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Towards the emergence of adaptation services : observation of adaptation governance across spatial scales

Anastasia Panenko

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THÈSE

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VERS LE DÉVELOPPEMENT DE SERVICES D'ADAPTATION.

Observation de l'adaptation au changement climatique à différentes échelles spatiales.

TOWARDS THE EMERGENCE OF ADAPTATION SERVICES.

Observation of adaptation governance across spatial scales.

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Abstract

This PhD thesis aims at understanding climate adaptation services and their place in multi-level governance of adaptation to climate change. So far, when depicting the value of these services for evidence-based adaptation policymaking, the literature has paid little attention to institutional contexts. We argue that these services may be impacted by the articulation of adaptation governance, as the approaches to vertical and horizontal integration of adaptation will differ from one country to another. Ergo our idea to address climate adaptation products, services, and knowledge-action systems as part of this landscape, and to tackle obstacles and boosting factors for their development and use. To shed light on these topics, we will adopt a mixed approach. We will combine qualitative and quantitative methods to map the development of climate adaptation services, and to address the potential of these services with their “users” and “producers”.

Climate services will be illustrated from the perspective of science-policy interactions (Funtowicz and Ravets, 1990; Nowotny, Scott, and Gibbons, 2001; Spruijt et al., 2014). In fact, the 1st generation of climate services took the form of projections, maps, or vulnerability reports (Goosen et al., 2014). These services did not match the demands of decisionmakers (WMO, 2011; Lúcio and Grasso, 2016). Hence our interest in adaptation services (the 2nd generation): they provide knowledge exchange mechanisms to make a better use of climate projections (Weichselgartner and Arheimer, 2019). More specifically, we will investigate boundary organisations offering adaptation services, such as Ouranos Inc, Climate Ireland, or CCCA among others (Cvitanovic et al., 2015; Choi et al., 2016). Our goal is to identify potential mismatches between offer and demand in science for adaptation, but also to illustrate key ingredients that allowed boundary organisations to cross the “valley of death” separating decisionmakers and scientists (Buontempo et al., 2014).

We will conduct a study on adaptation governance in France, and on knowledge needs of local authorities in Auvergne-Rhône-Alpes region. In fact, adaptation is still a small part of local climate plans, even if there was a significant improvement between the first (PCET) and the second (PCAET) generation of climate plans. Additionally, views on what is and what does adaptation vary between intercommunalities, reflecting several discrepancies in the vertical integration adaptation policymaking. When it comes to available adaptation products, these rarely support intercommunalities throughout all stages of adaptation cycles (Goosen et al., 2014). Local authorities have difficulties when framing adaptation, but also when monitoring and evaluating their progress. Therefore, we argue for managing, not solving adaptation. In fact, wicked problems such as adaptation cannot be solved because they are continuously changing and involving conflicting values (Churchman, 1967). Based on our findings, we argue that local authorities’ knowledge needs are not covered by adaptation products. There is need for adaptation services instead.

Key words: climate change adaptation, adaptation governance, adaptation services

Résumé

Cette thèse vise à comprendre les services d'adaptation climatique et leurs places dans la gouvernance multi-niveau de l'adaptation au changement climatique. Jusqu'à présent, lorsqu'elle décrit la valeur de ces services pour l'élaboration de politiques d'adaptation, la littérature a accordé peu d'attention aux contextes institutionnels. Nous soutenons que ces services peuvent être impactés par l'articulation de la gouvernance de l'adaptation, car les approches de l'intégration verticale et horizontale de l'adaptation diffèrent d'un pays à l'autre. Notre idée est donc d'aborder les produits, les services et les systèmes de connaissance-action dans le cadre de ce paysage, et de s'attaquer aux obstacles et aux facteurs stimulant leur développement et leur utilisation. Pour éclairer ces sujets, nous adopterons une approche mixte. Nous combinerons des méthodes qualitatives et quantitatives pour cartographier le développement des services d'adaptation au climat, et pour adresser le potentiel de ces services avec leurs « utilisateurs » et « producteurs ».

Les services climatiques seront illustrés du point de vue des interactions science-politique (Funtowicz et Ravets, 1990; Nowotny, Scott et Gibbons, 2001 ; Spruijt et al., 2014). De fait, la 1ère génération de services climatiques a pris la forme de projections, de cartes ou de rapports de vulnérabilité (Goosen et al., 2014). Ces services ne correspondaient pas aux demandes des décideurs (OMM, 2011; Lúcio and Grasso, 2016). D'où notre intérêt pour les services d'adaptation (la 2ème génération) car ils fournissent des mécanismes d'échange de connaissances afin de mieux exploiter les projections climatiques (Weichselgartner et Arheimer, 2019). Plus précisément, nous étudierons les organisations frontalière offrant des services d'adaptation, car elles ont été identifiées comme une solution pertinente au fossé entre la science et la politique (Cvitanovic et al., 2015; Choi et al., 2016). Notre objectif n'est pas seulement d'identifier les inadéquations potentielles entre l'offre et la demande en science de l'adaptation, mais aussi d'illustrer les ingrédients clés qui ont permis aux organisations frontalières de traverser la « vallée de la mort » séparant décideurs et scientifiques (Buontempo et al., 2014).

Nous allons mener une étude sur la gouvernance de l'adaptation en France, et sur les besoins de connaissances des collectivités locales en région Auvergne-Rhône-Alpes. En effet, l'adaptation concerne encore une petite partie des plans climats locaux, même s'il y a eu une amélioration significative entre la première (PCET) et la deuxième (PCAET) génération de plans climat. De plus, les points de vue sur ce qu'est l'adaptation varient entre les intercommunalités, reflétant plusieurs divergences dans l'élaboration des politiques d'adaptation. Quant aux produits d'adaptation disponibles, ceux-ci accompagnent rarement les intercommunalités à toutes les étapes des cycles d'adaptation (Goosen et al., 2014). Les autorités locales rencontrent des difficultés à encadrer l'adaptation, mais aussi à suivre et évaluer leurs progrès. Par conséquent, nous plaidons pour la *gestion* de l'adaptation. En fait, les problèmes perniciose tels que l'adaptation ne peuvent être résolus car ils changent continuellement et impliquent des valeurs contradictoires (Churchman, 1967). Sur la base de nos résultats, nous soutenons que les besoins en connaissances des autorités locales ne sont pas couverts par les produits d'adaptation. Pour s'adapter à l'échelle locale, il faut des *services* d'adaptation.

Mots clés : adaptation au changement climatique, gouvernance de l'adaptation, services d'adaptation

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List of Abbreviations

ADEME	French Environment and Energy Management Agency (Agence De l'Environnement et de la Maîtrise de l'Énergie)
AFP	Adaptation policy framework
AuRA	Auvergne-Rhône-Alpes
BC3	Basque Centre for Climate Change
BO	Boundary organisation
CA	Community of agglomerations
CAS	Climate Adaptation Services
CC	Community of communes
CCA KAS	Climate change adaptation knowledge- action systems
CCAP	Climate Change Adaptation Products
CCAS	Climate Change Adaptation Services
CCCA	Climate Change Centre Austria
CMCC	The Euro-Mediterranean Center on Climate Change
Creseb	Center for Resources and Scientific Expertise on Water in Brittany (Centre de Ressources et d'Expertise Scientifique sur l'Eau de Bretagne)
DDT	Departmental land-use directorate (Direction départementale des Territoires)
DREAL	Regional Department for the Environment, Development and Housing (direction régionale de l'Environnement, de l'Aménagement et du Logement)
EB	Evidence-based
EEA	European Environment Agency
ERA4CS	European Research Area for Climate Services
ERDF	European Regional Development Fund
EU	European Union
GDP	Gross domestic product
GFCS	Global Framework for Climate Services
GHG	Greenhouse gas
GIS	Scientific Interest Group
Grec-Sud	Regional Expert Groups on Climate (Groupes Régionaux d'Expert·es sur le Climat)
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
MedECC	Mediterranean Experts on Climate and environmental Change
MTES	Ministry of Ecological Transition (Ministère de la Transition écologique)
NAP	National adaptation plan
NAS	National adaptation strategy
NUTS	Nomenclature of Territorial Units for Statistics
ONERC	French National Observatory of the Effects of Global Warming (Observatoire National des Effets du Réchauffement Climatique)
ORCAE	Regional observatory on the effects of climate change (Observatoire Régional Climat Air Energie)
PCAET	Territorial climate, air, energy plan (Plan Climat Air Énergie Territorial)

PCET	Territorial climate energy plan (Plan Climat Énergie Territorial)
PNACC	National plan on adaptation to climate change
RECO	Network of expertise on climate change in Occitania (Réseau d'expertise sur les Changements climatiques en Occitanie)
SCoT	Territorial Coherence Scheme (Schéma de Cohérence Territoriale)
SMHI	Swedish Meteorological and Hydrological Institute
SRADDET	Regional Planning, Sustainable Development and Territorial Equality Scheme (Schéma Régional d'Aménagement, de Développement Durable, et d'Égalité des Territoires)
SRCAE	Regional Climate Air Energy Plan (Schéma Régional Climat Air Énergie)
TEPOS	Positive energy territory for green growth (Territoire à énergie positive pour la croissance verte)
UKCIP	UK Climate Impacts Programme
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organisation

Introduction

The effects of climate change can be seen all over the planet, from the increase, decrease or intensity of rainfall to rising sea levels and melting glaciers. Although in some cases these effects are less visible at the local level, the overall global warming trend affects all societies around the globe. The European Environment Agency has indicated that land temperatures in Europe have increased by 1.7-1.9°C compared to pre-industrial times, with varying impacts across Member States (European Environment Agency 2019). According to the Green Paper on Adaptation, several areas in the European Union (EU) will be particularly affected by climate change, such as Mediterranean and mountainous regions (European Commission, 2007). Mountain regions are already experiencing higher temperature increases and/or subsequent decreases in annual precipitation and river flows, reductions in glacier volumes and permafrost areas, and risks of biodiversity loss and species extinction (European Environment Agency 2016). Moreover, the summer of 2022, as the hottest and driest¹, could be our last call to accelerate mitigation efforts, and help our societies adapt to future challenges.

While adaptation refers to processes (actions and decisions) that improve our preparedness to withstand the impacts of climate change, mitigation aims to alleviate the impacts by reducing greenhouse gas (GHG) emissions into the atmosphere (eea.europa.eu). These strategies are now complementary, but it took some time to “*lift taboo on adaptation*” (Pielke et al., 2007). For example, the United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 with the objective “*to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference*” (unfccc.int). In the same year, US ex-vice president Al Gore defined adaptation as “*kind of laziness, an arrogant faith in our ability to react in time to save our skins*” (Al Gore, 1992, in Pielke et al., 2007). The general attitude towards adaptation changed more than a decade later with the publication of one of the most widely discussed documents on the impacts and costs of climate change - the so-called Stern Review², in which Nicholas Stern pointed out that climate change is the “*greatest and widest-ranging market failure ever seen*” (2007). According to recent estimates by COACCH project³, the

¹ Above average for the period 1991-2020 (ERA5, Copernicus Climate Change Service/ECMWF)

² The Economics of Climate Change: The Stern Review was released by Her Majesty’s Treasury of the UK Government in October 2006. The report was published in January 2007 by Cambridge University Press (<https://www.lse.ac.uk>).

³ COACCH - CO-designing the Assessment of Climate CHange costs- is an innovative research project that gathers leading experts on climate change sciences from 13 European research institutions (<https://www.coacch.eu/>)

number of Europeans exposed to flooding could range from 1.8 million to 2.9 million if no investment is made in adaptation (RCP2.6 and RCP8.5⁴). Indeed, the expected annual damage from floods is estimated at between €135 and €145 billion, rising to €450 or €650 billion by the 2080s (depending on the RCP scenario). In addition, the estimated number of excess deaths due to heat could range from 85,000 (RCP2.6) to 300,000 (RCP8.5) by the end of the century (COACCCH (2019)). Furthermore, impacts on the natural and man-made environment will lead to economic costs in climate-dependent sectors such as agriculture, fisheries, tourism, etc. These elements encourage us to focus on adapting to climate change in this Doctoral Thesis.

There are several ways to define adaptation. To the EU, “*adapting to climate change means taking action to prepare for and adjust to both the current effects of climate change, and the predicted impacts in the future*” (ec.europa.eu). Adaptation is defined by Adger et al. as “*continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes*” (2005:78). For us, adaptation to climate change is a process of policy making, the aim of which is to equip our societies for future challenges. To explore the process of adaptation policymaking, we will focus on the EU and its Member States, although some examples outside the EU will also be discussed.

Most EU countries have some basic legal rights related to the protection of citizens from the negative impacts of climate change: The European Convention on Human Rights, the European Charter of Human Rights, the EU Treaty, national constitutions or ordinary legislation, the global adaptation target in Article 7 of the Paris Agreement, Sustainable Development Goal 13, European climate law. Given the economic and human costs mentioned above, any new investment or policy should be climate-informed and climate-proof. Indeed, developing adaptation plans to manage impacts and minimise costs is a common strategy to prepare for future challenges.

From this point of view, climate services can be a solution - or rather a tool - for evidence-based decision making. The EU defines climate services as “*transformation of climate-related data — together with other relevant information — into customized products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use*

⁴ RCP stand for Representative Concentration Pathway s a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC. RCP2.6 stands for the most optimistic scenario where global temperature increase stays below 2°C, while the RCP8.5 projects an increase between 3.0 - 12.6 °C.

for the society at large” (European Commission, 2016). In fact, this definition is quite broad and does not specifically target adaptation. However, the market for climate services is characterised by the presence of different actors (from international organisations to local stakeholders) with different objectives and needs (e.g. different spatial and temporal scales).

Today, we can track changes in the atmosphere, produce reports on future climate conditions with varying degrees of uncertainty depending on the scope. We can provide estimates of the impacts of these changes on our livelihoods. Both the EU and the World Meteorological Organisation (WMO) stress the importance of ensuring that the best available research is used to inform decision-making for both adaptation and mitigation strategies (WMO, 2011). Knowledge provision is therefore key to achieving evidence-based decision making.

However, decision-making for adaptation is spread across spatial scales: from EU, to national, sub-national, and local ones. Adaptation to climate change is a multi-scale issue characterized by multi-level governance. Additionally, the European Commission argues that *“one of the greatest challenges for cost-effective adaptation measures is to achieve coordination and coherence at the various levels of planning and management”* (European Commission, 2013:5). Four main documents are used to guide adaptation action at EU scale: Green Paper (2007), White Paper (2009), Adaptation Strategy (2013 and 2021). While the EU adaptation strategies outline the breakdown of responsibilities between the EU, national and sub-national levels, these documents point out that many climate-related decisions are taken at the local level (European Commission, 2007). The Green Paper highlighted that the local level *“is where detailed knowledge on natural and human conditions is available”* (2007:11). Like most of EU countries, France has adopted its second version of national adaptation plan (PNACC⁵). French regions and local authorities have seen their climate policy responsibilities increase as new legal obligations have emerged. Since 2015, French intercommunal authorities with 20,000 inhabitants have had to draw up Climate Air Energy Plans (PCAET), the French local climate change management tool. But where does adaptation fit into these plans? How is it designed and implemented? What role could climate services play in the implementation of adaptation? How is adaptation articulated across different scales?

⁵ PNACC is elaborated by the Ministry of Ecological Transition and Territorial Cohesion

To answer these questions, our research will span the EU, national, sub-national and local levels. Indeed, one of our objectives is to map this multi-level governance in Europe and France, but also to delineate the role of climate services in adaptation policy-making. Therefore, we have adopted a funnel approach and designed our research protocol to analyse the institutional context, the decision-making process and the place of climate services for adaptation at different scales. To map adaptation governance, we will inquire about adaptation policies and plans at the European, national and sub-national levels. Furthermore, we will focus specifically on existing climate services for adaptation and inquire into the knowledge needs of intermunicipalities in a particular area: The Auvergne-Rhône-Alpes region in France.

Indeed, Auvergne-Rhône-Alpes (AuRA) is one of the most privileged areas in the EU to observe the effects of climate change. Considered the water towers of Europe, the Alps are the main source of fresh water for the whole continent. In fact, climate change is a major threat to socio-ecological systems: from hydrological systems to the livelihoods of its inhabitants (European Environment Agency 2009). If we consider the IPCC's definition of vulnerability to climate change, which is "*a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity*" (McCarthy, Intergovernmental Panel on Climate Change 2001:21). Auvergne-Rhône-Alpes is indeed a relevant area for our study. The IPCC defines exposure as the presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social or cultural assets in places and environments that could be adversely affected. Adaptive capacity is the ability of systems, institutions, people and other organisms to adjust to potential harm, take advantage of opportunities or respond to consequences. Sensitivity is the degree to which a system or species is affected, either negatively or positively, by climate variability or change (IPCC, AR6, 2022:2897-2927).

Firstly, the AuRA region is characterised by high exposure, being the second most populated region in France after Ile-de-France (Paris).. Roughly 8ml people are spread across its big cities such as Lyon or Grenoble, smaller towns and villages situated at more or less high altitude. The challenges of climate change and energy transition are particularly pronounced in AuRA due to the nature of human activities and the richness of its natural heritage. AuRA is the leading energy region in France, if not in Europe, thanks to the importance of hydroelectric plants in the Alps and on the Rhône and the presence of four nuclear power plants (Agence nationale de la cohésion des territoires 2014). Secondly, as highlighted above, the threat of climate change is particularly acute in Alpine regions. As noted, mountain regions experience higher temperature increases and precipitation changes (European Environment Agency, 2016). Changes in the mountain cryosphere (including

snow, glaciers, permafrost, lake and river ice) affect water resources and agriculture at lower altitudes (IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019). In addition, around 50% of Alpine plant species are projected to lose more than 80% of their suitable habitat (Alpine Convention, 2017). Finally, the vulnerability and adaptive capacity of institutions are at stake and will be the focus of our research. More specifically, we aim at understanding knowledge needs for adaptation for intercommunalities at local scales.

When discussing the role and the value of climate services, Roger Street has underlined that the “*potential market is largely untapped*” (2016:3). According to him, demand is relatively fragmented, and the available services are primarily supply driven. As a matter of fact, the mere production of knowledge on a particular topic does not indicate whether this information is being used:

“*More information does not mean better decisions*” (Sarewitz and Pielke, 2007).

According to Sarewitz and Pielke, “*the potential for science to contribute to societal goals depends critically on factors well beyond science*” and “*better science portfolios would be achieved if they reflected an understanding of supply, demand and the complex dynamic relationship between them*” (2007:6). Hence, to fully untap climate services’ market, there is need to understand the demand side: what are the users’ needs? For example, Räsänen et al have assessed the needs of Finnish municipalities to conclude that “*in addition to climate services, there is need for non-climate services, i.e. services that explain how to use information that is not directly related to climate*” (2017:29). The so-called first generation of climate services failed to create a twofold connection between science and policy. In practice, there is no common blueprint for climate services, as they vary from provision of mapping tools to capacity building activities such as workshops. Besides, they can be developed by NGOs, research institutions or consultancy companies; they can focus on specific sectors and spatial scales; they can be provided for free or not.

This complex constellation of different products and services developed by/for different stakeholders makes the comparison and evaluation quite a challenging task. Can we refine the terminology? Can we identify different kinds of climate services? Which type of climate service is suitable for adaptation strategies of local authorities in the Auvergne-Rhône-Alpes region? This thesis will be guided by a core research question:

To develop adaptation strategies at the local level, what kind of climate services do policy makers need?

To answer this research question, sub-questions are addressed, on the one hand, to understand the object of this study: knowledge for adaptation. On the other hand, to

understand the governance of adaptation on different spatial scales: from the EU level to the local one. Climate services should not be seen as isolated tools, but must consider how the governance of adaptation is articulated. We argue that their use for evidence-informed adaptation planning will be influenced by broader institutional context. However, existing research has not examined climate services from this “macro” perspective. Representing climate services as part of adaptation governance systems represents the ambition of this work.

To illustrate our approach, this manuscript is articulated in 5 chapters (Table 1):

Table 1 Thesis' structure

Thesis structure	Sub-questions
<p>Chapter 1: From climate services to adaptation service</p>	<p>Adaptation, its governance, and cycles. What are climate services, where are they used, and how are they evaluated? Multi-level governance of adaptation in France?</p>
<p>Chapter 2: Research design and methods</p>	<p>What methods and tools can we use to answer the main research question?</p>
<p>Chapter 3: Mapping the climate change adaptation knowledge-actions systems in EU</p>	<p>What is the state of adaptation in the EU and its Member States? Can the degree of decentralisation of a given country influence the development of adaptation systems?</p>
<p>Chapter 4: Boundary organisations in adaptation services</p>	<p>What are boundary organisations and what are their specificities in the field of adaptation? What are the main challenges faced by boundary organisations? What are the key ingredients for successful knowledge sharing?</p>
<p>Chapter 5: Knowledge needs for adaptation at local scale. Auvergne-Rhône Alpes case study</p>	<p>What is the horizontal and vertical integration of adaptation in France? How is adaptation framed at the local level? What climate services are available to local authorities and how are they used? What are the knowledge needs for adaptation at the local level?</p>

General conclusions**Main research question**

Climate services for local adaptation policymaking.

Chapter 1: Literature review

The first chapter presents the literature review on adaptation and climate services: from historical notes to examples of climate services, their strengths and weaknesses. As this market has been developing for 10 years, we can distinguish the first generation of climate services from a more recent one. The latter emerged in response to criticism of the first prototypes. More precisely, the main challenges of these services are rooted in the relationship between scientists and decision-makers. Indeed, the whole idea of unidirectional knowledge transfer is questioned and climate services are discussed through post-normal science and transdisciplinary approaches. This phase allowed us to break down climate services into precise categories and to refine the objectives of our fieldwork with producers of such services. We also conducted bibliographic research on science-policy interactions and adaptation governance.

Chapter 2: Research design and methods

This part outlines the methodology deployed, including the research framework, strategy, limitations, and means of data collection and analysis.

Chapter 3: Mapping the climate change adaptation knowledge-actions systems in EU.

Chapter 3 first discusses adaptation strategies and plans in the EU, its Member States and at sub-national (usually regional) level. We will discuss the differences between EU Member States in terms of the timing of implementation of national and sub-national strategies and plans. Second, we will illustrate all available climate products and services in EU countries, classifying them according to the typologies discussed in Chapter 1 (Weichselgartner and Arheimer 2019). This chapter was published in *Climate Services journal*, and it is available online: <https://doi.org/10.1016/j.cliser.2021.100265>.

Chapter 4: Boundary organisations in adaptation services

This chapter will zoom in on: adaptation services provided by boundary organisations. These services are nested in different countries (Ireland, Austria, Sweden, France, Spain, Italy, Netherlands, Canada). Our analysis aims to understand which factors need to be taken into account to ensure the development of boundary organisations, among which maturity (age), legal status, financial and institutional stability. Thus, we can identify strategies that have helped them to develop over time and to connect with their users.

Chapter 5: Auvergne Rhône-Alpes. Knowledge needs for adaptation

In this chapter, we will discuss adaptation and its wickedness, illustrate adaptation cycles and the legal framework for adaptation in France. We will then illustrate the knowledge needs specifically in the Auvergne-Rhône-Alpes region: what is the place of adaptation in adaptation plans of the local authorities? How do they currently use climate services and what are their needs? Do they need a specific type of climate service?

General conclusions

The final stage relates to the conclusions of this study. More specifically, we combine the findings from the case studies to answer the main research question of this thesis. In addition, this stage allowed us to critically evaluate our research design and identify opportunities for further investigation. The final chapter highlights the main findings of this thesis, its limitations and ideas for future research.

Chapter 1

From climate services to adaptation services



“More information does not mean better decisions”

Sarewitz and Pielke, 2007

What are climate services and what is their role in adaptation to climate change? This chapter will provide answers to these questions and illustrate theoretical frameworks guiding this PhD thesis. To comprehend climate services and their role in adaptation to climate change, we will address this topic from various perspectives. Firstly, adaptation to climate change will be discussed – its governance and policy cycles (section 1.1). Secondly, sections 1.2 and 1.3 will be dedicated to climate services, their history, use cases, and evaluation. Based on the inputs from previous sections, the last section of this chapter will propose new type of climate services – adaptation services (1.4).

1.1 Adaptation: governance and policy cycles

Although adaptation policies can be found at different scales and research projects tackle adaptation from different perspectives, Pielke et al. (2007) have pointed out that it took time to lift taboo on this topic. The authors explain that adapting to climate change was problematic for those advocating for emissions' reduction, consequently, the focus on mitigation has led to creation of policy instruments that are biased against adaptation (Pielke et al., 2007). Nonetheless, the efforts of IPCC and the Stern Review on Economics of Climate Change (2006) have contributed to the shift in attitude towards adaptation. In fact, several reasons have contributed to lifting the taboo (Pielke et al., 2007):

- Mitigation actions will take decades to produce effects on the climate (timescale mismatch).
- Vulnerabilities to climate impacts are also increasing due to non-climate reasons, such as population growth.
- The impacts on the natural and man-made environment will lead to economic costs in sectors which strongly depend on climatic conditions, such as agriculture, fisheries, tourism among others.
- Climate litigation cases are rising, as those who suffer from climate impacts are arguing for improved resilience of societies.

Numerous reports on the costs of inaction have contributed to the rise of adaptation on policy agendas (Stern review, 2007; COACC project's estimates, among others). In public health sectors climate change "*has gone from a possible concern to what appears to be an actual threat in just over two decades*" (Hess et al., 2014:1177). Additionally, as indicated in the introduction, Most EU countries have some basic legal rights related to

protection of citizens from negative effects of climate change⁶. It is not surprising that the numbers of climate change litigations are growing. citizens, businesses, and NGOs have turned to the courts to seek protection through the reinforcement of existing laws, integration of climate action into existing environmental and energy policy frameworks. The United Nations has pointed out that there were 884 law cases in 24 countries in 2017, compared to 1550 cases in 38 countries in 2020 (UNEP, 2020). According to the same UNEP report “*an increasing number of cases challenge environmental impact assessments, planning and permitting decisions for built infrastructure, and natural resources management on the basis that governments have failed to adequately account for climate change*”. (UNEP, 2020:25). In fact, “*account for*” does not exclusively refer to fighting the climate change, as in case of Paris agreement aiming at keeping the increase in global average temperature to below 2°C, or as in case of European carbon market directives implementing world's first international emissions trading system in 2005. Taking into account means developing capabilities to project ourselves into the future and prepare our societies for new challenges. However, climate change policies around the Globe remain inadequate to face present and future challenges (UNEP, 2020).

Nowadays adaptation is institutionalized at different levels of governance - UN, EU, national and sub-national levels (among others). Nonetheless, there are differences in how adaptation is framed: while for UNFCCC there is need to adapt because of changing climate, decisionmakers and sustainable development scholars argue for a broader range of actions, not limited to climate change (<https://unfccc.int>). The UNFCCC view on adaptation is the one to be largely accepted. For example, to the EU, “*adapting to climate change means taking action to prepare for and adjust to both the current effects of climate change, and the predicted impacts in the future*” (ec.europa.eu). As one can see, the EU argues for adaptation to the effects of climate change.

Given the above-mentioned economic and human costs, but also thanks to the shift in the views on adaptation, decision makers are expected to deliver climate-informed and climate-proof investments and policies. Adaptation strategies and plans improve our preparedness for the impacts of climate change. Climate services, in turn, aim to support evidence-based decision-making. The evidence-based (EB) decision making has its roots in public health sector, and it is defined as “*the development, implementation, and evaluation of effective programs and policies in public health through application of principles of scientific reasoning*” (Baker et al., 2009:342). According to Dang et al. (2022),

⁶ European convention of human rights, the European charter of human rights, the EU treaty, national constitutions or ordinary legislation, the global goal on adaptation in Article 7 of the Paris Agreement, Sustainable Development Goal 13, European Climate Law.

the EB is a process used to review, analyse, and translate the latest scientific evidence. While the core goal of EB is to apply the latest scientific evidence to improve public health, Hess et al. (2014) stress the importance of knowledge generation and translation so assure that scientific advances are translated into practice. In the case of adaptation, climate services should represent what Hess et al. (2014) define as “knowledge generation and translation” of latest scientific evidence on impacts of climate change into policies. Nonetheless, Swart et al. argue that adaptation is a wicked problem, and that “*inadequate knowledge for adaptation forms one important reason why progress in delivering adaptation action has been limited*” (2014:1). Originally, Churchman (1967) defined wicked problems as a type of social problem that are ill-defined, continuously changing, and involving conflicting values. Therefore, Swart et al. (2014) favor multidisciplinary approaches, as conventional disciplinary approaches are inadequate when dealing with wicked problems (these will be discussed in section 1.4 and 1.5). Swart et al (2014) make a distinction between **science of adaptation**, oriented by disciplinary approaches and aiming at understanding adaptation, and **science for adaptation**, which targets societal stakeholders and practice-side. Similar views are shared by EB scholars in the public health sector. Hess et al. have pointed out that for science to support the practice, “*researchers may consider prioritizing problems with real-world applications, sometimes in close collaboration with practitioners*” (2014:1184).

The need for different approaches was expressed by scholars in different domains. Rittel and Webber (1973) argue that science-based or technical approaches are not always efficient for public policy (positivist social science/linear transfer). The authors criticize science orthodoxy for social policy and urban planning. Other authors point out that sociocultural and cognitive differences can hinder agreement around complex issues in the context of plural policy-relevant knowledge (Head, 2019).

Wicked as it is, adaptation is a process of learning by doing that requires time and effort. Rittel and Webber explain that an issue becomes less problematic when through a “*process of negotiation a solution emerges gradually among participants*” (1973:162). According to several authors, wicked problems do not need to be ‘fixed’ but addressed and managed (Conklin, 2003). Therefore, managing adaptation is more realistic than solving it. Managing adaptation refers not only to specific approaches in spatial planning, but also to the coordination between spatial scales. According to the European Commission, “*one of the greatest challenges for cost-effective adaptation measures is to achieve **coordination and coherence at the various levels of planning and management***” (European Commission, 2013). What the EU is describing here is the so-called multi-level governance of adaptation, which we will discuss in the following section.

1.1.1 Multi-level governance of adaptation

There are several ways to define multi-level governance (Table 2). Both definitions in Table 2 talk about a system of governance across scales, as well as sideways and between sectors. Furthermore, Corfee-Morlot et al (2009) underlined 2 dimensions of multi-level governance: 1) a vertical dimension or a “*relationship between local and national action on climate change*”, where the local scale functions within legal and institutional frameworks implemented at higher scales (useful for understanding adaptation across scales); 2) a horizontal dimension, or “*a relationship based on formal and informal networks and coalitions, where actors operate across organisational boundaries*” .

Table 2 Multi-level governance, definitions

Definition	Authors
The multi-level system of governance combines sufficiently decentralized adaptive governance for local initiatives to grow, but also fostering networks and the diffusion of best practices and enhancing collective action across scales.	Underdal, 2010
Multi-level governance tends to refer to systems of governance where there is a dispersion of authority upwards, downwards, and sideways between levels of government – local, regional, national, and supra-national – as well as across spheres and sectors, including states, markets and civil society.	Daniell and Kay, 2018

In turn, the concepts of networks and cross-scale interactions are closely related to polycentric governance, a particular type of governance system that also spans across scales. Di Gregorio et al. defines polycentric governance as “*a structure that spans from global to national and sub-national levels, relying on both formal and informal networks and policy channels, where state and non-state actors are involved in formulating and implementing climate policies and actions*” (2019:64). Similarly, according to E. Ostrom (2005), polycentric governance systems are composed of overlapping decision-making units and include specific arrangements/special-purpose units that work across multiple jurisdictional levels to ensure sufficient coordination. Polycentricity is associated with better links to local knowledge, improved information transmission, and enhanced adaptive-management capacity (Marshall, 2009).

However, approaches to vertical and horizontal integration will differ between countries and will reflect their intrinsic features, such as degrees of decentralisation or policy-making traditions. Ergo our interest in addressing these issues first, and only then discussing climate services. As stated in introduction, we believe that the articulation of

adaptation governance may represent a barrier or foster the uptake of climate information and tools. Vertical and horizontal integration of adaptation across scales provides us with a “macro” perspective on adaptation policymaking. On the contrary, when zooming on a specific policy, we move to the “micro” perspective. While the macro perspective allows us to apprehend the broader context of adaptation policymaking, the micro perspective illustrates how one specific decision was taken. In fact, the process of policymaking relies on several stages. It will be discussed in the following section.

1.1.2 Policy cycles: stages, perspectives, and concepts

The conceptualization of policy cycles begun in 1950s with Harold Lasswell’s idea to break down this process into 7 major stages. Although public policy science has experienced evolution, and Lasswell’s theories have been criticized, the scientific community is still dividing policy cycles into four major functional stages: agenda-setting, policy formulation, policy implementation and policy evaluation (Skok, 1995; Howlett and Ramesh, 2003):

1. *Agenda setting*: a process in which actors and institutions, influenced by their ideologies, or interests transform social conditions into “public problems”, influencing their appearance and weight in political debates. According to Howlett and Ramesh, (2003) during this stage the existence of a problem and the need to tackle it have been acknowledged.
2. *Formulation*: identifying and assessing of solutions to the problem, analyzing their trade-offs and creating a policy-strategy (Howlett and Ramesh 2003).
3. *Implementation*: as policies are not self-executing, this phase will relate to enacting them (applying the strategy).
4. *Evaluation*: this stage aims at understanding how decision-making process can be improved (did it work?). Unfortunately, it is often a neglected part of the cycle (Barkenbus, 1998).

Agenda setting plays a crucial role in kick-starting the process. Yet it is at the next stage that climate adaptation services are more likely to be used. These stages are considered as the ‘traditional’ sphere for public administration. Although in the traditional public administration literature the dichotomy between politics (elected officials) and administration persists Palumbo (1988), authors such as Lewis (1984) or O’Toole (1989) suggest that these two roles are not functionally separate (Skok, 1995). Therefore, we will target public administration officials when constructing our sample. Moreover, as suggested in Howlett and Ramesh, (2003), we will not interpret this cycle as a linear process, but assume that the order can be altered, or some stages skipped. By introducing

the possibility of iterativity, we take the perspective of decision theorists and their concept of incremental decision-making, defined as: “*decision making involving a fragmented political process in which decision makers have limited knowledge, respond to political pressures, engage in limited successive comparisons, and make small tentative adjustments in existing policies*“(Wilson, 2000:48). In consonance with this citation, we assume that decision-makers have limited knowledge on the climate, respond to the pressures from society, adapt their strategies when contexts change, or new information becomes available. The abovementioned inputs from literature offer a general overview on policy cycles, their stages, and other important concepts from the relevant theories. However, our study targets adaptation planning.

Up to date, there are several ‘adaptation cycles’ elaborated by various researchers and institutions. However, two propositions for adaptation cycles’ formulation have received the most of attention:

1. UKCIP’s Adaptation Cycle (Willows and Connell 2003);
2. UNDP’s Adaptation Policy framework (AFP, Lim and Spanger-Siegfried 2004);

As Stafford-Smith et al (2022) point out, these two guides are rooted in risk management schools of thought and were built on earlier IPCC work. Moreover, inputs from risk management community went as far as being codified in ISO standards⁷, which are also applied to adaptation planning. While these two guides/frameworks represent foundational documents, many other guides were elaborated to accompany policymakers in their adaptation planning. Stafford-Smith et al. (2022) have identified as many as 39 guidelines for practitioners published in the last two decades. Moreover, the authors have proposed a third framework built on the comparison of 39 guides (Stafford-Smith et al. 2022). The authors point out that most of these guides follow the international risk management standard (ISO 31000), align with the IPCC’s guidance (e.g. IPCC, 2012; IPCC, 2014), or refer to the UKCIP or AFP adaptation cycles.

