée nationale, pour 2022. ANNEXE N° 29b - SÉCURITÉS (Programme 161 "Sécurité civile")".*** Sénat.

MAINTAIN THE LEVEL OF NATURAL HAZARD PREVENTION IN A CHANGING CLIMATE

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
€235 m/year fund for the prevention of major natural risks (FPRNM known as "Fonds Barnier") €200 m/year GEMAPI tax	6 Provide additional means (budget for action and coordination capacities) to boost efforts to support flood risk prevention, to at least maintain the current level of risk despite climate change **€ 125 m/year**	Possibly several billion if mass relocations are envisaged	€24 bn total damage caused by climate change-related hazards (period 2020-2050) *(FFA 2021, 10)*

Natural hazards are not a new emergence resulting from climate change. Prevention policies have been in place for many years. Nevertheless, the evolution of climate variability associated with an increase in certain extreme events (intense rainfall, droughts, periods of coastal flooding, etc.) due to climate change constitutes a new situation that must be taken into account.

The prevention of natural risks aims to reduce the vulnerability of people and property that are already exposed, and to control the development of buildings and economic activities in risk areas. This policy is organized partly on a national scale and partly on a decentralized basis. Significant national-level resources are dedicated to this policy within the framework of budget programme 181 *(Government 2022, 16)*, which includes: **€235 m** for the *Fonds de prévention des risques naturels majeurs* (FPRNM); while in 2020 at the local level, **€204 m** of the GEMAPI tax revenue was allocated to the policy[1].

Although prevention efforts are undoubtedly important, they cannot achieve zero risk. The sums allocated to these policies reflect a certain social compromise on the level of acceptable risk. Greater investment in prevention means possible further risk reductions; if such investment is not made, it is because the current level of risk is considered acceptable. However, damage caused by natural disasters remains significant: claims covered by the natural disaster guarantee *(Cat Nat)* amounted to €1.72 billion in 2020 *(CCR 2021a, 2)*.

Recent work has forecast an increase in annual losses due to climate change of 35% on average by 2050 *(JRC 2018; FFA 2021)* under a severe climate change scenario. This increase would represent a cost of **€24 bn** by 2050 *(FFA 2021, 10)*. Thus, climate change exacerbates hazards and raises questions regarding the effort made to maintain a level of risk that is considered acceptable. Not increasing the prevention effort implies an increase in the residual risk. Conversely, if we wish to maintain the same level of risk, it is necessary to increase prevention efforts. This will require an increase in the resources available to these policies and a better understanding of the risks, making it possible to improve the effectiveness of prevention actions.

To achieve progress in this regard, there are dynamics that allow risks to be addressed more effectively through a more detailed knowledge of adaptation solutions. This is the case, for example, with the AMITER[2] competition, which aims to stimulate innovative urban planning proposals that reduce natural hazard vulnerability and improve the resilience of nine emblematic urbanized areas. Another example is the *Trophée Bâtiment Résilient* (run by the *Mission des Risques Naturels*, in partnership with the *Agence Qualité Construction* and Construction21), which highlight sustainable projects that are part of a resilient approach.

1. See https://questions.assemblee-nationale.fr/q15/15-41310QE.htm - accessed on 10/06/2022
2. *"Mieux aménager les territoirs en mutation exposés aux risques naturels"* (Better management of territories undergoing change and exposed to natural risks). http://www.urbanisme-puca.gouv.fr/amiter-mieux-amenager-les-territoires-en-mutation-a2211.html - accessed on 10/06/2022

Case study: flood risk prevention

Flooding is the main natural risk in France, which affects more than 17 million people *(Panonacle 2022)* who live in one of the 122 territories with a flood risk (TRI). Since 1 January 2018, flood prevention has been entrusted to the EPCIs (within the broader framework of the GEMAPI).

To support them, the State has gradually developed prevention tools. For example, the *Plan de prévention des risques naturels d'inondation* is a major prevention tool that can influence the way land is inhabited and used. In terms of preventative and protective action, vulnerable territories have been able to develop *Programme d'Action pour la Prévention des Inondations* (PAPI) since 2002. This tool, contracted between the State and local authorities, enables the financing and implementation of an overarching risk management policy. Between 2011 and 2018, 96 PAPIs were approved, accounting for a total of **1.8 billion** *CGEDD 2019, 17), i.e. an annual investment in prevention estimated at* **€300 m/year**[3]. These programmes are largely State financed (*via* the FPRNM) and the local authorities concerned (which can raise a specific tax, i.e. the GEMAPI tax). PAPIs currently cover 45% of the at-risk population *(CGEDD 2019, 74)*. A study by the *Caisse Centrale de Réassurance (CCR 2020)* underlines the importance of this prevention, estimating that the coverage of municipalities achieved by the two mechanisms (PPRi and PAPI) has enabled a disaster frequency reduction of 51% and damage cost reduction of 28% on these same territories compared to the period without the mechanism.

Despite these prevention efforts, floods still cause significant damage. From 1982-2020, floods caused €21.6 billion in damage that was insured under the natural disaster guarantee, with an average annual cost of €554 million *(CCR 2021b)*. Furthermore, recommendations are regularly made to improve these systems and strengthen prevention. The CGEDD, for example, highlights the inadequacy of human resources in the PAPI carrier structures and observes how "the integration of one or two PAPI carrier full-time equivalent positions [...] was able to revitalise a PAPI that had been struggling until then" *(CGEDD 2019, 41)*. Taking on two additional FTEs in the 96 structures operating the recently approved programmes would represent a cost of **€12 m/year.**

RISKS INCREASE BUT PRECISE CHANGES REMAIN DIFFICULT TO MODEL

Climate change impacts on flood risk are not homogeneous; the development of precipitation patterns is critical, which may differ from one territory to another, but also depends on the characteristics of each basin. There are, for example, specific situations where territories experience Mediterranean weather episodes *(Météo-France 2020)*. Uncertainties surrounding precipitation changes and also the imperfect knowledge of runoff dynamics make complete and precise risk mapping difficult. However, data from the DRIAS portal make it possible to estimate that "the intensity of extreme rainfall increases slightly throughout the century over practically the entire territory and with the three RCP scenarios considered. The most at-risk regions are those in the northern half of France, particularly the northern and north-eastern borders and the Channel coast. The intensity of the expected increase of 3 to 6 mm corresponds to a variation of around 10%" *(Météo-France 2020, 51)*. The *Caisse Centrale de Réassurance* estimates that the increase in annual losses due to climate change related to floods by 2050 will be 38% *(CCR 2018)*.

AS A MINIMUM, MORE RESOURCES MUST BE ALLOCATED TO PREVENTION TO MAINTAIN THE SAME RISK LEVEL

To date, a detailed assessment has not been carried out to show what prevention needs are necessary to maintain a constant level of risk in the context of a changing climate. In April 2022, the CESE recommended increasing the sums allocated to the Barnier Fund in proportion to the estimated increase in losses *(CESE 2022, 67)*.

Applying the same logic to today's flood risk prevention efforts would mean that **€113 m/year** (38% more than the current total) should be dedicated to prevention policies. Making a total budget of **€125 m/year** (including €12 m/year for lead and coordinations).

SHOULD MORE BE DONE?

In the absence of a clear position on the level of acceptable risk, we have proposed initial estimates with the objective of roughly establishing the orders of magnitude entailed by an ambitious risk prevention policy.

For example, the Nîmes-Vistre PAPI (€113 m over 6 years) is one of the most ambitious programmes in France. Raising the ambition of existing PAPIs to a similar level would require an additional investment of around **€250 m/year**[4]**.** To apply this level of ambition to the entirety of the at-risk population (17 million people, compared with 8 million today) would require **€800 m/year** on top of current efforts. Furthermore, although risks are likely to extend into new territories, due to a lack of available data it is not possible at present to calculate the cost of the geographical extension of good practices.

These costs do not necessarily represent the total costs needed for adaptation, and questions involving more trans-

3. Assuming that all programmes run concurrently, and for a 6-year period (the duration of the programmes' accreditation), this represents an annual amount of 1,800/6 = €300 m/year
4. Bearing in mind that a similar prevention effort would not necessarily imply the same type of work.

formational choices must still be raised: in a context of climate change, is the current prevention mechanism still sufficiently robust, or does it need an in-depth review *(CESE 2022, 32)*? Should large-scale relocations be envisaged in areas where the risk is no longer deemed acceptable? How should these relocations be supported?

Case study: clay shrinkage and swelling

The shrink-swell capacity of clays (RGA) refers to the phenomenon of successive periods of drought and rewetting of clay soils, the consequences of which are detrimental to buildings, particularly individual houses (causing structural cracking). With a total cost of €15.2 billion (i.e. €475 million/year) between 1982 and 2020, it accounts for 37% of Cat Nat claims (excluding motor vehicle damage) *(CCR 2021b)*. Despite an understanding of the consequences of this phenomenon on housing, such knowledge has not been accompanied by any effective prevention policies *(Cour des Comptes 2022)*, even though more than half of the regions of mainland France are affected by this risk *(MRN 2018)*. A CGDD study estimated that in 2021, 10.4 million (or 54%) of family homes were built in areas of high or medium exposure *(CGDD 2021)*.

A SHARP INCREASE IN RGA RISK EXPECTED

The reinsurer group CCR estimates that by 2050, under a severe climate change scenario, the entire territory will be severely affected by significant soil drying over the period from July to December *(CCR 2018)*. The FFA estimates the total cost of damage linked to RGA (over the period 2020-2050) at €43 billion, of which €17.2 billion is due to the "climate change" factor alone *(FFA 2021)*. This represents a tripling of the average annual burden observed over the last 31 years.

ACCOUNTING FOR CHANGING RISKS IN NEW PROJECTS

For new construction in France, prevention is mainly governed by Law No. 2018-1021 of 23 November 2018 for housing, development and digital technology, known as the ELAN Law. This establishes the rules for construction in risk zones, particularly through the mandatory completion of a soil study and adapted works. Zoning is determined by the BRGM and is available as maps on the georisques.gouv.fr website. This legislative response should enable the reduction of the drought risk for new constructions *(FFA 2021)*: adaptation costs are then absorbed by construction costs. While these maps have been updated to take account of recent losses *(Cour des Comptes 2022)*, do they remain sufficiently robust in a context of changing risk? If not, they will not prevent the creation of a new wave of exposed assets.

RECONSIDERING THE MODEL OF PROTECTION FOR EXISTING BUILDINGS

Regarding buildings constructed prior to the ELAN law, a number of initial ideas have been mentioned that could reinforce prevention in response to the RGA risk *(CEREMA 2022; Cour des Comptes 2022)*, but they have not yet been quantified. In this section, we focus on the costs of damage compensation, which is currently the main response method.

At present, compensation for damage related to the RGA risk is included in the Cat Nat insurance scheme. All public and private stakeholders agree that this system is inadequate for this risk *(Cour des Comptes 2022)*. Moreover, climate change impacts are even raising doubts regarding its insurability: a risk where the probability of occurrence is certain becomes an uninsurable risk (according to the principles of insurance).

The CESE and the *Cour des Comptes* thus consider that the RGA risk could benefit from being removed from the *Cat Nat* regime. Without formulating a full recommendation, they propose avenues to be discussed with all stakeholders, which is a prerequisite to strengthen France's adaptation to this changing risk.

"At this stage, two main recommendations emerge:

- *Preservation of the RGA scheme within Cat Nat supported by increasing the rate of the compulsory extended cover excess from 12% to 18% over a 30-year period. This proposal is recommended by CCR but does not take into account the prevention imperatives regarding the RGA risk;*

- *The introduction of a separate drought regime from Cat Nat that would integrate the investment and prevention dimension. This measure would give the Cat Nat scheme leeway to absorb the development of claims linked to climatic hazards. Its financing will require arbitration between a mutualization of the risk to be borne either by the insured or by taxpayers."*

(CESE 2022)

Main references

- CCR. 2020. ***"Évaluation des impacts de la prévention des risques d'inondation sur la sinistralité."***
- ———. 2021a. ***"Les catastrophes naturelles en France."***
- ———. 2021b. ***"Statistiques générales sur la sinistralité due aux castastrophes naturelles."*** 2021.
- CCR, Météo France. 2018. ***"RCP8.5 : Conséquences du changement climatique sur le coût des catastrophes naturelles en France à l'horizon 2050."***
- CEREMA. 2022. ***"RGA - Retrait-gonflement des sols argileux."***
- CESE. 2022. ***"Climat, cyber, pandémie : le modèle assurantiel français mis au défi des risques systémiques."***
- CGDD. 2021. ***"Cartographie de l'exposition des maisons individuelles au retrait-gonflement des argiles — Juin 2021."***
- CGEDD. 2019. ***"Évaluation du dispositif des programmes d'actions de prévention des inondations (PAPI) et de l'efficacité de sa mise en œuvre."***
- Cour des comptes. 2022. ***"Sols argileux et catastrophes naturelles."***
- FFA. 2021. ***« Impact du changement climatique sur l'assurance à l'horizon 2050."***
- Gouvernement. 2022. "***Prévention des risques - PLF 2022."***
- Météo-France. 2020. ***"Les nouvelles projections climatiques de référence - DRIAS 2020."***
- MRN. 2018. ***"Sécheresse géotechnique : de la connaissance de l'aléa à l'analyse de l'endommagement du bâti."***
- Panonacle, Sophie. 2022. ***"Avis au nom de la Commission du Développement durable et de l'aménagement du territoire sur le projet de Loi de finances pour 2022 (n° 4482). Tome II. Économie, développement et mobilité durables. Protection de l'environnement et prévention des risques."*** Assemblée Nationale.

REDESIGN CITIES TO TACKLE THE URBAN HEAT ISLAND EFFECT

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
SGREEN and SGREEN+ technical assistance Specific actions by certain cities in their PCAET Announcement in June 2022 of a €500 million programme to regreen cities	7 Provide technical assistance to existing urban renewal programmes to enable them to integrate adaptation into the design of the operations they support: **€18 m/year** 8 Maintain an annual support fund for the extension of good adaptation practices in cities: **€500 m/year**	Possibly tens of billions of euros for in-depth restructuring of urban areas	Wide range of socio-economic costs resulting from extreme weather events (health impacts, loss of productivity and desirability, negative externalities due to the use of air conditioning...)

Urban areas are particularly exposed to climate change impacts (changes in flood risk, urban heat island, etc.). The INSEE defines these areas as all 774 densely populated urban areas and 3,419 medium-density areas inhabited by 25.3 and 19.6 million people respectively (i.e. 67% of the French population)[1]. These areas are highly affected through a concentration of vulnerabilities (vulnerable populations and activities). But they are also dynamic, offering opportunities for adaptation.

Integration of adaptation criteria into urban programmes

For decades, urban spaces have been designed without taking certain natural risks into account, thus making them particularly ill-suited to cope with climate change (few green spaces, large areas of sealed concrete surfaces, lack of open water in the city, etc.). The first challenge is therefore to stop making bad investments and instead take advantage of the opportunities to act on the morphology and structural characteristics of the city: it will always cost less to take climate change into account in a development project during the design stage, rather than to having to reinvest further down the line.

Several programmes are currently underway that will continue to renovate, requalify or revitalise a number of urban areas developed during the 20th century. This is the case, for example, with urban policy programmes such as the NPNRU (New National Urban Renewal Programme, led by the *Agence Nationale pour la Rénovation Urbaine*, and certain programmes operated by the *Agence nationale de la cohésion des territoires* and the *Banque des territoires* such as *"Action Cœur de Ville"*. Integrating adaptation into the specifications of these projects means allowing the possibility of designing spaces that will remain habitable, safe and comfortable for all, even in a changing climate.

At present, no assessment has been made of the possible additional costs associated with taking adaptation into account in development, renovation or urban requalification operations. In fact, feedback from certain projects seems to indicate that it may be possible to design adapted projects without modifying the cost of the work, provided that sufficient time is dedicated for this purpose, and the necessary expertise mobilized, during the project design phases *(I4CE and Ramboll 2022)*.

Based on the assumption of a 1% increase in the cost of designing more suitable projects (an amount that may, for

1. See https://www.insee.fr/fr/statistiques/5039883?sommaire=5040030 - accessed on 16/06/2022

example, cover technical assistance objectives such as those proposed by the SGREEN and SGREEN+ programmes of the *Banque des territoires*, consulting and support time for project management teams, etc.), we calculate an additional investment requirement for adaptation of **€18 m/year**[2].

The announced extension of the *"Action Coeur de Ville"*[3] programme should emphasize climate issues and could include new types of spaces such as city entry areas within its remit. Such spaces, which are often commercial areas with high levels of soil sealing, dominated by materials that absorb heat and buildings that rely heavily on air conditioning, present major challenges in terms of adaptation.

The revision of urban planning documents is also an opportunity to ensure a more systematic integration of adaptation in all urban developments. For example, it is possible to integrate measures on minimum percentages of open space, requirements in terms of risk prevention, and the creation of green and blue grids.

Extending good practice: already known solutions

Among the local authorities that have integrated an adaptation component into their PCAET[4], several have planned action that directly relates to urban public spaces *(ADEME 2021).* Most often, this has taken the form of greening policies or the creation of urban cooling islands; or action to increase open water in cities (fountains, lakes, misting systems, etc.) or to increase the permeability of surfaces. It can also involve the installation of shaded areas or innovative street furniture. These actions aim in particular to reduce the urban heat island (UHI) effect and to ensure more liveable cities during periods of high heat. Most of them generate significant co-benefits, particularly in terms of well-being, health and the fight against artificialization, and can also help to reduce water run-off and thus the risk of flooding during heavy rainfall.

Adaptation solutions to meet these objectives are well known and documented *(ADEME 2012; 2021; 2018; FNCCR 2019; Perrin 2020; CEREMA 2019)*[5] and tools for diagnosing the UHI effect are available to communities *(ADEME 2017; 2020).* However, the spread of such action is not accelerating. Even in cities that have initiated a genuine adaptation policy, the implementation of physical changes to their public spaces remains mostly very localized and concentrated around a small number of pilot schemes.

More ambitious action, along similar lines as the most advanced cities today, could be implemented without delay. Even if the precise needs can only be assessed on the basis of local decisions and according to each context, we propose some rough order of magnitude estimates for the costs of extending such action, based on existing factors:

For example, the city of Angers, confirmed as France's leading green city in 2020 *(Angers 2022)* with 100 m² of green space per inhabitant, dedicates an average budget of €98/inhabitant/year to green spaces, compared with an average of €76/inhabitant/year *(Observatoire des villes vertes 2020).* Raising the budget for green spaces in the 774 dense cities in France to the same level as that of Angers would represent an additional investment effort of **€563 million** annually. On the same issue, a study by *Carbone 4* estimated that the investment expenditure for the regreening of cities would be **€14 billion** over the period 2021-2050, i.e. **€480 million** per year for a total surface area greening of 12,500 ha *(Carbone 4 2022, 4)*. Beyond the initial investment, the greening of cities involves recurrent operating expenses to guarantee the maintenance capacities of the expanding green spaces. It should also be noted that, beyond the quantitative objectives, the way plants are used in these projects (choosing species adapted to the local climate, the planting quality, access to open land, etc.) has a considerable impact on the UHI effect.

Regarding the issue of heat absorption by mineral materials in urban areas, the city of Lille, for example, undertook a campaign in 2017 to de-seal and green its school playgrounds. By the end of 2021, all school playgrounds in the city (i.e. 79) had been addressed, at an average cost of €200,000 per school *(CEREMA 2022)*. To extend this practice from today until 2035, to address the 25,400[6] school playgrounds in the dense and medium-density urban areas of France, would represent a funding requirement of **€390 m/year.**

A **500 million** programme was announced on 14 April 2022 by the Prime Minister to "put nature back into cities"[7]. The preliminary figures for adaptation actions presented above tend to confirm the relevance of this order of magnitude for accelerating city adaptation, provided that this **€500 million** programme is implemented over several years, and that the scope of eligible projects is extended to include a greater diversity of good practices for combating heat in cities.

2. NPNRU = €800 m/year and *Action cœur de ville* = €1 bn/year
3. See https://www.banquedesterritoires.fr/action-coeur-de-ville-une-phase-ii-centree-sur-les-entrees-de-villes-et-les-quartiers-de-gares - accessed on 17/05/2022
4. This is an obligation for the 756 EPCIs of 20,000 inhabitants which have to design a PCAET
5. See https://www.adaptaville.fr/ - accessed on 16/06/2022
6. Number of schools estimated from the INSEE communal density grid coupled with the Ministry of Education's "Address and geolocation of primary and secondary schools" database.
7. See https://www.gouvernement.fr/actualite/500-millions-deuros-pour-remettre-de-la-nature-dans-les-villes - accessed on 16/06/2022

Human resources to coordinate, guide and create dialogue within departments

Establishing an ambitious city adaptation policy requires time and dedicated human resources. Primarily, it is a question of creating the necessary dynamics and ecosystem for the implementation of adaptation in all city policies. The work of several people will be required on a daily basis to connect with all urban services (urban planning, water, roads, etc.). Sufficient time must be provided to allow projects to be examined (at the State services, for example), to monitor project implementation, and to make requests for technical assistance and funding applications. Nevertheless, the resources for coordination are already included with the general needs for guiding adaptation at the EPCI level, which have been quantified elsewhere (see factsheet entitled "Lead and coordinate adaptation policies at national, regional and local levels").

Different types of adaptation actions (such as, for example, setting up places where vulnerable populations can go at certain times to keep cool during heatwaves) can also be very effective, but again, time is paramount in the planning and implementation of these actions.

Towards more structural transformations

These measures, even if their application is extended, do not cover all available adaptation options. The combinations of actions to be implemented depend on the characteristics and preferences of each territory. The upper limit for adaptation needs remains difficult to determine, and there is no unambiguous definition of what would constitute a city that is sufficiently adapted to climate change. Some areas are likely to require more structural changes to remain liveable with the predicted temperature change, possibly involving the complete reconfiguration of urban spaces. A number of essential facilities (e.g. urban transport) may need extensive modification to remain usable in a changing climate.

These transformations could represent very high investments – especially regarding the cost of land – which we have not been able to quantify.

Defining the level of ambition and also the form of such transformations can only result from political discussions and compromises in relation to multiple objectives (e.g. access to housing, energy transition, economic attractiveness) one of which being adaptation to climate change. Investment priorities will also have an impact on the primary beneficiaries of these policies[8].

Main references

- ADEME. 2012. **"Guide de recommandation pour lutter contre l'effet d'ICU à destination des collectivités territoriales."**
- ———. 2017. **"Diagnostic de la surchauffe urbaine."**
- ———. 2018. **"Aménager avec la nature en ville - des idées préconçues à la caractérisation des effets environnementaux sanitaires et économiques."**
- ———. 2020. **"Kit des données clés de l'adaptation. Diagnostiquer l'adaptation au changement climatique dans les documents d'urbanisme",** 52.
- ———. 2021. **"L'adaptation au changement climatique dans les PCAET."**
- ———. 2021. **"Rafraîchir les villes - des solutions variées."**
- Angers. 2022. **"Plan Nature en ville."**
- Carbone 4. 2022. **"Le rôle des infrastructures dans la transition bas-carbone et l'adaptation au changement climatique de la France. Annexe "Résilience des infrastructures."**
- CEREMA. 2019. **"ICU Investir aujourd'hui pour economiser demain."**
- ———. 2022. **"Solutions d'adaptation au changement climatique fondées sur la Nature en milieu urbain : quels retours d'expérience ?"**
- FNCCR. 2019. **"Rafraichissement urbain dans l'urbanisme et la planification."**
- I4CE, et Ramboll. 2022. **"Défis rencontrés par 5 démarches territoriales qui cherchent à être à la hauteur des enjeux d'adaptation."**
- Observatoire des villes vertes. 2020. **"Palmares 2020 - Les villes les plus vertes de France."**
- Perrin, Guillaume. 2020. **Rafraîchissement urbain et confort d'été: lutter contre les canicules.** Malakoff: Dunod

8. See for example the "green gentrification" phenomena - https://www.millenaire3.com/ressources/Eco-gentrification-l-effet-pervers-des-espaces-verts - accessed on 16/06/2022.

ACCOUNT FOR THE FUTURE CLIMATE IN THE CONSTRUCTION AND RENOVATION OF BUILDINGS

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
Few coordination and awareness-raising actions Exemplary cases (e.g. BDM) that aim to take future climate change into account No specifically targeted investment identified	9 Strengthen resources for coordination, awareness-raising and applied research on building adaptation, particularly relating to heatwaves **€31 m/year** 10 Cover the additional costs of enhanced requirements for sustainable and adapted to heat waves constructions in the building of educational and research facilities. **€500 m/year**	Possibly several tens of billions of euros if all buildings need adaptation to future risks. • What level of investment for what level of robustness? • What minimum level of service should be guaranteed, including in extreme situations? • What loss of service(s) may be acceptable in certain circumstances? • Under what conditions?	Externalities (emissions, electricity consumption, etc.) linked to the large-scale use of air conditioning Costs relating to major and unplanned renovation of certain buildings

Since buildings are places for essential economic, health and social activities, and given that they are constructed with the intension to last for decades, it is logical that they should be designed to take future climate (particularly heatwaves) into account. Indeed, climate projections *(Météo-France 2020, 42)* are for longer, more intense, earlier and more frequent heatwaves in 21st century metropolitan France. However, integrating this new reality remains a very marginal practice in both new construction and renovation work. Recent regulatory changes have helped ensure that thermal comfort in summer is better characterized and considered but without, however, accounting for the future changing climate: due to a lack of better data available, the 2003 heatwave is used as the reference climate scenario *(MTE 2021).* Thus, a recent study *(Pouget consultants 2021)* has estimated that new regulations *(RE 2020)* does not instigate any additional requirements regarding summer thermal comfort for three-quarters of the French metropolitan territory.