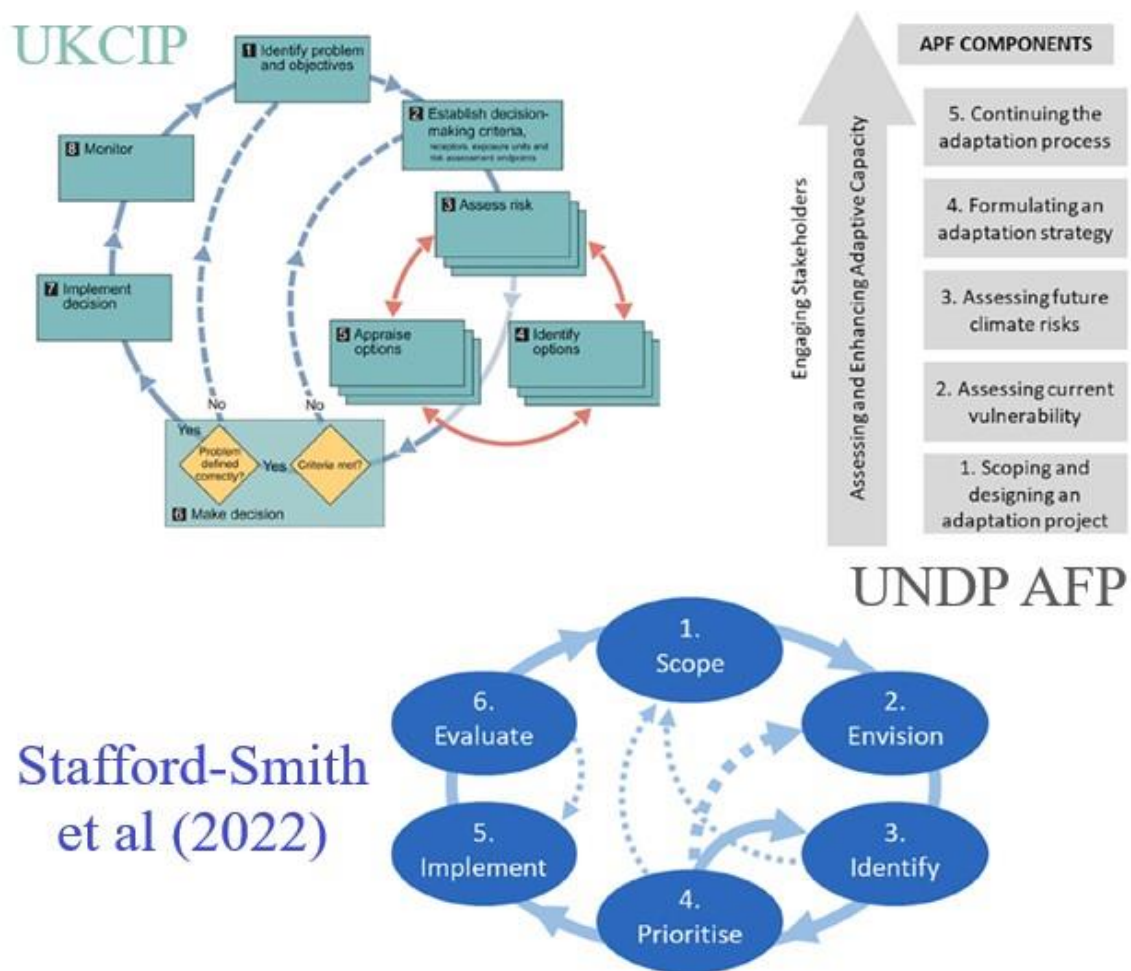
As it is illustrated in Figure 1, UKCIP’s framework is circular, enabling monitoring and revision of decisions. Moreover, it is iterative - the problem identification (stage 1), decision-making criteria (stage 2), risk assessment and options (stages 3, 4 and 5) can be refined prior to detailed risk assessments and options appraisals (Füssel and Klein, 2006). However, this framework applies to situations where 1) decision-makers have reached awareness of the potential relevance of climate change for their decision, 2) relevant

⁷ ISO 31000, ISO 14090, ISO 14091, ISO 14092

decision-makers and other stakeholders are clearly identified, and 3) they are actively seeking guidance (Füssel and Klein, 2006).

The UNDP’s framework (AFP) follows similar stages but offers some additional components, such as the stakeholder’s engagement or the increasing adaptive capacity. As illustrated in Stafford-Smith et al (2022), the adaptive capacity improves with the progress from one stage to another. The AFP “builds on what is already known rather than reinventing the wheel” (UNDP, 2004:10). In fact, this framework does not rely on an abundance of “high quality data”, but aims at strong stakeholder engagement (UNDP, 2004).

Figure 1 Adaptation cycles and guides



Stafford-Smith et al. (2022) explain that most of the guides encourage revisiting the whole cycle and depict them as iterative (eg.: circular imagine). However, the authors argue that there is a major difference in terms of the level of detail that they offer. For Stafford-Smith et al. (2022) one adaptation cycle can trigger another cycle - of a different form or

with more/less detail. The authors suggest that there are 3 types of adaptation cycles (Stafford-Smith et al., 2022:7):

- **Scan cycle** consists of engaging the right stakeholders, general understanding of risks and identifying priority areas for more detailed focus. This type of adaptation cycle is appropriate for well-defined issues or represents a first step for those newly exposed to the need for adaptation.
- **Portfolio cycle** explores a priority domain to identify, prioritises domains and sectors on which to act (often resulting in some activities that can be implemented without further analysis).
- **Project cycle** refers to detailed implementation of adaptation. It targets specific projects that have a well-defined goal and need to reach a specific investment decision, whether these are small or large (the level of quantification and complexity of analysis should be tailored to the size of the project and level of associated contention)

The idea of proposing 3 different types of adaptation cycles is rooted in the fact that not all policymakers will require the same level of detail (Webb et al., 2019; Stafford-Smith et al, 2022): those with little experience will prefer simplified guides, while those with experience will probably prefer detailed and complete guides. Policymakers operate in different contexts, have different access to knowledge and data, are at divergent phases of planning, or simply face different issues (Webb et al., 2019).

Goosen et al. (2014) have pointed out that most of the first generation of climate services deal only with the third stage of adaptation planning cycle – risk assessment (Goosen et al., 2014). These services simply do not aim at problem identification or decision-support as per their design. In fact, their core goal is to deliver climate projections, or climate data in general. Moreover, Stafford-Smith et al, (2022) have come to a similar conclusion. In the 39 guidelines they scrutinized, the scenario planning (Envision) is the step that was most often omitted. Additionally, they argue that the scenario planning was 1) often mixed with risk assessments; 2) focused on climate change and did not consider other factors such as population growth (UNFCCC and EU vision on adaptation).

These three frameworks are based on the “general” stages of policy cycle described above (Palumbo, 1988; Skok, J. E. 1995; Howlett and Ramesh, 2003). However, we find that UNDP’s version does not stress enough for iterativity, and it appears to be linear. UKCIP (2003) and Stafford-Smith et al (2022) follow roughly the same stages and as it is illustrated on Figure 1, the whole process allows for adjustments. For the purpose of this study, we will consider the “generic” policy cycle and couple it with the UKCIP’s adaptation stages. This will provide us with both a simple and a more detailed guide, as we expect that our sample will be characterized by decision-makers with dissimilar experience

and needs. This will allow us to navigate better through interviews with decision makers that operate on different spatial scales and are subject to different legal obligations.

Next section will start with a historical perspective on climate services and discuss the diversity of use cases identified in the literature.

1.2 Climate services for evidence-based adaptation to climate change

First, it is essential to make the difference between Weather Services and Climate services. Weather services provide information on atmosphere status at a given time/place. Climate services - based on historical data and climate modelling - offer estimates/predictions on future weather conditions on different scales and for different weather variables.

World Meteorological Organisation defines them as:

“A decision aide derived from climate information that assists individuals and organisations in society to make improved ex-ante decision-making” (2013:7).

While the European Union considers them as a process:

“Transforming climate-related data and other information into customized products such as projections, trends, economic analysis, advice on best practices, development and evaluation of solutions, and any other climate-related services liable to benefit that may be of use for the society” (2016:10).

For French Ministry for Social and Ecological transition climate services represent:

“Scientific support in terms of information and services for mitigation and adaptation to climate change” (2018).

These three definitions portray climate services as climate data or services for evidence-informed decision making. Policymakers are expected to assure evidence-based decision mechanisms when facing the impacts and the consequences of climate change, or any other environmental issue. The so-called “scientific approaches” have been providing policymakers with legitimacy and credibility when dealing with uncertainties (Head, 2019). Nonetheless, as these definitions are quite broad, climate services can represent completely different products, from “simple maps” to policy development. This chapter will be articulated as follows: we will start with definitions, historical notes, then provide with examples of climate services, discuss their limits, evaluation frameworks, new terminology, and their links to adaptation governance. Based on the inputs from relevant literature, we will conclude this chapter with illustration of our research design.

1.2.1 Brief history

The emergence of climate services can be traced back to the beginning of the 19th century, and the founding of the World Meteorological Organisation in 1950 to share climate-related information across borders (Vaughan and Dessai, 2014). As climate science and cooperation progressed, new institutions for international cooperation were established: more specifically, the Intergovernmental panel on Climate Change, the United Nations Framework Convention on Climate Change and, finally, the Global Framework for Climate Services (in 1988, 1992 and 2009 respectively, Table 3).

Table 3 Brief historical overview on climate services

<i>Years/ period</i>	<i>Main actors</i>	<i>Main actions</i>
<i>Late 19th century</i>	IMO, WMO	Creation of a framework for international cooperation on climate research and data exchange
<i>1979</i>	WMO	First World Climate Conference (or WCC1, Geneva). Mainly scientific. Led to the establishment of World Climate Program (WCP) and to growing interest in climate data by government and National agencies.
<i>1980s</i>	WCP	Creation of Tropical Ocean-Global Atmosphere research program within WCP -> development of predictive models of El Nino Southern Oscillation.
<i>1988</i>	UNEP, ICSU ⁸ , WMO, IPCC	The intergovernmental Panel on Climate Change was established to evaluate the impacts of greenhouse emissions on climate.
<i>1990</i>	WMO	Second WCC2 took place in Geneva to review the first 10 years of the WCP and to discuss the IPCC first assessment report.
<i>1992</i>	UN, WMO, UNFCCC	WCC2 led to the creation of United Nations Framework Convention on Climate Change (UNFCCC), of which Kyoto protocol is part; and the establishment of Global Climate Observing System
<i>1995- 2001</i>	IPCC, UNFCCC	The Climate Agenda was finally endorsed after developments within UNFCCC and after the second and the third IPCC's assessment reports.
<i>2006- 2007</i>	WMO	WMO organizes 2 conferences addressing the issues of importance of providing comprehensive scientific information for social and economic benefits.
<i>2009</i>	WMO	WCC3 takes place in Geneva, introduces the concept of a Global Framework for Climate services to foster the production, the accessibility, the delivery, and the use of climate prediction data.
<i>2012</i>	GFCS	The Global Framework for Climate services (GFCS) is established to provide a structure to support better informed decision-making
<i>2015</i>	EU	EU publishes its Roadmap for Climate services to guide the development of the sector.

Source: Elaborated from Vaughan and Dessai (WIREs Climate Change, 2014), WMO and EU sources.

⁸ICSU - International Council of Scientific Unions

In 2015 the European Commission published its “Roadmap for Climate services” to guide the development of the sector and reinforce Europe’s resilience to climate change (European Commission, 2016). As illustrated in Table 3, the development of climate-related institutions accelerated at the end of the 80s with the establishment of IPCC and the elaboration of assessment reports. We can argue that the idea of climate services originates in IPCCs assessment reports.

The creation of climate services is linked to the development of international cooperations on the topic of weather (international cooperation on climate research and data exchange). However, it is starting from 2009 and the third World Climate Conference (WCC3) that WMO and UN employ the term “climate services” to depict climate prediction data and forecasts. More than one decade later, an important variety of climate services was developed for various actors, spatial scales and use cases. These will be discussed in the following section.

1.2.2 The diversity of use cases, spatial scales, and actors.

Climate services, through the delivery and application of improved forecasting capabilities, can enable evidence-based decision making for a great number of different actors and sectors. Based on the literature from different sources⁹, Table 4 depicts the landscape of climate services. As illustrated in Table 4, some of these services were conceived for a specific sector, such as SMHI Aqua which contributes to water management. Others support the energy sector, such as Ukko project which offers seasonal wind prediction on the wind. The Clara¹⁰ project has been developing services for energy (solar and hydropower), disaster risk reduction, water management and agriculture. We also note climate services for insurance and derivatives, such as Sunshine Guarantee developed by Aon and METNEXT¹¹. The Sunshine Guarantee (Garantie Soleil) offers reimbursement to the tourists in case of bad weather. Other climate services aim at supporting public policies, such as urban planning, disaster risk reduction (National Flood Information portal in Ireland).

⁹ compiled from USAID (2013), John A. Dutton (2002) Daniel J. Scott et al (2011), Jorg Cortekar et al (2016), Catherine Vaughan et al (2016) and WMO.

¹⁰ Clara project aims at delivering leading edge climate services building upon the newly developed Copernicus Climate Change Services (<https://www.clara-project.eu>)

¹¹ METNEXT is subsidiary of Météo France

Table 4 Where are climate services used?

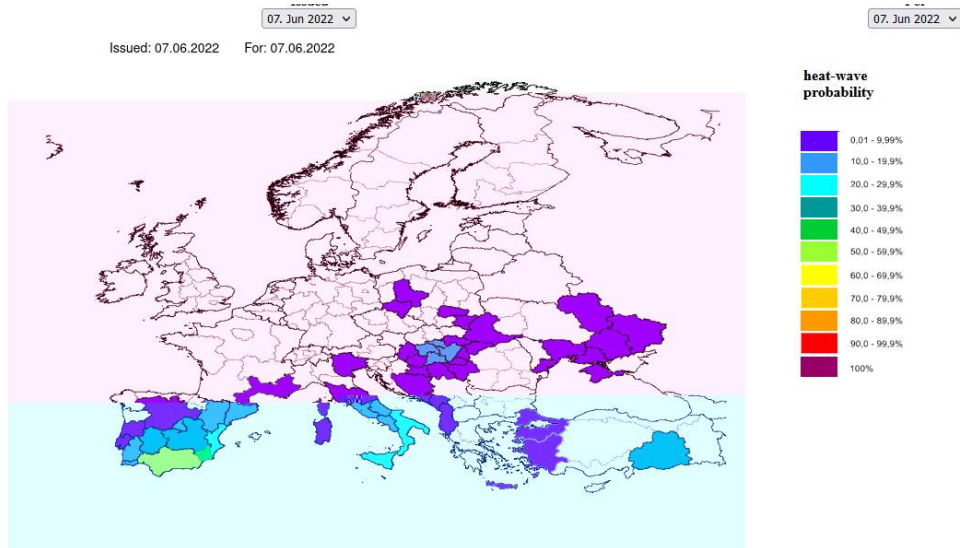
<i>Sector</i>	<i>Applications</i>
<i>Water</i>	Pricing and allocation, storage, and conservation decisions. e.g.: SMHI Aqua
<i>Agriculture</i>	Crop management; irrigation decisions; product marketing; herd management; input use (fertilizers). e.g., Climate Change Impact on Cotton (CCIC)
<i>Disasters</i>	Preparedness; early warning systems. e.g., National Flood information portal (Ireland)
<i>Health</i>	Endemic transmissions; disease surveillance e.g., Climatic suitability for the presence and seasonal activity of the Aedes albopictus mosquito for Europe derived from climate projections
<i>Energy</i>	Planning the purchase of gas and electricity; managing responses in emergency situations; grid/distribution management; optimization of reservoir/hydropower operations. e.g., Project Ukko: seasonal wind predictions for the energy sector
<i>Infrastructure</i>	Site location, facility design; emergency preparedness; in all domains of urban planning, e.g., Urban climate service centre.
<i>Transport</i>	Fuel purchasing; snow preparation/removal; accident reduction. e.g., Met Office Rail Weather and Climate services
<i>Finance</i>	Insurance and derivatives. e.g., Aon Sunshine guarantee
<i>Tourism</i>	Forecasts for aviation and transportation; revenue forecasting, seasonal occupancy forecasts. e.g., Prosnow: prediction system for snowmaking in Alpine resorts.
<i>Fisheries/ Forestry</i>	Harvest management; resource management. e.g., European Forest Fire Information System

Source: compiled from USAID (2013), John A. Dutton (2002) Daniel J. Scott et al (2011), Jorg Cortekar et al (2020), Catherine Vaughan et al (2016) and WMO.

In fact, these services contribute to both public and private evidence-based decision making. Climate services can refer to seasonal forecasts or long-range forecasts. Additionally, their spatial scales vary from forecasts for specific city, hydroelectric power plant or to the scale of entire continents (we will provide with examples below).

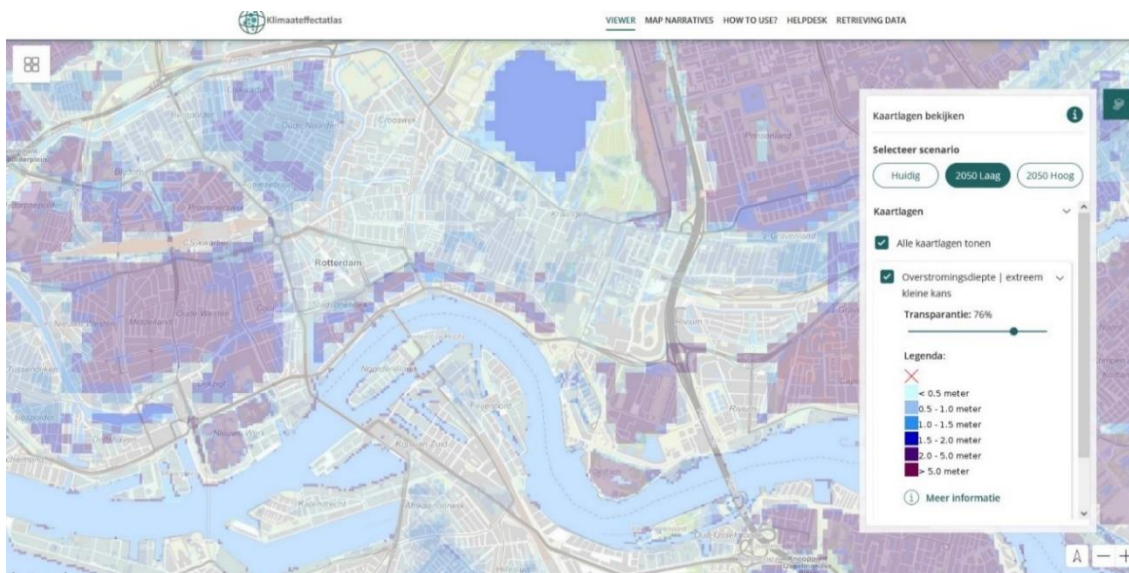
Climate services can also foster the protection of human health from the vagaries of climate variability and change such as heatwaves. For example, Figure 2 represents heatwave forecasts of EuroHeat project. Please note that these forecasts are available for the EU’s spatial scale and provide estimations on heatwaves probabilities. These estimations may reduce the exposure of population to health risks because they allow public authorities to anticipate negative consequences.

Figure 2 EuroHeat Project. Heatwave forecasts



Other climate services were developed on “smaller” scales. Figure 3 is an illustration of Climate Impact Atlas developed by several Dutch research institutes such as Wageningen University, The Royal Netherlands Meteorological Institute (KNMI), Deltares, and Climate Adaptation Services (2008-2014).

Figure 3 Climate Impact Atlas, Netherlands



This map illustrates the risk of extreme floods in Rotterdam in 2050, downscaled to the level of a neighborhood. It also provides estimations on water level rise (from 0.50 to more than 5 meters), thus it may contribute to the evidence-based spatial planning in the city. These projections are available for the whole country of Netherlands. Moreover, besides providing maps on impacts (mostly negative), Climate Atlas offers information on opportunities, such as a map for flood reduction opportunities.

Figure 5 depicts Météo France’s climate service DRIAS¹². More specifically, it provides a map with Forest fire weather index, which is an estimation of the risk of wildfire (for public authorities). Many other climate services were developed for specific sectors. Ukko project¹³ offers seasonal wind prediction for the energy sector. Prosnow (Figure 4) offers real-time optimization of snow management for mountain ski resorts through weather and seasonal forecasting and snow cover modelling.

Figure 5 DRIAS, forest fires indicators

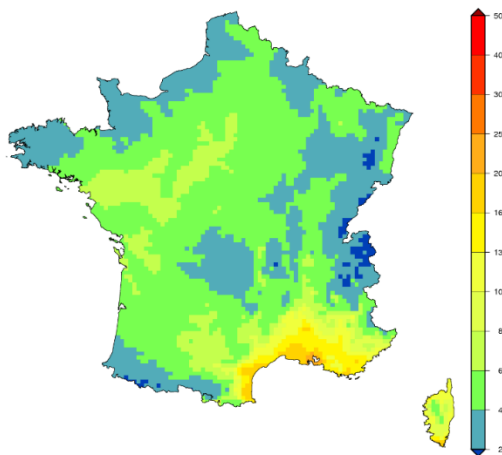


Figure 4 Prosnow, weather and seasonal forecasting and snow cover modeling

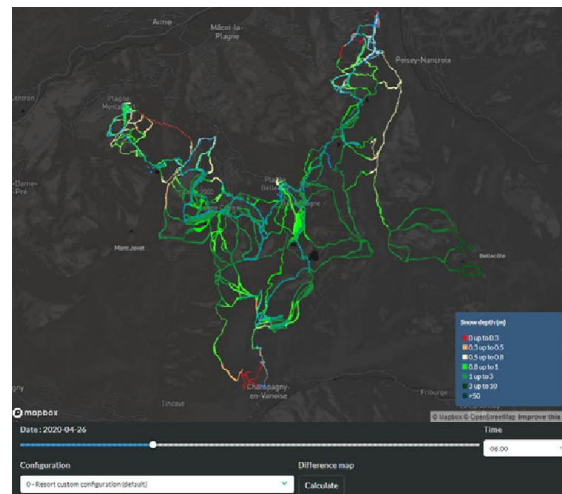


Table 4 and the figures above illustrate the diversity of products and services labelled as “climate services”. Moreover, these services are characterized by the presence of multiple users and producers, ranging from international to local producers and users:

¹² DRIAS - Donner accès aux scénarios climatiques Régionalisés français pour l'Impact et l'Adaptation de nos Sociétés et environnement (Provide access to Regionalized Climate Scenarios for the Impact and Adaptation of our Societies and Environment).

¹³ Ukko projects is part of European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales project funded funded by the European commission under the 7th framework program (EUPORIAS; <https://project-ukko.net>)

- intergovernmental entities such as IPCC or international organisations such as WMO or Red Cross.
- national/international research institutes (International Research Institute for Climate and Society, Climate Impact Group, Universities).
- national and sub-national climate services providers.
- climate services users from private or public sectors on different spatial scales.

Please note that often there is no clear cut between users and producers, as some entities can be both. For example, IPCC can use climate services from research institutions. At the same time, IPCC can also produce their own. Any comparison or evaluation of climate services must consider various use cases, their different spatial and time scales, the target audience, etc. The term “climate services” is too generic and can be source of confusion. Therefore, we believe that there is need to improve terminology, especially when addressing climate services for adaptation. Prior to proposing new concepts, the next sections will discuss existing evaluation frameworks, as improving science-policy interactions in the context of wicked problems is the key.

1.3 Evaluation of climate services

Even though the interest in and the use of climate information has increased during the last decade (mainly in agriculture, water, and disaster risk management), climate services are far away from being exploited to their full potential. In 2011 WMO recognized that climate services do not efficiently exploit scientific information, thus they do not meet the present and the future needs of users. Additionally, providers do not interact sufficiently with users, and the commitment to sustain climate services is inadequate (WMO, 2011). Restrictions on information sharing still exist. Given this, it is not surprising that the use of climate services in decision-making remains scarce (WMO, 2011; Lúcio and Grasso, 2016; Räsänen et al., 2017). The Global Framework for Climate services (GFCS) itself was established to overcome these problems, and to better coordinate the development of climate services on an international level.

In the official EU discourse, the development of climate services is aimed at enabling market growth (European Commission, 2016; R. Street, 2016). The EU takes the perspective of services, as stated from the outset in the foreword: “*climate services have the potential of becoming a supportive and flourishing market, where public and private operators provide a range of services and products that can better inform decision makers at all levels, from public administrations to business operators, when taking decisions for which the implications of a changing climate are an issue*” (2016:3). As stated in the

Introduction, currently the demand for climate services is relatively fragmented, and the available services are primarily supply driven (Street, 2016). More specifically, it appears that the supply does not match the demand, and that available climate services do not satisfy the needs of their potential users (Street, 2016). Nonetheless, several authors have discussed climate services' weak points, and several propositions were made for climate services' evolution.

Adapting to climate change is a complex process. This process often requires a constant link between science and policy. However, practice shows that most climate services are not connected to the end users (Sarewitz and Pielke Jr., 2007; Pita Spruijt et al (2014). The available data often does not help planners in their work. Hence, the illustration of limits and strong features of climate services can be portrayed from the perspective of social studies of science, which inquire on in the relationship between science and society.

1.3.1 Models of Science-policy interactions

The relationship between scientists and decision makers has been widely discussed in the literature. Spruijt et al. (2014) have identified 5 different approaches to the interaction between science and policy:

- *Post-normal science*. It is based on: management of uncertainty (particularly in environmental sciences); incorporation of the plurality of points of view inside and outside the scientific field; extension of the peer community; interdisciplinary teamwork (Funtowicz and Ravetz 1990).

Figure 6 Post Normal Science, Funtowicz and Ravets (1990)

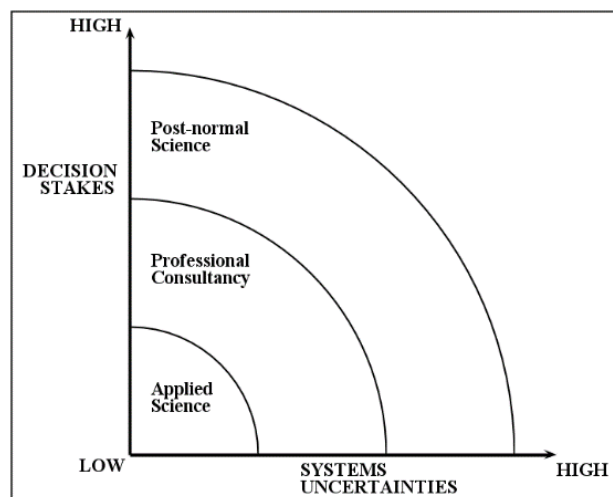


Figure 6 illustrates the need for applied or post-normal science depending on the correlation between system uncertainties and decision stakes: when high uncertainties are coupled with high decision stakes, post-normal science approaches are the most appropriate.

- *Science and technology* studies inquire on how social, political, and cultural contexts influence science and innovation. This branch emphasizes the concept of “technologies

of humility”¹⁴, or the acceptance of unintended consequences and different points of view when facing complex issues (Jasanoff, 2007).

- *Science policy studies* claim that today the research process and the production of knowledge are more democratic (Nowotny, Scott, and Gibbons 2001). Scholars of science policy studies highlight the importance of democratization of science to achieve the so-called socially robust science (will be discussed below). According to them, interaction with decision-makers is a must, and “humility” are necessary (Sarewitz and Pielke 2007).
- *The politics of expertise* approaches the issue from the perspective of power relations in the science-policy interface. They argue that coalitions based on deep fundamental beliefs influence policy-making, and that the dialogue between them is necessary: “scientificization of society” and the “politicization of science” are seen means of producing socially sound knowledge, while boundary workers might improve the collaboration between scientists and decision makers (Guston, 2001).
- *Risk governance* distinguishes between simple, complex, certain, and uncertain matters. For these studies, stakeholder participation is required, to a greater or lesser extent, depending on the nature of the problem. The authors insist on the collaboration between scientists and decision-makers, and recognize that today, as the "democratization of science" progresses, socially robust science results from the co-construction between these two categories of actors. Other suggestions were made including the use of other types of knowledge, such non-academic knowledge, or fostering public participation (Spruijt et al. 2014).

All five of these approaches highlight the importance of collaboration between scientists and decision makers. When uncertainties are high, socially robust knowledge is required. Nowotny describes socially robust science as knowledge having 3 interrelated features:

1. It is tested for validity inside as well as outside the laboratory, in a world with social, economic, cultural, and political factors.
2. It is most likely to be achieved by involving an extended group of experts (expertise spreads throughout society and become socially distributed expertise).

¹⁴ “These are methods, or better yet institutionalized habits of thought, that try to come to grips with the ragged fringes of human understanding – the unknown, the uncertain, the ambiguous, and the uncontrollable. Acknowledging the limits of prediction and control, technologies of humility confront ‘head-on’ the normative implications of our lack of perfect foresight” (Jasanoff 2007:227)

3. It results from iterative processes (Nowotny, 2003:155).

Given the inputs from the abovementioned literature, we can discuss climate services’ development as part of science-policy interactions. More specifically, we argue that these services must follow the logic of post-normal science and deliver socially robust information to decisionmakers. As many authors have pointed out, the very first climate services lack strong connection with the users, and are not exploited at their full potential (Spruijt et al. 2014; Street 2016; Räsänen et al. 2017). Others have pointed out that there is a need for the “*next generation of climate services*”, nested within the interfaces of science-to-service-to-practice, capable of improving connections between users and producers (Jacobs and Street, 2020). In fact, we can distinguish the first and the second generation of climate services based on their approach to science-policy interactions.

Nowotny, Scott, and Gibbons (2001) illustrate how the old paradigm (Mode 1) of scientific discovery is being superseded by a new paradigm of knowledge production (Mode 2). The Mode 1 is characterized by hegemony of disciplinary science with strong internal hierarchy between disciplines driven by the autonomy of scientists and their host institutions (Gibbons et al. 1994; Nowotny, Scott, and Gibbons 2001). We could assume that the first generation of climate services correspond to Mode 1. De facto, the first generation of climate services provides scientific information by forecasting the evolution of major climate variables according to IPCC scenarios (precipitation, temperatures, etc). However, these services suffer from lack of iterativity and connections between stakeholders. This peculiar situation has been described as “the valley of death” or “science policy gap” (Buontempo et al., 2014; Choi et al., 2016).

Sarewitz and Pielke Jr. explain this by introducing the so-called “Missed opportunity matrix”, where the match between the offer and the demand of information is linked to i) whether the information is relevant, ii) to whether the research agendas are appropriate, or iii) to whether institutional constrains or other obstacles are present (Figure 7, Sarewitz and Pielke Jr., 2007).

Indeed, as demonstrated by Sarewitz and Pielke (2007), these services will follow the logic of supply and demand and thus could suffer from a mismatch between what

Figure 7 The missed opportunity matrix (Sarewitz and Pielke Jr., 2007)

		Demand: Can User Benefit from Research?	
		YES	NO
Supply: Is Relevant Information Produced?	NO	Research agendas may be inappropriate.	Research agendas and user needs poorly matched; users may be disenfranchised.
	YES	Empowered users taking advantage of well-deployed research capabilities.	Unsophisticated or marginalized users, institutional constraints, or other obstacles prevent information use.

is being produced and what is being demanded. The use of information will depend on its relevance, the consistency between research and policy agendas, institutional constraints. (Sarewitz and Pielke, 2007).

Merely producing knowledge on a specific topic does not indicate whether this information is being used; also, “*more information does not mean better decisions*”. Such a variety of different actors, working on different temporal and spatial scales, implies the existence of contrasting goals, views, and needs. According to Sarewitz and Pielke, “*the potential for science to contribute to societal goals depends critically on factors well beyond science*” and that “*better science portfolios would be achieved if they reflected an understanding of supply, demand and the complex dynamic relationship between them*” (2007:6). These two quotes can be interpreted from the perspective of evidence-based (EB) decision making, although this concept was developed in the public health sector. In fact, to provide best practice services, one of the core principles of EB is to consider patient’s wants and needs (Hess et al., 2014). To ensure that scientific advances are quickly translated into practice settings, EB puts more emphasis on knowledge translation instead of evidence hierarchy (scientific, operational). Ergo, when considering lessons learned from other sectors and applying them to climate change adaptation, we must emphasise the wants and needs of the users of climate services.

Dilling and Lemos (2010) argued for better iterativity and “*purposeful and strategic interaction between climate knowledge producers and users so as to increase knowledge usability*” (2001:681). When defining iterativity, Sarkki et al (2015) stressed the need to “*go beyond simple repetition*” to “*foster constructive relationships and knowledge itself*” (2015:507). Policymaking is a dynamic process that requires feedback and adjustments. Thus, there is a need for a constant twofold connection and the exchange of feedback between all the stakeholders involved in the creation of knowledge for adaptation.

Finally, as WMO suggests, climate services are still underdeveloped and not fully exploited because of the nature of the “advice” they provide (WMO, 2011). Indeed, the term “climate service” itself has a very broad definition, which can lead to misconceptions: climate data, customized products, services, the development of solutions. As Pita Spruijt et al (2014) point out, “*policy makers seek certainties and solutions, whereas scientists typically offer probabilities, uncertainty and multiple scenarios*” (2014:17).

Despite several advances in climate science, local institutions still lack robust knowledge of the impacts on their territories. This is not due to lack of information on climate change and its impacts per se. Often this information is not directly exploitable at regional/local levels where most adaptation activities occur (Berrang-Ford, Ford, and Paterson 2011; Räsänen et al., 2017). Krauss and Storch pointed out that “*there are*

significant disturbances in communication between climate change science and the public” (2012:213). The authors argue that the increasing amount of information on the climate does not include the experiences and perceptions of people. According to them, the linear model of the science-society relationship is still dominant in climate science (Mode 1).

Crossing this valley of death is a challenging task, but numerous solutions have been identified. These solutions can be labeled as Mode 2 of scientific discovery, characterized by “*socially distributed, application-oriented, transdisciplinary knowledge, which is subject to multiple accountabilities*” (Nowotny, Scott, and Gibbons 2003). Additionally, several evaluation frameworks have been created to assess and guide climate services’ development.

1.3.2 Evaluation of climate services

We have identified three frameworks assessing the efficiency of research in informing policy and decision making. For example, the CRELE framework aims at assessing the **C**redibility, **R**Elevance (or salience), and **L**Egitimacy of information (Sarkki et al., 2015; Reinecke, 2015). Credibility refers to whether the knowledge and its production are perceived as valid and adequate (trust in science and scientists. Information will be relevant if it reflects the needs of society (when the demand for science matches its supply, as in Sarewitz and Pielke, 2007 and in McNie, 2007). Legitimacy is the fairness of knowledge and policy production – whether unbiased or not (Sarkki et al., 2015; McNie 2006; Cash et al., 2003; Reinecke, 2015).

Later, Dunn and Laing (2017) pointed out that most CRELE studies focused on the scientific side of the science-policy interface, without evaluating these concepts with decision-makers (often absent from study groups). Following their study with decision makers in Australia, Dunn and Laing (2017) built a different framework – ACTA, or the Applicability, Completeness, Timing and Accessibility of information. They concluded that these criteria better summarize the most important aspects of scientific research when it comes to influencing decision-making (Dunn and Laing, 2017). According to their findings, research questions are often framed without inputs from non-scientific stakeholders, and the whole research design process is mainly focused on research goals (Dunn and Laing, 2017). While Mode 2 cannot be “*authoritatively encoded in traditional forms of scholarly publication*” (Nowotny, Scott, and Gibbons 2003). We could argue that Mode 1 corresponds to the science of adaptation (disciplinary), while Mode 2 to the science for adaptation (transdisciplinary).

Furthermore, Dunn and Laing (2017) point out that scientific and policymaking stakeholders operate on different timescales and do not follow similar cycles. Academic

process is dictated by stable funding rules, whereas policy-making depends on political events and public sentiment, which can change rapidly (Dunn and Laing 2017). Besides the mismatch in agendas, the uptake of scientific knowledge will depend on opportunity windows, and the capacity of scientists to take advantage of such openings.

Schuck et al. (2016) from Climate Service Centre Germany (GERICS) have developed a specific framework for assessing climate services and co-produced services. Their framework evaluates criteria for products / services such as availability, visibility, quality, relevance; and results such as use, satisfaction, dissemination, user learning effects and their evaluation. Additionally, Schuck et al. (2016) apply this framework for climate services and knowledge transfer products and point out that German Council of Science and Humanities has included transdisciplinary research in its definition.