Neglecting to take climate change into account in the construction process means subjecting buildings to conditions that were not anticipated at the design stage. This can lead, firstly, to increased health risks for the most vulnerable (nearly 15,000 excess deaths were attributable to heatwaves in France in August 2003, INSERM 2003) and secondly, to prolonged periods of loss of use (buildings that are unusable during periods of high heat). This is likely to mean future reinvestment in major, unplanned renovations, or being forced to react to emergencies through the large-scale recourse to air conditioning, for example, which uses a great deal of energy, emits GHGs, and reinforces the urban heat island effect *(ADEME 2020).*

Major investment in potentially ill-suited projects

Every year, sums amounting to several tens of billions of euros (the construction industry represented €125 billion in 2019, FFB 2021) are diverted to projects that are potentially ill-suited to the future climate. For example, the State has planned to invest €2.7 billion in 2022 in the acquisition and construction of its building stock *(Government 2021)*, €9.6 billion for social landlords and €4.8 billion in maintenance and renovation *(USH 2021)*. In addition, €6.9 billion *(I4CE 2021)* spent on energy renovation financial aids in 2021, financed projects that for the most part do not take summer comfort or climate change into account.

Design adapted projects : it's already possible

FOR NEW CONSTRUCTION

Adaptation solutions are already widely available and well documented *(Cercle Promodul/INEF4 2020; OID 2021; ADEME 2021)*. For new construction work, it is mainly an issue of putting extra expertise into the definition of projects. Once designers have been well trained (particularly in the use of dynamic thermal simulation software) and well aware of the issues, this additional expertise does not necessarily generate additional design costs. Simple practices such as taking into account a building's environment (climate, vegetation, place in urban space) and working on a building's structure (orientation, doors and windows, etc.) make it possible to meet a large part of the challenge. The implementation of passive cooling solutions can meet requirements in terms of summer thermal comfort.

Among the exemplary projects, we can cite the *Bâtiments Durables Méditerranéens* approach that resulted from the work of the EnvirobatBDM association. This approach has been one of the most successful in terms of taking summer thermal comfort into account, among a more complete set of sustainability criteria (energy efficiency, bio-sourced materials, etc.). Several reports *(EnvirobatBDM 2018)* on buildings that have been awarded with the highest certification levels show additional investment costs due to the approach of around **10 à 15 %** in comparison to similar buildings without such certification *(RT 2012)*. This additional cost (often amortized after a few years of operation) is mainly a result of the technical choices, architectural qualities and the functional qualities of buildings.

With a view to setting an example, it could be worth ensuring that all new educational and academic buildings (which accommodate people who may be sensitive to the issue and activities that have particularly well-identified adaptation needs, CEREMA 2021; Government 2020) follow a similar approach. We estimate the additional cost of reinforcing these requirements at around **€500 m/year**, compared to basic construction of the same number of buildings.

FOR RENOVATIONS

Addressing summer thermal comfort through building renovations involves questioning all energy aspects: shell, carpentry, shading, active systems. These considerations are generally carried out during deep renovation projects (which address all energy renovation issues at once). Conversely, almost all renovations undertaken to date are limited to one work (e.g. insulating the roof or changing the heating system) *(I4CE 2022)*, where the issue of summer thermal comfort is not generally addressed (except *via* the installation of reversible heat pumps). Concerning housing, the objectives set out by the *Stratégie Nationale Bas-Carbone* in terms of mitigation aim to renovate all housing built before the year 2000 to a high level of performance: the inclusion of adaptation in these projects is an opportunity not to be missed. An initial approach without incurring additional costs would be to redirect current subsidies towards the most efficient renovations, while integrating summer thermal comfort criteria (at identical cost: fewer but more efficient renovations). To reach SNBC objectives (i.e. to carry out several hundred thousand deep renovations annually), the Institute for Climate Economics (I4CE) estimates the total investment need to be around €24 billion/year *(I4CE 2021)*. For tertiary buildings, the cost of taking climate change into account in renovation operations has not yet been estimated.

Resources for coordination, awareness raising and research

Several experts interviewed point to the lack of feedback, particularly in the operational phase of existing adaptation solutions. The establishment of a research programme dedicated to the challenges of sustainable construction, including that of taking climate change into account, could be proposed. In practice the use of a number of exemplary buildings and the monitoring of practices would enable a better understanding of thermal comfort conditions and their comparison with theoretical simulations. Utilizing the results of such a programme would constitute a solid base of technical reference solutions on which the whole sector could rely for the realization of sustainable buildings adapted to future heatwaves.

In terms of coordination and awareness, organizations such as the *Réseau Bâtiment durable* are already working with professionals in the sector to improve the quality and the environmental, energy and health performance of buildings. Additional human resources, specifically for the coordination of challenges related to climate change and thermal comfort, could be dedicated to this purpose. To take steps towards the training of professionals, a specific module on adaptation could be integrated into the *Reconnu garant de l'environnement* (RGE) contractor training. This action would make it possible to reach 62,000 companies when their certification is renewed (every 4 years). With regard to private individuals, awareness-raising could take place through national communication campaigns on issues relating to sustainable construction and deep renovations. Finally, the use of buildings in periods of high heat could also be the subject of a communication campaign detailing good practices and the limitations of air conditioning (based on the ADEME technical guide *"Chaud dehors, frais dedans"*).

The cost of all these proposals is estimated to be around **€31 m/year**.

TABLE: BUILDING 1 – ESTIMATION OF COSTS FOR COORDINATION, AWARENESS RAISING AND RESEARCH TO STRENGTHEN THE CONSIDERATION OF CLIMATE CHANGE IN NEW CONSTRUCTION AND RENOVATION

IDENTIFICATION OF NEEDS	ANNUAL BUDGET
— A research programme dedicated to sustainable construction issues, including climate change. Based on the cost of similar programmes that may have existed on other themes	**€10 m/year**
— Include a "summer thermal comfort" module when renewing the "RGE" label for contractors. One day every 4 years for the 62,000 certified companies	**€3.1 m/year**
— Integrate specialized "summer thermal comfort" facilitators into existing facilities 1 FTE in 20 identified structures	**€1.2 m/year**
— A specific communication campaign for sustainable construction and deep renovation Based on the cost of similar campaigns that may have existed on other issues	**€10 m/year**
— A communication and awareness campaign on the use of buildings in hot weather Based on the cost of similar campaigns that may have existed on other issues	**€7 m/year**

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Towards more structural changes in the building stock

These actions are only a first step towards improving the way that climate change is taken into account in buildings. To go further, the integration of this aspect into new building regulations seems essential. **The discussions underway to define a certification label to accompany the new regulations could be a first step in this direction.**

As far as renovation is concerned, summer thermal comfort could become one of the parameters for determining whether funding is granted (in the same way as for energy efficiency): the opportunity offered by energy renovation should not be missed. For the remaining buildings, case-by-case solutions such as the creation of cool zones in neighbourhoods could be envisaged, and limits to the use of individual air conditioning to cases where it is absolutely necessary.

Main references

- ADEME. 2020. ***"La climatisation de confort dans les bâtiments résidentiels et tertiaires",*** 13.
- ADEME. 2021. ***"Actions d'adaptation au changement climatique - En France, aujourd'hui."***
- Cercle Promodul / INEF4. 2020. ***"Rafraichissement passif et confort d'été : panorama de solutions pour l'adaptation du bâtiment au changement climatique."***
- CEREMA. 2021. ***"Rafraîchir les bâtiments publics non climatisés, le besoin se confirme pour le scolaire."*** Cerema (blog). 2021.
- EnvirobatBDM. 2018. ***"Études de rentabilité en coût global pour évaluer l'intérêt de la démarche "Bâtiments Durables Méditerranéens."***
- FFB. 2021. ***"Le bâtiment en chiffres - édition 2020."***
- Gouvernement. 2020. ***"Guide - améliorer le confort thermique des bâtiments scolaires pendant les vagues de chaleur."***
- Gouvernement. 2021. ***"Politique immobilière de l'état - Documents de politique transversale - Projet de Loi de finances pour 2022 ."***
- I4CE. 2021. ***"Panorama des financements climat - édition 2021."***
- I4CE. 2022. ***"Quelle aides publiques pour la rénovation énergétique des logements ?"***
- INSERM. 2003. "***Surmortalité liée à la canicule d'août 2003 – Rapport d'étape."***
- Météo-France. 2020. ***"Les nouvelles projections climatiques de référence - DRIAS 2020."***
- MTE. 2021. ***"Dossier de presse RE2020 : éco-construire pour le confort de tous."***
- OID. 2021. "***Guide des actions adaptatives au changement climatique."***
- Pouget consultants. 2021. "***De la RT2012 à la RE2020 - Concevoir un bâtiment RE2020 compatible 2050."***
- USH. 2021. ***"Investissements annuels dans le parc locatif HLM."*** L'Union sociale pour l'habitat. 2021.

ENSURE THE RESILIENCE OF CRITICAL NETWORKS AND INFRASTRUCTURE: TRANSPORT, WATER, ENERGY

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
Investment flows in infrastructure renewal: €13 bn/year in transport infrastructure >€6.5 bn/year in water networks €6 bn/year in electricity networks	11 Provide infrastructure managers and regulatory authorities with the means to assess their vulnerabilities and to guide adaptation, particularly within the network asset management framework **€15 m/year** 12 Establish and run a coordinating body for infrastructure managers: **€1.7 m/year** - Accelerate investment in the renovation of water networks to gradually reach: **+ €2.2 bn/year** 13 Provide an initial fund to finance targeted actions to address critical vulnerability points on transport networks: **€325 m/year**	% extra cost for modernization or construction – need to speed up renovation rates Transport: up to €1 bn/year Water networks: up to €2.2 bn/year Electricity networks: up to €408 bn/year	Restorative costs (e.g. +5% on top of the road renovation budget (€22 bn by 2050) *(Carbon 4 2022, 4).* Operational losses (e.g. €100 bn by 2050 in lost revenue due to some aircraft being unable to take off during heatwaves *(Carbon 4 2022, 28)* Socio-economic costs (e.g. a 2-month interruption of the Brest-Morlaix rail link costs society more than €2 m *(CGDD 2017, 11)*)

Transport infrastructure

Public support for the modernization of transport infrastructure has increased significantly in recent years and is now close to the pathways set out in the 2019 *Loi d'Orientation des Mobilités*. However, the *Conseil d'Orientation des Infrastructures* (COI) warns in its 2022 report that the needs over the next ten years require an even greater effort to go from **€13 bn/year** to €22 billion in the most ambitious scenario *(Conseil d'orientation des infrastructures 2022)*[1]. In particular, the issue concerns guaranteeing the sustainability of a level of service (comfort, safety) and of taking up today's challenges, the most important of which is the transition to low-carbon transport.

1. "At this stage, the scope of the COI's work concerns investments involving expenditure by the State and its national operators (including expenditure on the maintenance of assets and aid provided by the State specifically to local authorities on projects for which they are the project owners). It does not therefore include local authority investments that are not subsidized by the State or the future operational costs of services. Airport investment, which has been severely disrupted by the pandemic, has not been addressed" (p10). Included in the scope are investments in railways, roads, waterways and major urban projects (Grand Paris).

CATCHING UP ON INVESTMENT AND ADDRESSING KEY VULNERABILITY "HOTSPOTS"

International literature on the subject highlights the existence of well-functioning networks, and the need to regularly maintain them, which are already making a significant contribution to climate change adaptation *(Hall et al. 2019; Global Commission on Adaptation 2019; World bank 2019).* Catching up with the delays in renewing and accelerating the modernization of the French transport infrastructure by ensuring that the necessary investments are properly implemented is therefore already generating significant co-benefits in terms of adaptation *(Cour des comptes 2021; 2022; Maurey and Sautarel 2022).* This was, for example, CEREMA's conclusion in a 2021 study on road bridges and structures, noting that climate change impacts on such buildings "appear to be measured overall", while acknowledging that the affects are "far from negligible, with the higher frequency of extreme phenomena [which] cause various types of damage to structures" *(CEREMA 2021, 8).* The main adaptation need therefore consists of catching up on the renovation of structures without necessarily having to anticipate a specific additional cost to take account of climate change. This need to catch up was estimated in a 2019 Senate report to be **€110 to 120 m/year** as of 2020 and for at least 10 years – when the average expenditure in the 2010s was closer to €45 m/year *(Chaize et Dagbert 2019, 60)*[2].

Certain actions to strengthen robustness, notably concerning vulnerable hotspots that are well known to operators, could also be addressed without delay by targeted operations to reduce the adaptation deficit[3]**.** For this reason we propose the allocation of **€325 m** to this objective over the next few years. This is equivalent to 2.5% of the total annual public investment in the transport infrastructure, and comparable to the situation in other countries – for example, the 2021 US Infrastructure Bill[4].