Although these three frameworks offer different sets of criteria to evaluate climate services, we note that relevance (applicability) represents a common feature. A relevant climate service will answer to the needs of the decision-makers thus, its applicability will depend on the quality of interaction at science-policy interfaces. But how to organize these interactions? Next sections will illustrate different ways to create knowledge exchange between scientific and non-scientific stakeholders.

1.4 Improving science-policy interactions

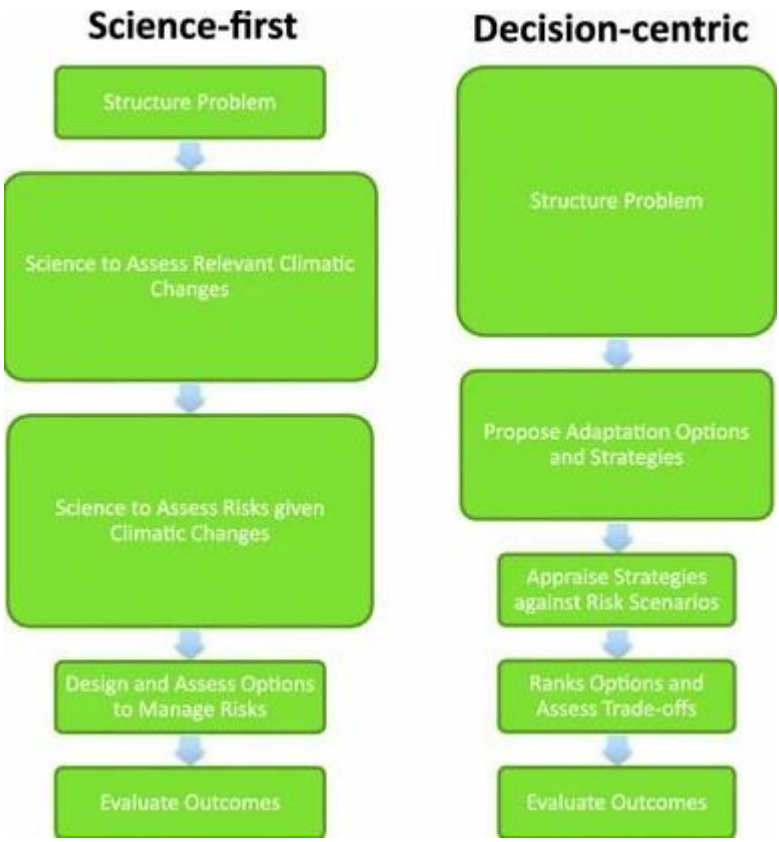
The importance of problem structuring has been previously discussed in Ranger, Reeder and Lowe (2013). In their study they analyse the uncertainties in long term infrastructure project (Thames Estuary 2100) and illustrate the differences between two approaches in adaptation planning: science first and the decision first. In science-first the projections from GCM¹⁵ are downscaled to provide estimation on impacts, and then used to appraise options. The authors argue that science-first approaches represented most of the literature on risks and adaptation planning, including IPCC and the Stern Review on the Economics of Climate Change (Ranger, Reeder, and Lowe 2013).

¹⁵ Global climate models

The Thames Estuary 2100 project has reversed this approach, as the understanding of decision problems was at the heart of their analysis. According to the authors, the values

of stakeholders, constraints, and decision criteria must receive major attention in adaptation planning. In decision-first approaches, the focus is on understanding the decision problem itself, rather than on inputs from GCM (Figure 8). Various related concepts have flourished in the domain of adaptation¹⁶: decision analytic approach (Brown et al. 2011), policy-first (Ranger et al. 2010, Fig. 2), bottom-up (Pielke Sr. and Wilby 2012), access-risk-of-policy (Dessai and Hulme 2007), or risk management approach (Willows and Connell 2003). There have been

Figure 8 Comparison of a 'science-first' and 'decision-centric' process, with size of the bubbles indicating the emphasis of that step (in terms of time or resources) within the process.



Source: Ranger, Reeder, and Lowe (2013), adapted from Dessai and Hulme, 2007

attempts to offer hybrid strategies to use all relevant information (knowledge from both GCM and stakeholders). Likewise, Goosen et al. (2014) combine top-down and bottom-up approaches: downscaling and vulnerability assessment according to the planners' needs.

The inputs from the abovementioned literature allow us to point out the roadmap for Mode 2 knowledge transfer:

¹⁶ Albeit being well established in decision analyses and operational research domains. For example, the ROAMEF cycle (Rationale, Objectives, Appraisal, Monitoring, Evaluation and Feedback) in Roe et al. 2007.

- Generally speaking, scientific knowledge must be relevant and answer to the needs of policymakers (Sarewitz and Pielke, 2007; McNie, 2007 Sarkki et al., 2015; Cash et al; 2003, Reinecke, 2015).
- More specifically, knowledge production should aim at transdisciplinarity (Ranger, Reeder, and Lowe 2013, Schuck et al., 2016). Mode 2 requires a greater diversity of types of knowledge. This was facilitated by the emergence of new kinds of knowledge entities such as think-tanks, boundary organisation, etc.
- Top-down approaches should be combined with bottom-up ones to combine and maximize the use of scientific knowledge with local stakeholders' knowledge.

In fact, the limits of traditional scientific approaches for complex issues do not represent a new topic. For example, Jackson argued that “*managers are sold simple solutions to complex problems*” (2006: 647). Stock and Burton pointed out that “*increasing prominence of issues concerning the linked nature of human and biophysical systems, coupled with an increasing understanding of system complexity leave traditional scientific disciplines often struggling to understand the problems facing environmental managers*” (2011:1091). Funtowicz and Ravets discussed post-normal science in 1990. While there are various ways to label different scientific approaches to knowledge production, for the purpose of our study, we will define them as follows (Stock and Burton 2011):

- Disciplinary approaches (Mode 1, Applied science) involve a single discipline.
- Interdisciplinary approaches refer to a research process that forces participants from various disciplines to cross boundaries and create new knowledge.
- Transdisciplinary approaches (Mode 2) involve not only multiple disciplines, but also non-scientific stakeholders.

On the one hand, above-mentioned scholars highlight the importance of paradigm shift in science-society relations. On the other hand, other scholars inquire on methods of collaboration between scientific and non-scientific stakeholders. For example, Biggs (1989) has identified 4 modes of engagement: contractual, consultative, collaborative, and collegial. **The contractual mode** is used for testing experimental technology under real world conditions (eg.: between scientists and farmers). In contractual mode scientists aim at answering stakeholder driven questions. **The consultative mode** aims at solving a problem pertinent to the community - scientists and stakeholders interact during a specific stage of the research process (eg.: problem definition). **The collaborative mode** occurs when answering specific questions requires input from stakeholders (eg.: local knowledge). **The collegial mode** refers to stakeholder-driven research, where scientists aim at increasing the stakeholders' capacity to solve problems.

The 4 modes describe different degrees of interaction between scientific and non-scientific stakeholders. The contractual and consultative modes refer to situations where scientists aim at solving an issue pertinent to non-scientific stakeholders. These two modes, defined as in Biggs (1989), do not specifically require input from non-scientific stakeholders. Additionally, it is not clear who is responsible for framing research questions and methods: scientists, community, or both. Non-scientific stakeholders' involvement becomes important in collaborative mode, while in collegial mode they become a central focus for the whole process of knowledge production.

Meadow et al (2015) have identified 4 approaches to collaboration: **action research**, or collaborative research in the social sciences; **transdisciplinarity research**, an approach that integrates multidisciplinary academic and practitioner knowledge; **rapid assessment process**, a structured approach for qualitative research methods, which aims at identifying the priorities from the perspective of local stakeholders; **participatory integrated assessment**, a multidisciplinary approach that seeks to develop policy- or decision-relevant knowledge about environmental problems through the integration of stakeholder knowledge into modeling and scenario-planning efforts (Salter, Robinson, and Wiek 2010; Toth and Hizsnyik, 1998).

Meadow et al (2015) describe ways of conducting research in multi-stakeholder settings, but also stress for multidisciplinary approaches. In fact, the shift in paradigm refers to: 1) including non-scientific stakeholders, and to 2) involving different disciplines in the research process. We argue that inter- and transdisciplinary approaches may be a solution for science-policy gap and thus improve the uptake of climate services. However, the boundaries between scientific disciplines and scientific/non-scientific actors need to be reconstructed to achieve socially robust science.

Besides barriers linked to the knowledge transfer process, other constraints will influence the use of climate change knowledge. Dilling and Lemos (2010) stress that the usability of climate services can be negatively influenced by a set of constraints linked to the context. Constraints can be rooted in formal and informal institutional obstacles related to regulations, or to the mismatch between climate change and electoral cycles (Dilling and Lemos 2011; Celliers et al. 2021). In fact, institutions often have inflexible rules that could slow down the implementation of new tools and, generally, policy makers prefer tested solutions (eg.: a policy maker might choose a tested option instead of taking risks with a new one). Therefore, institutional support is one of the most important pillars for successful science-policy interaction. Climate change knowledge and services will have a greater chance of being used if there is a strong political commitment use them in adaptation strategies. Cognitive institutional or individual gaps in science and decision-making

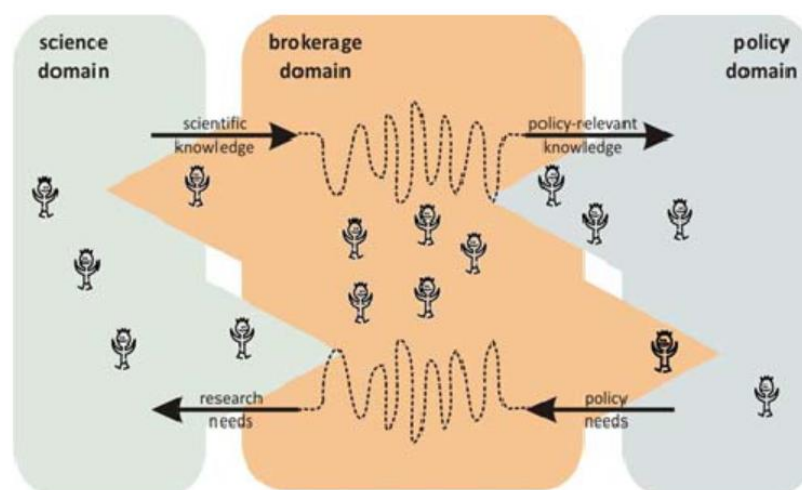
represent an obstacle to successful adaptation. For example, Porter and Dessai (2017) concluded that often climate scientists do not have the capacity to listen and respond to users' needs; Celliers et al. (2021) highlighted the presence of individual-level barriers, such as lack of understanding of climate change and adaptation solutions.

Technical barriers can subsist as well, especially if there are no specific material means available for the policymakers (and technical staff). Additionally, the usability of climate knowledge will be influenced by the understanding of:

- specific decision contexts can determine to which extent the information is useful and used.
- Spatial scales (policy makers prefer regional or local, as adaptation is mostly done on local scales¹⁷).
- the timing (are the research and policy agendas compatible?), the skill level (accuracy of climate services).
- the level of trust between stakeholders.

Finally, efficient communication - in terms of availability, visual representation, and format - is the factor of “attractiveness” and accessibility of climate services. Potential users will be more prone to use climate if the information provided is easy to understand and use. According to Reinecke et al. (2015), the so-called boundary organisations represent a pertinent solution to manage science-policy interactions across boundaries. As depicted in Figure 9, these entities enable the passage from scientific knowledge to policy relevant knowledge by improving the understanding of policy contexts and policymakers

Figure 9 Science-policy interactions across boundaries (Source: Reinecke et al. 2013)



¹⁷ Ford et al. (2011)

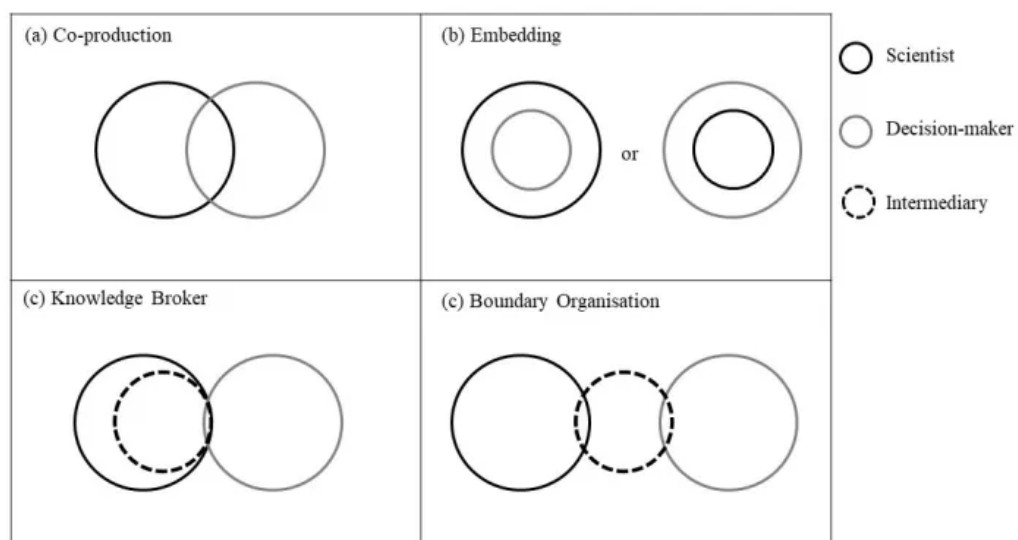
needs. Therefore, the next section will focus on boundary organisations as a solution to the science-policy gap.

1.4.1 Boundary organisations as a tool for science-policy interactions

While both Biggs (1989) and Meadow et al. (2015) describe different modes of engagement and collaboration between stakeholders, other scholars discuss the capacity of boundary organisations and knowledge brokers to manage relationships between different disciplines and stakeholders (Guston 2000, 2001; Cash et al, 2006; Crona et al, 2012). However, there is no clear distinction between these two categories of intermediaries. For Guston (2001), boundary organisation is a group or institution that takes on the challenging tasks of both working at and managing the science–policy boundary. Additionally, the concept of boundary organisation does not refer to any specific form of organisation, nor does it provide specific guidelines on how to organize science-policy interfaces (Crona et al. 2012).

For Crona et al. (2012) boundary organisations can link multiple stakeholders through some form of strategic bridging, facilitate collaboration and knowledge coproduction. For Cvitanovic et al (2015), knowledge brokers are usually embedded within research teams or institutions and act as intermediaries, while boundary organisations are not typically embedded within research teams or organisations (see Figure 10).

Figure 10 Conceptual diagram outlining the four primary models believed to increase knowledge exchange among scientists and decision-makers (Cvitanovic et al., 2015)



Boundary organisations are established as separate entities, thus more effectively representing both sides across the boundary (Cvitanovic et al., 2015). However, not all scholars agree with Cvitanovic et al.'s (2015) distinction. For example, Brown and Duguid, (1998) and Pawlowski and Robey (2004) define knowledge brokers as individuals participating to multiple groups (knowledge producers and knowledge users) and facilitating the transfer of information among them, without belonging to the groups they span. Boundary spanning is a form of brokerage where boundaries between departments or organisations, or cultures such as disciplines, are managed to exchange knowledge or mediate interactions (Friedman and Podolny 1992).

Furthermore, climate models require updates, while adaptation solutions can be revised and modified with time. From the perspective of policymaker, a stable intermediary can potentially alleviate uncertainty intrinsic to climate data, and wickedness related to the nature of adaptation problem. Not surprisingly, the interest in boundary work in the climate change domain is growing, as well as the numbers of boundary organisations engaged in climate-related initiatives. Cvitanovic et al. (2018) have analysed university-based boundary organisations and highlight the need for institutional innovation to foster knowledge uptake in the policy domain. This innovation, often occurring in the form of transdisciplinary projects, can significantly improve local adaptation strategies (Cvitanovic et al. 2018).

The value of boundary organisations (BO) is recognized across the literature. For Bremer and Meisch, BO have the capacity to “*facilitate the match between demand and offer of science, as they act as an intermediary or as a bridge across different knowledge systems*” (2017:11). While for Michaels, knowledge brokers aim at enabling decision makers “*to acquire, value and consider expertise that they would not otherwise obtain or incorporate into their decision making*” (2009:995). In fact, already in 2004 Spanger-Siegfried et al. stated that adaptation “*does not require an abundance of high-quality data, or extensive expertise in computer-based models. Rather, it relies upon a thoughtful assessment and a robust stakeholder process*” (2004:3). We argue that boundary organisations can foster the uptake of climate information and services for adaptation because they create conditions for “robust stakeholder process”. Ergo our interest in these institutions as a particular form of adaptation services’ provider.

1.4.2 Climate services according to science-policy interactions

The interest in BO as climate products and services providers is nested in evidence from literature and practice. Many case-studies have highlighted the importance of knowledge brokers and boundary organisations as means of improving both CRELE and

iterability (Kirchhoff et al, 2015). For example, Räsänen et al. (2017) have surveyed 33 Finish Municipalities on their needs and practices in climate risk assessment and management. The survey showed that the usability of climate information is a major barrier, while at the same time there is need for more networking and capacity-building. On one hand, first generation climate services are often criticized for their lack of connection with end-users. On the other hand, there is increasing interest in the so-called “adaptation services”.

Goosen et al (2014) define adaptation services as “*an information service supporting the assessment of vulnerability in a wider perspective and including the design and appraisal of adaptation strategies in a multi-stakeholder setting*” (2014:1035). The concept of adaptation services (AS) is also used by the German Climate Preparedness Portal KLiVO, where AS are defines as “*guidelines, web tools and maps, and the provision of specialist training, while climate change adaptation services offer assistance in choosing, planning, and implementing appropriate measures and evaluating their effectiveness*”.

From this perspective, the terminology suggested by Weichselgartner and Arheimer (2019) is particularly interesting (2019:395) for describing different forms of institutionalisation of climate services (Table 5).

Table 5 Different types of climate services.

Climate Change Adaptation Products (CCAP)	<i>“Data, tools to support decision-making for adaptation, including efforts to identify information needs”.</i>
Climate Change Adaptation Services (CCAS)	<i>“Activities, consultations, and other forms of interaction that enable decision-makers to make better use of CCAP. CCAS are not only products, but also the mechanisms for interaction and knowledge exchange between producers, users, and providers”.</i>
Climate change adaptation knowledge-action systems (CCAKAS)	<i>“Networks of individuals, organisations, coordinating bodies, and institutional and communication structures that cooperatively design, produce, provide and use CCAP and CCAS”.</i>

Source: Weichselgartner and Arheimer (2019).

What distinguishes CCAS (and CAS) from CCAP are the notions of “multi-stakeholder setting”, “interacting”, “knowledge exchange mechanism” and “assistance”. Therefore, it is safe to assume that to be considered as an adaptation service, a given CCAP needs to provide more than just data and tools but be built with end-users to allow them to

appropriate, monitor and evaluate them (e.g., iterability). In fact, while CCAP can be considered as Mode 1 product, the CCAS have features of Mode 2.

We imply that CCAS will have several of the features of boundary organisations described in Cash et al. (2003): 1) accountability on both sides of the boundary; 2) the use of co-produced maps, reports; 3) cross-boundary participation; 4) conveying, translation, mediation, coordination, and synergetic expertise.

In fact, beside intrinsic characteristics of a given CCAP or CCAS, we believe that the articulation of adaptation governance itself will impact the use of such products and services. Climate adaptation services as tools for evidence-informed adaptation planning are not isolated from the context and must consider (or be part of) demographic, cultural and economic changes (W. Adger, Arnell, and Tompkins 2005). At the same time, decision making for adaptation requires an integrated cross-sectoral approach, capable of capturing the complexity of decision processes, greatly affected by environmental and social contexts (Celliers et al. 2021). Interestingly, the concept of CCAKAS can be interpreted from the perspective of multi-level governance systems. As a reminder, Di Gregorio et al. defines polycentric governance as “*a structure that spans from global to national and sub-national levels, relying on both formal and informal networks and policy channels, where state and non-state actors are involved in formulating and implementing climate policies and actions*” (2019:64). In fact, the notions of networking, coordination between and across scales are common to the polycentric governance and adaptation knowledge-action systems.

Conclusions

In this chapter we have discussed adaptation and climate services for adaptation. We have seen that it took time to finally incorporate adaptation to political agendas across the world. In fact, adaptation was off-limits for those advocating for mitigation, consequently policy instruments biased against adaptation were implemented (Pielke et al., 2007). Nevertheless, several reasons have contributed to the shift in the perception of adaptation. Firstly, there is a timescale mismatch between mitigation and its effects, while the vulnerabilities to climate change are increasing due to climatic and non-climate factors. Secondly, the impacts of climate change are already threatening economic sectors with strong dependence on climatic conditions, such as agriculture, silviculture, etc. Thirdly, climate change will also cause humans costs. For example, excess deaths from heat could range from 85,000 (RCP2.6) to 300,000 (RCP8.5) by the end of the century (COACCH (2019). European heatwave of 2003 led to 15,000 deaths in France alone (Hémon and Jouglu, 2004).

Nowadays, decision makers are expected to deliver climate-informed and climate-proof investments and policies. Adaptation strategies and plans became a common tool to face the impacts of climate change, while climate adaptation services may represent a solution for evidence-based decision making. Adaptation is now institutionalised at various levels of governance, from the international scale (UN, EU), to the scale of local authorities, such as the intercommunalities in France. In fact, adaptation to climate change is characterized by multi-level governance, where a vertical dimension refers to the relationship between local, national and international policies, while the horizontal dimension is based on formal and informal networks operating across the boundaries (Corfee-Morlot et al., 2009).

We have discussed the potential value of climate services for EB decision making, but also illustrated their limits when supporting the development of adaptation policies at local scales. We argue that these services are not used to their full potential due to several reasons:

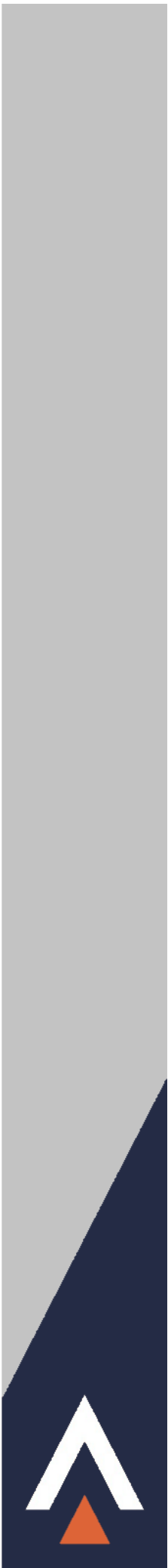
From macro perspective, climate products and services may be impacted by the articulation of adaptation governance. However, approaches to vertical and horizontal integration of adaptation will depend on the institutional context, thus differing from one country to another. Institutional contexts will reflect countries' intrinsic features, such as degrees of decentralisation or policy-making traditions. Ergo our idea to address climate products and services as part of this landscape.

From a micro-level perspective, there is a need for efficient interactions between science and policy. In the context of adaptation to climate change, the linear transfer of knowledge from science to policy does not satisfy the demands of decision makers. We can assume that wicked problems such as adaptation require a different type of climate services to overcome the science-policy gap. Goosen et al. (2014) have pointed out that most of the first generation of climate services deal only with the third stage of adaptation planning cycle – risk assessment (Goosen et al., 2014). Weichselgartner and Arheimer (2019), but also German Climate Preparedness Portal KLiVO, have proposed to differentiate between climate adaptation products (maps, projections) and services which represent “*mechanisms for interaction that enable decision-makers to make better use of products*”.

The first generation of climate services simply do not aim at supporting decision makers throughout all stages of adaptation cycles; therefore, we will focus our research on adaptation services, and illustrate our research design in the next chapter.

Chapter 2

Research design and methods



2.1 Research framework

Based on the literature review, this chapter precises scientific objectives of this research and our approach for the collection, the selection, and the analysis of data. It represents our research protocol used to answer the main research question:

What kind of climate services policy makers need to elaborate adaptation strategies and plans at local scales?

This research work is grounded in human geography and evolves within constructivist paradigm described in Lincoln and Guba (1985). We will explore socially constructed dynamic reality and offer a description of the phenomenon from the context-sensitive perspective of participants (Yilmaz 2013). Firstly, the science-policy interactions for adaptation to climate change are located in complex socio-political settings and may be trapped in the national-local tensions rooted in “*institutional design that centralizes decision-making authority (political authority) and the centralization of fiscal power (economic authority)*” (Dolšak and Prakash 2018:326). Secondly, adaptation itself is a complex issue that spans across scales and sectors, generating conflicting views.

This thesis is of qualitative nature. Denzin and Lincoln define qualitative research as “*a set of interpretive activities, privileges no single methodological practice over another*” (2005: 6). For Strauss and Corbin qualitative research is “*any type of research that produces findings not arrived at by statistical procedures or other means of quantification*” (1998:10). We aim at capturing and interpreting in-depth experiences on both sides of the knowledge transfer process (science and policy): how do they experience adaptation, its governance, and the process of knowledge transfer (Lincoln and Guba, 1990)? We argue that adaptation at local scales is not characterized by a singular reality, but is influenced by environmental, institutional, and individual differences (Sofaer, 1999). Qualitative methods may allow us to move from understanding of these realities toward more meaningful explanations, or even to contribute to the generation of new theories and conceptual frameworks (Sofaer, 1999).

We employ both deductive and inductive approaches. In fact, the first part of our study was guided by a hypothesis (Chapter 3). The second and the third part were based on an organized framework of themes (a start list) used later in coding process (Miles and Huberman, 1994; Braun and Clarke, 2006). As we illustrated in literature review, the use and the development of climate adaptation services should be guided by inputs from science-policy interaction and adaptation governance theories. As explained in Chapter 1,

most of the literature on climate services described and analysed a particular climate service, while we would like to consider a broader context – what is the role of adaptation services within the governance of adaptation to climate change? How does this context influence the emergence of such services? Nevertheless, our research protocol was built in a way to also employ the inductive approach. More specifically - to collect and to analyse the experiences of participants, and to derive concepts and themes from the “data”.

Case studies are methods commonly used in qualitative research. Literature review on science-policy interactions and polycentric governance allowed us to 1) have at least some ideas on what we are looking for (set of theoretical considerations, a start list), and 2) make decisions on sampling design. Our inventory of tools comprises:

- Semi-structured interviews to ensure consistency with themes identified in the literature review (Brewster et al. 2015).
- Documentary sources for content analysis (documents are “*the fabric of our world*”, Love, 2003:83).
- Statistical data on climate services from Climate Knowledge Hub.

From now on, we will apply the terminology proposed by Goosen et al (2014) and Weichselgartner and Arheimer (2019). However, to avoid overusing abbreviations, we will use:

- Adaptation products or AP, when referring to Climate change adaptation products (CCAP), or to the first generation of climate services.
- Adaptation services, or AS when referring to climate change adaptation services (CCAS).
- Adaptation knowledge action systems, or AKAS, when referring to Climate change adaptation knowledge action systems (CCAKAS).

Interview guides, as well as items for content analysis will be described in the following sections.

2.2 Research design

Our research protocol is designed in a way to analyse adaptation products, services, and systems on different scales and from various perspectives. Our first goal is to portray these from the perspective of multi-scale governance of adaptation. Ergo, a funnel approach was adopted as depicted in Figure 11.

Figure 11 Research design, funnel approach

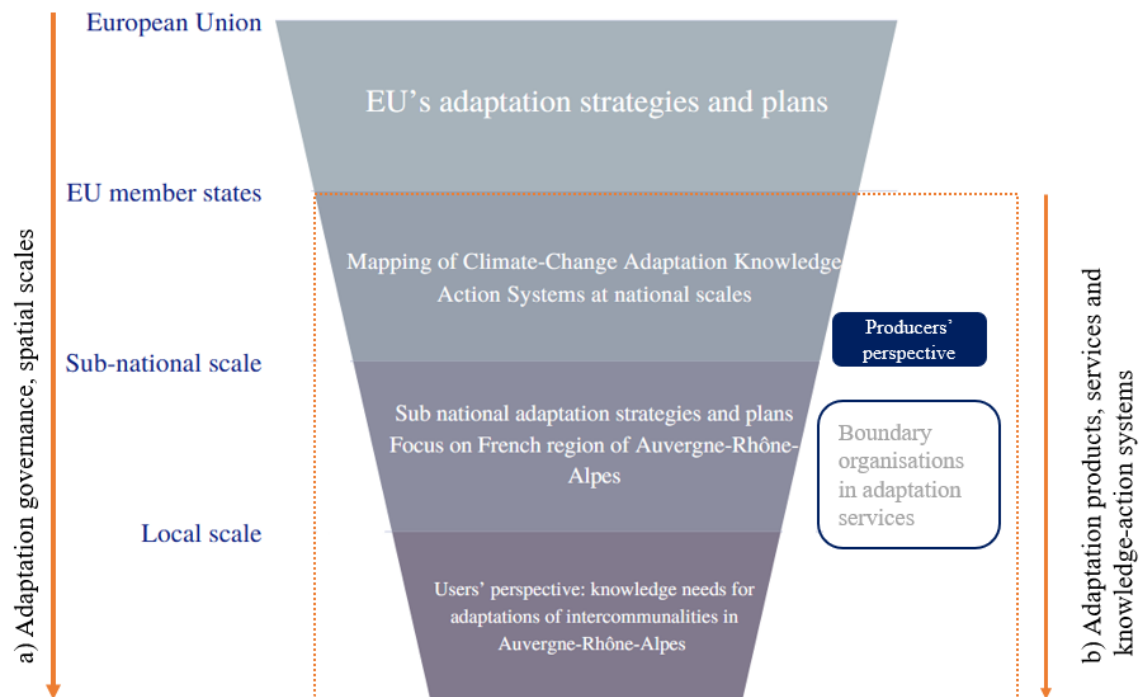


Figure 11 a) illustrates the spatial articulation of adaptation (from the EU to local scales). We have scrutinized all available adaptation policies in the EU, its member states (on national scales), and Auvergne-Rhône-Alpes region of France. Section b) portrays the articulation of adaptation products, services, and systems. The next sections will provide details on these steps. Please note that each chapter provides additional information on methodological and theoretical choices.

2.2.1 European and national content exploration

This part of the investigation consists in mapping adaptation knowledge action systems (CCAKAS) on national and international scales, and it is guided by desk research and content analysis. Collected data is illustrated in Chapter 3 but was also published in a peer-reviewed journal “Climate services”. As discussed in chapter 1, adaptation to climate change is characterized by a plurality of policy-relevant knowledge (Fischer and Gottweis, 2013). Additionally, this knowledge is spread across units situated at multiple jurisdictional

levels thus, there is need for coordination to improve information transmission, and enhance adaptive-management capacity (E. Ostrom, 2005; Marshal, 2009). From this perspective, a case study on the EU and its member states may shed light on the country-specific characteristics that foster or stymie the development of adaptation systems (CCAKAS). More specifically, we are interested in the distribution of responsibilities between jurisdictional levels and can formulate our hypothesis as follows:

The degree of decentralization of a country may influence the development of climate change adaptation knowledge-action systems

To test this hypothesis several steps were taken. We define the European Union's adaptation strategy as a common framework for all member states. However, there are multiple ways to characterize European Member States: they can be centralized or decentralised, statist or corporatist, federal or unitary (Keskitalo 2010). We will focus on the distribution of resources and responsibilities, thus on the governmental system and the level of decentralisation in each country. To this end, we will use the Ljiphart's (2012) federal-unitary axis which includes the level of decentralization:

- Federal and decentralized: Austria, Belgium, Germany.
- Semi-Federal: Netherlands, Spain.
- Unitary and decentralized: Sweden, Finland, Denmark, Italy (to a certain extent).
- Unitary and centralized: Bulgaria, Croatia, Czech Republic, Cyprus, France, Greece, Estonia, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Romania, Poland, Portugal, Slovenia, Slovakia.

Firstly, to shed light on how governmental systems have influenced the development of adaptation policies on sub-national levels, we analysed the timing of implementation of European and national adaptation strategies and plans.

Secondly, a systematic review of national and sub-national adaptation strategies was conducted to assess the correlation between the degree of decentralisation and the timing of implementation of sub-national adaptation policies. We will employ the term "sub-national" instead of NUTS 1, NUTS 2 and NUTS 3 levels (Nomenclature of territorial units for statistics)¹⁸. Selected countries have different national administrative units and different legal obligations applies to them: in federal states such as Germany or Belgium, adaptation strategies and plans concern the NUTS1; In France or Netherlands it is the

¹⁸ The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU and the UK for the purpose of: the collection, development and harmonisation of European regional statistics; Socio-economic analyses of the regions. (<https://ec.europa.eu/eurostat/web/nuts/background>)

NUTS2 (Région and Province respectively); in Sweden it is the NUTS3 (län or county). Therefore, for the purpose of our research the distinction between different NUTS is not relevant.

Then we analysed the national forms of adaptation products, services and systems to create a map portraying each country's status. In order to classify national adaptation products and services, we followed the definitions formulated by Weichselgartner and Arheimer (2019) and used inputs from multi-level governance theories.

We did not consider private providers as we are interested in the public and non-profit sectors only. In line with Samuelson (1954), we consider that spontaneous market initiatives would not provide an optimal level of collective consumption goods. According to the EU, "*market forces alone are unlikely to lead to efficient adaptation because of a certain degree of uncertainty in climate projections and a lack of financial resources*" (European Commission, 2007:2) This does not undermine the value of numerous for-profit climate products that have emerged in recent years, but at this stage we consider climate change adaptation as a matter of collective action.

To build the database for this analysis, we used the EUR-Lex portal¹⁹ as a source for the EU's adaptation strategies and communications, while information on national adaptation strategies and plans was obtained from the Europe-ADAPT platform²⁰. Missing or outdated data were completed by using information available on national adaptation portals and by extended research on the web. Please refer to Annex 3 and 4 for details on EU, national and sub-nation climate adaptation policies, as well as adaptation products, services and systems identified for this investigation.

2.2.2 Multi-level governance of adaptation in France

In this section we will overview French national, regional, and sub-regional climate plans. Since Auvergne-Rhône-Alpes is part of our case studies, we will provide more details on this region specifically. Please note that all French regions have seen their responsibilities increase as the decentralization progressed. Nonetheless, we will focus only on environmental and climate responsibilities.

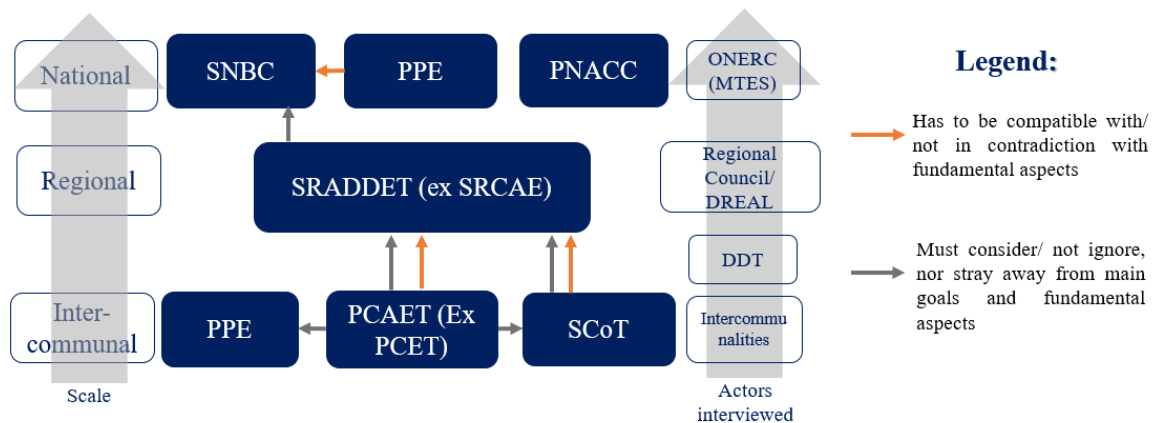
¹⁹ <https://eur-lex.europa.eu/EN/legal-content/glossary/climate-action.html>

²⁰ The European Climate Adaptation Platform Climate-ADAPT was set up by European Commission and the European Environment Agency (EEA) to support Europe in adaptation to climate change. Climate-ADAPT is maintained by the EEA with the support of the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA). It contains information on climate change and vulnerabilities in Europe, EU, national and transnational adaptation strategies, actions, and tools (<https://climate-adapt.eea.europa.eu/about>).