CAPITALIZING ON MODERNIZATION TO INCREASE NETWORK ROBUSTNESS

Beyond renovation in line with usual standards, feedback provided in the literature shows that modernization can bring co-benefits in terms of adaptation, which can be optimized and certain errors can be avoided by explicitly integrating adaptation into the design stage of operations. For example, it is important to avoid building drainage systems with inadequate capacity by not taking changes in flood risks into account; to avoid keeping essential facilities in an at-risk area when they could be easily moved; or to choose materials more adapted to the new conditions. The modifications to be made to the operational programmes and their exact costs can only be defined after a specific work of assessing the challenges and identifying and comparing the available options, which has yet to be carried out.

It is nevertheless possible, based on European and international experience, to estimate what could represent an increase in the level of resilience targeted at the scale of investment programmes *(Hallegatte et al. 2019; Miyamoto International 2019; Watkiss and Hunt 2019).* Thus, by applying a range of additional costs of between 0.6% and 5.0% (consistent with the figures used by the European Commission in its 2021 Adaptation Strategy *(European Commission 2021)*), we calculated the following estimates:

TABLEAU : NETWORK 1 – ESTIMATED RANGE OF COSTS FOR ADDITIONAL CLIMATE CHANGE RESILIENCE (TRANSPORT)

PLANNED CAPITAL EXPENDITURE	ESTIMATED ADDITIONAL COSTS
— **Based on an investment scenario extending recent trends:** €13 bn/year	**[€78 m – €650 m/year]**
— **Based on investment needs shown by the COI:** €22 bn/year	**[€120 - €1 bn/year]**

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2. Various tools have since been implemented to identify structures at risk and to finance the preparation and implementation of works: see https://www.caissedesdepots.fr/actualites/ponts-soutenir-la-renovation-des-ouvrages-art-collectivites ; https://www.cerema.fr/fr/actualites/france-relance-candidatures-au-programme-national-ponts – accessed on 12/06/2022
3. As an illustration of the type of work that could be involved, Carbone 4 identifies, for example, a need of €200 million between now and 2030 to improve protective structures in the main French ports (Carbone 4 2022, 26)
4. See https://www.whitehouse.gov/bipartisan-infrastructure-law/ - accessed on 12/06/2022

UNDERSTANDING VULNERABILITIES TO FACILITATE THE INTEGRATION OF ADAPTATION INTO THE MANAGEMENT OF NETWORK ASSETS

The savings made by targeting the most vulnerable parts of networks are "several orders of magnitude greater than the costs of data collection and modelling that would be needed to improve knowledge of current and future risks" *(Hallegatte et al. 2019, 8)*. Without targeting vulnerabilities, the additional investment cost could rise from a maximum of + 5% to a maximum of + 30% (i.e. + €3.9 bn/year based on current trends or + €6.6 bn/year based on the COI scenario).

It is therefore only by starting with a precise assessment of the vulnerabilities and by understanding the issues at stake that real adaptation strategies, which can be divided into prioritized action plans, can be set up and financed. Objectively assessing exposure and vulnerability to different climate change scenarios, discussing this knowledge within organizations, being in a position to monitor changes, identifying, comparing and prioritizing the responses, are all essential to truly take ownership of the adaptation challenge. This requires an initial assessment, but also the implementation of monitoring tools, the mobilization of climate services, the organization of internal governance for these subjects and the internalization of new skills. Adaptation choices, which may favour different technical and organizational options (for example, by changing operating or maintenance principles), always result from compromises that are specific to each context, taking limitations and priorities into account.

However, this upstream work still needs to be carried out at different levels: at the level of a major network – or even a part of a network – but also at the territorial level (in regions for example) to better take into account the interdependencies between modes. Methodological building blocks (e.g. developed by CEREMA as part of the PNACC1 *(CEREMA 2019)*) are available but need more widespread mobilization.

On the basis of existing experiences, we have proposed a theoretical procedure for the extension of these processes, which would begin by initiating the process at the level of each region[5] and would be completed by a more detailed examination by operators according to the issues identified.

In addition to the initial analyses, it is necessary to set up the long-term coordination of these subjects within each operating body concerned, but also across the board to enable knowledge sharing. This therefore requires the main public and private actors in this ecosystem (SNCF, VNF, the Road Directorates, the regions, motorway operators, port managers, etc.) to designate contacts and dedicate time to this subject. Some organizations that manage several routes and/or networks (such as SNCF) should even be able to set up an internal team with the means to analyse and relay information to the management bodies.

It will only be possible to put an exact figure on these needs once the outlines of such approaches have been refined. Nevertheless, it is possible to formulate the following initial assumptions leading to a budget of **€15 m/year** :

TABLE: NETWORK 2 – THEORETICAL FRAMEWORK AND COST ASSUMPTIONS ASSOCIATED WITH THE EXTENSION OF A PROCESS AND REGIONAL GOVERNANCE TO BETTER UNDERSTAND VULNERABILITIES AND MANAGE INTERDEPENDENCIES OF CRITICAL INFRASTRUCTURE NETWORKS

FIRST YEAR	— **Carrying out regional studies** (assumption: €500,000/Region x18 Regions)	**€9 m**
	— **Initial in-depth studies** for each transport link at risk[6]	**€6 m**
SUBSEQUENT YEARS	— **Internalization of skills** among operators and continuation of ad-hoc studies for each transport link and issue	**€15 m/year**

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5. The Southern region of France has initiated such an approach by focusing on transport infrastructure, and has thus identified around 20 actors to be involved on a regional scale (departmental councils managing departmental roads, the Interdepartmental Road Directorate and motorway operators managing the national road network, the cities managing major roads, SNCF Réseau for the rail network, VNF and CNR for the river network, as well as the manager of the main ports and airports).
6. It is impossible to determine the correct size and scope of the studies without first going through an analysis phase involving the operators and organizations that are familiar with the analysis methodologies. Nevertheless, more than 100 specific transport links and facilities (e.g. 11 national road networks, 16 motorways, 12 TER regions (with Transilien), 7 major ports, etc.) can be identified and each may require further analysis; each study may cost from a few tens to a few hundred thousand euros. The figures proposed above therefore assume an annual flow of in-depth knowledge over several years.

Water networks

The high level of leakage - around 20% - from drinking water networks is a well-known issue *(OFB 2021; MTES 2018)* which becomes even more problematic in a context of increased resource demand due to climate change

Following the first stage of the 2018 *Assises de l'eau,* the observation was made that Regions, particularly rural ones, were facing an "investment barrier" to the renovation of these networks *(MTES 2018)*. In response, several financial schemes (as well as other measures to promote innovation and governance) were set up over the 2019-2024 period to support investments (which in 2018 reached to around €6 bn/year – source FP2E), including:

- A 50% increase in *Agences de l'eau* funding to support work in rural areas: **€2 billion** mobilized within the 11th agency programme;
- An improvement in the lending conditions for local authorities *via* new offers specific to the needs of the water sector, particularly the *Aquaprêt* of the *Banque des Territoires* (with a **€2 billion**) ;
- The commitment of EU funding for water;
- **€1.4 billion** in grants to set up progress contracts;
- **€50 m** to help local authorities gain a better understanding of their water and wastewater assets.

FURTHER ACCELERATE NETWORK RENOVATION

Climate change adaptation justifies the further acceleration of network renovation and therefore the dedication of additional means in the long term.

The Fédération des Entreprises de l'Eau cites the need for an additional **€3 billion/year** for the entire national public water services reinvestment policy *(FP2E 2022, 11)*[7]. This organization also notes that, beyond the need for volume, it is necessary to better integrate environmental issues into the management of water policies and, in particular, into the management of network assets by better targeting priority action.

Noting that in France "pipes are changed every 160 years on average" and that "the leakage rate is due in particular to pipe corrosion caused by the water passing through, or to the ageing joints between pipes", Carbone 4 in a 2021 analysis estimated that a doubling of the renovation pace would be sensible, aiming to bring the network's maximum average age to 80 years by increasing the renewal rate of the drinking water and wastewater network to 1.25%/year (compared to 0.5%/year in 2009). Achieving this objective would imply the renewal of an additional 6,800 km of the water network each year, and an additional 3,000 km of the wastewater system. In total, this would make the additional investment requirement to be **€2.2 billion** annually *(Carbone 4 2022, 41).* This figure is in line with the orders of magnitude put forward by companies in the sector and by local authorities[8].

Electrical networks

FIRST STEPS HAVE ALREADY BEEN TAKEN

The links between electricity networks and climatic conditions are well known. Episodes such as the 1999 storms or the 2003 heatwave have played important roles in revealing vulnerabilities.

Since then, RTE and Enedis have implemented significant action programmes to improve the resilience of their infrastructure and operations. RTE invested €2.8 billion between 2002 and 2017 to "implement a major programme to mechanically secure structures that are vulnerable to climatic events" *(Cour des Comptes 2019, 46)*. RTE and Enedis have also developed their crisis response capabilities, for example, through the establishment of 11 platforms for storing intervention equipment on the territory (Enedis) as well as FIRE, a rapid reaction force ready to act within 24 hours, with the necessary equipment for emergency repairs. French stakeholders are also participating in the European monitoring centre (CORESO) and in exercises to better manage cross-border vulnerabilities.

Furthermore, regular investments in the maintenance and modernization of these networks (e.g. **€1.5 billion** invested in 2018 by RTE, 60% of which went towards existing structures, and **€4 billion** invested by Enedis in 2020) – made possible by their internalization of electricity prices[9] – enable these operators to maintain a level of performance over time. These investments have already provided an opportunity to reduce certain vulnerabilities: for example, by renewing urban electrical cables, the insulation of which is sensitive to heatwaves; by safeguarding the electricity supply of large urban areas (programmes to improve reliability of large urban substations, flood resilience), by strengthening overhead

7. This sum therefore theoretically exceeds the needs for investment in network renovation and also includes needs related to protection and uses discussed in the section on the global water cycle.
8. See for example https://www.adcf.org/contenu-article?num_article=6048&num_thematique= - accessed on 13/06/2022
9. These expenses are financed by the Tariff for the Use of Public Transmission Electricity Grids (TURPE)

cables against climatic hazards, and by deploying sensors for better detection of anomalies[10].

These different actions have so far been conducted on the basis of climate conditions that have already been experienced. Nevertheless, climate change impacts have been well integrated into the most recent forecasting exercises *(RTE 2021a)*. In particular, RTE has worked with *Météo-France* to obtain 200 years of climate data, that are representative of the 2050 climate according to two emissions scenarios *(ONERC 2022, 212)*.

CAPITALIZING ON MODERNIZATION TO INCREASE NETWORK RESILIENCE

The results of these exercises have not yet been translated into future investment needs. While waiting for this work to be carried out and using the same approach as that proposed for transport infrastructure and by applying a range of additional costs of 3% to 6% *(based on what was used by Hallegatte et al. 2019; Miyamoto International 2019)*, it is possible to work out a rough order of magnitude estimate of additional costs:

TABLE: NETWORK 3 – ESTIMATED RANGE OF COSTS FOR ADDITIONAL CLIMATE CHANGE RESILIENCE (ELECTRICITY) @I4CE_

PLANNED CAPITAL EXPENDITURE	ESTIMATED ADDITIONAL COSTS
— **Planned investment expenditure in the transmission network infrastructure (TEN 2019):** €33 billion over 15 years, i.e. €2.2 billion annually on average	**[€66 - €132 m/year]** over the next 15 years
— **Planned expenditure in distribution network infrastructure (Enedis):** €69 billion over 15 years, i.e. €4.6 billion annually on average	**[€38 - €276 m/year]** over the next 15 years

BEYOND THE NETWORKS, THE POWER SYSTEM AS A WHOLE

The foresight study "Futurs Energétiques 2050" distinguishes two main climate change impacts on the electricity network (RTE 2021b; 2021a; France Stratégie 2022a):

- **Increasing outages of the nuclear fleet during heatwaves and droughts, with impacts on annual production that will remain limited (1 to 2 TWh in typical scenarios and up to 10 TWh in unfavourable years);**
- **Disruption of the supply-demand energy balance: supply is affected by the impact of climatic variability on renewable energy production (lack of wind affects wind production, heatwaves can reduce photovoltaic production, droughts can reduce outputs from hydroelectricity and nuclear power); while demand is affected by possible consumption peaks due to the need for cooling (air-conditioning and industrial cooling).**

We have not calculated the additional investment needs to anticipate these impacts[11]. Nevertheless, these results underline the importance for actors in the sector to increasingly integrate the climatic dimension. For many years, EDF has had a specialized R&D department with in-house climatology expertise to support its decision-making[12].

Depending on the type of production unit and the associated issues, there are different levels of resilience sought. In particular, a maximum level is needed for nuclear power plants [13] (the reference event taken to calculate flood risk is, for example, an event with an expected frequency of once every 10,000 years, for heatwaves it is the 100-year event *(ASN 2013)*) which can be strengthened when new information is provided. Thus, additional safety assessments were requested by the French Nuclear Safety Authority in 2013 following the Fukushima accident. This led to the application of new safety factors, taking into account the expected sea level rise over the lifetime of the plants[14].

The whole range of possible longer-term climate changes must also be taken into account in the location and design of new investments (particularly "new nuclear" – with six second-generation EPR reactors, the first of which will be delivered in 2037 for a total estimated budget of between €52 and €57 billion *(Government 2022)*.

10. See https://www.rte-france.com/l-heritage-de-la-tempete/ et https://www.enedis.fr/garantir-la-qualite-du-reseau-electrique - accessed on 8/06/2022
11. The same sources as those used for the costing of the networks give ranges of additional costs of 1 to 5% for nuclear power and 5 to 15% for renewable energy
12. See https://www.edf.fr/groupe-edf/inventer-l-avenir-de-l-energie/r-d-un-savoir-faire-mondial/pepites-r-d/neutralite-carbone/contexte-climatique - accessed on 08/06/2022
13. See https://www.irsn.fr/fr/connaissances/installations_nucleaires/la_surete_nucleaire/risques_aleas_climatiques_installations_nucleaires/Pages/0-Sommaire-risques-aleas-climatiques.aspx#.Y2JPkuSZND8 - accessed on 08/06/2022
14. See https://www.irsn.fr/FR/connaissances/Installations_nucleaires/Les-centrales-nucleaires/reacteur-epr/Pages/2-Amelioration-surete-reacteur-EPR-Flamanville.aspx- accessed on 08/06/2022

Other networks and interdependencies

OTHER NETWORKS

Other networks are also exposed to climate hazards and their evolution. Several studies highlight the potential impacts on other energy infrastructure (e.g. gas networks) and telecommunications networks *(EY and ARCADIS 2018; France Stratégie 2022b).*

In this publication, however, we focus on transport, water and electricity because these networks are the ones for which we have been able to identify documented adaptation needs in France.

More in-depth studies are needed to better address these other infrastructure types. A better understanding of their vulnerabilities is a prerequisite to make progress in this direction. For this to happen, the operators of such infrastructure must seize the issue and a dialogue among stakeholders must be initiated.

INTERDEPENDENCY ISSUES

In a 2022 report, France Stratégie stated that the various networks "are linked, during normal operation and in times of crisis, by numerous dependencies, both physical and arising from the relationships between actors. For example, electricity and telecommunications cables in the immediate vicinity of roads are subject to hazards that affect these roads, while telecommunication networks depend on a power supply." The report's authors noted that "this tends to increase the vulnerability of networks to climate change" and the current responses remain incomplete *(France Stratégie 2022b, 1).*

To address this, the authors propose various solutions, including the creation of a "working body that at least brings network operators and the State together", the implementation of better monitoring, making better use of information on vulnerabilities, and conducting joint crisis simulation exercises.

The costs associated with setting up such a body would depend on its exact scope and form. In the UK, for example, an infrastructure operators adaptation forum[15] has been initiated with public support. It is coordinated by the environment agency to enable these actors to learn from each other and to work together to reduce vulnerabilities, particularly through a better understanding of the interdependencies of their networks. The long-term functioning of such a forum in France would initially require the support of at least one facilitator's post position and an operating budget to run and provide secretarial services for meetings, and possibly a shared study budget. Regional hubs could also be envisaged.

The organization of crisis simulations also has a cost and requires many organizations to make an investment in time. For example, the 2015 Sequana exercise organized by the Paris police (an exercise that included infrastructure operators, but other actors too) required a budget of **€1.37 m**, 54% of which was provided by the EU[16].

On the basis of these first elements, it is possible to propose an annual budget of **€1.7 m/year** which would be dedicated to the consideration of this issue:

TABLE: NETWORK 4 – ESTIMATE OF RESOURCES NEEDED TO SET UP AND RUN A COORDINATION BODY FOR INFRASTRUCTURE OPERATORS

— **Facilitation of forums for exchange and coordination:** • 2 national FTEs • FTE of contact per region (x18 regions)	**€1.2 m/year**
— **Budget available to a national body to conduct joint studies;** to work on joint actions or organize crisis simulation exercises	**€500,000/year**

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15. See https://www.arcc-network.org.uk/infrastructure/ioaf/ - accessed on 07/07/2022
16. See https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/eu-civil-protection-knowledge-network/list-eu-supported-civil-protection-exercises_en - accessed on 07/07/2022

Main references

- ASN. 2013. ***"Guide de l'ASN n°13 : Protection des installations nucléaires de base contre les inondations externes."***
- Banque Mondiale. 2019. ***"Lifelines: The Resilient Infrastructure Opportunity."***
- Carbone 4. 2022. ***"Annexe - Le rôle des infrastructures dans la transition bas-carbone et l'adaptation au changement climatique de la France. Annexe « Résilience des infrastructures."***
- CEREMA. 2019. ***"Vulnérabilités et risques : les infrastructures de transport face au climat."***
- ———. 2021. ***"Impact du changement climatique sur les ouvrages d'art en France : conseils aux gestionnaires et concepteurs."***
- CGDD. 2017. ***"Thema - Indisponibilité d'une infrastructure de transports Mesurer et réduire les coûts."***
- Chaize, Patrick, et Michel Dagbert. 2019. ***"Sécurité des ponts : éviter un drame ».*** Rapport d'information fait au nom de la commission de l'aménagement du territoire et du développement durable [1] par la mission d'information sur la sécurité des ponts (Sénat).
- Conseil d'orientation des infrastructures. 2022. ***"Bilan et perspectives des investissements pour les transports et les mobilités : Prendre le cap des nouvelles mobilités."***
- Cour des comptes. 2021. ***"Le réseau ferroviaire français : des évolutions significatives mais des choix nécessaires à venir."***
- ———. 2022. ***"Entretien routes nationales et départementales."***
- European Commission. 2021. ***"EU Adaptation Strategy."***
- EY, et ARCADIS. 2018. ***"Adaptation des grands projets d'infrastructure au changement climatique Rapport pays pour la France."***
- FP2E. 2022. ***"L'eau, les français et les territoires face au dérèglemet climatique : plance à l'action !"***
- France Stratégie. 2022a. ***"Impacts physiques et socio-économiques du changement climatique en France : synthèse de la littérature."***
- ———. 2022b. ***"Risques climatiques, réseaux et interdépendances : le temps d'agir."***
- Global Commission on Adaptation. 2019. ***"Adapt now: A Global Call for Leadership on Climate Resilience."***
- Gouvernement. 2022. ***"Travaux relatifs au nouveau nucléaire. PPE 2019-2028."***
- Hall, Jim W, Michael Mullan, Raghav Pant, Amelie Paszkowski, Julie Rozenberg, Fulai Sheng, Vladimir Stenek, et al. 2019. ***"Adaptation of Infrastructure Systems: Background Paper for the Global Commission on Adaptation."*** Environmental Change Institute, University of Oxford.
- Hallegatte, Stephane, Julie Rozenberg, Jun Rentschler, Claire Nicolas, et Charles Fox. 2019. ***"Strengthening New Infrastructure Assets: A Cost-Benefit Analysis."*** Background Paper. Lifelines: The Resilient Infrastructure Opportunity. World Bank Group.
- Maurey, Hervé, et Stéphane Sautarel. 2022. ***"Rapport d'information : Comment remettre la SNCF sur rail ?"*** Sénat.
- Miyamoto International. 2019. ***"Overview of Engineering Options for Increasing Infrastructure Resilience."*** for World Bank Group.
- MTES. 2018. ***"Assises de l'eau : des réseaux rénovés pour une eau de qualité."*** Dossier de presse.
- OFB. 2021. ***"Observatoire de services publics d'eau et d'assainissement. Panorama des services et de leur performance en 2019 ."***
- ONERC. 2022. ***"La Prospective au service de l'adaptation au changement climatique."***
- RTE. 2019. ***"Schéma décennal de développement de réseau 2019 - Rapport complet."***
- ———. 2021a. ***"Chapitre 8 : "Climat et système électrique" ."*** In Futurs énergétiques 2050.
- ———. 2021b. "***Chapitre 10 : "Les Réseaux" ."*** In Futurs énergétiques 2050.
- Watkiss, Paul, et Alistair Hunt. 2019. ***"Economic Implications of Climate Change for Glasgow City Region: Adaptation Report. Report from Paul Watkiss Associates to Climate Ready Clyde."***

SUPPORT THE RESHAPING OF COASTAL AREAS TO COPE WITH RISING SEA LEVELS

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
A few million euros annually for technical assistance[1], calls for research proposals, and specific examples of local actions	14 Provide communities with the means to objectify their vulnerabilities and to develop and lead a coastal adaptation strategy: **€15 m/year** 15 Create a fund to support coastal reshaping: **€150 m/year**	Possibly several billion euros to be invested to transform these territories - planning and territorial development policies	At least [€0.8 – 8 bn] in terms of exposed housing (CEREMA 2019) + public infrastructure and economic assets that have not been assessed at the national scale

The characterization of climate change adaptation needs in coastal areas must account for the different stages of a strategic approach to adaptation as a risk management process and as a process of (re)planning and sustainable economic development of these territories *(Meur-Ferec et al. 2021; La Fabrique Écologique 2020; CEPRI 2016; ONERC 2015)*[2].

Knowing the issues – developing the strategies

This requires the mobilization of the necessary resources for a detailed and contextualized analysis of the issues, an initial version and then a gradual enrichment of a local adaptation strategy and its management. Based on available observations, the total requirements can be estimated at **€15 m/year** for the 250 municipalities concerned on a national scale[3]. For the first two years, this sum would cover the initial costs of carrying out detailed risk mapping and a local pilot scheme (derived from an initial study lasting 18 to 24 months – based on the assumption of €60,000/municipality – possibly within the framework of an inter-municipal project). For subsequent years, it reflects the need to internalize human resources within the municipalities concerned (assumption: at least 1 FTE for 2 municipalities) and to structure governance and regional support capacities (assumption: 10 FTE per region). These expenses would probably be borne primarily by the local authorities (EPCI and the regions) but could require national support.

1. See for example, the first 19 territories to be supported by CEREMA within the framework of a partnership with ANEL, for which CEREMA is mobilizing the equivalent of €500,000 in total, representing 50% of the costs, i.e. a total of €1 m, approximately €50,000 per territory. See https://www.cerema.fr/fr/appel-partenaires-gestion-integree-du-littoral - accessed on 1/06/2022. The Climate Resilience Law also provides for an initial budget of €2 m to support the first 126 municipalities that have urban planning and development policies that must take coastal erosion into account - i.e. approximately €15,000 per municipality.
2. Current public policies distinguish the management of erosion phenomena from that of submersion risk. Submersion risk is partly addressed as a component of the flood risk in the section on the prevention of natural risks. It is primarily therefore the erosion issue that gives rise to new needs addressed here. Nevertheless, many territories exposed to both phenomena do not distinguish between them when planning their future with the evolution of sea levels as a global issue.
3. An initial list of 126 municipalities has been drawn up for 2022, but this does not cover all of the municipalities potentially concerned. Depending on the assumptions made, the exact number of municipalities affected may vary. See https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000045726134 - accessed on 13/06/20222

First steps of implementation

The first steps in implementing local adaptation strategies generally consist of immediate actions to manage short-term emergencies and initial measures to prepare for more significant transformations (e.g. carrying out additional studies, opportunistic land mobilization, relocation of small infrastructure, purchase of assets threatened in the very short term, etc. *(Chambre régionale des Comptes, Occitanie 2021; GIP Littoral 2018)*). The total need for this start-up phase of implementation is estimated at €150 m/year on a national scale. This order of magnitude corresponds to the support capacities that could be provided by a national fund to assist with coastal reshaping, such as that proposed by the Buchou report or by the MP Sophie Panonacle *(Buchou 2019; Panonacle et al. 2022; CGEDD, IGA, and IGF 2019).*

Prepare now for more structural transformations

Nevertheless, these initial actions cannot cover all of the transformation needs. A precise evaluation of the total requirements will not be possible until a contextualized analysis of each situation has been conducted. Indeed, the adaptation costs will depend both on the value of the exposed assets and on the combination of responses favoured in each region. While a national estimate of the value of vulnerable housing is available – from **€0.8 to €8 billion** according to the assessment drawn up by CEREMA on the basis of a national indicator of coastal erosion *(CEREMA 2019, 19)* – there is currently no equivalent for vulnerable economic activities and infrastructure. Analysis conducted in the Nouvelle Aquitaine region by the GIP Littoral nevertheless seems to indicate that the stakes are **at least as high** for these latter two asset categories *(GIP Littoral 2018).* Furthermore, as the data produced by CEREMA indicate, the identification of vulnerable assets is not the only cost determinant: the methods of valuing such assets (e.g. the buy-back price of housing, ability to take advantage of renewal opportunities, etc.) and the decisions taken on adaptation are criteria that are at least as important. Deciding which assets will be protected by maintaining or increasing active control, temporarily or permanently; which assets will be 'abandoned' and which will be relocated makes a big difference. The costs of each of these options are also highly dependent on the specific conditions of each context (e.g. active control costs can vary from €50/ml/year for soft active protection in the simplest situations to €35,000/ml for hard active solutions on rocky coasts *(CEREMA 2018; GIP Littoral 2018; Madelenat 2019)*).