National level

The Figure 12 illustrates the governance of climate and adaptation policies in France. Each level of public administration must elaborate specific documents and assure coherence between them. These will be discussed in the following sections.

Figure 12 Multilevel governance of climate and adaptation in France (adapted from ADEME, 2016:30)



On the national level we find:

- The first French National Adaption plan: PNACC1 was officialised in 2011, while PNACC2 was adopted in 2018²¹. The PNACCs aim at presenting concrete measures to prepare France to changing climatic conditions. PNACCs are elaborated by ONERC through broad public consultation. So far, France has adopted 2 national adaptation plans which are split into 5 groups of actions: governance, improvement of knowledge and information, prevention and resilience of the economy and the nature, international cooperation. PNACC2 recognizes that legal frameworks, standards, and technical benchmarks can represent levers for action. The ambition is to use Medium- and long-term regionalized climate projections to develop the laws, codes, standards, and technical regulations in various sectors, such as transport, infrastructure, telecommunications, energy, and construction. In fact, adaptation is not sufficiently addressed by territorial plans and there is need to reinforce the regulations in that sense (PNACC2, 2018:6).
- The SNBC, the national low carbon strategy (SNBC) refers to the national climate change mitigation policy and it was set up by the law 2015-992 of 17 august 2015

²¹ National Adaptation Strategy was adopted in 2006. This strategy illustrated the State's point of view on how adaptation should be addressed (eg.: definition of adaptation, vulnerabilities, illustration of impacts). PNACCs represent concrete, operational actions to face new challenges (<https://www.ecologie.gouv.fr/adaptation-france-au-changement-climatique>).

(LTECV²², also known as energy transition law). It aims at reducing GHG emissions and increasing their sequestration potential. It provides guidelines for implementing and developing low-carbon, sustainable and circular economy.

- The PPE, or the Multi-annual energy programs (PPE), represent energy policy management tools, were created by the law on energy transition for green growth. The PPE trace the orientations and priorities for the management of all forms of energy. For example, the improvement of energy efficiency or the development of the use of renewable and recovered energies.

A recent energy and climate package (2019) has initiated an energy and climate program (LPEC, loi de programmation sur l'énergie et le climat). This initiative must set the main objectives for French multiannual energy program (PPE) and the low-carbon strategy (SNBC). The PPE and the SNBC represent a starting point for the national integrated energy climate plan required by EU.

Legal obligations on regional level

Regions in France represent a new level for public administration. Although they have emerged in 1960s, French regions had to wait till the 80s to see their powers increase. The so-called Decentralization package (Decentralisation Acte I) contained forty laws and about 300 decrees which, between 1981 to 1986 granted regions with new powers and responsibilities, such as economic development, regional planning, vocational training, and education (Law of 7 January 1983). These laws were based on the idea that local democracy and greater autonomy of local authorities rhyme with modernization of the country. In fact, better public management and economic development were major objectives of decentralization laws.

These reforms were recently amplified with the law of January 16, 2015 on delimitation of regions, regional and departmental elections, and the law of August 7, 2015 known as the "NOTRe Law" (Decentralisation Acte III). The first law reshaped the administrative and political subdivision of the country: 13 new regions were created out of 22 existing ones. In fact, Auvergne and Rhône-Alpes merged into a new region – Auvergne-Rhône-Alpes (AuRA).

Both these regions have previously elaborated Climate Plans, and both have highlighted the role of international, European, and national climate laws and frameworks. For example, Auvergne has approved its regional climate, air, and energy roadmap (SRCAE) in 2008, while Rhône Alpes in 2012. Both these documents contain references

²² Loi sur la transition énergétique et pour la croissance verte

to Kyoto protocol, rectified in 2005, the EU Emissions Trading System (2003/87/CE), the EU's Climate and Energy Packages (2008). Furthermore, the objectives of these documents were integrated into French National CO₂ allocation decrees (décret n°2005-190 du 25 février 2005; 2008). However, like in the case of EU's Climate and Energy Packages, the first climate-related roadmaps refer to mitigation only, and contain no traces of adaptation.

The NOTRe law has further increased regional and local powers and responsibilities. For example, regions' competence in economic development was reinforced. More specifically, nowadays regions must elaborate:

- a strategy for economic development and internationalisation (schéma régional de développement économique, d'innovation et d'internationalisation, SRDEII).
- a strategy for sustainable and equal development (schéma régional d'aménagement durable d'égalité des territoire, SRADDET). In fact, SRADDET replaced the above-mentioned SRCAE. The SRADDET sets medium and long-term objectives in several domains: infrastructures of regional interest, housing, economical management of space, intermodality and development of transport, supervision, and development of energy, fight against climate change, air pollution, protection and restoration of biodiversity, prevention, and management of waste.

The 2015 was also a turning point for climate policies on the subregional levels. With the adoption of the law 2015-992 of 17 august 2015, local authorities became chefs and coordinators of territorial climate-air-energy plans. Previously, only intercommunality or federations of intercommunality (urban agglomerations or community of communes) with more than 50 000 inhabitants were obliged to produce such plans. Nowadays, this legal obligation concerns smaller intercommunalities - 20 000 inhabitants. Additionally, the energy transition law has transformed the PCET (territorial climate-energy plan) into PCAET, adding air quality to intercommunalities' domains of responsibility (the elaboration of Atmosphere protection plan, PPA).

On the level of regional public administration, we can find several actors implied in climate-related policymaking, such as Regional Council, the DREAL and the DDTs (will be discussed below). Each of them has specific responsibilities and power when it comes to producing or coordinating policy formulation and implementation. However, whereas the Regional Council is an elected body, the DREAL and the DDTs are subordinate to the French Ministry for Ecological Transition (MTES).

The **Regional Council** of Auvergne-Rhône-Alpes is the deliberative assembly of the region. It is made up of 204 regional councillors **elected** for 6 years. The Auvergne-Rhône-Alpes Regional Council was created following the law of January 16, 2015.

The **DREAL**²³ represents the Ministry for Ecological Transition and has the implementation of Ministry's policies on the regional level as a main duty. The DREAL was created in 2009 by decree n° 2009-235 (27/02/2009). It coordinates and finances environmental protection, water, and landscapes policy. It is responsible for assessing the impact of construction or development projects and the air quality. Moreover, it is up to the DREAL to monitor both anthropogenic (technological) and natural risks (floods, avalanches).

The **DDT**²⁴ is a decentralized service of the French State created in 2010. It represents the declination of DREAL on the department level of public administration, and consequently has similar missions. The DDT is responsible for implementing sustainable development policies, as it provides authorizations for construction and promotes sustainable balance between urban and rural areas. It also participates in agricultural, urban planning, environmental and transport policies. The DREAL and the DDTs co-elaborate SRADDET with regional authorities.

Legal obligations on sub-regional level

As depicted in the Figure 12, inter-communal level must elaborate 2 documents which include climate-related strategies or orientations. The PCAET is constructed by urban agglomerations and communities of communes. The territorial coherence schemes (SCoT) are a common effort of agglomerations and communities of communes (law 101-2 Urban Code). In fact, the PCAET objectives and actions must take into consideration the SCoT's orientations. Although we have discussed adaptation with Grenoble Urban Agency, which is responsible for SCoT, we will not focus on this document. Firstly, the last SCoT was approved in 2012 and it will be in place till 2030. It is extremely difficult to trace the evolution of adaptation as an issue. Secondly, it contains a few references to adaptation to climate change, which are vague. For example, it commands to diversify tourism activities of ski resorts, or better manage water resources, without more precise solutions.

As depicted on Figure 12, adaptation is still framed as national responsibility. The SRADDET (ex SRCAE) provides with a general framework for the territorial climate, air, and energy plans (PCAET, ex PCET). As the same time, regional SRADDET must be compatible with national SNBC, but does not have the same obligation towards PNACC (ADEME, 2016). Although adaptation has made its appearance in SRADDET and PCAET of selected authorities, it rarely goes as far as concrete measures with evaluation and

²³ DREAL is the Regional Department for the Environment, Development and Housing (direction régionale de l'Environnement, de l'Aménagement et du Logement)

²⁴ DDT is the Departmental land-use directorate (Direction départementale des Territoires)

monitoring criteria. Nonetheless, the will to establish a connection between national and regional administrative levels can be found in PNACC2. These activities are part of the development or revision of regional guidelines dealing with adaptation to climate change (SRADDET). To establish this national-regional connection, PNACC2 encourages the creation of regional adaptation committees to incorporate adaptation into Territorial Climate-Air-Energy Plans (PCAET). As a large part of adaptation is implemented at regional and local levels, a better articulation between national and territorial plans is needed (PNACC2, 2018:5).

2.2.3 Interviews' frameworks

The sections above-described systematic review of EU, national and sub-national adaptation plans, and strategies. It allowed us to illustrate country-specific contexts, and to discuss the role of decentralization. This step was useful to begin the assessment of how EU States address climate change and adaptation, but it was not enough to provide a comprehensive analysis of knowledge needs for adaptation at regional and local scales (administrative, not climatic). To achieve this goal, two separate case studies were conducted. In fact, we moved from the macro level of EU and national strategies and plans to the micro levels of boundary organisations and authorities on sub-national scales. These case studies allow us to shed light on producers' and users' perspective on climate adaptation services. Table 6 illustrates empirical material employed for each part of our research.

Table 6 Case studies and empirical material

	Content analysis	Semi-structured interviews	Statistical study
European and national contexts	+	-	+
Producers of adaptation services	+	+	+
Users of adaptation services (regional and local scales)	+	+	-

Content analysis is used for all three investigations. Semi structured interviews are used to capture in depth experiences of producers and users of adaptation services. As already pointed out in the literature review, sometimes the boundaries between users and producers might be blurry (like in case of IPCC). For the purpose of this study, there was no need for a clear cut between these two groups. Therefore, we will apply the term “producer” to boundary organisations and the term “user” to decisionmakers. Statistical

studies concern European and national contexts, as well as producers of adaptation services. The following section will provide details on users, producers, and research protocol we put in place.

Producers' perspective

First, we have investigated the “producers’ perspective” to climate services. We focused on boundary organisations offering climate adaptation services as their main activity. We will use boundary organisation and knowledge brokers concepts as synonyms. Although in the literature boundary organisations (BO) and knowledge brokers do not share the same institutional design, both will deploy the same strategies to manage the science-policy boundaries.

Additionally, we focused on boundary organisations and knowledge brokers only when these represented an independent institution, or a specific department of a given institution (Figure 10, c - types). Although climate related research projects could deploy knowledge brokering techniques and aim at co-production. However, they all come to an end, while building trust between stakeholders requires time. Kirchhoff et al. (2013) and Reed et al. (2014) identified two-way communication and long-term relationships as keys to effective knowledge exchange. Classical duration of research projects is not long enough to ensure this trust-building. Additionally, there is no guaranteed match between research and policy agendas.

We believe that the degree of institutionalization will have a strong impact on boundary organisations’ capacities to effectively implement their knowledge brokering strategies. We used Europe-ADAPT platform to identify boundary organisations in EU’s Member States and contacted those who fall into adaptation service and knowledge action systems categories (Please see Annex 3: EU, from CCAP to CCAKAS. for the complete list).

The sample for this study is composed of 13 entities from different countries:

- 6 from the EU member states (CCCA, Austria; Climate Ireland, Ireland; CMCC, Italy; CAS, Netherlands; BC3, Spain; SMHI, Sweden).
- 1 focusing on the Mediterranean area (MedECC).
- 1 from Canada (Ouranos Inc.).
- 5 from France (Acclimaterra, Creseb, Grec- Sud, Ouranos AuRA, RECO).

All these boundary organisations are in the EU, except for Ouranos Inc. which is based in Quebec, Canada. We choose to include Ouranos Inc. in our sample for several reasons. Firstly, we aim at tracing the development of these institutions. Adding to the sample a boundary organisation with more than 2 decades of experience may allow us to

better understand the evolution of adaptation services' providers. Secondly, the government of Quebec recognised the value this boundary organisation:

*Ouranos is the flagship of Quebec*²⁵

(2009, Line Beauchamp, Minister of Sustainable Development, Environment and Parks)

The Government of Quebec points out that the works of Ouranos Inc. often served as a basis for government decisions affecting the fight against climate change (2022, <https://www.quebec.ca>)²⁶. Moreover, the absence of language barriers allowed us to travel to Montreal and spend a month in Ouranos Inc. headquarters to conduct the interviews.

When it comes to boundary organisations in France, please note that all of them are regional entities – their operations concern regional and local scales. However, it is necessary to point out that we have deliberately excluded from our sample adaptation products providers and focus exclusively on adaptation services (purposeful sampling technique).

It is worth mentioning that in Auvergne-Rhône-Alpes region, where we conduct the case study with “users”, a regional adaptation products' provider is present. More specifically, it is the regional observatory on the effects of climate change (ORCAE). Although we have conducted an interview with ORCAE, we did not include it in the producers' case study for several reasons:

- It is not a boundary organisation. The Climate Air Energy Observatory of Auvergne-Rhône-Alpes is supported by 5 institutions: the State (DREAL Auvergne-Rhône-Alpes), the Regional Council (Auvergne-Rhône-Alpes Region), two Water Agencies (Rhône-Méditerranée Corse and Loire Bretagne) and ADEME, represented by its Auvergne-Rhône-Alpes regional office. It is operated by a GIS (Scientific Interest Group) bringing together 4 structures: Atmo Auvergne-Rhône-Alpes, Auvergne-Rhône-Alpes Energy Environment (AuRA EE), Cerema and Météo France (<https://www.orcae-auvergne-rhone-alpes.fr>). However, ORCAE has no scientists onboard, no links with universities and research institutions.
- It represents what we defined as first generation of climate services (or CCAP), at least at the time this thesis was written. It does not offer adaptation services, but products: territorialized data and indicators relating to climate, air and energy; communication documents; thematic analyses. These will be discussed in Chapter 5.

²⁵ Translation from “Ouranos est un fleuron québécois”

(<https://www.environnement.gouv.qc.ca/infuseur/communiqu.asp?no=1461>)

²⁶ <https://www.quebec.ca/nouvelles/actualites/details/le-gouvernement-du-quebec-accorde-une-aide-financiere-de-pres-de-20-m-a-ouranos-pour-poursuivre-la-recherche-en-adaptation-aux-changements-climatiques-39069>

As indicated in Table 6, different types of empirical material were mobilized for this case study. Firstly, desk research was conducted. We have analysed internal reports, project descriptions, and scientific papers produced by/about selected organisations. Secondly, 21 interviews were conducted in French, English and Italian. Each interview took between 40 minutes and 1 hour and a half, for a total of 24 hours of recording. The interviews were transcribed, translated, and interpreted by means of thematic analysis.

Annex 1 represents the interview guide used for boundary organisations (BO). We have identified several themes to address during interviews and elaborated a detailed list of questions. Although this list may appear long and rather structured, the interviews were open-ended. The idea was to introduce a theme with a question, and let the participants talk freely. The themes span from evaluation techniques to the variety of scientific disciplines and evolution of BO. This guide was adapted to the specific BO. Table 7 illustrates our empirical material. We have classified collected data into 3 groups:

- Internal, such as annual reports, project descriptions and other deliverables.
- External, such as scientific reports or reviews.
- Web sources for videos or tools developed by selected organisations.

Additionally, the last column indicates the number of interviews conducted with each boundary organisation.

Table 7 Boundary organisations, sample, and empirical material

	Country	Internal: annual reports, project descriptions, deliverables	External reports: scientific papers, reviews	Web sources	Interviews with staff
Basque Centre for Climate Change (BC3)	Spain	Activity reports 2009-2020; Strategic Plan 2018-2021; RESIN City Assessment Report Bilbao, 2016;		https://www.bc3research.org/ https://resin-cities.eu/cities/tier1/bilbao/	1
Climate Adaptation Services (CAS)	Netherlands	KE4CAP project description; Climate Impact Atlas description; final report of the national Knowledge for Climate (KfC) research programme	Goosen et al., 2013, 2014; Laudin et al 2015.	https://www.climateadaptationservices.com https://www.deltares.nl/en/ https://klimaataadaptatienederland.nl/en https://www.klimaateffectatlas.nl/en/	2
Climate Change Centre Austria (CCCA)	Austria	APCC report, 2014; factsheets; Climathon description; Workshop 2048 “Climate services” contribution by CCCA; Science Plan on the Strategic development of climate research in Austria;	ALPACA-Dialogue: Implementing local climate action – barriers & solutions (webinar)	https://ccca.ac.at/en https://literature.ccca.ac.at/ http://www.greentech.at/jam2021/ https://klar-anpassungsregionen.at	1
The Euro-Mediterranean Center on Climate Change (CMCC)	Italy	Strategic Plan 2019-2029. Annual Reports 208-2021;	Overview of key climate change impacts, vulnerabilities and adaptation action in Italy, CMCC Research Paper No. 178, 2013.	https://www.cmcc.it/ http://www.blueap.eu/site/	1
Climate Ireland (CI)	Ireland	All Ireland Adaptation Network Overview and Agenda, 2016. Leaflet August, 2018.	Assessing Vulnerability to Climate Change: An Approach Illustrated through the Large Urban	https://urbadapt.com/ https://urbadapt.com/ https://www.marei.ie/climate-change-projections-for-ireland/	1

		CARO Agenda: CARO presentation “Identify, Assess and Prioritize adaptation measures”	Scale Adaptation (Urb-ADAPT) Project	https://www.caro.ie/	
Ouranos Inc.	Canada (Quebec)	Annual reports 2018-2021; Climate Scenarios and Services program description; Adaptation Governance program description. Webinar: De la science à la prise de décision dans l’adaptation aux changements climatiques (youtube video)	Vescovi et al (2009); Interviews on Radio-Canada: 1) Québec investit dans Ouranos pour mieux s’adapter aux changements climatiques (2019); 2) Ouranos ou quand la science aide les politiciens à s’adapter aux changements climatiques (2015)	https://www.ouranos.ca ; https://www.youtube.com (chaîne Ouranos Inc); https://mern.gouv.qc.ca/ ; https://ici.radio-canada.ca	5
MedECC	Focus on Mediterranean	Flyer, concept note and leaflet (distributed during COP21 in Paris) Climate and Environmental Change in the Mediterranean Basin Current Situation and Risks for the Future, Report 2021; Interviews with MedECC researchers (youtube)	Video on MedECC (UfM Secretariat); Video on climate change in the Mediterranean and MedECC (Brut)	https://www.medecc.org https://www.youtube.com (MedECC channel)	1
SMHI	Sweden	Annual reports 2018-2020; About SMHI fact sheet;	Clara project (leading-edge climate services) and its multi-user Forum activity report (focus on SMHI AQUA); Lindström et al., 2010, C Photiadou, 2020; Polo et al., 2020	https://www.smhi.se/ http://www.klimatanpassning.se/en https://www.clara-project.eu https://aqua.smhi.se/ https://aquaclew.eu/	1
Acclimaterra	France	Les impacts du changement climatique en Aquitaine, Report 2013; Anticiper les changements climatiques en Nouvelle-Aquitaine. Pour agir dans les territoires, Report 2018; Description of EU	Néo-Terra Roadmap;	https://www.acclimaterra.fr/ https://www.neo-terra.fr/ https://trainduclimat.fr/ https://www.nouvelle-aquitaine.fr	1

Creseb	France	Project « Deep Demonstration » Democlim project description; Impact socio-économique du changement de pratique en agriculture Bretagne -project description and youtube video; H.M.U.C webinaires		https://www.creseb.fr/ https://www.creseb.fr/projet-democlim/	2
Grec-Sud	France	Thematic reports (Mountain, Seaside, Cities, Health, Water resources, climate evolution);	Les groupes locaux d'experts sur les changements climatiques (GLEC): un levier de l'action des territoires, Article by Comité 21	http://www.grec-sud.fr/	3
Ouranos AuRA	France	Artaclim project description and results; Gauquelin et al., Quelle place pour les données issues des sciences humaines et sociales dans le développement de services climatiques régionaux? Vertigo, 2017. Users' needs survey results ;	Anquetin et al., Ouranos- AuRA: La science au secours des territoires de montagne, Géosciences, BRGM, 2019.	https://plateforme-ouranos.fr/ https://action-climat-3.sciencesconf.org/ http://artaclim.eu/index.php/fr/ http://lig-tdcge.imag.fr/steamer/trajectories/public/	1
RECO	France	Cahier Régional Occitanie sur les Changements Climatiques, Report 2021; Survey on Users' needs, results, 2020;	Les groupes locaux d'experts sur les changements climatiques (GLEC) : un levier de l'action des territoires, Article by Comité 21	https://reco-occitanie.org/	1
Total interviews					21

A detailed description of selected boundary organisations will be provided in chapter 4. The next paragraphs will illustrate the last case study – the users’ perspective on adaptation services.

Users’ perspective

AuRA region is situated in the South-East of France (Figure 13). The region is rich in landscapes: from the highest peaks of the Alps (Mt Blanc) to the valleys like the Rhône and Loire, from the Drôme hills to the volcanoes of Auvergne. As stated in the introduction, AuRA represents an interesting territory to study because of its “rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity²⁷”(McCarthy, IPCC 2001:21).

Figure 13 Auvergne-Rhône-Alpes



Exposure: with its 8ml inhabitants, AuRA is the second most populated region after Ile-de France (Paris). It is characterised by a high concentration of human activities, such as world known ski resorts of Chamonix Mont Blanc or Courchevel. It is the 7th European region in terms of creation of wealth and it hosts multiple international companies such as STMicroelectronics, Schneider Electric, HP (<https://www.welcometofrance.com>). AuRA is the leading energy region in France, if not in Europe, thanks to the importance of the hydroelectric installations in the Alps and on the Rhône River, and the presence of four nuclear power stations (French National Agency for Territorial Cohesion, 2014).

Sensitivity: mountain regions register higher temperature rises and changes in precipitations (European Environment Agency, 2016). Changes in mountain cryosphere

²⁷ In this context, **exposure** is defined as the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

Adaptive capacity is the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences.

Sensitivity is the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change (AR6:2897-2927).

(including snow, glaciers, permafrost, lake, and river ice) impact water resources and agriculture at lower altitudes (IPCC, 2022). Additionally, around 50% of Alpine plant species are projected to lose more than 80 % of their suitable habitat (Alpine Convention, 2017). The consequences of climate change will impact multiple ecosystems, and in particular the mountain ones. The entire water regime is changing and undermining the Alps status of “Water Tower” of Europe. Additionally, it will change the amplitude and distribution of natural risk such as floods, avalanches, landslides, forest fires etc.

Adaptive capacity: is what we aim to understand in this case study. More specifically, we would like to shed light on the mainstreaming of adaptation from vertical and horizontal perspectives, as well as knowledge needs for adaptation at local scales.

This stage was supported by desk research, coupled with semi-structured interviews (Table 6). In AuRA, there are two major documents tackling climate change mitigation and adaptation. Consequently, we expect adaptation services to be used for the elaboration of these strategies:

- SRADDET, the strategy for sustainable and equal development elaborated by Regional Council (schéma régional d'aménagement durable d'égalité des territoires).
- PCAET, the Climate Air Energy Plan, elaborated by intercommunalities.

Following this logic, we aim at addressing the issue of climate adaptation products and services with regional and local authorities in charge of these spatial planning tools. More specifically, our sample will be composed of two groups of actors:

- The first category is composed of regional and sub-regional administrative units, such as Regional Council, or the departmental land-use directorates (DDT). This category includes state services (DDT, DREAL) and regional ones (Regional Council). The first category corresponds to NUTS1 (region) and NUTS3 (department) subdivision of European Union (2020)²⁸.
- The second category refers to intercommunalities. There are 4 types of public establishments for inter-municipal cooperation²⁹ in France: the community of communes (CC), the community of agglomerations (CA); the urban community (CU), and the metropolis (métropole). The four forms of intercommunality have the right to levy local tax but differ in terms of composition and integration. For example, the CC

²⁸ NUTS stands for Nomenclature of Territorial Units for Statistics

²⁹ Public establishments for inter-municipal cooperation - an établissement public de coopération intercommunale à fiscalité propre (EPCI).

refers to rural entities, CA to mid-size cities and their sub-urbs, the Metropolis refers to the biggest cities and their suburbs. Metropolis are the most integrated form of intercommunality in France, while the CC the least integrated. Additionally, CA and Metropolis must respect population thresholds to organize intercommunality, while for CC the only constraint is geographical continuity (no enclaves allowed).

Our sample also includes several state and regional agencies involved in environmental or climate policies. These agencies play a key role in regional and local climate planning thus it was imperative to include them in our study. For example, ONERC, the French National Observatory of Climate Change Effects, is in charge of tracking climate change and adaptation solutions on the national level. While ORCAE is Auvergne-Rhône-Alpes' regional observatory on climate, air, and energy. Therefore, their views on climate adaptation products and services are mandatory for a good understanding of French climate adaptation panorama.

Our empirical material includes various documents produced by selected authorities (Table 8). More specifically, we focused on documents related to climate and adaptation, such as climate plans (PCAET, PCET), numerous reports on local impacts and vulnerability (diagnostic), presentations of existing initiatives and tools (eg.: TerriSTORY³⁰, workshops). Additionally, we have consulted reports on economic activities since 1) this information is essential to better grasp local reality and needs, and 2) we expect major economic sectors to be prioritized during adaptation spatial planning.

Table 8 portrays the final sample and empirical material. Auvergne-Rhône-Alpes is divided into 12 departments and 173 intercommunalities. Finally, we conducted interviews with:

- 5 DDT out of 12 (DDT of Isere, Savoy, Haute-Savoy, Puy de Dôme, and Loire).
- 4 metropolises out of 4 (Grand Lyon, Grenoble -Alpes, Sainte-Etienne, and Clermont-Auvergne).
- 2 communities of agglomerations out of 27 (CA Grand Anancy and CA du Pays Voironnais).
- 6 communities of communes out of 132 (CC Genevois Français, CC Saint Marcelin Vercors, CC Le Grésivaudan, CC du Trièves, CC de l'Oisans, CC Chamonix).

³⁰ TerriSTORY is website, a tool to help manage energy transition of Auvergne-Rhône-Alpes, offered by the Auvergne-Rhône-Alpes Regional Energy-Environment Agency. TerriSTORY covers a wide range of topics such as energy, air, greenhouse gas emissions, carbon storage, waste management, mobility, environment, climate, economy, etc (<https://auvergneRhônealpes.terristory.fr/>). It does not address adaptation.

Entitiy	ITW*	Consulted reports, presentations, and other documents	Website
Conseil régional (La Région)	1	Description of workshops SRADDET October 2020; SRADDET and bilan 2021; Plan Energie Climat 2009 (Auvergne); SCRAE 2012 (Auvergne); SRCAE 2014 (RA) ; SRADDET 2020 (AuRA)	https://www.auvergneRhônealpes.fr
DREAL AuRA	4	Decree 2016-519 of 28-04-2016 – environmental authorities’ reform. Results of survey on data needs; Description of regional seminar on PCAET	https://www.auvergne-Rhône-alpes.developpement-durable.gouv.fr/
DDT Puy de Dôme	1	Bilan and numbers for 2019; Puy-de-Dôme PCET2013-2018	http://www.puy-de-dome.gouv.fr
DDT Loire	1	Plan climat Energie Territorial (Conseil Général de la Loire, 2017)	http://www.loire.gouv.fr https://teo-paysdelaloire.fr/
DDT Isère	1	Report: Climate change: economic, health and environmental issues in Isère (Cerema, 2017)	https://www.isere.gouv.fr
DDT Savoie	1	Artificial snow observatory in Savoie, season 2018-2019; White book on Climate in Savoie;	https://www.savoie.fr/
DDT Haute-Savoie	1	Rapport développement durable, 2020	https://www.haute-savoie.gouv.fr/
Grand Lyon	2	PCET 2017; PCAET 2020-2030	https://www.grandlyon.com
Clermont Auvergne Métropole	1	PCET 2014, PCAET 2018	https://www.clermontmetropole.eu
Grenoble-Alpes-Métropole	3	PCET 2015, PCAET, 2020-2030; Air, energy, climate action plan (2019-2025), and its evaluation 2018, 2019 et 2020;	https://grenoblealpesmetropole.fr
Saint Etienne Métropole	1	PCAET 2019-2025; PCAET updates 2021; PCET 2011	https://www.saint-etienne-metropole.fr/
CA Grand Annecy	1	Bilan of Climate workshops 2019; PCAET 2020-2025; PCET 2013	https://www.grandannecy.fr
Genevois Français	1	Presentation of Metropolis development scheme;	https://www.genevoisfrancais.org/
CA du Pays Voironnais	1	PCAET 2019-2025, synthesis and diagnostic of strategies 2018-2024, PCET 2012;	https://www.paysvoironnais.com/
CC Saint Marcellin Vercors	1	PCAET 2019; Vulnerability Report 2020 ; Description of workshop on “ energy transition, air and climate” 2020	http://www.saintmarcellin-vercors-isere.fr/
CC Le Grésivaudan	1	PCET actions’ description 2013-2019; PCAET 2013	https://www.le-gresivaudan.fr

CC du Trièves	1	PCAET 2020 (diagnostic);	https://www.cc-trieves.fr
CC de l'Oisans	1	PCET 2016	https://www.ccoisans.fr/ http://www.oisans2040.fr/
CC Chamonix	1	PCET 2012	https://www.cc-valleedechamonixmontblanc.fr/
ONERC	1	National adaptation plans (2011 and 2018), Adaptation plan's assessment (2011-2015)	https://www.ecologie.gouv.fr/adaptation-france-au-changement-climatique
Orcae	1	TerriSTORY presentation; Global methodology explanations ; several thematic documents on indicators such as precipitations, temperatures, heat islands, ; Study on snow tourism 2017 ; State of art on risks in mountains 2017 ;	https://www.orcae-auvergne-Rhône-alpes.fr
Cerema	1	Feedback on technical seminar « Adaptation to climate change » 2017	https://www.cerema.fr
Scot AURG	1	ScoT, 2020	https://www.aurg.fr http://scot-region-grenoble.org/
Total	29		

Table 8 Users: sample and empirical material

Table 9 Sample: spatial and institutional distribution

Scales	Local	Department	Region	State
Producers	SCOT AuRG	-	Regional council ORCAE DREAL	ONERC CEREMA
Users	12 intercommunalities	5 DDT	Regional Council DREAL	ONERC

Table 9 illustrates the spatial distribution of the sample. It also depicts the funnel approach of this part of research (from national to local scale). Although it is labelled as “users’ perspective”, we conducted interviews with both users and producers to have the full picture. Additionally, some of these entities fall into both categories because the distinction between those who merely produce or merely use adaptation services is not always clear. For example, DREAL does both: it coordinates environmental policy and translates national orientations into regional policies (one of knowledge brokerage activities), while it also uses adaptation products and services, such as DRIAS. On the contrary, the intercommunalities do not produce adaptation services and fall into one category - the users.

Annex 2: Interview guide: intercommunalities in AuRA represents the interview guide used with the ‘users’. Like for producers, this guide is split into several themes and contains several questions, some of which are quite detailed. The PCAET’s analysis was conducted prior to each interview, thus some questions are very specific. This guide is in its general template, but it was adapted to each interview. For example, in order to tackle specific aspects of knowledge transfer, the theme “specific needs” contains information found in PCAETs. Additionally, it is worth noting that intercommunalities showed interest in climate adaptation services, even if most of them were not accustomed to this term. Indeed, as the spirit of these interviews was to keep them open-ended, plenty of insights were collected “off-topic” at the end, when the ice was broken.

We can say that our sample is representative for metropolis type of intercommunalities (4 out 4 interviewed). Out of 132 federation of communes, only 11 have more than 50k habitants, and we have interviewed 6. Our sample is not representative for communities of agglomeration type of intercommunalities: interviewed 2 out of 27. However, our sample is slightly biased towards intercommunalities surrounding Grenoble city for several reasons. Firstly, geographical proximity was an important criterion during COVID restrictions. Secondly, institutional proximity played an important role. In fact,

Grenoble-Alpes-University has strong ties with its territory, therefore convenience sampling was applied (a non -probability sampling method).

The following sections will describe the data analysis, but also discuss methodological limits.

2.3 Data analysis

Thematic analysis is a qualitative method that allows to generate new insights, and which can be widely used across a range of epistemologies and research questions (Nowell et al. 2017). For DeSantis and Ugarriza a theme is “*an abstract entity that brings meaning and identity to a recurrent experience and its variant manifestations. As such, a theme captures and unifies the nature or basis of the experience into a meaningful whole*” (2000:362). Based on the inputs from literature, we elaborated a “start list” and used it later in coding process (Miles and Huberman, 1994). There are many ways to conduct thematic analysis. Themes can be generated inductively from data or deductively from existing literature.

Thematic analysis is a flexible approach allowing both deductive (confirmatory) and inductive (exploratory) methodology. For example, Braun and Clarke (2006) distinguish between top-down theoretical thematic analysis (driven by research questions), and bottom-up data-driven approach (inductive, similar to grounded theory). Top-down thematic analysis tends to offer a less rich description of the data overall, but a more detailed analysis of specific aspects. In our case, we will start with a deductive approach to build interview guidelines but leave a lot of space for new themes and concepts to arise during the process of codification. Moreover, as Braun and Clarke have legitimately pointed out “*researchers cannot free themselves of their theoretical and epistemological commitments, and data are not coded in an epistemological vacuum*” (2006:12). We will follow stages described in Braun and Clarke (2006) and illustrated in Table 10.

The interviews took place between 2019 and 2021. Interviews with producers were conducted in 2019, and the thematic analysis took place in 2020/21. The interviews with users started at the end of 2020, but most were conducted in the beginning of 2021. These interviews were transcribed and analysed between 2021 and 2022.

We consulted a specific service in PACTE laboratory to better understand which software to choose for our needs. In fact, as we follow the inductive approach and we are not interested in lexical analysis, Excel appeared to be the most appropriate tool. Secondly, the number and the length of interviews allowed us to easily familiarize ourselves with the “data”. We reached thematic saturation and were able to build thematic maps “manually”.

Therefore, we did not use any specific software such as Nvivo and opted for Excel for several reasons.

Table 10 Stages of thematic analysis (adapted from Braun and Clark, 2006)

Stage	Description	Producers	Users
Phase 0: conducting interviews	Organizing and conducting interviews	2019	2020-2021
Phase 1: familiarising with data	Transcribing data. Generating an initial list of ideas.	2019-2020	2021
Phase 2: generating initial codes	production of initial codes ³¹ from the data. Organising data into meaningful groups.	Jan-February 2021	October 2021
Phase 3: searching for themes	Collating codes into potential themes, Identification of main themes and sub-themes	March-May 2021	November 2021
Phase 4: reviewing themes	Generating a thematic ‘map’ of the analysis.	March-May 2021	December 2021- January 2022
Phase 5: defining and naming themes	Refining of each theme ³² Generating clear definitions and names for each theme	June-August 2021	February -March 2022
Phase 6: producing the final report	Selection compelling extract examples Final analysis of selected extracts Relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.	July- September 2021	March-June 2022

³¹ Codes refer to “the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon” (Boyatzis, 1998: 63).

³² Process of refinement of candidate themes according to Patton’s (1990) dual criteria for judging categories - internal homogeneity (coherence within themes) and external heterogeneity (clear distinction between themes).

2.4 Methodological limitations

One of the most important limitations of this PhD thesis refers to the size and the compositions of the samples:

- Providers (boundary organisations, Chapter 3) - small sample (13), composed of organisations working in different countries. Half of these organisations were established in France, introducing an important bias in our results. Although the outputs from this field work cannot be generalized, they offer a good understanding of the main challenges of selected BO.
- Users (intercommunalities, Chapter 4) - the size and the homogeneity of the sample is less problematic, especially for specific types of intercommunalities, such as metropolis. Nonetheless, several intercommunalities did not respond to our requests. Others have put in place climate plans without specific legal obligations; thus, it is hard to assess the exact representativeness of our sample.
- Users/producers dichotomy may be tricky (Chapter 5). As discussed in section 1.6.3, some of these entities fall into both categories because the distinction between those who merely produce or merely use adaptation services is not always clear. Although our main focus for this part of the study was to tackle knowledge needs, discussions with producers allows us to have a better understanding of French context, especially on the regional and local scales.