Coastal reshaping projects, involving the relocation of certain assets and activities, cannot be considered solely as adaptation costs. The facilities and installations concerned, which are often quite old, would have required modernization or reshaping even without climate change. When well thought out and implemented over time, **adaptation is thus a component of land-use and economic development** that can pursue many other objectives and generate multiple benefits.

Such projects must be developed and discussed on a case-by-case basis, in each territory, according to its own challenges, limitations, opportunities, ambitions, etc. This has been happening in the town of Lacanau (5,000 year-round residents), which has proposed four 'desirable' scenarios at costs ranging from **€44 to €360 million** (for an active riprap control scenario and other scenarios involving seafront relocation) *(GIP Littoral 2015, 98*). These costs should be viewed in the context of the time scales of the projects considered, which may be spread across several decades. The proposal of several alternatives can thus foster an initial discussion on the preferred forms of development and their costs, but also their benefits, before considering who should finance these costs. Indeed, depending on the distribution of socio-economic benefits, different actors – public or private – could make different financial contributions.

Main references

- Buchou, Stéphane. 2019. "***Quel littoral pour demain ? Vers un nouvel aménagement des territoires côtiers adapté au changement climatique".*** *Report submitted to the Prime Minister and the Minister for Ecological and Solidarity Transition.*
- CEPRI. 2016. ***"Les collectivités territoriales face aux risques littoraux Élaborer et mettre en oeuvre une stratégie de réduction du risque de submersion marine ».***
- CEREMA. 2018. "***Coût des protections contre les aléas littoraux."***
- ———. 2019. "***Évaluation prospective des enjeux affectés par le recul du trait de côte."***
- CGEDD, IGA, et IGF. 2019. ***"Recomposition spatiale des territoires littoraux."***
- Chambre régionale des Comptes, Occitanie. 2021. ***"Gestion du trait de côte et recomposition du littoral sur la "côte ouest" de Vias (Hérault)."*** Rapport d'observations définitives et ses réponses.
- GIP Littoral. 2015. ***"La relocalisation des activités et des biens en Aquitaine # 2 | Site atelier de Lacanau # 2.13 | Scénarios souhaitables, leur analyse et leurs enseignements."***
- ———. 2018. ***"Actualisation et nouveaux chiffres clés : érosion du littoral aquitain."***
- La Fabrique Écologique. 2020. ***"L'adaptation au changement climatique sur le littoral français."***
- Madelenat, Jill. 2019. ***"L'adaptation au changement climatique sur le littoral français."*** La Fabrique Écologique.
- Meur-Ferec, Catherine, Stéphane Costa, Caroline Lummert, et Gaëlle Ezan. 2021. ***"Érosion côtière : un risque (pas) comme les autres ?"***
- ONERC. 2015. ***"Le littoral dans le contexte du changement climatique."***
- Panonacle, Sophie, Marina Sage, Stéphane Claireaux, et al. 2022. **Proposition de loi visant à créer un fonds permettant de financer les dispositifs d'aménagement adaptés aux communes concernées par le recul du trait de côte, dit *"Fonds Érosion Côtière."***

TAKE ACTION FOR RESILIENT FORESTS AND MAINTAIN THE SERVICES THEY PROVIDE

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
[100-150] €m/year to support forest renewal[1] €400 m invested for innovation and competitiveness of the wood sector	16 Finance the implementation of the roadmap for the adaptation of French forests to climate change: **€25 m/year** to ensure that investment flows in forest renewal and the wood industry take adaptation criteria into account	"30% of forest areas are now vulnerable or threatened by climate change, i.e. over 5 million hectares" (Ministre de l'Agriculture et de l'Alimentation 2020)	The wood industry represents 1.1% of GDP From 2018 to 2021: bark beetle damage affected 10 million m³ and 30,000 ha[2]

The forest health crises of recent years (particularly the bark beetle outbreak of 2019-2021) have highlighted the vulnerabilities of forests to climate change that research has documented for more than ten years *(Cattelot 2020; Humanité & Biodiversité et al. 2020; Cour des Comptes 2020).*

Adaptation has been the subject of a roadmap drawn up by all forest and timber stakeholders and submitted to the Minister for Agriculture in 2020 *(Ministre de l'Agriculture et de l'Alimentation 2020).* This roadmap, which applies to forests in mainland France, identifies nine priorities associated with around thirty actions that mobilize the main actors in the sector. Adaptation was also one of the central themes of the *Assises de la forêt et du bois* which ended in March 2022. In these documents and discussions, several visions were expressed, corresponding to different perceptions of the forest, its uses and different understandings of the risks linked to climate change. The attitude that should be adopted regarding the adaptation of French forests (which species to promote, which silvicultural practices to develop, etc.) remains a subject of lively debate.

Nevertheless, the various studies converge on fundamental principles that should protect the multifunctionality of forests. In particular, the key is to prioritize strategies that can be applied to existing forest stands, that accept the context of uncertainty and foster resilience by increasing diversification, and that aim to maintain soil health and biodiversity *(Roadmap 2020 p8)*. Such studies constitute a widely shared basis for action to be deployed now and in the years ahead to ensure that adaptation is possible.

Government announcements following the *Assises de la forêt et du bois* are a further step towards the implementation of these actions *(Government 2022; Cattelot et al. 2022).* This implementation implies changes to the sector's organization, to forest governance and to the resources allocated and mobilized for this purpose.

1. As an indication, the first €80 m mobilized through the France Recovery Plan enabled the renewal of 16,000 hectares (Government 2022, 10)
2. See https://agriculture.gouv.fr/crise-scolytes-sur-epiceas-bilan-fin-2020-10-millions-de-m3-et-30-000-ha-de-bois-scolytes-depuis - accessed on 13/06/2022

An investment issue: invest enough but mostly invest better

In terms of volume, the dynamics set in motion by the France Recovery Plan in 2020-2021, that were bolstered by the France 2030 after the *Assises de la forêt et du bois*, seem to converge towards similar estimates of resource needs.

- In terms of forest renewal, sectoral actors agree on an annual need of **around €100 million** and on the major importance of ensuring visibility regarding the available means over time. Recent announcements confirm the aim to allocate between **€1.1 and €1.4 billion** to forest renewal between 2021 and 2030. It therefore seems that the announced resources will be sufficient to meet the needs both quantitatively and for several years to come.

- In terms of downstream investment in the wood industry, the *Comité Stratégique de Filière Bois* (CSF Bois) mentions in a publication that there is an investment need of "**€1.2 billion/year** for the next 5 years" from businesses and companies in the furniture and wood industry sector *(CSF Bois 2021)*. According to the first announcements made after the Assisses de la forêt et du bois, **€400 m** should be invested as part of the France 2030 Plan to "ensure the innovation and competitiveness of the wood and forest industry" *(Government 2022)*. As not all of the sector's investment needs are likely to be covered by public support, this fund has been welcomed by professionals in the sector as a substantial contribution to meeting the challenge described by CSF Bois.

The current adaptation challenge therefore does not necessarily involve mobilizing more resources than has already been announced, but to ensure not only that these resources are actually released, but also that the industrial policy being promoted takes ongoing climate change into account, and that the support provided includes adaptation criteria.

Beyond the need to invest more, adaptation requires better investment, i.e. ensuring that mobilized resources really contribute to forest adaptation. The sums that will be dedicated to forests must therefore be directed towards options that take climate change into account. If the preferred options do not make future climate a determining factor in the choices made, there is a risk of reinforcing forest vulnerability and therefore of ill-suited investment.

- This means, firstly, that particular care is needed in defining the forest stands to be renewed so as not to reduce the natural adaptation capacities of forests. It also means ensuring that endorsed renewal maximizes the resilience of planted forests, particularly by encouraging species diversity.

- Investment in industrial facilities must also take better account of forest requirements that are evolving with climate change. In addition to the capacity to absorb wood surpluses in the aftermath of crises, industries must also be able to process a wider range of woods, particularly hardwoods.

Funds also needed for monitoring, experimentation, expertise, monitoring, coordination and dialogue

In addition to the major investment items, the *Feuille de route pour l'adaptation des forêts au changement climatique* also mentions a number of actions that are less costly but whose importance for adaptation is crucial. For example, coordinating the interface between research and forest management, health monitoring, monitoring the state of forests and crisis situations, carrying out foresight studies on using a more diverse range of wood, and coordinating dialogue between forestry professionals and civil society are essential for adaptation and require resources.

While some of these priorities have been reflected in various statements, there is uncertainty about the resources that will be allocated to them. Such actions are rarely associated with clearly identified budgetary resources. Packaged within broader programmes or the current activities of certain organizations (e.g. ONF, CNPF), they must deal with budgetary and organizational limitations that do not always consider the climate change context. This observation calls for particular attention to be paid to the issues of monitoring and guiding adaptation.

In the course of our detailed analysis of the implementation needs for this roadmap, we were able to specify the following requirements – leading to an estimated total budget of **€25 m/year** *(I4CE 2022)* – see Table 1.

TABLE: FOREST 1 – ESTIMATING THE NECESSARY COSTS OF IMPLEMENTING VARIOUS ROADMAP ACTIONS*

QUANTIFIED ACTIONS	ASSOCIATED BUDGET
— **Strengthening and extending** RENECOFOR-type observation networks	**€1 m/year**
— **Organizing and coordinating a thematic centre of expertise** for economic, human and social sciences	**€200,000/year**
— **Strengthening efforts to promote forest experiments,** supported by scientific research	**€5 to €12 m/year**
— **Extend the activities of RMT Aforce and the sector's capacity** to facilitate interaction between research and forest management	**€2.3 m/year**
— **Broaden support for silvicultural investment issues** beyond forest renewal (e.g. forest stand diversification)	**€2 m/year**
— **Strengthen forest health observation and monitoring, organize crisis management** (strengthen the department of the Ministry of Agriculture in charge of forest health's networks of correspondent observers, develop analytical capacities, create and lead a national crisis management unit)	**€2 m/year**
— **Strengthen dialogue and consultation, develop coordination and mediation between stakeholders within territories** (increase the number of workshops and discussions between professionals in the sector and civil society, organize consultation processes upstream of forestry projects, support locally elected representatives in mediation, etc.).	**€2 m/year**

* Related to strengthening scientific cooperation, disseminating and appropriating knowledge, promoting forestry practices that increase resilience, forest health observation and monitoring, organizing crisis management and supporting dialogue within the sector and between forestry groups and society *(I4CE 2022)*

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Main references

- Cattelot, Anne-Laure. 2020. ***"La forêt et la filière bois à la croisée des chemins : l'arbre des possibles."***
- Cattelot, Anne-Laure, Pierre-Olivier Drège, Michel Eddi, Meriem Fournier, Catherine Loisier, Pierre Piveteau, Rémy Rebeyrotte, et Patricia Schillinger. 2022. ***"Synthèse des travaux des Assises de la forêt et du bois."***
- Cour des comptes. 2020. ***"La structuration de la filière forêt-bois, ses performances économiques et environnementales."***
- CSF Bois. 2021. ***"Communiqué de presse : la filière forêt-bois renforce sa dynamique grâce au plan d'investissement "France 2030"."***
- Gouvernement. 2022. ***"Clôture des Assises de la forêt et du bois : Dossier de Presse."***
- Humanité & Biodiversité, France Nature Environnement, LPO, UICN, Réserves naturelles de France, et Fondation WWF. 2020. ***"Forêts françaises en crise : Analyse et propositions des ONG de conservation de la nature."***
- I4CE. 2022. ***"Adapter la forêt métropolitaine au changement climatique : d'abord mieux investir."***
- Ministère de l'Agriculture et de l'Alimentation. 2020. ***"Feuille de route pour l'adaptation des forêts au changement climatique - Agir pour des forêts résilientes et un maintien des services qu'elles rendent."***

SUPPORT THE DIVERSIFICATION AND TRANSITION OF MOUNTAIN ECONOMIES

EXISTING CONTRIBUTION TO ADAPTATION	TO DO NOW	PERSPECTIVE ON THE GLOBAL ISSUE	OVERVIEW OF THE COSTS OF INACTION
The *Fonds Avenir Montagne* (technical assistance: €31 m and invest-ment: €300 m over 2 years) Regional mountain plans	17 Maintain the *Avenir Montagnes Ingénierie* fund and strengthen its coordination capacity to meet the adaptation needs of mountain territories: **€16.7 m/year** 18 Maintain the State's share of the *Avenir Montagnes investissement* fund, encourage regional authorities to do the same (to reach a total of €150 m/year) and direct investments towards projects contributing to adaptation: **€75 m/year**	Possibly several billion euros to be invested to transform these territories – planning and territorial development policies	350 ski resorts 20,000 jobs €20 bn/year from threatened economic spin-offs

Mountain regions have already been particularly affected by climate change impacts, a trend that will continue in future. Their geography makes them more exposed and vulnerable to natural hazards (floods, landslides, forest fires), while they have also seen a more pronounced warming than other territories *(DRIAS 2020, 30)*. The reduction in snow cover, particularly noticeable at medium altitudes, is forcing many territories where winter tourism has long been the main economic activity to question their future.