The second important limitation is the language barrier. To map adaptation systems in the EU we relied on information available on the EU's platforms, but an additional desk research was conducted when information was outdated or simply not available. In fact, some information was not available in English, and this represented an important barrier during desk research phase. On the contrary, knowledge of Italian and French did facilitate interactions with boundary organisations from Italy and Quebec.

Although we believe that COVID restrictions did not have an impact on the size of the sample, conducting interviews on Zoom might not be the best solution for semi-structured interviews. In fact, we believe that face-to-face interviews would have been better, especially for such controversial topics as adaptation and spatial planning.

So far, we have illustrated the theoretical and the methodological background of this thesis. Finally, in the next chapters we can illustrate how our research unfolded. We will start with the multi-level governance of adaptation in the EU.

Chapter 3

Mapping the climate change adaptation knowledge-actions systems in EU



*A kind of laziness, an arrogant faith in our ability to react in
time to save our skins.*

Al Gore, 1992

This chapter will discuss the emergence of climate-change knowledge action systems in the EU. This part of research aims at testing the following hypothesis

The degree of decentralisation of a country may influence the development of climate change adaptation knowledge-action systems.

To answer this question, multiple sub questions will be addressed. We will first analyse EU adaptation strategies and plans, and national adaptation policies and plans in terms timing of adoption (section 2.1). Then we will inquire on the timing of sub-national policies (2.2) and discuss whether country-specific features, such as the degree of decentralization, have impacted the timing of implementation of adaptation strategies and plans across these jurisdictional levels. After portraying multi-level governance through the abovementioned policies, the last section (2.3) of this chapter will be dedicated to mapping the climate change adaptation knowledge action systems in the EU.

3.1 Adaptation strategies in the European Union

This section will provide an overview of adaptation strategies on both the EU and national levels. Most EU countries have legislation aimed at protecting citizens from the current and future negative effects of climate change (European Convention of Human Rights, the European Charter of Human Rights, the EU treaty, national constitutions, and ordinary legislation). There are several perspectives on why a government should engage in adaptation actions - not only for *safety* reasons, but also from the economic viewpoint. Indeed, *“from the perspective of economic theories, the provision of collective goods is one of the most important reasons for the government to take the lead in climate adaptation”* (European Commission, 2007:2). Moreover, failure to implement policy responses will trigger reactive action, which is more expensive compared to active or proactive adaptation (European Environment Agency, 2007). According to the EEA (Report No. 12/2012), the costs of not adapting to climate change were estimated to range from EUR 100 billion a year in 2020 to EUR 250 billion a year in 2050 for the EU.

To date, four main documents are used to guide adaptation action in the EU. As one can see from the table below, all of them highlight the importance of knowledge provision for better decision-making. Indeed, climate services are part of *“knowledge adaptation as a tool for better resilience”* (European Commission, 2013).

Table 5 - Adaptation in the EU, a summary of communications and plans

Document	Core ideas and aims
Green Paper (2007)	<p>The need to support practitioners through guidance on existing scientific knowledge and adaptation measures; promote European-wide networks for the exchange and consolidation of knowledge, experience, and adaptation; facilitate the transmission of knowledge from the research community to practitioners (SEC (2007)849). Modern Information and Communication Technologies (ICT) are shown to be a key instrument to support the above-mentioned processes (European Commission, 2007).</p>
White Paper (2009)	<p>Built on consultations carried out in 2007, the white paper sets out a framework to reduce the EU's vulnerability through: 1) building a solid knowledge base on the impact and consequences of climate change for the EU; 2) integrating adaptation into key EU policy areas; 3) employing a combination of policy instruments (market-based instruments, guidelines, public-private partnerships) to ensure the effective delivery of adaptation; and 4) stepping up international cooperation on adaptation (European Commission, 2009).</p>
Adaptation Strategy (2013)	<p>This document structures the EU's action-plan around 3 main objectives: 1) encouraging Member States to implement adaptation strategies (funding LIFE and Covenant of Mayors); 2) promoting better informed decision-making (bridging the knowledge gap and further develop Climate-ADAPT); 3) promoting adaptation in vulnerable sectors (climate-proofing of the Common Agricultural Policy, the Cohesion Policy, and the Common Fisheries Policy, Infrastructure) (European Commission, 2013).</p>
Adaptation Strategy (2021)	<p>Stresses the “<i>need to act NOW</i>” and to accelerate adaptation; highlights the costs of climate change and “<i>an increasing demand to translate the wealth of climate information available into customised, user-friendly tools</i>” to support policy development at all levels and in all sectors (European Commission, 2021:4).</p>

Source: European Commission, <https://eur-lex.europa.eu>

The existence of knowledge gaps was identified in the EU's very first adaptation-related documents (Table 5). Research on climate services and adaptation has been conducted within multiple research programs. For example, the EU has been investing in developing applications in the framework of the Global Earth Observation System of Systems (GEOSS), in the Copernicus Climate Change Service (C3S), in the European Climate Adaptation platform (Climate-ADAPT), and in the European Research Area for Climate services (ERA4CS). The C3S has released an interactive tool with climate

variables and indices - the European Climate Data Explorer (ECDE). The ERA4CS, among others, has mapped climate service providers - Climate Knowledge Hub.

From a vertical perspective, the EU’s Green and White Papers for adaptation recognize the importance of different territorial levels and the interplay between them. Indeed, for each level the EU assigns its own role as follows:

Table 11 Multi-level governance of the adaptation and distribution of roles according to the EU

Scale	Role
EU level	Coordinating role for impacts that transcend national boundaries (e.g., river basins), or for sectors that are integrated through the single market and common legislation (e.g., agriculture, fisheries, etc.); providing funding for disadvantaged States and regions (Life+ program, Cohesion Funds, etc.); coordinating research and innovation (Horizon 2020).
National level	Developing adaptation strategies and improving disaster crisis management.
Regional level	Including adaptation in spatial planning to raise the awareness of citizens and decision-makers (e.g., development of specific technical guidance or “good practices” and exchange of information).
Local level	Since many climate-related decisions are taken on local levels, local authorities have an important role to play (European Commission, 2007). In addition, the Green Paper highlighted that the local level “ <i>is where detailed knowledge on natural and human conditions is available</i> ” (2007:11).

Source: European Commission, 2009, 2013:5

In the light of the above, we expect European and national institutions to ensure vertical integration, and national and sub-national knowledge brokers and networks to promote the horizontal dimension. For example, the EU’s Climate-ADAPT platform aims at facilitating the collection, sharing and use of information; at encouraging the effective uptake of the relevant knowledge by decision-makers; and at contributing to a greater level of coordination between sectors and institutional levels (EEA, 2016). However, approaches to vertical and horizontal integration will differ between countries and reflect their intrinsic features, such as degrees of decentralisation or policy-making traditions. We assume that the development of CCAKAS will be impacted by these characteristics, an aspect discussed in the next section.

3.1.1 The articulation of the EU and national adaptation strategies and plans

Timing the EU and the national adaptation strategies and plans represents the first step to depict multi-level governance of adaptation in the Union. More specifically, it is

adaptation strategy, the heatwave enabled a shift in the perception of climate and adaptation activities (ONERC, 2007:17). Likewise, the Netherlands, as a low-lying country, launched a coastal management program after a disastrous flood in 1953 that claimed 1836 lives and destroyed 42,000 homes (<https://www.rijkswaterstaat.nl>). With time, the constant “*battle against water*”, coupled with growing concern over rising sea levels due to climate change has led the Dutch authorities to adopt “*a new water vision*” and formulate the first Dutch National Adaptation Strategy (Dutch Minister for the Environment, NAS 2016). The early birds’ group is characterized by countries with high GDP per capita and high Human Development Index (HDI), such as Denmark, Finland, or Luxembourg among others (Eurostat, 2022; UNDP, 2021).

The just-in-time group is less numerous, and it is composed of a non-homogeneous group of countries such as Austria, Romania, Lithuania, Poland among others. The Post-EUAS is characterized by lower GDP and HDI indexes. The presence of an integrated single market, governed by common policies, entitles the EU to play a crucial role in this domain. Several Central and Eastern European countries have formulated their NAS as part of European and international programs. For example: Romania took part in the World Bank Initiative; the Croatian NAS/NAP was partially funded by the Purchaser Central Finance and Contracting Agency for European Union Programs and Projects (SAFU); the Estonian NAP was funded by an EEA grant and driven by the Stockholm Environmental Institute (Tallinn); Bulgaria and Poland made use of the EU’s Cohesion Funds; Cyprus’ combined NAP/NAS was formulated within the CYPADAPT project, which was co-financed by the EU through the LIFE+ program.

When comparing the composition of the three groups of states (early birds, just-in-time and post-EUAS), we can clearly see how these are impacted by GDP per capita and HDI. Indeed, as pointed out by IPCC “*many aspects of economic development also facilitate adaptation to a changing climate, such as better education and health*” (2014:948). As pointed out by several authors (Adger et al., 2005; Amundsen et al., 2010), and by the European Commission itself (European Commission 2013:5), the impacts of climate change will not respect boundaries, and as a consequence will require multi-scale coordination. Cross-boundary actions represent sine qua non mechanisms for building up coherent adaptation practices across European States. Moreover, several joint adaptation projects between EU states have emerged. The Cohesion Fund co-finances many cross-border and interregional projects such as the EU macro-regional strategies in the Danube area, the Baltic Sea, and the Alps (Eg.: Interreg Alpine Space). Figure 16 allowed us to illustrate how the EU and the national climate adaptation policies emerged, and how these are articulated on these two spatial scales. In order to complete our analysis on multi-scale

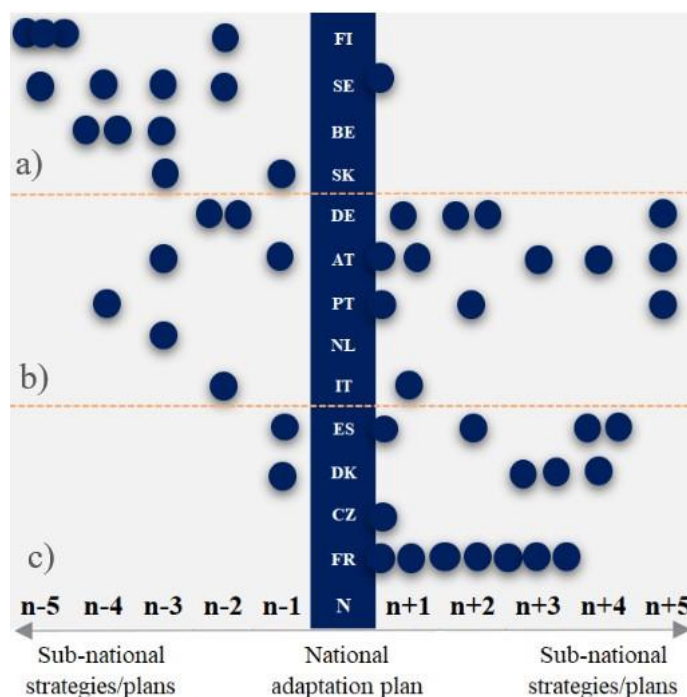
governance of adaptation in the EU, will inquire on the sub-national policies in the following section.

3.2 Adaptation policies at sub-national levels

Following a funnel approach to adaptation governance, and to address our initial hypothesis on whether a country's decentralization/centralization had impacted adaptation policymaking, we have inquired on all available adaptation-related policies in the EU member states. Our aim is to portray how policies on national and sub-national scales are related to each other from a timing perspective.

In which countries local authorities issued adaptation plans before national ones were adopted? Figure 15 depicts the timing of the implementation of sub-national strategies/plans compared to national plans (for more details, please see Appendix A). The horizontal N-axis depicts the year of emergence of sub-national strategies and plans. It was normalised around the publication of national adaptation plans. This enables cross-country comparison in terms of sub-national capacities to engage in adaptation actions. More specifically, the plot illustrates whether regional strategies and plans emerged prior (on the left of axis N), or after the national plan (on the right of axis N).

Figure 15 Adaptation policies at sub-national levels



While the aim of the national adaptation strategy (NAS) is to introduce adaptation issues in policy agendas, the national adaptation plans contain specific means to achieve the objectives of the NASs. Therefore, it is interesting to assess whether sub-national adaptation policies emerged before specific guidelines from national governments. Out of EU's 27 countries, 13 have seen their sub-national levels produce adaptations plans and strategies: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy,

Netherlands, Portugal, Slovakia, Spain, and Sweden (Figure 15). Please refer to Annex 3 for a complete database of available climate adaptation policies in the EU.

As it was expected, federal and decentralised states show similar patterns, although the distinction between federal/unitary (or decentralized/centralized) alone does not fully explain the differences on sub-national scales. Whilst it is not possible to establish a single rule that would explain differences between these countries, the Figure 15 allows us to draw several conclusions. The upper part (a) of the Figure 15 regroups countries where sub-national climate policies have been adopted prior to the national ones (Finland, Sweden, Belgium, Slovakia); the middle part (b) contains countries where sub-national adaptation policies have emerged both prior and after the national ones (Germany, Austria, Portugal, Netherlands, Italy); part (c) refers to countries where sub-national scales issued adaptation-related policies after the national ones (Spain, Denmark, Czech Republic, France).

In Sweden, Finland, Slovakia or Belgium, sub-national authorities have elaborated adaptation strategies years before national plans were published. In Belgium climate policy is subject to intergovernmental negotiation, but the regions have significant decision-making powers (Jorgensen et al., 2015). In Germany, the landers are “*fully responsible for the implementation of their environmental, climate and energy policies and can put in place a variety of crucial measures including the setting of ambitious targets, the removal of planning barriers, instituting strong heating laws and facilitating ambitious research and education*” (Jorgensen et al., 2015:241).

The group (b) is rather a mixed one, as countries such as Germany and Austria have several climate adaptation policies adopted before the national one, while in Portugal and Italy was the case for only 1 sub-national entity. In Italy, regional statutory autonomy and legislative competences were enhanced by a constitutional reform in 2001. However, the central government exercises exclusive legislative power in environmental and ecosystem protection. Nonetheless, the region of Lombardy adopted an adaptation plan in 2012 and an adaptation strategy in 2015. It is noteworthy that Lombardy is the most populated region and second in terms of GDP per capita (ISTAT, 2019). Besides Lombardy, the only region to have adopted an adaptation plan was Sardinia (an island region) in 2019. Similarly, in Portugal, 2 autonomous island regions adopted their plans before or at the same time as the national one (2011 Azores, 2015 Madeira). In fact, Portugal’s Constitution of 1974 makes provision for the two autonomous regions, while referendum to extend this to mainland was defeated in 1998.

France and Portugal - unitary and centralized countries - have seen their regions adapt “massively” after the national strategy was published. However, these countries represent different degrees of centralization and sub-national fiscal autonomy, as major

administrative reforms have been implemented during the last three decades. For example, in France a reform of 2015 (Law no. 2015-991) reorganized the administrative system and reduced the number of regions from 22 to 14. This law, while increasing regional responsibilities in spatial planning, made it mandatory to include climate adaptation in strategic documents such as the regional plan for land use planning, sustainable development, and equality (SRADDET, or schéma régional d'aménagement, de développement durable et d'égalité des territoires). In addition, French regions obtained the authority to manage European funds only in 2014.

Unfortunately, it was not always possible to have a complete assessment of sub-national strategies in Central and Eastern European Countries due to the lack of available information and language barriers. Overall, we can conclude that adaptation policies have blossomed everywhere across the European Union (Figure 14). Moreover, as illustrated in Figure 15 countries characterized by a higher level of decentralisation have seen their sub-national levels implement adaptation plans and strategies before national guidelines (eg.: Belgium, Austria, Germany, or Sweden). Centralized states, such as France or Portugal, followed different patterns – sub-national adaptation strategies were developed after the national guidelines, except for autonomous regions (Azores and Madeira in Portugal).

Does the capacity of sub-national scales to engage in pro-active adaptation contribute to the development of climate change adaptation knowledge-actions systems (CCAKAS)? CCAKAS are defined as “*networks of individuals, organisations, coordinating bodies, and institutional and communication structures that cooperatively design, produce, provide and use climate change adaptation products and services*” (Weichselgartner and Arheimer, 2019:395). We argue that decentralization will have a positive impact on the development of CCAKAS. On the contrary, the institutional inertia of centralized top-down approaches represents a barrier to contextually robust answers to climate change (Fraser and Kirbyshire, 2017).

3.3 Climate change adaptation products, services, and systems in the EU

The role of institutional context in climate change governance has been largely discussed in the literature. As outlined in Dilling and Lemos (2010), formal and informal institutional barriers will have an impact on the use of climate services. Institutions operate within inflexible rules which slow down the implementation of new mechanisms (e.g., the impacts to climate change are addressed within existing decision processes). Socio-political barriers to adaptation actions include, among others, the complexity of local politics and the role of networks (Celliers et al., 2021). Therefore, the institutional context and political support are among the most important pillars for successful adaptation and climate service

use. The integration of climate issues in policy and practice can take the form of intra- and inter-organisational mainstreaming, or the promotion of collaboration and networking with other departments and stakeholders to generate shared understanding and knowledge (Berkhout et al. 2015, Wamsler and Pauleit 2016). Nowadays, the numerous and diverse climate institutions have shifted adaptation governance from monocentric structures, such as the Kyoto protocol and the Paris Agreement, towards more polycentric systems, where subnational governments and actors have expanded their commitments and roles (Abbott, 2017). Nonetheless, although in general polycentric governance theory organisations can emerge and coordinate their actions spontaneously, in climate governance such organisations are created thanks to facilitation operated by the state and other actors. Polycentric climate governance will rely on extensive orchestration between intergovernmental (IPCC, The UNFCCC), state (for national laws and policies), subnational actors (individually or through transnational associations, such as the Covenant of Mayors), and private initiatives (Abbott, 2017). Therefore, climate adaptation knowledge action systems must rely on networks between relevant stakeholders - institutional, research and professionals. Weichselgartner and Arheimer (2019) highlighted that climate adaptation products will gain value for decision-makers as they evolve from products into services, and from services into knowledge-action systems. This process is characterized by the transformation of useful knowledge into knowledge used for decision making (Celliers et al., 2021).

Given the inputs from the literature, we assume that decentralization will foster the development of climate change adaptation knowledge action systems, as decentralization is characterized by multi-level governance and stronger polycentricity. In fact, those countries where polycentric networks for other issues exist, will see CCAKAS emerge faster. To test this hypothesis, we have built a database (Annex 3) with all available climate change adaptation products, services, and systems in the EU. This process was facilitated by the presence of the European Climate Adaptation Platform Climate-ADAPT which centralizes information on adaptation policies, initiatives, and tools in the EU and across its member states. We have also conducted online research to complete missing data.

Figure 16 portrays the status of CCAKAS in winter 2022. More specifically, it classifies the countries according to the availability of: CCAPs, or tata, tools, maps produced by CCAS or by national meteorological services; CCAS, or boundary organisations involved in CCAP production or selected adaptation services offered by CCAS; CCAKAS refer to the presence of coordination mechanisms built by at least 2 different entities/networks (institutional, research, professional).

Figure 16 From to CCAKAS in the EU

	CCAKAS (a)						CCAS (b)				CCAP (c)						(d)										
Country	Austria	Denmark	Germany	Ireland	Netherlands	Spain	Sweden	Finland	France	Italy	Belgium	Czech Republic	Hungary	Lithuania	Latvia	Poland	Portugal	Romania	Slovenia	Slovakia	Croatia	Estonia	Cyprus	Bulgaria	Greece	Malta	Luxembourg

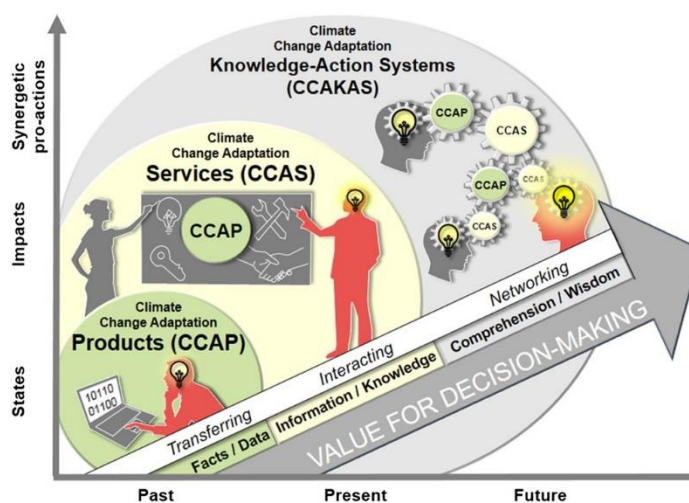
Based on Figure 16 we can roughly distinguish 4 groups of countries:

- (a) *Countries with climate change adaptation knowledge action systems (CCAKAS):* Austria, Denmark, Germany, Ireland, Netherlands, Spain, Sweden.
- (b) *Countries with climate change adaptation services (CCAS):* Belgium, Finland, France, Italy.
- (c) *Countries with climate change adaptation products (CCAP):* Czech Republic, Hungary, Latvia, Lithuania, Poland, Portugal, Slovenia, Romania.
- (d) *Countries without CCAP:* Bulgaria, Cyprus, Croatia, Greece, Estonia, Malta, Luxembourg, Slovakia

Please note that adaptation systems CCAKAS are composed by CCAP and CCAS, while the CCAS integrate CCAP, as depicted in Figure 17. We should interpret the development of adaptation systems as a stepwise process: from products to services, and from services into the systems.

Figure 17 CCAP, CCAS, CCAKAS (Weichselgartner and Arheimer, 2019)

As expected, several decentralised countries have developed CCAKAS. Countries such as Austria, Denmark, Germany, Ireland, the Netherlands, Norway, Spain, and Sweden were able to articulate climate products and adaptation services into CCAKAS. In Austria, “The Climate Change Centre Austria (CCCA) is a



research network supported by Austria’s most important research institutions. It promotes climate research and climate impact research and fosters collaboration in and among those fields. It also provides society and policymakers with scientifically sound information and

advice on climate-relevant topics” (<https://ccca.ac.at>). What is more, the CCCA has developed partnerships with Green Tech Valley in Styria, the European Forum Alpbach (an interdisciplinary platform for science, politics, business, and culture) and Disaster Competence Network Austria (a scientific collaboration platform between universities, research institutes and their stakeholders).

In Germany, *“The two administrative offices, DKD and KlimAdapt, are in each case supported by a network which forms the interface between the providers and users of climate services. This network provides support and advice to the administrative offices regarding climate-related information and adaptation services. They hold discussions on existing services, on the interests of users, on gaps in research activities and on the further development of the services offered”* (<https://www.dwd.de>). These two networks group several Federal Agencies such as the Federal Environment Agency and the Federal Ministry for Economic Affairs and Energy, cities such as Munich and Hannover, the German Association of Local Utilities, Deutsche Bahn AG, the German Insurance Association (GDV), WWF Germany, etc. This was probably facilitated by the presence of existing coordination mechanisms and by the accumulated experience of collaboration between different administrative levels. For example, in both Austria and Germany there is strong emphasis on networking between government, societal actors and research. Moreover, this networking is institutionalized through networking coordination mechanisms.

The AdapteCCa portal in Spain is an initiative of the Spanish Climate Change Office and the Biodiversity Foundation, aimed at information exchange and communication between various actors across different scales: *“the AdapteCCa platform for the exchange of information on impacts, vulnerability and adaptation to climate change, facilitates the coordination and transfer of information, knowledge and experiences in this field between the different Spanish administrations and the scientific community, planners and managers, both public and private, and other agents, thereby forming a multi-directional communication channel with each other”* (<https://adaptecca.es>).

Countries such as France and to some extent Italy, did not integrate climate products and services in knowledge-action systems. Although regional CCAS are emerging in France (e.g., AcclimaTerra and Ouranos AuRA), there is no strong coordination between national and sub-national levels regarding adaptation. French regional CCAS cooperate and organise events on regional and national scales (e.g., 3rd National Adaptation Conference³³). Nonetheless, the vertical dimension of multi-level governance is not fully operational: the

³³ <https://action-climat-3.sciencesconf.org/>

national adaptation portal is still a work in progress. In Italy, the CMCC (The Euro-Mediterranean Centre on Climate Change) has networking activities and involves stakeholders on different scales, but a knowledge portal/knowledge exchange mechanism is still missing. When it comes to Greece or Central and Eastern European Countries, we cannot assume that their degrees of decentralisation alone represent a barrier to the development of CCAKAS. Zbigniew W. Kundzewicz et al. (2017) pointed out that Central and Eastern European Countries have no national climate services. The availability of resources - technical, human, financial - is as important as the institutional context itself. Figure 18 illustrates spatial distribution of CCAKAS, CCAS, and CCAP. We note that there is a separation between the western and the eastern European countries. Although our empirical material does not allow us to argue for a correlation between the distribution of adaptation products, services, and systems in the EU, we note a similar pattern on Figure 19, which illustrates real GDP per capita. More specifically, there is a divide between the West and the East. Nonetheless, several Eastern and Southern countries have benefitted from Cohesion Funds and the EU research programs. The Greek National

Figure 18 Spatial distribution of adaptation products, services, and systems

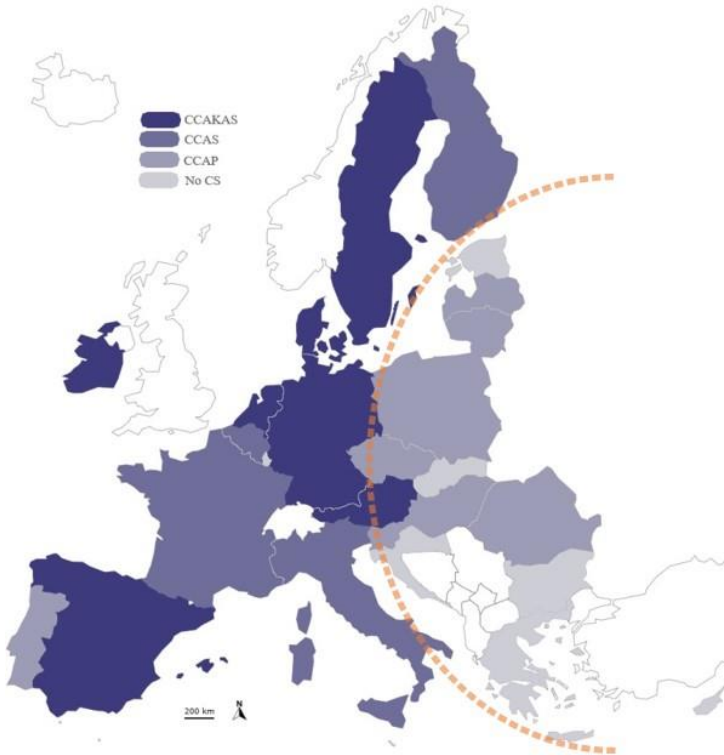
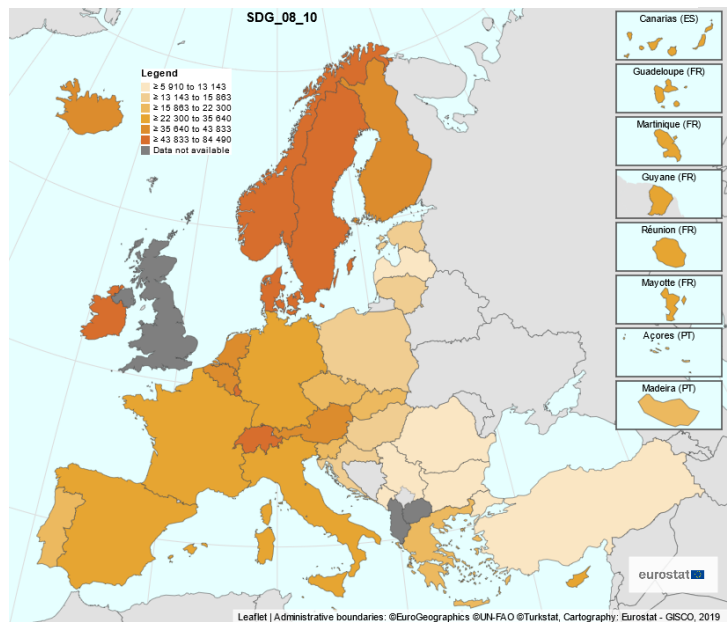


Figure 19 Real GDP per capita (Eurostat, 2021)



adaptation portal is still a work in progress. In Italy, the CMCC (The Euro-Mediterranean Centre on Climate Change) has networking activities and involves stakeholders on different scales, but a knowledge portal/knowledge exchange mechanism is still missing. When it comes to Greece or Central and Eastern European Countries, we cannot assume that their degrees of decentralisation alone represent a barrier to the development of CCAKAS. Zbigniew W. Kundzewicz et al. (2017) pointed out that Central and Eastern European Countries have no national climate services. The availability of resources - technical, human, financial - is as important as the institutional context itself. Figure 18 illustrates spatial distribution of CCAKAS, CCAS, and CCAP. We note that there is a separation between the western and the eastern European countries. Although our empirical material does not allow us to argue for a correlation between the distribution of adaptation products, services, and systems in the EU, we note a similar pattern on Figure 19, which illustrates real GDP per capita. More specifically, there is a divide between the West and the East. Nonetheless, several Eastern and Southern countries have benefitted from Cohesion Funds and the EU research programs. The Greek National

Adaptation Hub is under construction within the LIFE-IP AdaptInGR programme. The CCAP developed in some Central and Eastern European Countries rely on LIFE+ programs and Cohesion Fund grants. For example, the Polish Klimada knowledge portal is financed by the European Cohesion Fund and is expected to be completed by 2021. In fact, the development of adaptation products, services and systems may depend on multiple factors related to the institutional context of a country. The GDP per capita may be one of these, as much as the degree of decentralization.

Conclusions

This chapter discussed a possible correlation between the degree of decentralization of selected countries and the integration of climate change adaptation products, services, and systems into adaptation governance.

Indeed, CCAKAS were mostly developed in decentralized countries such as Austria, Denmark, Germany, Ireland, Netherlands, and Spain. To ensure coherent spatial planning and resource management across scales regarding adaptation, these countries have: 1) created coordination structures at the national level, such as knowledge portals (built in collaboration with multiple stakeholders) or adaptation networks; 2) pursued the integration of climate information in policy and practice through science-policy interfaces and boundary organisations such as BC3, CAS and Climate Ireland. The statist countries in our sample showed different degrees of integration of climate products and services in their adaptation governance. As underlined in the literature, policy networks are unstable in statist countries, leading to barriers for the inter- and intra-organisational mainstreaming of adaptation. France has developed CCAP via regional CCAS initiatives such as Ouranos AuRA, Grec-Sud, Acclimaterra, and RECO, but top-down coordination is still work in progress. From our analysis we can conclude that countries with strong coordination traditions and policy networks are those where the most CCAKAS have emerged. When it comes to Greece and Central and Eastern European Countries, we cannot assume that their statist traditions alone represent a barrier to the development of CCAKAS. The availability of resources - technical, human, financial - is as important as the institutional context itself.

Several countries were difficult to classify because of a lack of information in English, or because climate service providers fell between two categories. Finland, for example, has a national climate adaptation and mitigation portal, but this entity does not have networking activities, nor a forum for knowledge exchange. The next step would be to complete a case study for each country to provide an in-depth analysis of their adaptation governance systems.

Finally, one of the objectives of this study was to put in practice the definitions by Weichselgartner and Arheimer (2019) and provide a state of the art on climate and adaptation services in the EU. We believe that better use of terminology (e.g., product vs service) is an important step for the development of adaptation services and a sign of increasing maturity in the field.

In line with the funnel approach illustrated in the chapter 1, next chapter will zoom on several adaptation services identified in the EU and on one AS from Quebec (Canada).

Chapter 4

Boundary organisations in adaptation services



Knowledge is a free good. The biggest cost in its transmission is not in the production or distribution of knowledge, but in its assimilation

Stiglitz and Greenwald, 2014:507

As discussed in previous chapters, adaptation to climate change is an emerging concern for governments across the scales. As we illustrated in Chapter 1 and 2, the very first adaptation policies of the European Union (EU), its member states and sub-national authorities were developed in the beginning of 2000s, while their scope was amplified with time (Panenko et al., 2021). On one hand, policymakers are under pressure due to increasing climate change litigation cases and new legal requirements (UNEP, 2020). On another hand, they are expected to act in a rational and well-informed manner (Rickards et al., 2014). To support evidence-based decision making in climate-policy, the EU has been promoting the development of climate services (ref roadmap). However, several authors and institutions argue for the development of adaptation services, which offer not only climate products (maps, projections), but also the mechanisms for interaction and knowledge exchange between producers and users (Goosen et al, 2014).

As we have already seen in Chapter 1, the interactions between scientific and non-scientific stakeholders, and the role of scientists as advisers in policymaking has been largely discussed in the literature (Pita Spruijt et al, 2014). Some authors advocate for post-normal science approaches, which aim at achieving plurality of viewpoints within and outside of the scientific domain (Funtowicz and Ravetz, 1992). Others point out the need for “*socially robust science*,” which is tested for validity inside as well as outside of the laboratory (Nowotny, 2003). Additionally, several scholars highlight the fact that science-policy should be seen as a dynamic process to allow for adjustments in case of new circumstances (Dessai and Hulme, 2007). In this part of our study, the question is: how to implement these mechanisms?

We have previously seen that evidence-based practice was necessary and that it can be split in two phases: the first phase consists of generating the evidence, while during the second phase the evidence is used and put in practice (Sackett et al, 2000). Generating socially robust science will rely on engagement between scientists and other relevant stakeholders (Nowotny, 2003). This topic has received a lot of attention in the literature - from advocates of post normal-science approaches (Funtowicz and Ravetz, 1990), to those who argue for the so-called Mode 2 (Gibbons et al, 1994, Nowotny et al., 2003), or for the “*technologies of humility*” (Jasanoff, 2007). Additionally, the idea of switching from linear model of science-society to the iterative model has found support from political institutions. For example, the European Commission launched consultation on science 2.0 in September 2014. Science 2.0 relates to information-sharing and collaboration made possible by network technologies. The consultation aimed at identifying policy implications and actions to strengthen the competitiveness of the European science and research system. In

fact, according to the European Commissioner for Research, Innovation and Science Máire Geoghegan-Quinn: “*We must ensure that we are at the forefront of the next paradigm shift*”. To boost information sharing and collaboration, Copernicus Climate Change Service was put in place by the European Centre for Medium-Range Weather Forecasts (ECMWF) on behalf of the European Commission. Nowadays, it offers free and open access to climate data and tools on European and Global scales. Although this data is not downscaled to smaller scales (region/city), Copernicus represents an important joint initiative aiming at providing best available science for EU’s member states.

The critiques of first-generation of climate services (Chapter 1) argue that there is a mismatch between offer and demand in science and point out that often these services are based on unidirectional transfer of scientific knowledge (Sarewitz & Pielke Jr., 2007; Pita Spruijt et al, 2014). In fact, due to this mismatch the uptake of climate services on local scales remains scarce, and some studies have pointed out that local authorities need “*non-climate services*” (WMO, 2011; Street, 2016; Räsänen et al. (2017). Therefore, our interest in boundary organisations as a particular form of second generation of climate services, or as Goosen et al (2014) and Weichselgartner and Arheimer (2019) label as adaptation services. Authors such as Michaels (2009) and Bremer and Meisch (2017) stress that boundary organisation (BO) and knowledge brokers (KB) may indeed facilitate the match between the demand and the offer in science and thus, allow decisionmakers to use scientific expertise for their decision making. In fact, boundary organisations can foster the uptake of climate information and services for adaptation, as they create mechanisms of interaction between scientific and non-scientific stakeholders.