The various research projects conducted on the climate change adaptation of mountain territories all conclude that there are as many different situations as there are territories concerned *(IRSTEA et al. 2017; Achin, George-Marcelpoil, and Bernard 2015; George et al. 2019; George-Marcelpoil et al. 2016; I4CE and Ramboll 2021)*. The challenges are different from one situation to another (for example, some resorts will continue to enjoy good snow conditions for longer than others, depending on altitude and exposure) and the possible solutions are even more numerous. They will have to take into account the specific resources of each territory, the diversity of opportunities and the preferences of local stakeholders. While the second half of the 20th century saw the extension of the ski-resort model, a new model does not yet exist to take over wherever necessary.

The necessity of building a desirable and shared vision of a territory

Mountain adaptation can therefore only be regarded as a territorial project, developed on a scale that is consistent with local economic and demographic dynamics and that includes all socio-economic actors in the area *(Diaz 2018)*. The issue concerns the way space is occupied, how land-use planning is carried out, and the place given to tourism in the economy. Despite initially encouraging initiatives (such as the *États Généraux de la transition du tourisme en montagne* (*Mountain Wilderness and 2TM 2021)*, these types of foresight study are either lacking or need to be more detailed in the case of most French mountain territories.

Until such deliberations on the future of these territories have been carried out, adaptation responses will be limited to isolated development solutions (snow cannons, summer

sledges, etc.) which risk locking certain territories into "mal-adaptation" pathways.

Tools to help territories to develop their strategies

Such a transformation project first requires time to build an understanding of the issues at stake and then a shared vision of the desirable development pathways. To support these approaches and better understand the issues in question, forward-looking analysis and decision-making tools are very useful. The ClimSnow service, for example (developed by Météo-France, INRAE, and Dianeige) provides prospective information on snow cover on a resort scale. Coupled with methods for optimizing operational and maintenance management, it allows future investments to be planned while taking climate change into account. In addition, the modelling of local socio-economic dynamics, such as changes in tourist flows or the modelling of tourist numbers, allows to complete our knowledge of the territorial issues.

The results of these analyses, however useful, only make sense once contextualized and put into perspective and, above all, properly interpreted, particularly by ski zone operators. They should not be used to systematically justify "snow" investment, but rather to develop and create coherent adaptation pathways linking immediate decisions and long-term developments.

Maintaining existing resources, particularly technical assistance

Several support measures have been implemented since 2020 for mountain areas. In response to the health crisis, the State mobilized more than €5.4 billion, mainly to support the cash flow of companies, businesses and ski lift operators. Following these emergency measures, the *Plan Avenir Montagnes* (PAM) took over, with the aim of reviving investment to achieve a transformation objective. This two-year programme has a fund of €31 million for technical assistance and €300 million (State/Regions) for investment *(Government 2021)*. Given that it proposes to respond to the different requirements of mountain areas, the technical assistance component has been particularly well received by the sector's actors (source: interviews). In particular, it enables the financing of 62 dedicated project managers in the regions, and the provision of a range of technical assistance tools. Regarding investments, with a very tight schedule (which was part of the post-Covid recovery dynamic), the funding allocated to PAM initially led to the financing of projects that were already ready to be examined.

The construction of real territorial projects, involving the transformation of economic models, can only be envisaged as a long-term process. As noted in a 2022 National Assembly information report, support mechanisms must therefore also be long-term *(Battistel and Gayté 2022, 83).*

The *Plan Avenir Montagnes* seems to have enabled the initiation or support of an initial dynamic in most directly affected territories *(source: interviews).* The main challenge now is to ensure that this dynamic can continue, that the shared visions are able to mature and gradually transform into territorial projects in which to invest. This observation highlights the need to **make permanent the resources mobilized over the last few years, firstly in terms of technical assistance,** to the amount of **€16 m/year,** because the work of the project managers employed can only produce results if part of a continuity, which is a pre-requisite for developing a detailed knowledge of a territory and the building of trust between stakeholders *(I4CE and Ramboll 2022).*

And secondly **in terms of investment,** by continuing the State's share of PAM's investment component of €75 m/year and by encouraging the regions to do the same (to reach a total of **€150 m/year**).

Regarding this second component, the requirement criteria in terms of anticipating climate change impacts should be strengthened. Indeed, the fund can currently be used for "the modernization of facilities to enable winter sports to take place in a resort" without any particular requirement in terms of climate change. This would seem to be an increasingly risky option in a climate change context.

The programme's management is entrusted to the ANCT at the national level and to the mountain commissariats at the local level. This management requires significant resources to operate the programme, to support project leaders, and to coordinate and process applications. Additional resources seem necessary to support these functions over time, including an estimated 12 FTEs (i.e. **€700,000/year**) (based on the current organization: 2 FTEs for general programme coordination at the ANCT level, and 10 FTEs for coordination within the mountain authorities). In other words, **€16.7 m/year** in total for resources dedicated to technical assistance (through the PAM) and coordination.

Significant investment needs once a territorial vision has been built

Adaptation plays the role of a trigger for transition dynamics in these territories, because the effects of climate change are becoming increasingly visible every year. It implies the construction and implementation of genuine economic development and land-use strategies. These strategies must be able to respond to other equally essential challenges such as the low-carbon transition or biodiversity conservation. The total sum of investment needs is not available at this stage, it will depend on political choices and transition pathways that have not yet been defined. The upstream steps presented here are essential to instigate virtuous investment dynamics as soon as possible.

The issue will then be about accompanying the evolution or development of the tourism sectors (for example, with the development of thermal spas in certain territories) but also of agriculture or certain types of artisanal trades or even other industries; and about investing in infrastructure, notably transport, and in housing and various amenities, including tourist facilities (without necessarily excluding skiing in the short term, but questioning the medium-term viability of the model).

It should also be noted that mountains could become an area of refuge, offering cooler temperatures to people from other areas – particularly urban – that are exposed to summer heatwaves. If these developments were to materialize, it would be necessary to plan for them, so that these areas can be appropriately organized to enable the various functions to take place in the best possible conditions.

Main references

- Coralie Achin, Emmanuelle George-Marcelpoil, et Vincent Bernard. 2015. ***"L'innovation lue au prisme de son volet organisationnel : l'exemple de la diversification dans les stations de moyenne montagne."*** Sciences Eaux & Territoires Numéro 17 (2): 52.
- Battistel, Marie-Noëlle, Laurence Gayte. 2022. ***"Rapport d'information sur le tourisme de montagne et les enjeux du changement climatique."***
- Diaz, Isabel. 2018. Massifs en transition : Vosges, Jura, Alpes du Nord.
- Drias. 2020. ***"DRIAS, Les futurs du climat."*** DRIAS, Les futurs du climat. 2020.
- Emmanuelle George-Marcelpoil, Coralie Achin, Hugues François, Pierre Spandre, Samuel Morin, et Deborah Verfaillie. 2019. ***"Changement climatique et stations de montagne alpines : impacts et stratégies d'adaptation."*** Sciences Eaux & Territoires Numéro 28 (2): 44.
- Emmanuelle George-Marcelpoil, Coralie Achin, Gabriel Fablet, et Hugues François. 2016. ***"Entre permanences et bifurcations : une lecture territoriale des destinations touristiques de montagne."*** Mondes du tourisme, no Hors-série (septembre).
- Gouvernement. 2021. ***"Plan avenir montagne - dossier de presse."***
- 4CE, et Ramboll. 2021. ***"Défis rencontrés par 5 démarches territoriales qui cherchent à être à la hauteur des enjeux d'adaptation."***
- ———. 2022. ***"Défis rencontrés par 5 démarches territoriales qui cherchent à être à la hauteur des enjeux d'adaptation."***
- IRSTEA, Météo-France, CNRS, et ONERC. 2017. ***« Projet ADAMONT : rapport final."***
- Mountain Wilderness, et 2TM. 2021. ***"Bilan des États généraux de la transition du tourisme en montagne."***

GLOSSARY AND USEFUL LINKS FOR FURTHER UNDERSTANDING OF FRENCH ADAPTATION ISSUES

- **ACV - Action Cœur de ville** - https://agence-cohesion-territoires.gouv.fr/action-coeur-de-ville-42 - The national plan Action Coeur de ville responds to a double ambition: to improve the living conditions of the inhabitants of medium-sized towns and to consolidate the driving rolew of these towns in the development of the territory.
- **ADEME - Agence de la transition écologique** - https://www.ademe.fr/French agency for ecological transition.
- **Agences de l'eau** - https://www.lesagencesdeleau.fr / Created by the 1964 water law, the six French water agencies are public state institutions. They carry out a mission of general interest of managing and preserving water resources and aquatic environments.
- **ANCT - Agence nationale de la cohésion des territoires -** https://agence-cohesion-territoires.gouv.fr / French national agency for territorial cohesion.
- **ANRU - Agence Nationale pour la Rénovation Urbaine -** https://www.anru.fr/French national agency in charge of urban renewal.
- **ARS – Agences régionales de santé -** https://www.ars.sante.fr / French regional health agencies.
- **Assises de l'eau -** https://www.ecologie.gouv.fr/assises-leau - Between November 2018 and June 2019, the Assises de l'eau initiate a broad and unprecedented consultation with all water stakeholders: local authorities, companies, professional agricultural organizations, nature protection associations, consumer associations, research institutes.
- **Assises de la forêt et du bois** - https://agriculture.gouv.fr/les-assises-de-la-foret-et-du-bois - Launched in October 2021, The Assises de la forêt et du bois aimed to design the French forest of tomorrow and respond to the challenges it faces based on a shared vision of all the stakeholders of the wood-forest sector.
- **Banque des territoires** - https://www.banquedesterritoires.fr/ - Created in 2018, the Banque des Territoires brings together, within a single structure, consulting and financing expertise for territorial actors to accompany the completion of their projects.
- **BDM - Bâtiments Durables Méditerrannéens** - https://www.envirobatbdm.eu/ - Created in 2009 by EnvirobatBDM, the BDM approach aims to improve the quality of projects (in terms of sustainability) and strengthen the skills of building and urban planning professionals in the French south region.
- **BRGM - Bureau de Recherches Géologiques et Minières** - https://www.brgm.fr/en - BRGM, the French geological survey, is France's leading public institution for Earth Science applications for the management of surface and sub-surface resources with a view to sustainable development.
- **Cat Nat -** https://www.economie.gouv.fr/particuliers/catastrophe-naturelle-fonctionnent-indemnisations
- Cat Nat is the French natural disaster guarantee mechanism.
- **CCR – Caisse Centrale de Réassurance -** https://www.ccr.fr/ - CCR is a French public reinsurer that works in the general interest by covering against natural disasters and uninsurable risks.
- **CEREMA - Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement -** https://www.cerema.fr/en - The Cerema (Center for Studies and Expertise on Risks, the Environment, Mobility and Urban Planning), is a public establishment under the supervision of the Ministry of Ecological Transition and Territorial Cohesion which supports the State and local authorities in the development, deployment and evaluation of public planning and transport policies.
- **CESE - Conseil Économique Social et Environnemental -** https://www.lecese.fr / - The Economic, Social and Environmental Council (ESEC) is a constitutional consultative assembly. It represents key economic, social and environmental fields, promoting cooperation between different socio-professional interest groups and ensuring they are part of the process of shaping and reviewing public policy.
- **CGAAER Conseil général de l'alimentation, de l'agriculture et des espaces ruraux -** https://agriculture.gouv.fr/le-conseil-general-de-lalimentation-de-lagriculture-et-des-espaces-ruraux-cgaaer - Chaired by the ministry of agriculture. The CGAAER provides advice, expertise, evaluation, audit and inspection, for example on strategic issues such as agro-ecology and the fight against climate change, market crisis management or health crises, international support. It can also participate in the design of laws.
- **CGDD - Commissariat général au développement durable –** https://www.ecologie.gouv.fr/commissariat-general-au-developpement-durable-cgdd - Chaired by the ministry of energy, the general commission for sustainable development (CGDD) informs and feeds, through the production of data and knowledge, the action of the ministry in all of its fields of competence.
- **CGEDD (now IGEDD)- Conseil général de l'Environnement et du Développement durable -** https://www.igedd.developpement-durable.gouv.fr/ - The General Inspectorate for the Environment and Sustainable Development (CGEDD now known as the IGEDD) advises the Government on ecological and energy transition, planning, housing, mobility, water, biodiversity.
- **CNRS Centre national de recherche scientifique - https://www.cnrs.fr/en -** The French National Center for Scientific Research (CNRS) is among the world's leading research institutions. Its scientists explore the living world, matter, the Universe, and the functioning of human societies in order to meet the major challenges of today and tomorrow.
- **Comité pour l'économie verte -** https://www.ecologie.gouv.fr/comite-leconomie-verte - The green economy committee brings

together the authorities and stakeholders concerned by the challenges of energy taxation, the circular economy, water and biodiversity, as well as all the economic tools allowing, in addition to traditional budgetary and regulatory levers, to promote the energy transition.