There are several studies illustrating different core activities of boundary organisations (Reinecke et al, 2013), and classifying their activities according to knowledge exchange intensity (Michaels, 2009). For example, Reinecke et al (2013) have conducted an analysis of 30 national forms of institutionalization of scientific climate-policy advice. Their analysis illustrates how these institutions achieve credibility, salience and legitimacy when delivering climate adaptation products and services. Yet, what could be the institutional factors that undermine or foster boundary organisations’ capacities to accompany policymakers in their adaptation planning? What are key components of sound interactions between scientific and non-scientific stakeholders? We aim at answering these questions by analysing boundary organisations (BO) of different maturity and institutional design. Therefore, we have conducted semi-structured interviews with 13 BO involved in adaptation to climate change at different scales (supranational, national, and sub-national). Could the degree of institutionalization have an impact on boundary organisations’ capacities to effectively implement their knowledge brokering strategies? The degree of institutionalization will refer to:

1. institutional stability (source and stability of the budget, legal status, age).
2. the presence of strong links with non-scientific stakeholders (shared networks, shared decision-making).

Further details on BO and their activities, sample and study material will be provided in the following section and it is summarized in Annex 5.

4.1 Boundary organisations in adaptation services

The idea of boundary organisations as adaptation services providers is nested in evidence from literature and practice. For example, Räsänen et al. (2017) have surveyed 33 Finish Municipalities on their needs and practices in climate risk assessment and management. The survey showed that the usability of climate information is a major barrier, while at the same time there is need for more networking and capacity-building. In fact, the emergence of the concept of adaptation service is particularly interesting, as it highlights the trend for “*second generation*” of climate services (in opposition to the first generation following the linear model of science-to-practice knowledge transfer). Based on the inputs from relevant literature (Chapter 1), this section will provide a framework for BO analysis.

4.1.1 Framework for analysis of adaptation services

As we already illustrated in Chapter 1, we have identified two frameworks for boundary organisations’ (BO) analysis that fit our goals. The first framework was elaborated by S. Michaels in 2009 and it focuses on knowledge brokering from a general perspective. The second framework was elaborated by Reinecke et al. in 2013. It refers to the typologies of activities put in place by BO engaged in climate-policy advice. Finally, we have merged these two frameworks with climate services typologies proposed in Weichselgartner and Arheimer (2019):

- **Climate Change Adaptation Products (CCAP)** “*data, tools to support decision-making for adaptation, including efforts to identify information needs*”.
- **Climate Change Adaptation Services (CCAS)** “*activities, consultations and other forms of interaction that enable decision-makers to make better use of CCAP...CCAS are not only products, but also the mechanisms for interaction and knowledge exchange between producers, users and providers*”.

Michaels (2009) has identified six strategies of knowledge brokering – informing, consulting, matchmaking, engaging, collaborating, and building adaptive capacity. These strategies have complementary functions, are appropriate for different policy issues, or for the same issue at different points in time. These strategies can overlap, and their use will

depend on the: 1) overall objectives of a given organisation, and 2) decision regimes. These last were discussed by Lindquist (1988, 2001) who distinguished between routine, incremental, emergent, and fundamental decision regimes. Routine decisions will refer to updating existing policies and frameworks without changing the policy base. These regimes are characterized by standard operating procedures which are not subject to scrutiny. In the incremental regimes only marginal changes occur, while existing frameworks and policies are updated gradually to match new conditions. When core principles of existing frameworks and policies are scrutinized, the decision regimes are fundamental. Emergent decision regimes refer to unexisting policy bases. These last two decision regimes are characterized by higher degrees of uncertainty and complexity, “*require more resources and information for planning and suasion*” (Lindquist, 2001:102). According to the author, the type of information sought will depend on the decision regime (Lindquist, 2001). For example, routine and incremental regimes will require new data to update existing policies, such as adapting fishing and hunting permissions to new environmental conditions. These regimes may be supported by informing and consulting brokering techniques, as there is no need to renegotiate core principles of an existing decision framework.

On the contrary, fundamental, and emergent decision regimes “*re-think approaches to policy domains, whether as result of crisis, new governments, or policy-spillovers*” (Lindquist, 2001:19). When there is no consensus on methods and goals, collaborating and capacity building techniques are the most appropriate because the information sought by decisionmakers is of considerable scope, while the expertise is spread across various stakeholders. It is typically the case of wicked problems such as adaptation to climate change. For example, conflicts of use of water resources between various users will require negotiation to achieve consensus on the policy. Therefore, there is need for collaboration and coproduction between stakeholders. In these situations, the collaborative and the collegial mode are particularly pertinent, as they require input from all relevant stakeholders (scientists and policymakers).

While Michaels (2009) has discussed knowledge brokerage from a general point of view, Reinecke et al. (2013, 2015) have proposed a typology of activities found at climate-policy interfaces. According to Reinecke et al. (2013), usually these institutions take the form of permanent research or advice bodies; their establishment is mainly driven by governmental actors; they are funded by publicly financed research programs, or directly from ministries or agencies at different state levels. The authors identify the main activities of climate-policy interfaces: from compilation and translation to capacity building and policy development. Reinecke et al. (2013, 2015) have applied CRELE framework (Chapter 2) to inquire on how the selected initiatives produce credible, relevant, and legitimate information. On the contrary, we will not inquire on CRELE techniques

specifically, but take the institutional perspective and investigate the factors that can determine their capacities to implement CRELE and evolve in time. Table 12 represents a summary of boundary organisations’ strategies, activities found in the literature and discussed in this Chapter.

Table 12: Boundary organisations’ typologies activities in literature

Strategies (Michaels, 2009)	Typology of knowledge brokerage activities (Reinecke, 2015)	Type of climate services (Weichselgartner and Arheimer, 2019)
Inform	Compiling and translating scientific information (fact sheets, reports)	CCAP
Consult	Knowledge needs and research gap identification	CCAP
Engage	Personal consultation	CCAS
Matchmake	Coordinating and networking (peer and stakeholder networking, matchmaking)	CCAS
Collaborate	Decision support (decision support tools, capacity building)	CCAS
Build capacity	Policy evaluation and development (develop, analyse, and evaluate policy, draft legislation)	CCAS

Source: adapted from Michaels, 2009; Reinecke, 2015; Weichselgartner and Arheimer (2019)

In fact, knowledge brokering techniques were theorized and applied in sectors where knowledge spans across boundaries, such as education or public health sector, like in Dobbins et al (2009) or Newman et al (2020). Reinecke et al’ (2015) have specifically addressed knowledge brokering for climate issues, thus there is no perfect match between above-mentioned typologies (Table 12). Nonetheless, we can merge these two frameworks with the concepts of climate change adaptation products (CCAP) and service (CCAS), as proposed in the last column of Table 12:

1. Informing consists of translation of existing knowledge and research gap identification (fact sheets, websites). These two strategies correspond to CCAPs. Typical examples are maps, projections, and data on climate.
2. Engaging and matchmaking will rely on coordination and networking activities. These strategies will correspond to CCAS because these activities create mechanisms for knowledge exchange.

3. Collaboration and capacity building refer to decision support activities and to policy development. This category corresponds to CCAS. It is based on collaboration and knowledge exchange between scientific and non-scientific stakeholders.

Based on all the above-mentioned inputs from relevant literature, we aim at illustrating differences and common traits of boundary organisations (BO) with different knowledge brokering techniques. We excluded from the sample organisations that offer only CCAP because these correspond to the 1st generation of climate adaptation services. These CCAP are often built following the linear model of science-policy interactions and lack connection with their users. In the previous paragraphs we have pointed out that adaptation policies are characterized by emergent or fundamental regimes. The uncertainties and the complexities of adaptation issues are aggravated by the absence of consensus on policy methods and goals. Since CCAS offer knowledge exchange mechanisms and capacity building activities, we argue that they are more suited to tackle adaptation.

Several authors in literature argue that multiple factors can foster or undermine knowledge exchange activities. For example, Fazey et al. (2015) point out that political, social, and individual contextual factors can significantly impact knowledge exchange. Saarela et al. (2015) have explored knowledge brokerage for impact assessment. According to the authors, contexts and various case specific factors may be significant for success of the impact assessments. Among context factors they have identified:

- different decision-making regimes (Lindquist, 2001).
- the existence of well-established policy structures (institutions, networks).
- organisational norms (in-house or outsourced tools and knowledge, resources).
- legal requirements (flexibility and predictability of the policy process, no mandatory requirements to detailed regulations).
- shared history of knowledge exchange between users and producers of knowledge.
- scientific credibility, autonomy, and independence (similar to CRELE).

In fact, both Fazey et al. (2015) and Saarela et al. (2015) stress the importance of institutional and political contextual factors for knowledge exchange practices. We are expecting to identify several of the abovementioned factors in our analysis. However, as boundary organisations (BO) will offer different set of services and operate in different contexts, these factors may change from one BO to another.

4.1.2 Public or private adaptation service?

The public/private nature of adaptation has been discussed in chapter 1. For example, Mees et al. (2012) point out that adaptation often addresses impacts to public

goods, such as safety peace and security, national defence, fire and flood protection. Similarly, Berke and Lyles (2013) classify climate change as “*public risk*” which requires solutions delivered in the form of public good. Other authors point out that there is “*insufficient attention to ways that private benefits may boost political support for adaptation investment by local governments*” (Woodroof et al., 2019:2). While in practice adaptation is a mix of public and private initiatives, private adaptation will rarely have spill-over effects to parties not directly involved in such initiatives (Woodroof et al., 2019).

Our research is not focused on adaptation per se, but on the transmission of knowledge for adaptation. In fact, we treat adaptation as public good, defined by Ostrom et Ostrom (1977) as a good characterized by unfeasible exclusion (anyone can benefit) and joint use (nonsubtractibility). When knowledge is treated as a private good, it is owned by the organisation and can be exchanged like any other good. When treated as a public good, knowledge is socially generated, owned by the community and can be transferred throughout the community without losing its value (McLure Wasko and Faraj 2000). For example, Ostrom and Ostrom (1977) classified weather forecasts as public goods.

According to Tompkins and Eakin (2010, 2012), when private actors do not have access to information on risks and impacts, governments may distribute knowledge as public good. From this perspective, we find that “*public provision of adaptation goods for public benefit*” is the most suitable approach to knowledge transmission for several reasons:

1. The possibility of a market failure due to high uncertainties of climate projections and lack of financial resources (European Commission, 2007:2).
2. Limited access to strong infrastructure and knowledge on climate. Private businesses will have to access specific infrastructure for climate modellisation, or secure access to the latest data through specific arrangements with public producers.
3. Potential distributional inequalities between local territories in terms of impacts and costs. Climate change’s impacts and costs vary significantly across the scales. Different territorial entities will face different challenges, while disposing of different material means. In the previous chapter we have illustrated the west/east divide in the EU: climate change adaptation knowledge action systems, but also services were mainly developed by western European countries.

Based on different authors, we believe that private businesses are in a weaker position to produce adaptation services, and distribute them as public goods (Marino and Ribot, 2012; Bulkeley et al., 2013). This does not imply that there are no adaptation services developed by private actors (on the contrary), or that there are no private actors using adaptation services. However, we will focus on adaptation services for public authorities, delivered by public or non-profit providers. According to us, public distribution of adaptation services may alleviate inequalities in terms of costs and access to relevant data.

Adaptation as public good deserves a systematic inquiry, which was not the objective of this thesis.

Unfortunately, it was not possible to assess the private/public dichotomy in climate adaptation services', as these concepts are not commonly used in literature and practice. However, it was possible to inquire on the 1st generation of climate services, which we associate with CCAP. We have used the Climate Knowledge Hub³⁴ database to assess the distribution by country and by type of provider. This database was developed by ERA4CS³⁵ Climate Service Centre Germany, and Climate Change Centre Austria. It represents a map with providers by country and it offers information on institution types, their competences, finance, and other criteria. Although this database represents a useful starting point for sampling, it is also characterized by several flaws which are going to be discussed below.

Table 13 Climate services providers per type and country (Climate Knowledge Hub)

Country	University or research	Extension of national weather service	Public climate service not from national weather service	Private business	Non-profit	Other	Total
Austria	32	1	11	4	1	6	55
Belgium	6	1	6		2	3	18
Czech Republic	3					1	4
Denmark	4		1		1		6
Finland			1	2			3
France	10	8		4	2	4	28
Germany	19		15	24	4	10	72
Greece	3						3
Ireland	7	1		1		2	11
Italy	4		4	2	3		13
Netherlands	3				2	1	6
Portugal	4	1				2	7
Romania	2			1			3
Spain	7	1		4	1	1	14
Sweden	2	1	1				4
Total	106	14	39	42	16	30	247

Source: Climate Knowledge Hub database (<https://www.climate-knowledge-hub.org/>).

³⁴ <https://www.climate-knowledge-hub.org/>

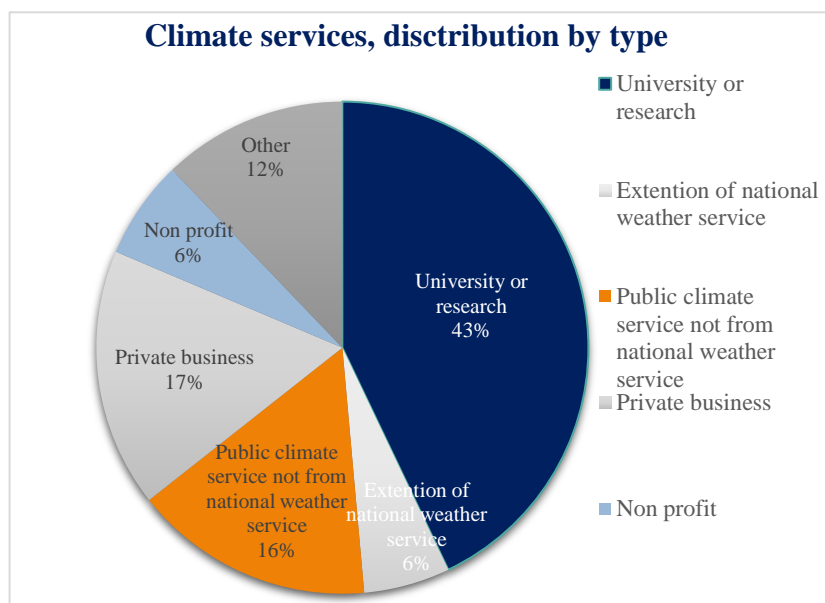
³⁵ Within the European Research Area (ERA), the ERA4CS Consortium is aiming to boost, research for Climate Services (CS), including climate adaptation, mitigation, and disaster risk management, allowing regions, cities and key economic sectors to develop opportunities and strengthen Europe's leadership (<https://cordis.europa.eu/project/id/690462>)

The rows in Table 13 contain all CCAPs listed in the database, while the columns correspond to the type of CCAPs' provider: university, extension of national weather service, public CCAP, private, non-profit, and other.

As exposed in Table 13, Germany and Austria represent 51% (127 out of 247) of climate services' providers. This is because Climate-Knowledge Hub is an initiative of Austrian (CCCA) and German (GERICS) institutions. Therefore, the first bias is related to the countries that are at the origin of this database. Nonetheless, the Table 13 confirms - at least partially - Chapter 3 findings: most of climate services and products are located in the Western Europe. For example, France account for 11%, Spain 6%, Italy, and Ireland 5% each.

Figure 20 Climate services, distribution by type

Figure 20 illustrates distribution of providers and highlights the dominance of public providers (Universities, Meteorological services, public services) over private providers. More specifically, private businesses represent



17%, while public ones 65%. In total, 247 providers were listed in the database by September 2021. This database is developed as part of a research initiative, and this represents an additional bias. In fact, as we can see from the figures, 43% of respondents are from Universities and Research domains.

The information available is not exhaustive, as only those who completed the survey are listed. Furthermore, if we compare the Swedish and French providers listed in the database as extension of the national weather service, we can clearly see significant differences between them. The Swedish extension of the national weather service is an independent department of the Swedish Meteorological and Hydrological Institute (SMHI), where climate adaptation products and services are the main activity. The French extension of the weather service represents various individuals rather than a specific service centre.

To conclude, we have identified 2 major flaws of Climate Knowledge Hub for the purpose of our analysis: 1) it is dominated by German-speaking institutions, 2) most of

whom are from university and research fields. Additionally, as we have seen in the comparison between Swedish and French providers, significantly different providers can be listed under the same category. However, Climate Knowledge Hub can represent an interesting starting point, as it is using the same typologies of providers as European Commission in its Roadmap for Climate services (2015). In fact, we will also use these categories in the following sections. However, we will conduct additional online research to mitigate the abovementioned biases.

4.2 Boundary organisation in our sample

The sample for this study is composed of 13 boundary organisations from different countries:

- 6 from the EU member states (CCCA, Austria; Climate Ireland, Ireland; CMCC, Italy; CAS, Netherlands; BC3, Spain; SMHI, Sweden).
- 1 focusing on the Mediterranean area (MedECC).
- 1 from Canada (Ouranos Inc.).
- 5 from France (Acclimaterra, Creseb, Grec- Sud, Ouranos AuRA, RECO).

We have selected boundary organisations (BO) listed on the Climate-ADAPT platform and conducted online research to identify additional institutions matching our sampling criteria (please refer to methodology section of chapter 1 for details). Geographical and institutional proximity allowed us to have privileged access to the 5 French BO, as well as to Ouranos Inc. The sample is composed by BO of different maturity (age) and various forms, following the categories of climate adaptation products and services providers used by the EU (Figure 20). In fact, our aim was to achieve diversity in our sample to collect feedback from BO with different experiences and operating in different contexts. Additionally, at this stage of development of BO, it was not possible to focus exclusively on one country because the quality of sample would suffer.

As discussed in chapter 1, we have conducted 21 interviews for a total of 24 hours of recording. Additionally, we have analysed internal reports, project descriptions, and scientific papers produced by (or about) selected organisations. following Reinecke et al (2015) knowledge brokerage activities (Annex 5). First, we identified knowledge brokering activities of boundary organisation in our sample: compiling, consulting, knowledge needs and research gap identification, networking and coordination, decision support tools, policy development (Reinecke et al., 2013, 2015). Additionally, we have inquired about their:

- *Type*: we have used the categories from Climate-Knowledge Hub and the EU's Roadmap for Climate services: university and research, non-profit, public climate service, etc.
- *Source of funding*: we have differentiated between those who rely on one or multiple sources to finance their operations. The first category will refer to mixed funding, or funding from public entities (EU, state, regional funds). The second category will refer to those who rely on both public and research funds through participation in European national, or local research projects.
- *Year of establishment* to tackle their maturity.
- *Participation in research projects*: whether they produce scientific papers, participate or coordinate research projects.

All this information is presented in Annex 5, which provides details on brokering activities (examples of actions) and all other above-mentioned data. In the section below we will provide a short description of each of these institutions in following order: 6 BO from the EU, MedECC, Ouranos Inc., 5 BO from France.

4.2.1 Description of boundary organisation in our sample

Spain - Basque Climate Change Centre (BC3)

The BC3 Basque Centre for Climate Change – Klima Aldaketa Ikergai was established as a non-profit association in 2008. BC3 operates as a research centre whose associate members are:

- Ihobe: the public agency of environment, belonging to the Department of the Environment, Territorial Planning and Housing of the Basque Government.
- The University of the Basque country (EHU/UPV), biggest public university in the Basque Country.
- Ikerbasque, the Basque Foundation for Science, was created in 2007 by the Basque Government to foster the Basque Science System.

BC3 are directly involved in over 50 research and stakeholder networks, and have created, supported, or led 9 networks to co-produce and share knowledge on climate. BC3 is regularly consulted by different media as an expert adviser in this topic. As a result of active press and social media management, 157 interviews and media appearances were obtained during the year 2018. In 2020 scientific production generated 143 publications: 123 peer-reviewed journal articles, 9 books and chapters, 11 technical and policy reports. The BC3 team is composed of 69 researchers and 7 administrative employees.

Netherlands - Climate Adaptation Service (CAS)

Climate Adaptation Service (CAS) was established in 2008 within Dutch national research programs «Knowledge for Climate» and Climate Changes Spatial planning (2008-2014). CAS was set up as a non-profit association to continue these programs' work and it is closely related to:

- Wageningen Environmental Research (WENR).
- Royal Netherlands Meteorological Institute (KNMI).
- Deltares, an independent institute for applied research in the field of water and subsurface.

CAS specializes in combining information about climate change with innovative communication and visualization techniques including story maps, apps, and websites. For example, they have developed the Climate Impact Atlas for the Netherlands and manage the Netherlands' leading climate adaptation platform – The Knowledge Portal for Climate Adaptation. In 2020, CAS counted 22 members.

Austria - Climate Change Centre Austria (CCCA)

The Climate Change Centre Austria (CCCA) was founded in 2011 as non-profit association, and it represents a research network composed and supported by Austria's most important research institutions. More than 27 research-performing/coordinating organisations are involved in further developing the CCCA. They position themselves as neutral knowledge brokers whose objective is to represent a clearing point for thematic inquiries from science, administration, industry, and general public, to facilitate the dissemination of information.

The CCCA also organizes networking events and projects in collaboration with partners from various sectors. For example, together with the Climate Service Center 2.0 in Hamburg, CCCA has built a platform to survey and represent the providers of climate services throughout Europe - <https://www.climate-knowledge-hub.org>. In 2020, CCCA counter 13 employees and it is supported by 500 Austrian researchers.

Italy - Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)

CMCC was established in 2005 and it is organized in the form of a network that involves and connects public and private entities around climate sciences. CMCC has a vast research portfolio composed of 268 national, European, and international projects. At the same time, these projects are supported by nine interdisciplinary divisions whose objectives vary from R&D in computational science, climate simulations and predictions, to climate impacts and policy development.

CMCC Foundation relies on the experience of its 9 cofounders: National Institute of Geophysics and Volcanology, University of Salento, Italian Aerospace Research Center, Ca 'Foscari University of Venice, University of Sassari, University of Tuscia, Polytechnic of Milan, Resources for the Future, University of Bologna³⁶. In 2020 CMCC has produced 186 research papers and employed 197 people (65% of which are researchers).

Ireland - Climate Ireland (CI)

Climate Ireland was established in 2011 as part of the EPA-funded project “*A Climate Information Platform for Ireland*” (ICIP). Climate Ireland is being designed and developed by the Centre for Marine and Renewable Energy (MaREI) at University College Cork (UCC) and the Irish Centre for High End Computer (ICHEC) at the National University of Ireland, Galway. Today it works as a research service that “*connects and integrates scientific research, policy making and adaptation practice for the purposes of enhancing adaptation decision making in Ireland*” (<https://www.climateireland.ie>). They aim at bringing together relevant stakeholders and to provide a support network for adaptation plans development. In 2020, Climate Ireland had 6 employees (2 software engineers, 2 post doc, 1 project coordinator, and 1 public relations and communication responsible).

Sweden - Swedish Meteorological and Hydrological Institute (SMHI)

SMHI is a national weather service provider of Sweden established in 1983. The regional and global climate modelling at Rossby Centre was established in 1997, while the national knowledge centre in 2012. SMHI has an R&D department which carries out research mainly through externally financed projects in collaboration with state agencies, academia, and end-users. In fact, they participate in the Copernicus program, in the CLARA project³⁷ (H2020) or in AQUACLEW³⁸ (ERA4CS). SMHI is producing, compiling, and conveying information and knowledge, including about climate change adaptation in Sweden and internationally. The SMHI has approximately 660 employees.

³⁶ National Institute of Geophysics and Volcanology, University of Salento, Italian Aerospace Research Center, Ca 'Foscari University of Venice, University of Sassari, University of Tuscia, Polytechnic of Milan, Resources for the Future, University of Bologna

³⁷ The aim of CLARA innovation action is to develop a set of leading-edge climate services building upon the newly developed Copernicus Climate Change Services near term forecasts and sectorial information systems (SIS) and sustain their marketability and value (<https://www.clara-project.eu/about/>)

³⁸ The AQUACLEW project is funded by European Research Area for Climate Services (ERA4CS), under the Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate), which is a collaboration between the European commission and national research councils in member states, who share the costs. AQUACLEW project investigates how to increase user uptake in a broad community using general information from a web interface, as well as tailored user-specific decision-support in multiple case studies (<https://aquaclew.eu/>).

Mediterranean Experts on Climate and Environmental Change (MedECC)

The MedECC is a network of Mediterranean Experts on Climate and Environmental Change aiming at providing sound scientific information about environmental issues of concern for the Mediterranean region. MedECC's institutionalisation is not fully achieved (September 2021). At the moment, its membership is voluntary and approximately 150 experts have expressed interest in joining. Now it is coordinated by researchers and has one employee.

MedECC intends to provide regular reports, ad hoc reports on demand, to organize and co-host scientific workshops, to train decision-makers, and foster dialogue between relevant scientific and non-scientific stakeholders. MedECC has published its first report on the current state and risks of climate and environmental changes in the Mediterranean in the beginning of 2020. This report covers the drivers of climate change and its impacts across different sectors such as water, food, energy, ecosystems and ecosystem services, development, health, and human security. Additionally, it includes best practices for adaptation and mitigation, and a summary for policymakers. MedECC is also aiming at fostering its public outreach³⁹.

Canada (Quebec) - Consortium on Regional Climatology and Adaptation to Climate Change - Ouranos Inc.

Ouranos Inc. was established in 2002 by the Government of Québec, Hydro-Québec, and the Meteorological Service of Canada to coordinate climate-change research in Québec. Ouranos Inc. is a consortium composed of several scientific and non-scientific stakeholders such as: UQAM, INRS, McGill, Laval University, Quebec University, ETS, HydroQuebec, Ontario Power Generation, Manitoba Hydro, Government of Quebec, Montréal City, Environment and Climate Change Canada. Today it is composed of a network of approximately 450 researchers, experts, practitioners, and policymakers from a variety of disciplines. Ouranos Inc. has more than 50 employees and it is engaged in more than 100 projects.

The scientific program is articulated around 4 mains domains: climate science, adaptation science, socio-economic analyses, knowledge mobilization and training. Its mission is to “*Acquire and develop knowledge on climate change and its impacts, as well*

³⁹ For further details, The French media Brut has created a video about climate and environmental changes in the Mediterranean and about the MedECC (<https://www.youtube.com/watch?v=p1lsp6yHqYg>).

as relevant socio-economic and environmental vulnerabilities, to help policy-makers identify, evaluate, promote and implement national, regional and local adaptation strategies” (<https://www.ouranos.ca/>). Ouranos Inc. is engaged in a set of very different activities: from climate modellisation, production of scientific information on climate, creation, and management of research projects (eg.: 277 published scientific articles) to capacity building and decision support.

France - AcclimaTerra

Acclimaterra is a non-profit association established in 2016 to foster adaptation capacities of the Nouvelle-Aquitaine French region. It was built on an existing scientific group operating since 2012. One of the main products of Acclimaterra is the AcclimaTerra report “*Anticipating climate change in Nouvelle-Aquitaine. To guide policy at local level*” (Nouvelle-Aquitaine Region editions, 2018, 488 p). Additionally, several web complements are available on the website. These compliments form the “*Knowledge for stakeholders*” report, a tool allowing local stakeholders to express their expertise or experience in adaptation and climate vulnerability. It employs one full-time and one part-time coordinator.

Acclimaterra is engaged in public outreach activities, such as conferences or seminars. So far, they have co-organized two conferences at the Bordeaux University and multiple seminars with other regional groups of experts on climate change (will be discussed later). They also aim at raising awareness among university and high school students and teachers (AcclimaCampus and AcclimaLycées). With the support of the regional council, they have co-organized the “Climate Train”- a regional train traveling through cities to raise awareness on climate change. Acclimaterra is also part of the regional “*NeoTerra*” roadmap for energy transitions in Nouvelle Aquitaine.

France - Brittany’s Scientific Expertise Center on Water resources (Creseb)

Creseb is a Scientific Interest Group (GIS⁴⁰) established in 2011 by Brittany's Regional Council to support water management and ecological restoration of aquatic environments. Creseb positions itself as an interface, a platform for exchanges and cooperation between water management actors and scientists. Creseb promotes knowledge sharing in a multi-actor and multidisciplinary setting to boost Brittany’s social appropriation of science for decision making in the water sector. The Creseb brings together around fifty members, such as: representatives of public institutions (Water Agency of

⁴⁰ GIS, or the Scientific Interest Group is the legal designation for a type of entity that frames a scientific partnership agreement around a specific object of study. It can be a public-private partnership or a partnership between public sub-entities such as universities. On average, GIS (also called “research program contracts”) are expected to last about 4 years..

Loire Bretagne or the Brittany Chamber of Agriculture, Regional Council), and scientists from Breton research establishments and water management actors (INRA, RENNES and Bretagne Universities). It is coordinated by 4 employees.

Creseb produces and disseminates scientific information via reports and factsheets, creates tools, organises workshops (eg.: cycle of webinars dedicated to the deployment of Hydrology, Environment, Uses and Climate analyses), promotes and co-constructs interdisciplinary projects (eg.: DEMOCLIM: impacts of climate change on Breton water resources⁴¹). The French State and Brittany Region have solicited Creseb's scientific support for elaboration of a regional plan against the proliferation of green algae (PLAV2⁴²).

France - Grec-Sud

Grec-Sud was established in 2015 and it is supported by the Air Climate Research and Innovation Association (A.I.R Climat). It is coordinated by 2 people, and it relies on a network of researchers who contribute on a voluntary basis.

The group produces and disseminates thematic publications (books and web articles) and organizes events to raise awareness and foster collaboration between scientific and non-scientific stakeholders (conferences, thematic days, etc.). Grec-Sud collects scientific knowledge on climate, climate change and their impacts and proposes adaptation and mitigation solutions. It relies on a network of volunteer researchers covering all disciplines related to climate change issues.

France - Ouranos AuRA (Auvergne-Rhône-Alpes)

Ouranos AuRA is one of the French local initiatives based in Grenoble, Auvergne-Rhône-Alpes. It was created in 2012 as the regional climate platform GIS Envirhônalp, with the aim of facilitating links between research and operational actors on climate change. The Envirhônalp climate platform became Ouranos-AuRA in 2014. Ouranos-AuRA promotes synergies between several local research institutions and regional/local actors: by translating and disseminating scientific information, by assessing the needs of local actors and by supporting researchers in their inter- and transdisciplinary approaches. In addition, Ouranos AuRA offers traineeships to increase the capacity of local actors (climate data labs) and supports the implementation of research projects. As the name suggests, Ouranos AuRA has informal links with Ouranos Inc. More specifically, the Envirhônalp climate platform was inspired by the Canadian model of the science-society interface. However,

⁴¹ <https://www.creseb.fr/projet-democlim/>

⁴² <https://www.creseb.fr/plav-organisation-appui-scientifique/>

Ouranos AuRA did not fully replicate the governance model of Ouranos Inc. due to the institutional context, which we will discuss later. If Ouranos Inc. remains an inspiring example, Ouranos AuRA took the opportunity of its integration into OSUG to change its name to Grec Alpes-Auvergne to strengthen its links with other French BOs. Together with other French institutions in our sample, Ouranos has organized a National Adaptation Conference to foster networking around adaptation issues. It took place in Grenoble in 2021.

France - Occitan network of climate experts (RECO)

RECO is a non-profit association established in 2017 to foster adaptation in the Occitanian French region. Its objective is to bring together knowledge and initiatives across the Occitanie region, and foster evidence-based decision making. Like other French regional initiatives, RECO aims at facilitating the transfer of knowledge and positions itself as a science-policy interface. In fact, they act as mediators between scientific and non-scientific stakeholders and provide a space for knowledge exchange and collaboration

RECO has elaborated its first report on climate change in Occitanie in 2021 and developed an online tool for mapping climate action in the region (research projects, public actions, non-profit initiatives, etc). This tool aims to identify, bring together and give a cartographic portrait of the regional initiatives put in place to deal with climate change. Thanks to summary sheets, RECO makes accessible the results of scientific projects and the impact of actions carried out by territorial actors. By thus promoting the dissemination of knowledge and the exchange of information between regional actors, RECO wishes to encourage new actions in the face of climate impacts. RECO is composed of 2 coordinators and 3 researchers.

Boundary organisations from France form a network of regional groups of experts on climate change. In fact, GREC stands for “Groupement Régional d’Experts sur le Climat”. As we will see in the following section, these BO have different governance structures and activities. They rely on a network of local scientists and territorial stakeholders to facilitate decision-making in the context of climate change.

The French network of regional groups of experts on climate change is composed by:

- AcclimaTerra –Nouvelle-Aquitaine region – www.acclimaterra.fr
- GREC-SUD – Provence-Alpes-Côte d’Azur region: www.grec-sud.fr
- RECO – Occitanie region: www.reco-occitanie.org
- Ouranos-AuRA –Auvergne-Rhône-Alpes region: <https://ouranos-aura.osug.fr/>
- Climibio/cerdd – Hauts de France region: www.climibio.univ-lille.fr/cercle
- Groupement Guadeloupe – www.synergile.fr

- GREC Francilien – www.su-ite.eu/un-giec-ile-de-france/
- GIEC Normandie: www.normandie.fr/giec-normand
- HCBC – Haut Conseil Breton pour le Climat – <https://www.bretagne.bzh/le-haut-conseil-breton-pour-le-climat/>
- GIEC Pays de la Loire: <http://comite21grandouest.org/grand-ouest/comite21/comite21-en-action.html?id=14621>
- GREC Strasbourg: work in progress
- GREC Corse: work in progress

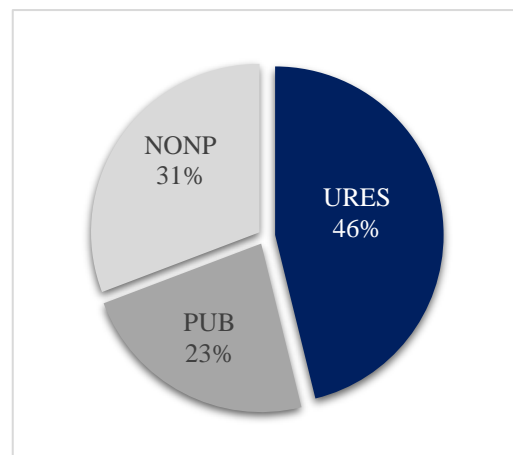
The landscape of boundary organisations in France is evolving very fast. In fact, at the time the interviews took place, several BOs listed above were not existing (HCBC, GREC Francilien, GIEC Pays de la Loire, GIEC Normandie). These BO formed a networked to improve their capacities of interaction with national and European public institutions.

4.2.2 Boundary organisations and knowledge brokering activities.

Using the classification of producers from the EU Roadmap for Climate Services, our sample consists of the following types:

- University or research (URES): BC3, CAS, CCCA, CMCC, CI, Ouranos-AuRA (5 in total).
- Public climate service (PCS): Creseb, Ouranos Inc. (3 in total).
- Extension of National Weather Service (ENWS): SMHI (1 in total).
- Non-Profit (NONP): Acclimaterra, GREC-Sud, MedECC, RECO (4 in total).

Figure 21 Boundary organisations, distribution by type



To protect the anonymity of interviewees, we will merge the “Extension of national weather services” (ENWS) with the “public climate service” (PCS) into a new category of public providers - PUB (Figure 21). This will also improve the balance between different categories of boundary organisations in our sample: 23% belong to public entities not related to universities, 31% to non-profit, and 46% to university and research institutions. The composition of BOs in our sample is similar to the one from Climate-Knowledge Hub (Figure 20). The share of “University and research” and “Public climate services” types are roughly similar: 43% and 22% in Climate-Knowledge Hub. The non-profit BOs are

overrepresented⁴³ in our sample, thus this latter is not fully representative. However, this does not represent an obstacle for our analysis. Moreover, the Climate-Knowledge Hub itself presents several weak points discussed in section 3.2.

Before discussing their activities, it should be noted that several of the BOs referred to in this chapter as university-based or public CS could be juridically assimilated to French non-profit associations. More specifically, this is the case for the CCCA, the CAS, the CMCC, the BC3 and the Ouranos Inc. However, these structures are strikingly different from the French non-profit associations in our sample. First of all, these structures have strong links with research institutions or are embedded in universities. In addition, they were funded by universities or by the respective governments. BC3, for example, was created as a non-profit association but represents a research centre on the causes and consequences of climate change. BC3's associate members are the University of the Basque Country, the Basque Science Foundation and Ihobe (the public environmental agency of the Department of Environment, Territorial Planning and Housing of the Basque Government). Similar observations could be made for other examples. The CCCA was also founded as non-profit association. It is, however, a research network that is supported by Austria's most important research institutions (26 Austrian universities are full members of the CCCA⁴⁴). The CAS works with Deltares on EU-funded research projects (REACHOUT⁴⁵, LIFE IP⁴⁶). In addition, the CAS collaborates with Wageningen University & Research to organise events on climate-related topics. These characteristics explain why CCCA, CMCC, CAS, BC3, CMCC and Ouranos Inc. are involved in research projects and produce peer-reviewed publications. In fact, scientific publications are an important pillar of their activity reports.

On the contrary, most of the French BOs do not share these characteristics. Acclimaterra, GREC-Sud, MedECC, RECO are not attached to research institutions and do not produce scientific publications. Only Ouranos AuRA, following the model of Ouranos Inc, differs from other French BOs in this regard. For our study, labels such as "public CS", "university-based" or "non-profit" are assigned according to whether they are 1) carry out research (CAS); 2) act as a research centre (BC3, CMCC, Ouranos Inc., etc.); 3) are nested

⁴³ 31% in our sample versus 6% Climate-Knowledge Hub

⁴⁴ The complete list of 26 members: <https://ccca.ac.at/en/about-ccca/the-association-ccca/members>

⁴⁵ REACHOUT “is a European Commission funded research and innovation project to advance user-oriented climate services to support the implementation of the Green Deal” (<https://reachout-cities.eu/>).

⁴⁶ LIFE IP is a is a Dutch programme, co-funded by the European Union (<https://klimaadaptatienederland.nl/en/policy-programmes/life-ip-climate-adaptation/>).

within universities (Ouranos-AuRA, CCCA). Although these labels may not be optimal, the differences between the selected BO are important enough to highlight these categories.

Table 14 depicts boundary organisations’ (BO) knowledge brokering activities as in Reinecke et al (2015). All BO are engaged in compiling, consultation, and knowledge gap identification. Most of them (12 out of 13) have networking and coordination activities. However, when looking at decision support and policy development (last two columns of Table 14), there are differences between URES (University and research), PUB (public providers) and NONP (non-profit).

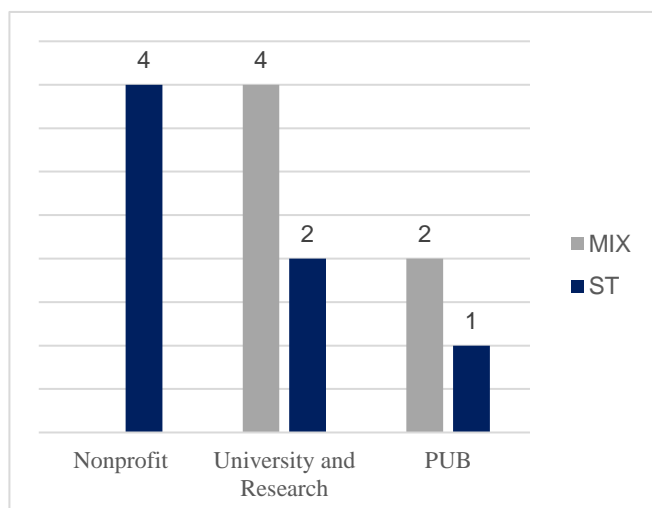
Table 14 Sample: BO type, funding and knowledge brokering activities

Type	University and Research						Public CS			Nonprofit			
Funding	M	M	M	M	ST	M	M	M	ST	ST	ST	ST	ST
BO	BC3	CAS	CCCA	CMCC	CI	Ouranos AuRA	SMHI	Ouranos Inc.	Creseb	Acclimaterra	MedECC	Grec-Sud	RECO
Compiling	■												
Knowledge needs and research gap	■												
Networking and coordination	■												
Decision support tools	■												
Policy development	■												

The URES and PUB types of boundary organisations are more likely to provide the whole spectrum of knowledge brokerage activities. More specifically, 7 out of 9 URES and PUB BOs provide all 5 categories of knowledge brokerage activities, while 2 out of 9 provide decision support tools, but not policy development. Nonetheless, one NONP organisation (Acclimaterra) represents an exception, as they also offer decision support and policy development.

Figure 22 illustrates the distribution of BOs in relation to the source of funding. The non-profit organisations in our sample rely exclusively on public funding (ST), while those who fall into public and university-based categories tend to have a mixed one (MIX). BOs with

Figure 22 BO: type and funding



mixed funding rely on public sources (state, region), but also on funding from research projects (state, region, EU).

All public and university-based BOs are involved in research and produce scientific publications (Figure 23). In fact, when analysing their activity reports, we note that the number of scientific publications is one of the criteria depicting their achievements. Nonetheless, as already mentioned in previous section, BO in France are evolving and expanding their activities. For example, Acclimaterra together with Nouvelle Aquitaine region, the EU, University IPSL Sorbonne and EIT Climate-KIC have co-constructed the research project “Deep Demonstration”. Nonetheless, this evolution took place almost 1 year after the interviews took place, thus we will not take it into account.

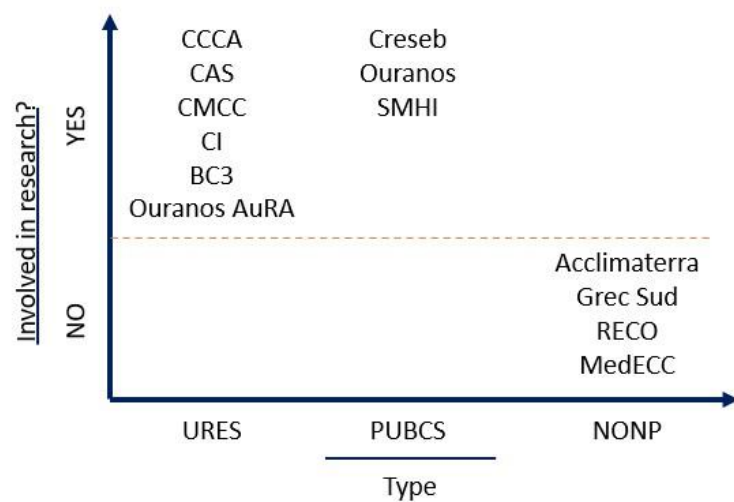
Additionally, it appears that the source of funding did influence knowledge brokering activities. As depicted in Figure 23, boundary organisations with mixed funding were more likely to provide all 5-knowledge brokering (KB) activities:

- 7 boundary organisations with mixed budgets: 5 offer 5 KB activities (BC3, CCCA, CMCC, SMHI, Ouranos Inc.) 2 offer 4 activities (CAS, Ouranos AuRA).
- 6 boundary organisations with public funding: 3 offer 5 KB activities (CI, Creseb, Acclimaterra); 2 offer 3 activities (MedECC, Grec-Sud), 1 offers 2 activities (RECO).

Out of 3 boundary organisations with public (ST) funding and 5 activities, two were university-based and public CS types (CI and Creseb), while only Acclimaterra is a non-profit. We can conclude that the source of funding and the type of institution had an impact on the diversity of knowledge brokering activities. However, other factors may play an important role. These were addressed in the interviews and will be illustrated in the following sections.

4.3 Rome was not built in a day

Figure 23 Sample: BO and scientific production



One of the core assumptions of this part of our research is that the degree of institutionalization will have an impact on boundary organisations' capacities to effectively expand and implement their knowledge brokering strategies. The degree of institutionalization will refer to:

- Institutional stability (source and stability of the budget, legal status, age).
- The presence of strong links with non-scientific stakeholders (shared networks, shared decision-making).

Our goal is to identify factors that represent obstacles or levers for boundary organisations delivering climate change adaptation services. As we have selected organisations with various institutional stability, and operating in different contexts, we hope to shed light on several aspects, such as their creation, operations, and evolution. To discuss our findings and to preserve the anonymity of the interviewees, geographical locations will be replaced with an "X", while the verbatims will be contextualised with these categories:

- Form: University and research (URES), public service (PUBCS), non-profit (NONP).
- Funding: public (ST), or mixed (MIX).

Additionally, we will provide information on how many boundary organisations have expressed similar opinions by indicating it in the brackets (for example, 4 out of 13).

4.3.1 Establishing a boundary organisation. What common traits?

Although these institutions face several similar challenges, they are also characterized by specific challenges linked to the nature of services they offer, to their form, or to their institutional stability. Nonetheless, we believe that the context in which these BO navigate will play a major role in their establishment, evolution, and expansion. What can foster the uptake of knowledge that was previously ignored? For Kingdon (2003), it is the so-called windows of opportunity (or policy windows). According to the author, the absence of policy windows can slow down the process of uptake of scientific knowledge. This is particularly relevant for several countries in the European Union. We have already discussed how the European heatwave of 2003 has pushed several EU's countries to elaborate adaptation strategies. Since extreme weather events cause not only economic, but human losses as well, climate change effects started to be perceived as public security issue:

In fact, the Government of X perceives climate change and its impacts as a matter of public safety. The creation of our organisation is linked to extreme weather events /PUBCS, MIX/.

From this citation we can assume that sudden focusing events act as catalyst and force the governments to opt for proactive adaptation solutions. In our case, sudden events

lead to the establishment of a BO. Nonetheless, not only weather events can push for adaptation planning. One of our interviewees explained that the economic crisis of 2008 had opened the window of opportunity, and that their institution was created as a scientific gap on impacts of climate change was identified:

At the time in X, there were no studies on climate change from an economic point of view. Therefore, X initially focused on the economics of adaptation (and the first director was an economist) /URES, MIX/.

However, when events are chronic and reproduce in time, they occupy a major place in political agendas, and can go as far as:

Adaptation is our DNA. We have the most protected coast in the world /URES, ST/.

The same participant has pointed out that:

The idea of creating X has been well received by the government, as it could potentially narrow the gap between local users and the “Met Office” /URES, ST/.

This can only mean that some of the public authorities had already tried a climate adaptation product (CCAP) but did not find it fit for their purpose. In fact, as discussed in Chapter 1 boundary organisations represent a solution to the co-called science-policy gap between producers and users of climate information. Nonetheless, this participant has pointed out that, when an issue is too institutionalized, it can also be counterproductive. A country accustomed to dealing with one particular impact will tend to focus most of its attention on that impact, making it difficult for other issues to enter the public and political discourse. When illustrating possible barriers for climate adaptation products and services' use (Chapter 1), we have pointed out that elected officials prefer tested solutions. From this perspective, institutional rigidity should not be underestimated, while adaptation priorities must be revised according to the evolving contexts.

Several of our interviewees pointed out that the pressure from civil society plays an important role (4 boundary organisation out of 13). Nowadays during the elections most candidates have an environmental program (if not a climate one), and Green Parties are gaining importance in the whole EU. For example, German Green party has doubled its seats in the Bundestag in 5 years, and it is no longer in the opposition. Similar outcomes have been registered during last election for European Parliament in 2019: 67 Members of the European Parliament were from green parties (50 in 2014). Additionally, civil society is more and more active in the domain of climate justice. For example:

- The “*State of the Netherlands versus Urgenda Foundation*”. It is the first successful case where a government was judged accountable for climate change based on human rights charts (the European Convention on Human Rights, ECHR). Urgenda Foundation (Dutch environmental group) together with 900 Dutch citizens have sued the Dutch government to increase its efforts for the prevention of climate change: “*the Supreme Court determined the exact level of greenhouse gas (GHG) emissions reduction that the Netherlands is required to meet to comply with its ECHR obligation, specifically, a 25 percent reduction compared to its 1990 level by the end of 2020*”(Meguro, 2020:729).
- The “*L'affaire du siècle*”. Oxfam France, Notre Affaire à tous, Fondation pour la Nature et l’Homme and Greenpeace France have sued the French state which was condemned for its insufficient efforts in mitigating climate change in 2021. The administrative court of Paris (for the first time) ordered the State to repair the consequences of its shortcomings in the fight against climate change. To this end, the court ordered that the overrun of the greenhouse gas emissions cap set by the first carbon budget (2015-2018) be compensated by December 31, 2022, at the latest (Administrative court of Paris, sentence nr. 1904967-1904968-1904972-1904976).

On the other hand, political context can represent both an opportunity and a major obstacle. For example, the following non-profit boundary organisations’ opportunities are influenced by regional political context, and more specifically by the approaches to climate change:

The political context in X, on the contrary, is not favourable. The issue of adaptation is addressed as part of regional strategy to create "Europe's first energy positive region", but the focus is on renewable energies, with little focus on consumption and adaptation itself. There are conflicts of interest with some research institutions and regional DREAL⁴⁷ /NONP, ST/.

In the meantime, the majority (refers to the Regional Council) has changed, and now it is a bit more difficult to convince them that climate change is an important issue. In the end we did convince them, and the Region has even organized some meetings. In fact, their new idea is to become pioneers in mitigation and adaptation to climate change. But it’s just a slogan /NONP, ST/

AS one can see, the first verbatim refers to a situation where mitigation-related issues represent a priority for regional authorities, and where even state services DREAL

⁴⁷ DREAL is the Regional Department for the Environment, Development and Housing (direction régionale de l’Environnement, de l’Aménagement et du Logement)

represent an obstacle. The second extract depicts a situation where the new ruling majority suffers from greenwashing.

The following citation refers to an opposite situation, where political context is favourable:

Our establishment was driven by the Regional Council. The president of the region wanted to set up a scientific committee which could provide information on the impacts of climate change in the region /NONP, ST/.

Indeed, these two non-profit boundary organisations operate in contexts where the views on, and the approaches to adaptation are dictated by the regional or state authorities. Another non-profit BO has pointed out that their establishment was facilitated by ruling parties at the Regional Council (coalition of socialists and greens):

So, they (the Region) found a bit of money to create a database of all researchers working on climate in our region /NONP, ST/

Lack of incentives to engage in adaptation policymaking represents a major obstacle not only for the creation, but also for the stability of these BO (will be further discussed in the following paragraphs). As discussed in Chapter 1, until recently addressing adaptation was perceived as giving up on fighting climate change. Whilst policymakers recognise the importance of integrating adaptation into their policies, we cannot assume that everyone has the same vision nor the capacity to implement it. In fact, as it will be discussed in the next Chapter, adaptation is often the weakest link of Climate Plans in France (“parent pauvre des plans climat”).

Lack of incentives is nested not only in the political domain, but in the scientific one as well. Lack of recognition of interdisciplinary research represents an important barrier. On one hand, hard and soft sciences struggle to work together, as they do not share the same methods and vocabulary. Additionally, interdisciplinary research does not share the same level or recognition as classical one-discipline studies. This translates into difficulties to establish yourself within academic world, and to struggles on the job market in general, as we can see in the verbatim below:

We had to stop asking our PhD students to do everything - to be a hydrologist, a sociologist, at the same time. On the one hand, not everyone is able to do it. On the other hand, it could put PhD students in difficult situations - it is very complicated to defend a thesis in one discipline, when you have done fifteen disciplines in your thesis. Additionally, it's complicated to find job positions afterwards /URES, MIX/.

However, whereas some respondents highlighted the difficulties faced by young researchers (2/13), some scientists pointed out that being at the end of their career alleviates a lot of pressure (1/13). In fact, they are not subject to “*publish or perish*” culture and “*have nothing to prove*” (URES, MIX). On the other hand, adaptation to climate change in general, and the development of climate adaptation services, require input from several disciplines: economics, climate sciences, health sciences, engineering, etc. As a matter of fact, the critiques of first generation of climate services point out that climatologists assume that “*all have the required level of knowledge, capacity, and resources to use climate information*” (Porter and Dessai, 2017). However, this assumption refers not only to the decision makers, but also to the scientists from other disciplines.

To finish this first part on a brighter note, the struggles of working in an interdisciplinary setting can be overcome with learning by doing:

Simple discussions during coffee breaks made us understand that scientists from different disciplines are 'mentally different' and that working under one roof is good exercise /URES, MIX/.

When I came to the X, my first impression was “oh my goodness it's just like natural scientists talking about birds and trees” and I pushed it really hard to bring in all the technical universities of X as well, even if typically, they don't see themselves as a climate research institution /URES, MIX/.

These two citations illustrate how interdisciplinarity is not achievable on the spot. It is a process of learning how to work together. It is also a process of understanding how various disciplines may contribute to adaptation to climate change. As the interviewees point out, spatial proximity, or simply put “*sharing the same roof*” enables scientists to challenge the boundaries of their respective disciplines. However, these verbatims refer to specific settings, where interdisciplinarity represented a goal and a method of research. Specific conditions were reunited to enable interdisciplinary work:

- Material conditions, such as “*sharing the same roof*”.
- Human resources, such as motivated people responsible for organizing interdisciplinarity.

From the above-mentioned citations, we can conclude that the establishment of boundary organisations will be influenced by two conditions: 1) one condition from political domain - favourable political context, desire to work on adaptation; 2) one from scientific domain - incentives and means for interdisciplinarity. In addition, although not explicitly mentioned, establishing interdisciplinarity takes time. Besides these two common

themes, the BOs in our sample face structural challenges. These will be discussed in the following section.

4.3.2 On the role of stability

Before discussing the importance of institutional stability, we would like to remind that our sample is composed of boundary organisations with different type of funding (mixed and public) and of different form (university based, public service, and non-profit). We have seen that university-based and public service types are more likely to offer all five knowledge brokering activities, such as compiling, research gap identification, networking and coordination, decision support tools, and policy development (Annex 5). The non-profit organisations are less homogeneous. Acclimaterra is engaged in all 5 knowledge brokering activities, while the other 3 BO of this type do not offer decision support and policy development (Grec-Sud, RECO, MedECC).

The non-profit boundary organisations present similar characteristics and face similar issues. This should not be surprising, as all of them are non-profit associations working on regional levels in France. They depend on short-to-medium term financial arrangements with regional authorities (5 years contracts). Additionally, Acclimaterra, Grec-Sud, RECO, MedECC are not coordinating or taking part of research initiatives (Table 14). Worth noting that this type of BO is not present only in France. However, they were more difficult to identify due to language barriers and geographical distance. We believe that BO involved in research are easily accessible as English is one of their working languages (peer reviewed articles in English, websites in English). The presence of this bias in our sample does not impact the goals of this study: we aim at inquiring on institutions developing different climate adaptations services, not on differences between countries.

One of the main challenges of non-profit BO is securing financial stability. The interviews took place during regional elections. In fact, all 4 non-profit associations expressed concerns related to legislative turnover. For example:

Regional elections are held at the end of the month - will we be funded for next year? Will we get the same financial support, or will we finally be able to have more funding? /NONP, ST/

This verbatim illustrates how legislative elections, and more specifically changes in ruling parties at the Regional Council, may have a direct impact on the non-profit boundary organisations. Legislative turnover can create issues in terms of financial stability, but also influence the views and the methods to tackle climate change. In fact, another non-profit BO has pointed out that having intercommunalities as their partners allowed them to alleviate obstacles at the regional scale. Additionally, those who at the time (2019) were

undergoing the process of institutionalization, aimed at securing funding from different sources to avoid this problem. Not only their financial stability is impacted by short-to-medium term contracts, but it also follows electoral cycles of respective regions.

French political parties do not share the same degree of awareness or vision on climate change. Although climate issues have now become an important part of any political discourse, the strategies adopted by different political coalitions will be very different. For example, France Info (public service radio) and Les Shifters (thinktank), have analysed programs of candidates running for presidential elections in 2022, and classified them according to their distance from Paris Agreements and French National strategy on low carbon (SNBC)⁴⁸. They argue that the socialists and the greens (Jadot, Melanchon) were the closest to the abovementioned climate policies, while the extreme right (Le Pen) and the extreme left (Arthaud) candidates had almost no climate-related propositions.

Financial stability was also mentioned by university or public service types of boundary organisations. Nonetheless, their capacities to participate in research projects enable them to attenuate these problems:

We got a funding reduction from the government. It was a reduction of 40%, a crazy amount. So, we need to turn more into external funding from research projects /PUB, MIX/

As illustrated by the verbatims above, this boundary-organisation pointed out that European scientific projects represent a solution to budget cuts. Similarly, as shown in the citations below, being able to participate in scientific projects represents an important source of funding, and or solution to financial obstacles:

We participated in the X project to have more support and to develop our activities /URES, MIX/.

Full members like the big universities put in a lot of money to have our salary paid. In many cases they get back more money because we generate projects through the ministry or through our organisation /URES, MIX/.

In fact, we have already seen that that university-based and public service types of BO in our sample are more likely to offer all five knowledge brokering activities (compiling, research gap identification, networking and coordination, decision support tools, and policy development, Annex 5). It appears that these types of BO are characterized by higher financial stability because they are eligible for scientific funding. We could

⁴⁸https://www.francetvinfo.fr/elections/programmes-election-presidentielle-2022/programmes-climat/exclusif-crise-climatique-on-a-epluche-les-programmes-des-candidats-a-la-presidentielle-pour-voir-s-ils-respectent-l-accord-de-paris_5033276.html

assume that their form can impact the access to funding and thus, their institutional stability. However, their form may also create conflicts of interest with local research institutions, like in the case of this non-profit BO:

Some laboratories prohibit their researchers from participating in X meetings because "it is not in the scientific strategy of the laboratory". In addition, it is not clear whether researchers can be part of an association if it works in their field of research" /NONP, ST/.

It is worth mentioning that scientists in the non-profit climate adaptation services (CCAS) are involved on a voluntary basis and do not receive any monetary compensation for their contribution. From a certain perspective it is beneficial to involve only the most enthusiastic people. However, not all scientists have time, resources, or adequate academic positions to dedicate part of their job to CCAS. When considering young researchers, we have legitimate concerns about their capacities to contribute on voluntary basis because they are under pressure to “*publish or perish*”. As pointed out by one of interviewees, “*not having to seek visibility on international level*” is something you reach at the end of your career.

Moreover, their form raises concerns about their scientific legitimacy. Can we assume that a non-profit association has scientific legitimacy to accompany national or sub-national governments in their adaptation planning? Three non-profit boundary organisations in our sample managed to overcome this barrier by relying on the contribution from local researchers (2 NONP), or by developing tight links with universities and research institutions (1 NONP). Nonetheless, as illustrated in the verbatim above, conflicts of interest with local research institutions can represent a nonnegligible obstacle.

4.3.3 On the role of time

So far, we have discussed issues related to institutional stability and pointed out that non-profit climate adaptation services (in our sample) are more likely to suffer from issues related to their funding and local elections. We have also pointed out that time and material means were needed to set up interdisciplinary approaches. But how about transdisciplinary approaches? Not surprisingly, it appears that institutional stability is a factor that enabled boundary organisations to put in place transdisciplinary approaches, and to set up a twofold connection with their users.

Financial stability enabled long term planning, and granted the possibility to hire professionals, such as scientific mediators, psychologists, or graphic designers. In fact, organizing a science-policy interface is a multi-step process which requires several professional figures. Previously we have illustrated challenges from political sphere

(awareness) and scientific sphere (conditions for interdisciplinarity). However, there are additional conditions. All interviewees expressed the need for professionals and scientific mediators. For example:

We've learned, because we're working with psychologists as well, to understand how the human brain and how people preserve things, and they told us "Hey you need to change your language" /URES, MIX/.

If you leave it to the researchers, you will get all kinds of complicated animations, probabilities, and thousands of pages of research material. These do not fit users' needs /URES, MIX/.

These two quotes refer to challenges occurring when working in transdisciplinary settings. Both express the need for understanding the non-scientists' needs – starting from the use of language to the design of adaptation products and services. They highlight the gap between scientists and decision makers. Additionally, they argue that there is need for people capable of creating a bridge between them and their users: psychologists, mediators, graphic designers etc. This confirms the shift in science-policy paradigm in climate adaptation services (CCAS) from many perspectives. In other words, for CCAS to thrive, several boundaries must be reconstructed: 1) boundaries between disciplines, as discussed in previous sections; 2) boundaries between stakeholders, scientists, and non-scientists.

Institutional stability rhymes with the possibility to evolve in time, to expand knowledge brokering activities, and to engage in mutual learning:

Our audience got more technical. Initially we would have been dealing with biodiversity, it was a huge area. But now we deal with road engineers etc. As I said previously, the website would only be 50% of our work and even less at this point. So, we tend to work directly with these people and understand, helping them, supporting them, and employing climate data, employing the whole idea of climate change within their decision making. We went through three phases of project funding and now we're put onto an operational basis. I mean, that was one of the successes of X - it got over the project phase, and I think that in adaptation and climate services that's recognized as a key challenge /URES, MIX/.

This citation is one of the most emblematic ones. It illustrates how learning-by-doing enabled their users to achieve a certain level of appropriation of climate data and services. In fact, the governments and the users had recognized this CCAS' contribution to their evidence-based decision making. This recognition enabled them to “get over the project phase”, to establish themselves as an institution, and to expand their activities. Another university-based boundary organisation had its roots in a governmental scientific

program, which aimed at developing applied knowledge through cooperation between the government, the business community and scientific research institutes. Approved by the government in 2007, this program has been granted a budget of 50 million euros. Nowadays, this boundary organisation has also been put onto an operational basis.

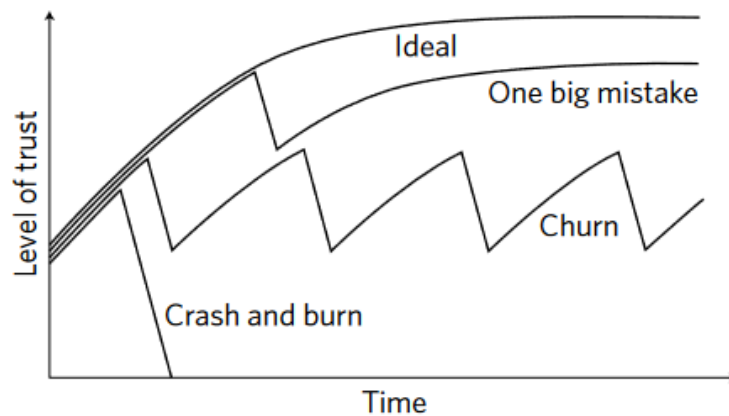
As one interviewee pointed out, nowadays the website (with products) is not the main part of their job. Today they focus on the service side of their offer – decision support and capacity building activities. It seems crucial to highlight that these achievements took time. They didn't start as a stable institution with a stable budget, and a long list of products and services (Rome was not built in a day). Furthermore, the appropriation of products and services delivered by CCAS allowed the users to increase their own capabilities:

Stakeholders don't know what they want, and there's learning that they must go through. In that development they've increased their capacity, they've increased their understanding of the issues, and they want more sophisticated products /URES, MIX/.

Learning-by-doing emerges as a two directional process, where both scientists and non-scientific stakeholders learn from each other. As non-scientific stakeholders became “*more technical*” and demanded “*more sophisticated*” products, the scientific stakeholders improved their understanding of decision-making processes. However, this implies that all categories of stakeholders are willing to learn, and the knowledge exchange conditions are adequate. More specifically, as emerged from the discussions, scientists may adopt a “*predatory*” behaviour during transdisciplinary projects. If one party is using knowledge exchange solely to “*gather the data*”, the whole process may be compromised. This is particularly relevant for climate products and services developed in scientific projects. In such circumstances collaborations are limited in time and scientists are under pressure to publish. The scientific stakeholders' final aim could be to gather enough material for their own research purposes (predatory), and not to accompany decision makers in their evidence-based decision making. Although this is not the case for every scientific project, it emerged as a possible barrier to successful knowledge-exchange.

Boundary organisations have pointed out that time was needed to achieve a good understanding of local authorities' needs. These findings can be interpreted with Lacey et al. (2018) model of trust/time. The Figure 24 depicts four scenarios of the evolution of trusting relationships at the climate science–policy interface (Lacey et al. 2018). According to the authors, these relationships are characterized by non-zero starting point, as decisionmakers will engage with scientists based on individual or institutional reputation.

Figure 24 Four scenarios describing the evolution of a trusting relationship (Lacey et al. 2018)



The Crash and burn scenario occur when there is misuse of scientific information by policymakers (propaganda), or miscommunication of scientific outputs by scientists. The Churn is characterized by institutional challenges such as turnover within policymaking agencies, grant-based research, or short-term research contracts. One big mistake refers to situations when one act or incident significantly erodes trust. (Lacey et al. 2018) explain that this scenario occurred when IPCC committed a typographical error regarding the melting of the Himalayan glaciers. Finally, Ideal scenario, albeit being rare, portrays a situation where trust is built gradually over time. In this scenario, the science-policy gap is minimized.

The interpretation of Lacey et al. (2018) raises questions on the nature of climate change adaptation products and services from the perspective of legitimacy and credibility. Most of the capacity-building boundary organisations in our sample are nested at universities or represent a public institution, such as extension of national weather service or a public agency. This allows them to build connections with decision makers from a non-zero starting point because of their institutional reputation and scientific credibility. Additionally, as they are more likely to have institutional stability, the level of trust and the quality of connection with their users may evolve in time. Moreover, climate adaptation services are seen as common good by two interviewees. They argue for the role of public institutions as climate services providers:

I have always been convinced that these structures should remain anchored within the university. It is a common good, and as a common good it should be delivered by public institutions /URES, MIX/.

They point out that climate products and services should be free of charge because:

*The taxpayers have already paid for the research /URES, MIX/.
Unless access to information is democratized, and the user granted the possibility to become independent, this will be completely useless. You can become a modeler, a user who contributed /URES, ST/.*

As illustrated by these 3 verbatims, for these 3 university-based boundary organisations, the climate change adaptation products and services should be seen as “*public provision of adaptation goods*” (Tompkins et Eakin, 2012). We have already discussed why adaptation in general should be interpreted as a public good in Chapter 1, but these 3 verbatims raise the question of scientific credibility of climate adaptation services: is the knowledge and policy production fair and accessible? However, three boundary organisations have pointed out that the service should have a price or membership fees. According to them, decision-makers will be more interested in participating in “*something they have paid*”. Please note that the question of price and membership was introduced by university-based boundary organisations with more than 10 years of experience, where decision makers are involved in governance.

Nonetheless, mutual learning does not refer exclusively to the co-construction of a particular product or service. Five boundary organisations in our sample have the particularity of sharing decision-making bodies with non-scientific stakeholders:

Every research project in X also has a steering group, so we sit on several of them, and their local authority representatives also sit on them. The key factor that has worked for us is strong collaboration, and I would say collaboration with local authorities, with the sector, with the users, whatever we want to call it. And that's important. The second part is that you can use collaborations to understand what's out there, what they do need, what data so we can start to anticipate what these people are going to require in future /URES, ST/.

As this interviewee pointed out – shared steering committees enabled them to create strong links and to anticipate users’ needs. The collaboration between stakeholders can go beyond product development, and include aspects not related to the climate adaptation product or service itself. Shared steering committees provide an additional opportunity to build trustful relationships, to improve the match between demand and offer of science. Sharing decision-making mechanisms within boundary organisations can also improve

coordination, or matching agendas between scientific and non-scientific stakeholders. What is most important – shared steering groups guarantee the iterativity between scientific and non-scientific stakeholders. It allows them to exchange ideas outside of a given project and improve their understanding of decision-making process.

In fact, institutional rigidity has been highlighted as a major obstacle across literature and has been pointed out in the interviews as well:

Sometimes users were not trusting the data, especially because they were not ready to switch their decision based on seasonal forecasts /URES, MIX/

The citation above sheds light on institutional rigidity - “*not ready to switch their decision*”. It also raises the question of uncertainties - “*trusting the data*”. Nonetheless, working together and having the opportunity to build trust relationships in time, allowed the participants to find solutions to institutional rigidity:

It is necessary to build on existing mechanisms, as new tools can be seen as “additional work”. New information should be integrated into a system that is already used by the government /URES, MIX/

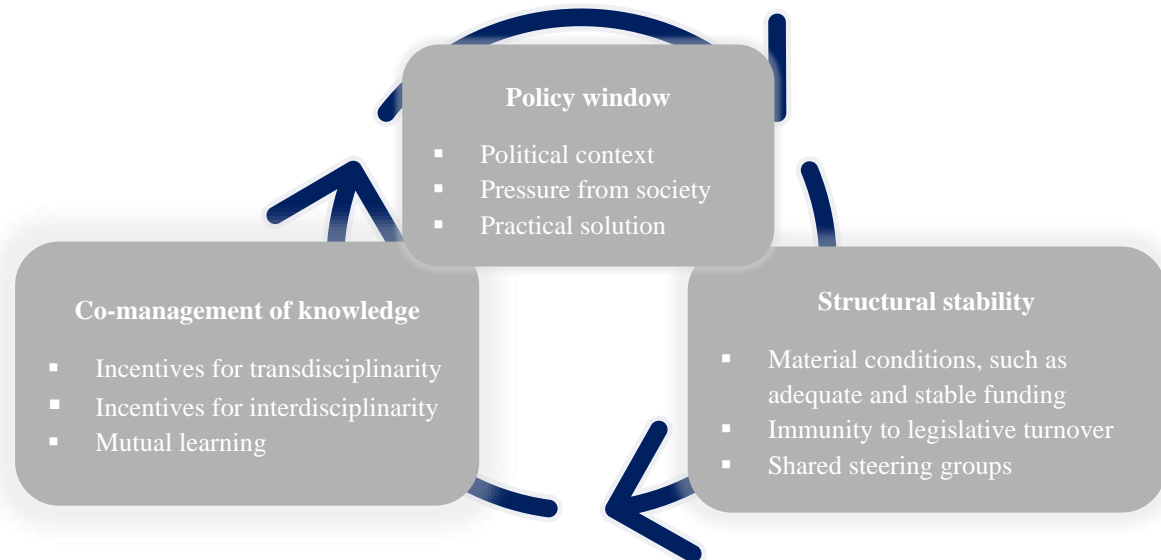
While Dilling and Lemos (2011) have pointed out that decision-makers prefer tested solutions, our interviewees argue for the use of already existing channels to overcome this rigidity. In fact, as illustrated in this section, not only the form of climate adaptation products and services products and services matters. The understanding of decision-making processes represents an important factor for these boundary organisations and their users. However, this “understanding”, or mutual learning requires adequate material conditions, such as institutional stability and the possibility to evolve in time.

Conclusions

The first generation of climate adaptation services are often criticized because they lack connection with end-users. As illustrated in Chapter 1, usually these services take the form of climate change adaptation product (CCAP), such as a map with projections or reports on main climate variables. The first generation CCAP represent sophisticated modellisation efforts or may take form of risk assessments. Hence our interest in climate change adaptation services (CCAS) instead, as they go beyond “simple” data transfer and offer knowledge exchange mechanisms to make a better use of CCAP. Our goal is not only to identify potential mismatches between offer and demand in science, but also to illustrate how CCAS providers overcome the science-policy gap in adaptation. For us, adaptation to climate change is a process involving stakeholders from both political and scientific domains. Ergo, inquiring on boundary organisations offering CCAS allowed us to shed

light on this relatively new topic. What are the key ingredients of the knowledge exchange process in the context of adaptation? The Figure 25 represents a graphic illustration of our findings.

Figure 25 BO key ingredients: from establishment to co-management



Following the thematic analysis of the interviews, we have organized our findings around 3 pillars: policy window, structural stability, and co-management. The participants pointed out that several factors facilitated the establishment of boundary organisations. These factors are linked to the Kingdon’s (2003) policy window concept. More specifically, for a policy window to open, several conditions must be met:

1. Favourable political context due to legislative turnover may lead to positive changes in a government’s agenda. Environmental and climate concerns have become an intrinsic part of any political campaign, even if political parties may have different views on adaptation.
2. A problem may become impossible to ignore (eg.: Extreme weather events). In fact, climate change problem is becoming more and more difficult to ignore. Heatwaves, melting glaciers, droughts – the impacts of climate change became part of our landscape. Pressure from civil society due to sudden and crippling events, such as storms or sea water level rise, there is a steady build-up of pressure from civil society.
3. A policy solution may appear that is practical to adopt (eg.: knowledge broker). In our case, the establishment of a climate change adaptation service was perceived as a solution to the knowledge and to the science-policy gaps.