- **CNPF - Centre National de la Propriété Forestière -** https://www.cnpf.fr/ - The CNPF is the public establishment in charge of developing the sustainable management of private forests.
- **COI – Conseil d'Orientation des Infrastructures -** https://www.ecologie.gouv.fr/conseil-dorientation-des-infrastructures-coi The Infrastructure Orientation Council (COI) is an advisory body chaired by the ministry in charge of transport
- Conseil Régional The regional council is the deliberative assembly of the regions. It manages the affairs of the region.
- **Cour des Comptes -** https://www.ccomptes.fr/en - main mission of the Cour des Comptes is to ensure the proper use of public money and to inform citizens about it. It is an independent jurisdiction which assists both the parliament and the government.
- **CSF Bois - Comité Stratégique de Filière Bois -** https://csfbois.wixsite.com/website - CSF Bois is the forum for dialogue between the entire professional sector and public actors. The strategic contract for the wood sector constitutes the framework for inter-ministerial and inter-professional work to implement a global strategy to improve the competitiveness of the entire Forest-Wood sector.
- **DDT – Direction départementale des Territoires -** DDT are the departmental decentralized services of the French State in charge of planning and sustainable development.
- **DREAL/DEAL - Direction régionale de l'Environnement, de l'Aménagement et du Logement -** DREAL are the regional decentralized services of the French State in charge of environment, planning and housing.
- **EDF – Electricité de France -** https://www.edf.fr - EDF, is a French multinational electric utility company, largely owned by the French state.
- **ENEDIS -** https://www.enedis.fr/ - The main operator of the public electricity distribution network in France, managing the low and medium voltage network over 95% of the territory.
- **Entente valabre -** https://www.valabre.com/ - The Entente Valabre brings together 15 departments, 15 departmental fire departments, as well as the Territorial Collectivity of Corsica with the aim of sharing and pooling skills and means for services especially related to information and prevention against forest fires and training for civil security.
- **EPCI - Établissement public de coopération intercommunale -** Public inter-municipality cooperation establishments.
- **Feuille de route pour l'adaptation des forêts au changement climatique -** https://agriculture.gouv.fr/plan-france-relance-une-feuille-de-route-au-service-de-la-filiere-foret-bois-face-au-defi-du - The French Roadmap for Adapting Forests to Climate Change is a roadmap made in 2020 by the forest stakeholders. It contains a list of actions including actions to adapt the forest to climate change.
- **FFA - Fédération française de l'assurance -** https://www.franceassureurs.fr/ - The French insurance federation.
- **FPRNM - Fonds de prévention des risques naturels majeurs -** https://www.ecologie.gouv.fr/financement-prevention-des-risques-naturels-et-hydrauliques - The FPRNM also known as "Fonds Barnier" is a French funds for major natural hazards prevention.
- **FP2E - Fédération des Entreprises de l'Eau -** https://www.fp2e.org/ The French federation of water companies.
- **France stratégie -** https://www.strategie.gouv.fr/ - France Strategie is an institution attached to the Prime Minister. Its objective is to contribute to the determination of the main orientations for the future of the nation and the medium and long-term objectives.
- **GEMAPI / GEMAPI tax - Gestion des milieux aquatiques et la prévention des inondations -** https://www.ecologie.gouv.fr/gestion-des-milieux-aquatiques-et-prevention-des-inondations-gemapi - The management of aquatic environments and the prevention of floods (GEMAPI) is a competence entrusted to the EPCI by the 2018 decentralization law. EPCI can raise a GEMAPI tax to support actions for flood risk prevention and aquatic environments management.
- **GICC - Gestion et Impacts du Changement Climatique -** https://www.ecologie.gouv.fr/gestion-et-impacts-du-changement-climatique - objective of the GICC is to develop knowledge in support of public policies by considering climate change from the angle of its impacts, adaptation to deal with it and measures to mitigate greenhouse gas emissions.
- **GREC - Groupements régionaux d'expertise sur l'évolution du climat -** https://www.acclimaterra.fr/en/ - The GREC are permanent and independent groups of scientific experts within each region capable of providing regional stakeholders the knowledge necessary for their strategy of adaptation to climate change.
- **HCC – Haut Conseil pour le climat -** https://www.hautconseilclimat.fr/en/ - The High Council on Climate (HCC) is an independent body tasked with issuing advice and recommendations to the French government on the delivery of public measures and policies aimed at reducing France's greenhouse gas emissions
- **IGF - Inspection générale des finances –** https://www.igf.finances.gouv.fr/sites/igf/accueil.html - The French general inspectorate of finance.
- **INSEE - Institut national de la statistique et des études économiques -** https://www.insee.fr/fr/ - The French national institute of statistics and economic.
- **INRAE - Institut national de recherche pour l'agriculture, l'alimentation et l'environnement -** https://www.inrae.fr/ - INRAE is a public research institute working for the coherent and sustainable development of agriculture, food and the environment.
- **INRS - Institut national de la recherche scientifique -** https://inrs.ca/ - The Institut national de la recherche scientifique is a Canadian academic institution dedicated exclusively to graduate level research and training. Since its creation in 1969, the institute has built its success on interdisciplinarity, innovation, and excellence.

- **IPSL - Institut Pierre-Simon Laplace -** https://www.ipsl.fr/en/home-en/ - IPSL was created to combine the resources and instruments of the various laboratories to increase their scope and visibility, and to support multidisciplinary studies on the environment.
- **LCR - Loi climat et résilience -** https://www.ecologie.gouv.fr/loi-climat-resilience - The LCR is a 2021 french law on fighting against climate change and building resilience to its effects.
- **LOM - Loi d'Orientation des Mobilités -** https://www.ecologie.gouv.fr/loi-dorientation-des-mobilites - The 2019 mobility orientation law profoundly transforms mobility policy, with a simple objective: make everyday transport easier, less expensive and cleaner.
- **LTECV - Loi de transition énergétique pour la croissance verte -** https://www.ecologie.gouv.fr/loi-transition-energetique-croissance-verte - The 2015 law on energy transition for green growth (LTECV) aims to contribute more effectively to the fight against climate change and the preservation of the environment.
- **Météo-France -** https://meteofrance.fr/ - Météo-France is a public establishment contributing to the safety of French people. It delivers forecasts and data, provides its expertise to meet climate challenges and participates in the progress of research in meteorology and climate science.
- **MRN – Mission Risques Naturels -** https://www.mrn.asso.fr/ - MRN is a French association for the insurance stakeholders. It is a central player between public authorities and insurance stakeholders.
- **OFB – Office Français de la Biodiversité -** https://www.ofb.gouv.fr/ - The French Office for Biodiversity (OFB) is a public institution dedicated to the protection and restoration of biodiversity in mainland France and the Overseas Territories, under the supervision of the Ministries of Ecological Transition and Agriculture.
- **ONERC - Observatoire national sur les effets du réchauffement climatique -** https://www.ecologie.gouv.fr/observatoire-national-sur-effets-du-rechauffement-climatique-onerc - Created in 2001, ONERC's main missions are to collect and disseminate information on the risks associated with global warming, to make recommendations on the adaptation measures to be considered in order to limit the impacts of climate change and to be the interlocutor of the IPCC.
- **ONF – Office National des Forêts -** https://www.onf.fr/- The French office in charge of public forest.
- **PAPI - Programme d'Action pour la Prévention des Inondations -** https://www.ecologie.gouv.fr/prevention-des-inondations - The purpose of the Flood Prevention Action Programmes (PAPI) is to promote comprehensive flood risk management at the scale of a coherent risk basin, with a view to reducing their harmful consequences on human health, property, economic activities and the environment.
- **PCAET - Plan climat-air-énergie territorial -** http://outil2amenagement.cerema.fr/le-plan-climat-air-energie-territorial-pcaet-r438.html - The PCAET is a territorial air-energy climate plan. It is a planning tool, both strategic and operational, which allows local authorities to address all of the air-energy-climate issues in their territory. It is mandatory for EPCI of more than 20,000 inhabitants.
- **Plan Avenir Montagnes / Fonds Avenir Montagnes / Avenir Montagnes Ingénierie / Avenir Montagnes investissement -** https://www.cohesion-territoires.gouv.fr/avenir-montagnes-accompagner-les-territoires-de-montagne - The Plan Avenir Montagnes is a 2 years plan (2020-2022) made within the French Recovery Plan to accompany mountain stakeholders in engineering (Avenir Montagnes ingénierie) and investments (Avenir Montagne investissement) for the achievement of sustainable projects. It is fund using the Fonds Avenir Montagne.
- **Plan Bâtiment Durable -** http://www.planbatimentdurable.fr/ - Launched in 2009, the Plan Bâtiment Durable brings together building and real estate stakeholders with a common mission: to promote the achievement of energy and environmental efficiency objectives of this sector.
- **PNACC 1, 2 & 3 -** Plan national d'adaptation au changement climatique - https://www.ecologie.gouv.fr/adaptation-france-au-changement-climatique - PNACC are the French National Climate Change Adaptation Plan. The first PNACC was realised in 2011 and the second in 2018. The third plan should be realised by mid-2023.
- **PPRi - Plan de prévention des risques naturels d'inondation -** Natural flood risk prevention plan PPRi are made by local authorities to prevent flood risk into their territory.
- **Réseau Bâtiment Durable -** http://www.planbatimentdurable.fr/reseau-batiment-durable-r123.html - The Reseau Bâtiment Durable network unites resource centers and clusters that works for the quality and environmental, energy and health performance of the buildings sector.
- **RGE - Reconnu garant de l'environnement -** https://www.economie.gouv.fr/entreprises/batiment-label-rge - RGE is an environmental standard for French craftsmen and companies of building sector.
- **RTE -** https://www.rte-france.com/ - RTE is the manager of the French electricity transmission network.
- **Santé Publique France -** https://www.santepubliquefrance.fr/ - Santé Publique France is a public institution that carries out epidemiological observation and surveillance to know and deepen the knowledge of the state of health of the population in order to advise for health policies.
- **SDIS - Service Départemental d'Incendie et de Secours -** The departmental fire and rescue services.
- **Société du Grand Paris -** https://www.societedugrandparis.fr/ - The Société du Grand Paris is a public institution in charge of designing and building the public transport network of the Grand Paris.
- **SFEC - Stratégie Française Énergie Climat -** https://concertation-strategie-energie-climat.gouv.fr/ - The Stratégie Française Énergie Climat is a new strategy that will be realized by mid-2023. It contains the third Stratégie National Bas Carbone (SNBC), the third Programmation pluriannelle de l'énergie (PPE 2024-2033), the third Plan National d'Adaptation au Changement Climatique (PNACC), and the first Loi de Programmation sur l'Énergie et le Climat (LPEC).

- **SNBC - Stratégie Nationale Bas-Carbone -** https://www.ecologie.gouv.fr/strategie-nationale-bas-carbone-snbc - The National Low-Carbon Strategy (SNBC) is the French roadmap for fighting against climate change. The third version is under construction and should be realized by mid-2023.
- **SNCF Réseau -** https://www.sncf-reseau.com/en - The French manager for railway network.
- **TACCT - Trajectoires d'Adaptation au Changement Climatique des Territoires -** https://tacct.ademe.fr/ - The TACCT approach is made by ADEME to accompany local authorities to develop their adaptation to climate change policy from the diagnosis of vulnerability to the monitoring of measures and the evaluation of the strategy.
- **Trophées Bâtiments Résilients -** https://www.mrn.asso.fr/resilience/trophees-batiments-resilients/ - Trophées Bâtiments Résilients is an annual competition that aimed to reward resilient buildings, new, renovated or rebuilt, designed to cope with natural hazards and climate change.
- **Varenne agricole de l'eau et de l'adaptation au changement climatique -** https://agriculture.gouv.fr/varenne-agricole-de-leau-et-de-ladaptation-au-changement-climatique-3e-conference-de-la-thematique - This round table aims to engage a collective reflection and to build sustainable policies for the resilience of agriculture facing climate change.
- **VNF - Voies navigables de France -** https://www.vnf.fr/vnf/ - VNF is a public establishment responsible for managing approximately 80% of the network of inland waterways in France.

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