As outlined in Dilling and Lemos (2011), the usability of climate adaptation products and services can be negatively influenced by a set of constraints linked to the

political context, or to intrinsic features of climate information. Yet, institutional barriers linked to political awareness represented the first and the major challenge for several non-profit boundary organisations in our sample. In their case, lack of awareness of policy makers translated into insufficient political support, thus concerns over their financial stability. Fortunately, the electoral cycles at regional scales had no impact on their activities, as their funding contracts were renewed.

When it comes to co-management and structural stability, it is important to point out that these are influenced by an additional factor – time (depicted by circular arrows). Time represented an important feature from scientific, political, and structural perspective. In fact, the co-management ingredients, such as inter- and transdisciplinary approaches should be seen as iterative processes:

- From interdisciplinarity to transdisciplinarity => working on boundaries between disciplines first, then managing the boundaries between scientific and non-scientific stakeholders. The participants have pointed out that these processes are not automatic, they require effort, understanding and dedication.

In fact, constraints can also be rooted in the rigidity of academic institutions, such as lack of incentives for inter-and transdisciplinary approaches. Scientists face a double challenge of operating within new and often not recognized frameworks of interdisciplinary work. For example, a couple of interviewees explained that they had to give up certain academic ambitions to set up the respective climate adaptation service. In the context of evidence-based decision making, scientists are solicited to co-produce knowledge and to accept new roles and responsibilities (Porter and Dessai (2017)). At the same time, “*publish or perish*” logics are still dominant and may hinder co-production of climate adaptation services. This institutional rigidity in academia raises the question on the adequacy of current evaluation metrics (number of published articles, patents), especially in the context of adaptation to climate change. As Swart et al. (2014) have explained, there is science of adaptation, oriented by disciplinary approaches and aiming at understanding adaptation, and science for adaptation, which targets societal stakeholders and practice-side. According to us, both should be recognized.

Mutual learning should be seen as an iterative process - a twofold connection for knowledge exchange. Trust, better connections, and joint re-thinking of socially constructed boundaries between science and policy are believed to foster the appropriation of new tools. As illustrated by Lacey et al’s (2018) trust/time model, institutional challenges, such as grant-based research, or short-term research contracts, do not allow for trust to build gradually over time (Figure 24). As we have illustrated in the previous section, institutionally stable boundary organisations were capable of avoiding the abovementioned

institutional challenges. The fact that their users ask for more sophisticated products is a sign of successful appropriation and trust building relationship:

- From scientific gap to knowledge gap => from the need for climate information for a specific territory or impact (region, city, etc), to the need for useful information for evidence-based decision making.

As pointed out in Porter and Dessai, “*it is assumed that users either have the same capacity, resources, and time needed to make sense of technical knowledge*” (2017:10). However, as the participants explained – decisionmakers are not climatologists and complicated graphs and figures are not an adequate form of knowledge transfer. They have highlighted that their role is to enable policymakers to use all the relevant information and tools. Additionally, they aim at increasing scientists’ capacities to communicate and understand other stakeholders’ needs. Successful management of the boundaries (between disciplines and stakeholders) enabled their users to ask for more sophisticated products, while allowing them (BO) to anticipate users’ needs. Institutionally stable boundary organisations went through the process of learning by doing and have identified solutions to institutional barriers. For example, a university-based BO that it is better to “*make an evolution, not a revolution, it will be more solid*”. Similarly, a public service BO suggested using existing channels, as new tools can be perceived by policymakers as additional work.

The issue of institutional rigidity, “*institutional inertia*” or “*the stickiness of institutions*”, has been largely discussed by political scientists (Lustick, 2011). Although stable institutions allow our communities to take effective action, institutional rigidity could also lead to suboptimal decisions (Lustick, 2011). Sydney Halpern (2008) has discussed new governance models as a solution to this issue. She argues that the so-called “*hybrid model*” can enable regulatory flexibility and responsiveness. A governance model can be hybrid from different perspectives. For example, it can bring together governmental and non-governmental controls, it can combine central and local authority, or engage a multiplicity of policy actors (Halpern, 2008:85). Interestingly, hybrid governance’s features are closely related to:

- Polycentric governance, and the idea of balance between centralized and decentralized governance (Imperial, 1999).
- The concept and the aims of boundary organisations. More specifically, to their role as knowledge brokers between governmental and non-governmental actors, or between governmental and scientific stakeholders.

Focusing specifically on adaptation, Pelling and High (2005) argue for “bounded instability” to promote innovation through experimentation and learning. While the

interviewees highlighted the presence of institutional rigidity, they also pointed out that there are feasible solutions to this barrier. The thematic analysis shows that most of the institutional barriers to interdisciplinary and transdisciplinary work can be overcome through learning by doing. However, this learning by doing is only possible if scientific and non-scientific actors take the time to learn from each other. In turn, taking time is possible in the presence of well-established boundary organisations. In line with Saarela et al 2015, the role of shared history of knowledge exchange between users and producers of knowledge was identified.

Assuring a stable relationship can enable stakeholders to clarify on: spatial scales (policy makers prefer regional or local, as adaptation is mostly done on local scales); the timing (are the research and policy agendas compatible?); the skill level (accuracy of climate projections); and uncertainties of information (Ford et al., 2011). For example, Ouranos Inc. was established in 2002. Nowadays, it is composed of 450 researchers, experts, practitioners, and policymakers from a variety of disciplines. Ouranos Inc. has more than 10 research programs from climate simulation and services to vulnerability assessments and climate adaptation (from general to sector and context specific). Climate Ireland has started as a research project but successfully got over the project stage. As they pointed out, long term collaboration with local authorities enables them to anticipate users' needs. Acclimaterra started with public outreach activities and reports on climate in Nouvelle Aquitaine region. Nowadays, they are also part of the regional "*NeoTerra*" roadmap for energy transitions.

The aim of this study was to identify institutional factors that undermine boundary organisations (BO) capacities to accompany policymakers in their adaptation planning. We have found out that BO in our sample face different challenges, as they operate within different political and scientific contexts (political support, incentives for trans- and interdisciplinary approaches). BO are supposed to manage relationship between these two domains as per definition. Nonetheless, as Rome was not built in a day, a successful knowledge-exchange mechanism requires time to develop and to unfold.

This study offers a producer perspective on climate adaptation services. On the contrary, the next chapter will be dedicated to users' perspective. What is the articulation of adaptation governance in France and in Auvergne-Rhône-Alpes region? What are knowledge needs for adaptation at local scales?

Chapter 5

Knowledge needs for adaptation at local scale.

Auvergne-Rhône Alpes case study



The trouble is that on the basis of uncertain inputs, decisions must be made, under conditions of some urgency.

Silvio Funtowicz and Jerry Ravetz, 1991:21

Chapter 3 was dedicated to the producers' perspective on climate products and services. We have discussed the formal and informal institutional barriers, such as the lack of incentives for transdisciplinary approaches, or the assumption that policymakers have the same capacities as climatologists (Dilling and Lemos, 2011; Porter and Dessai, 2017). We have concluded that the boundary organisations in our sample face challenges related to their structural stability and the rigidity of academic institutions. More specifically - to the difficulties of scientific actors to engage with their pairs from different disciplines, or with actors from "the outside world".

Chapter 4 will provide users' perspective on adaptation and adaptation services. As stated in the Introduction, adaptation is "*a continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes*" (Adger et al., 2005:78). Is there a link between the number and the content of climate plans adopted by an intercommunality, their views on adaptation and their needs? This chapter aims at shedding light on these questions.

To achieve our research objectives, we have conducted 31 semi-structured interviews with local authorities in Auvergne-Rhône-Alpes on regional and local scales. Furthermore, we have analyzed several institutional documents, such as:

- French national adaptation strategy and plans elaborated by ONERC (NAS, PNACC1 and 2).
- Regional Air Energy Scheme (SRCAE) and Strategy for sustainable and equal development elaborated by Regional Council (SRADDET).
- Local climate air energy adaptation plans elaborated by intercommunalities (PCET, PCAET).
- Vulnerability and evaluation reports when these were not part of local climate air energy plans. Additional documents on specific events and tools were also consulted.

The empirical material was organized in Table 8 which provides information on consulted documents, the sample, and the number of interviews conducted with each entity. Once we have positioned each one of these climate plans on a timeframe, we can discuss their contents, the timing, and the links with other administrative scales. To preserve the anonymity of the participants, we will follow two principles: 1) when the interview extract contains rather sensitive information or opinion, no indications on the entity will be provided (X); 2) in other cases will indicate who's talking by adding the name of concerned

intercommunality, DDT, or DREAL. Additionally, in many cases we have interviewed more than 1 person per entity, which also contributes to anonymity.

Section 5.1 will illustrate adaptation on national, regional, and local levels, as well as discuss its evolution when relevant. Section 5.2 will be dedicated to the articulation of adaptation policies between these administrative levels and will tackle the coordination side of the issue. Section 5.3 will illustrate local authorities' needs: what climate change adaptation products and services do they use now and what kind of products and services do they need?

5.1 Articulation of adaptation policies across spatial scales

Our empirical material includes various documents produced by selected authorities (Table 8). More specifically, we focused on documents related to climate and adaptation, such as climate plans (PCAET, PCET), numerous reports on local impacts and vulnerability (diagnostic), presentations of existing initiatives and tools (eg.: TerriSTORY⁴⁹, ateliers). Additionally, we have consulted reports on economic activities since 1) this information is essential to better grasp local reality and needs, and 2) we expect major economic sectors to be prioritized during adaptation spatial planning.

5.1.1 National policies: NAS, PNACC and PNACC2

France has adopted 1 national adaptation strategy (NAS), and 2 national adaptation plans - the PNACC1 (2011) and the PNACC2 (2018)⁵⁰. These 3 documents were elaborated by ONERC (National Observatory of the impacts of climate change), under the authority of Ministry of Ecological Transition⁵¹.

We have pointed out that it took time for adaptation to become a part of political agendas. However, as discussed in Chapter 3, France was one of the very first countries to adopt a national adaptation strategy in 2006. In fact, the PNACC1 points out that two documents have contributed to lifting the taboo on adaptation: the IPCC's report on impacts, adaptation, and vulnerability (2007) and the Stern Review on the economics of

⁴⁹ TerriSTORY is website, a tool to help manage energy transition of Auvergne-Rhône-Alpes, offered by the Auvergne-Rhône-Alpes Regional Energy-Environment Agency. TerriSTORY covers a wide range of topics such as energy, air, greenhouse gas emissions, carbon storage, waste management, mobility, environment, climate, economy, etc (<https://auvergneRhônealpes.terristory.fr/>). It does not address adaptation.

⁵⁰ While the aim of the national adaptation strategy (NAS) is to introduce adaptation issues in policy agendas, the national adaptation plans (NAP) contain specific means to achieve the objectives of the NAS.

⁵¹ Ministry of ecological transition is responsible for state policy on sustainable development, climate, energy transition and biodiversity (<https://www.ecologie.gouv.fr/>).

climate change (2006). Nonetheless, in 2006 the NAS highlighted that adaptation should follow several principles, such as coherent articulation with mitigation policies, no-regret measures, and equity. More specifically, one of the main goals of NAS is to prevent climate change and to reinforce existing inequalities between territories and population. An argument we use to highlight the importance of adaptation as public good.

France adopted the IPCC's definition of adaptation - "*adjustment of natural or human systems in response to climatic stimuli or their effects, in order to mitigate adverse effects or to exploit beneficial opportunities*" (2011:7). The PNACC1 also distinguishes between spontaneous and planned adaptation. The first one refers to an immediate reaction to a climatic event. On the contrary, planned adaptation refers to deliberate strategies. When it comes to planned strategies, PNACC1 has a rather broad view on how and where to implement adaptation measures, as it pointed out 19 possible sectors/themes⁵². More specifically, it spans from water and natural hazards to spatial planning, finance, and insurance. In 2011 there were still many uncertainties about the magnitude of changes thus, PNACC1 recommended prioritizing certain types of measures, such as (2011:17):

- No regret measures, which can be beneficial even in the absence of climate change (example: thermic renovation).
- Reversible measures, such as taking climate change into account in public service contracts.
- Measures aimed at increasing safety, such as mapping of forest fire areas.
- Long-term measures, such as regional forestry guidelines.
- Measures that can be adjusted and revised according to the evolution of knowledge, as adaptation should be a dynamic and reviewable process (for example: new requirements for summer comfort in buildings).

The PNACC2 is structured slightly differently and provides orientations for six fields of action, which it considers a priority:

- Governance measures aim to effectively articulate the national and territorial levels and to involve society in the implementation and monitoring of the PNACC2.
- Knowledge and information measures to promote the use of best scientific knowledge and to improve the awareness of the society.
- Presentation and resilience, aiming at protecting people and property from climate risks.

⁵² 1 Transversal actions; 2 Health; 3 Water 4 Biodiversity 5 Natural hazards 6 Farming 7 Forest 8 Fisheries and aquaculture 9 Energy and industry 10 Transport infrastructure 11 Town planning and the built environment 12 Tourism 13 Information 14 Training 15 Research 16 Financing and insurance 17 Coastline 18 Mountain 19 European and international equities

- Economic sector measures to boost the resilience to climate change (ex: tourism).
- Nature and Environment measures promoting nature-based solutions.
- International measures, aiming at benefiting from experience of other countries, but also supporting developing countries in their efforts.

Three fields are particularly interesting for the aims of our research: governance, knowledge, and information. The Governance measures include the establishment of coordination mechanisms between the territorial and the national level through the creation and coordination of regional adaptation committees as part of development or revision of regional guidelines concerned by adaptation (SRCAE and SRADDET). Additionally, these regional committees will accompany local authorities in the elaboration of PCAETs.

The field of knowledge and information measures include promoting the accessibility of public data, establishment of a system for collecting local data on climate change. It is in this context that regional observatories should integrate issues related to climate change while considering territorial and social differences. Moreover, PNACC2 points to the importance of climate services for the actors involved in adaptation:

The actors involved in adaptation will have easy access, through dedicated services, to climate data, methods and tools that make it possible to identify and quantify the impacts of climate change observed and expected and thus to determine the appropriate measures to adapt to it (2018:7).

Based on this extract, we can argue that ONERC recommends adaptation services – not only data and tools (stage 3 of adaptation cycle), but also the identification of relevant measures (stage 4-5 of adaptation cycle). As described in Chapter 1, adaptation policy making can be broken down into stages (Willow and Connel, 2003; Spanger-Siegfried et al., 2004; Stafford-Smith et al., 2022). As a reminder, adaptation policy cycle is composed of 8 stages:

Stage 1 – Problem identification	Stage 4 and 5: Identify and appraise options
Stage 2 – Establish decision-making criteria	Stage 6 and 7: Make and implement the decision
Stage 3 – Risk assessment	Stage 8 – Monitor

While stage 3 corresponds to risk assessment (vulnerability reports), other stages may require decision-support to identify pertinent adaptation measures. Adaptation cycles will be discussed later in section 5.3.

Moreover, these services should be co-constructed with actors engaged in adaptation, and climate projections should be regionalized according to their needs:

State operators, higher education and research establishments and service companies will develop a national network of climate services, in the spirit of the DRIAS portal, in particular promoting its extension to specific sectors particularly affected by adaptation and providing access to climate information, in particular regionalized climate projections, in a form adapted to the needs of the actors concerned and co-constructed with them (2018:7).

According to IDDRI (2019) the existing PNACCs have failed to create a real public adaptation policy because they contain dispersed measures and actions which are often reactive. Additionally, 86% of PNACC2 actions have no time scale (IDDRI, 2019). Nonetheless, not only French national adaptation strategies and plans have rather received negative assessments. (Biesbroek et al. 2010) have conducted a comparative analysis of adaptation strategies of Finland, France, Denmark, Germany, Netherlands, Spain, and United Kingdom: all available strategies and plans were quite general and contain few specific actions. Additionally, the authors point out that national climate plans and strategies are characterized by a vague notion of vulnerability, and do not stress enough that vulnerabilities vary across different geographical and social contexts (Biesbroek et al. 2010). While national adaptation plans aim at providing a framework for adaptation to climate change in France, we expect regional and local levels to address adaptation in a more systematic way. The following sections will illustrate how adaptation was framed on the regional level.

5.1.2 Regional policies: SRCAE and SRADDET

The challenges related to climate change and energy transition are particularly marked in Auvergne Rhône-Alpes (AuRA) due to the nature of human activities and the richness of its natural heritage. To understand how adaptation is addressed on regional scale, we have analysed 3 documents: SRCAE of Auvergne (2012), SRCAE of Rhône-Alpes (2014), and SRADDET of Auvergne-Rhône-Alpes elaborated after the fusion (2020). Figure 26 depicts the weight of adaptation actions in selected regional documents, as well as total number of actions and the contents of adaptation measures. As one can see, these figures make a distinction between “adaptation” and “linked to adaptation” because this distinction was present in all 3 documents. For example, in SRCAE of Auvergne we find a dedicated chapter to adaptation, but also other measures that might have a positive impact on adaptation. We have only taken these measures into account where a link to adaptation has been identified in these plans.

We can compare Auvergne's and Rhône-Alpes Regional Air Energy Scheme (SRCAE) of 2012 and 2014 respectively. Indeed, there is a significant difference in terms of the number of adaptation actions and their weight in terms of %:

- 6 adaptation measures which account for 18% in Auvergne SRCAE (2012).
- 11 adaptation measures which account for 29% in Rhône-Alpes SRCAE (2014).

Figure 26 also illustrates the contents of adaptation measures. Some adaptation measures in these SRCAE refer to the same themes, such water resources and agriculture among common ones. In fact, both SRCAE point out that climate change will impact the quality and quantity of water resources, thus to the need to adapt the consumption to avoid conflicts of use (Auvergne SRCAE 2012:10; Rhône -Alpes SRCAE 2014:139). In the case of tourism, both regions highlight the vulnerability of ski stations to snow conditions and the importance of diversification of touristic activities. Nonetheless, Auvergne puts more emphasis on opportunities for the development of other forms of tourism, possible thanks to medium mountains present in the region (Auvergne, SRCAE 2012:69). Rhône-Alpes, and specifically its northern mountains famous for world class ski resorts in high altitude, paid more attention to artificial snow production (Rhône -Alpes, SRCAE, 2014:84). Nonetheless, artificial snow may be used if its *“effects on the environment are minimized, and if the contribution of the equipment to the maintenance or development of the economic activity of the ski area is established and proportionate to the impacts on the environment”* (Rhône-Alpes, SRCAE, 2014:84).

Other measures are unique. For example, the Rhône-Alpes region paid more attention to the governance side, as it aims at mainstreaming adaptation to regional and local policies (these will be discussed later). Additionally, the Rhône-Alpes SRCAE (2014) highlights the need for improved knowledge base on climate change and its impacts. For example, it argues for the importance of providing reliable information for relevant actors:

For this, it seems particularly relevant to provide actors with a reliable information, as localized and precise as possible, on climate change and its effects, already noted or predicted through a regional observatory of the climate change (ORCAE) in Rhône-Alpes. The objective of this ORCAE will be to collect, order and disseminate knowledge. This observatory will allow networking of information and methodologies (vulnerability of winter sports resorts, identification of urban heat islands, impact on ecosystems and biodiversity, reassessment of natural hazards, etc.) and data sharing (2014:142).

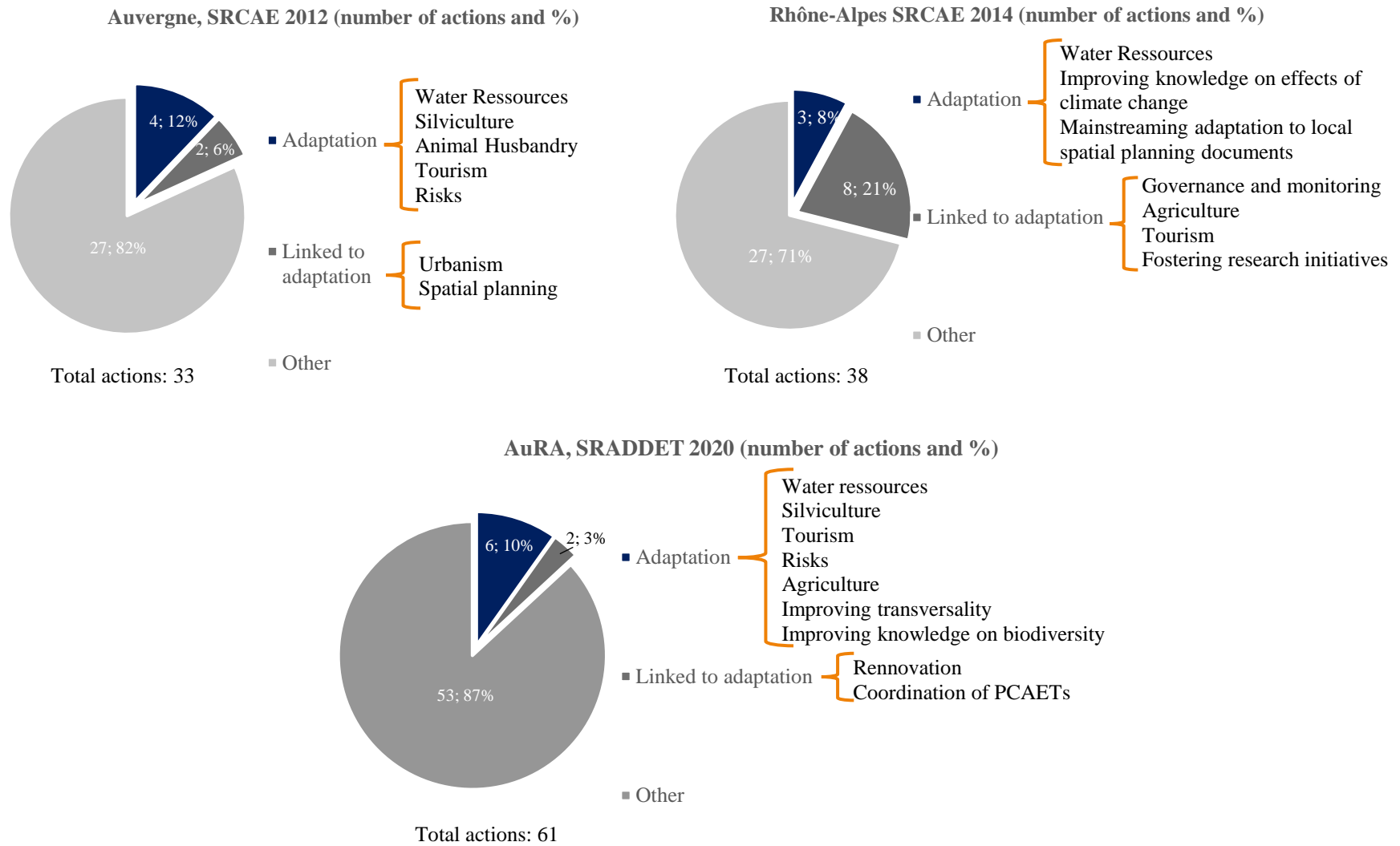
After the fusion, the new Auvergne- Rhône-Alpes region has adopted a regional strategy for sustainable and equal development (SRADDET) in 2020. It seems that this new

document features adaptation actions previously found in the SRCAEs: water resources, agriculture, risks, tourism, etc.). However, adaptation occupies a smaller place in this document, as it represents 13% of measures. Nonetheless, the need for a common knowledge base is highlighted also in SRADDET.

The SRADDET (2020), elaborated after the fusion of these 2 regions, stresses that it must tackle both mitigation and adaptation. On one hand, it points out that the region has already been engaged in adaptation activities, such as the so-called “snow-plan” (Plan Neige), aiming at sustainable development of ski resorts (diversification and artificial snow production). On another hand, it highlights that the answers to the challenges of climate change can also be found at local levels.

The production of artificial snow is a contradictory measure. It aims at supporting ski resorts and tourism economy, which account for 8% of regional GDP (SRADDET, 2020:23). Nevertheless, artificial snow was identified as one of the causes of biodiversity loss *“wetlands are in decline on a regional scale. The major causes of this development are linked to the creation of lakes and reservoirs, in particular for the urbanization, agriculture, the production of electricity and artificial snow”* (SRADDET, 2020:27).

Figure 26 Adaptation in Auvergne, SRCAE 2012 ; Rhône Alpes, SRCAE, 2014 ; AuRA, SRADDET, 2020



The SRADDET is a document guiding sustainable development (développement durable). When describing regional strong points, SRADDET makes a list of economic sectors where Auvergne- Rhône-Alpes has impressive results:

- 1st meadow of France.
- 1st for the surface of woods (silviculture including).
- 1st for energy production.
- 1st for nuclear energy.
- 1st for hydroelectricity production.
- 2nd region for tourism (173 ski stations).

In fact, there is a link between the abovementioned economic sectors and adaptation measures. Indeed, animal husbandry, silviculture and tourism are economic sectors concerned by adaptation measures in the latest SRADDET. The idea to tackle major economic sectors first was also highlighted in the interviews with DREAL:

We did not have the means to put everything in place, so we started with impacts on economic activities and mountain tourism (DREAL)

It appears that tackling the impacts on major economic activities represents a lever for action. The sustainable development rhetoric, or rather “business as usual” path, can also be found in regional Mountain Plan 2, adopted by the regional council in 2021. In fact, the president of the region Laurent Wauquiez aims at transforming AuRA in “*the first sustainable mountain in Europe*⁵³”. The second version of Mountain plan represents an envelope of 100ml euros dedicated to the development of mountain activities, such as promotion of winter spots for school kids, the purchase of hydrogen snow groomers, or the support to local seasonal workers. Nonetheless, roughly half of this budget aims at ensuring the snow cover. Does artificial snow represent a valid strategy to tackle climate change impacts? It is an on-going debate, as AuRA is home to multiple mid-mountain resorts, which are particularly sensitive to climate change. Previously we have mentioned that artificial snow production is one of the causes of biodiversity loss (SRADDET, 2020:27). Moreover, climate change will have negative effects on the quantity and the quality of water, a resource concerned by adaptation measures in all 3 regional documents discussed in this section. Conflicts of use due to water scarcity can have negative spillovers in other domains. For example, a DDT has expressed their concerns on maladaptation, defined by IPCC as “*actions, or inaction that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the*

⁵³ “Demain les Alpes françaises seront la première montagne durable d'Europe” (Tomorrow French Alps will become the first sustainable mountain of Europe) <https://www.auvergnerhonealpes.fr/actualites/plan-montagne-faire-dauvergne-rhone-alpes-la-premiere-montagne-durable-deurope>

future” (2014:857). This DDT has identified possible conflicts of use of water resources between agricultural and ski sectors:

Maladaptation is also an issue. How would you qualify hill water reservoirs? Because everything that is retained at altitude for artificial snow... some will say that it is adaptation, others that it is maladaptation. In X there is a resurgence of hill reservoirs, also for agricultural sectors: are we on intelligent adaptation, on maladaptation or on “no regret” operations? (DDT)

As this verbatim illustrates, maladaptation is a tricky one. On one hand, it can reduce climate vulnerability in the short run. On the other hand, it may decrease climate resilience over time. Furthermore, it can damage sectors and territories that may incur in spillover effects (Dolšak and Prakash, 2018). The risk of facing negative spillovers of certain measures was also pointed out in AuRA’s SRADDET:

Although the water resource is abundant at the heads of the watershed, it is under significant pressure, particularly in winter, both for skiing activities (artificial snow) and the supply of drinking water to a population multiplied by tourism (SRADDET, 2020:138)

To reduce the risks of maladaptation and to promote coherence between various actions and measures, SRADDET aims at mainstreaming adaptation in local spatial planning documents, and at coordinating the elaboration of PCAETs.

In terms of governance, and in conformity with PNACC2, a regional committee will be put in place by the state, the Region, the intercommunalities, and other relevant actors to assure the best possible articulation of adaptation policies from national to local scales. This represents an important factor, as it fosters the sharing of best practices. This action represents a coordination mechanism between relevant territorial levels (SRADDET, 2020:86).

Indeed, the need for a shared view and coordination is clearly expressed in SRADDET. The establishment of coordination mechanisms may alleviate risks related to negative spillovers linked to maladaptation, as in the example of conflict of use of water resources. It enables intercommunalities to share their experiences, and to build adaptation policies on common knowledge base. However, the regional committees were yet to be put in place at the time this chapter was written:

For the moment we do not yet have any state-region dialogue bodies on the question of adaptation, so we know that we still have a lot of progress to make (DREAL).

In this section we have illustrated how adaptation is framed on regional level. We have seen that the Region is focusing on water resources, risks, tourism, agriculture and on the mainstreaming adaptation into local climate plans. The following section will discuss how adaptation is addressed by local authorities in PCETs and PCAETs.

5.1.3 Adaptation in local policies: PCETs and PCAETs

Building our database on adaptation measures was a delicate exercise. We have considered actions which were labelled as adaptation or “*contributing to adaptation*” in specific chapters and throughout available PCETs or PCAETs. In fact, assuring coherency of this exercise was a challenge. There is a significant difference in how adaptation is tackled in selected PCETs and PCAETs. For example:

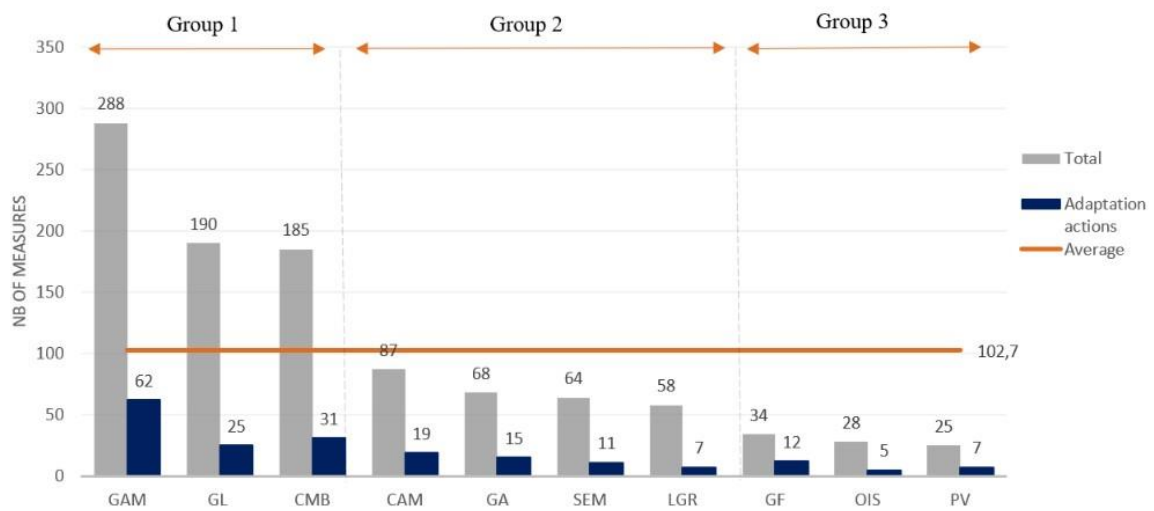
- Grand Lyon has decided to not create specific adaptation chapters in their PCAETs “*For the new PCAET, it was decided not to include an “adaptation” component but to integrate it into 23 core-actions*” (p.57). Sainte Etienne Metropole follows a similar strategy.
- In Grenoble Alpes-Metropole and Clermont Auvergne Metropole adaptation is the very first chapter of PCAETs, while usually it’s air, energy, or governance.
- Genevois Français has both a dedicated chapter and adaptation-related measures spread across other themes.

The following figures aim at comparing intercommunalities according to number of adaptation measures, their weight in available PCET and PCAET, and the variety of themes addressed. However, adaptation represents a minor part of all available PCETs and PCAETs. For example, when overviewing adaptation in Clermont Auvergne Metropole, AuRA-EE argues that “*elected officials and inhabitants have appropriated the mitigation, while adaptation is still quite problematic*” (AuRA EE, Fiche Adaptation Clermont Auvergne Metropole, 2018). This observation was also confirmed in the interviews:

Adaptation is the weakest link of the chain⁵⁴ (GA)

⁵⁴ Translation from « Adaptation c’est le parent pauvre des Plans Climat »

Figure 27 Total and adaptation actions



As shown in Figure 27 there is a significant difference in terms of the number of actions, adaptation included, in the latest climate plan (PCET or PCAET). For example, Grenoble-Alpes Metropole has the highest number of actions (288), while CA du Pays Voironnais the smallest (25). Although this parameter sheds light on the degree of detail in selected climate plans, it does not specifically illustrate their quality. The average of overall actions being 102, we can distinguish three groups of intercommunalities: those above average with 100+ actions (Group 1: Grenoble Alpes Metropole, Grand Lyon, and CC Chamonix Mont Blanc), those who are situated around the average, but below 102 (Group 2: Clermont Auvergne Metropole, Grand Annecy, Sainte Etienne Metropole, and CC Le Gresivaudan), and those who are significantly below average (Group 3: Genevois Francais, CC de l’Oisans, and CA du Pays Voironnais).

In terms of number of adaptation actions (Figure 27), we note that Grenoble-Alpes Metropole (GAM), Grand Lyon (GL), and CC Chamonix Mont Blanc (CMB) are again situated above the average (19). However, likewise for overall number of actions, there are important differences in selected PCETs and PCAETs. In fact, the range spans from 62 actions in Grenoble-Alpes Metropole (GAM) to 5 actions in CC de l’Oisans (OIS).

Figure 28 Adaptation in selected PCETs and PCAETs, %

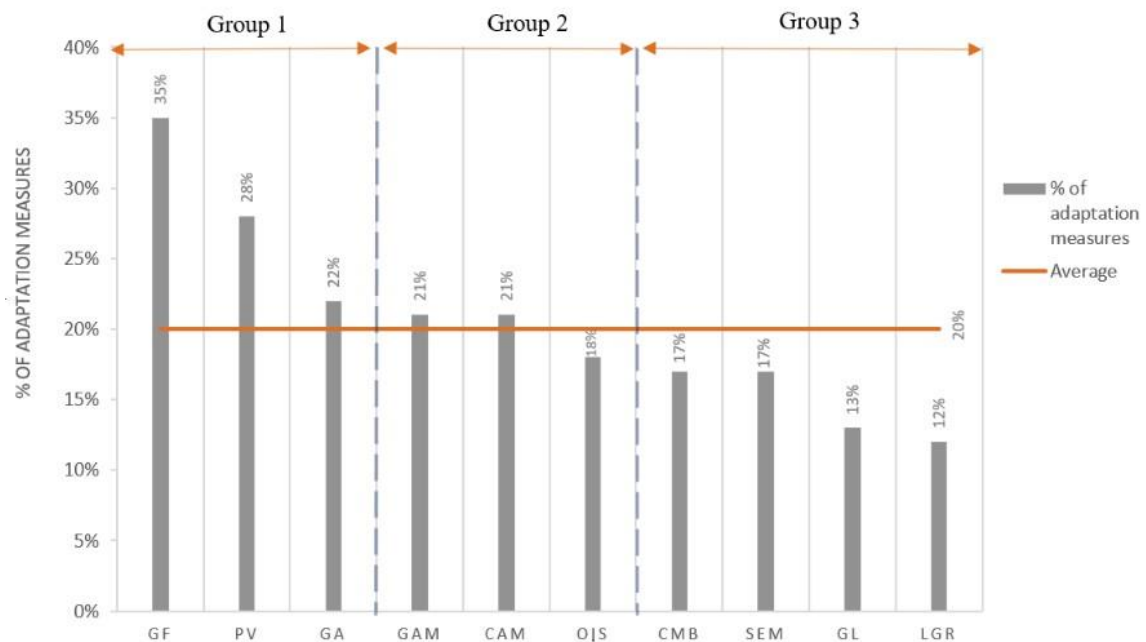


Figure 28 depicts the percentage of adaptation measures. The average for our sample is 20%, thus we split the intercommunalities into three groups like for the figures above (orange separators). The Group 1, or where % of adaptation measures is above the average: - CA du Pays Voironnais (PV) and Genevois Français (GF), intercommunalities with the smallest number of adaptation actions; and Grand Annecy (GA) where the number of adaptation measures is withing the average. The Group 2 consists of intercommunalities where the % of adaptation is situated around the average: Grenoble Alpes Metropole (GAM), Clermont Auvergne Metropole (CAM), and CC de l’Oisans (OIS). Group 3 depicts the intercommunalities where the % of adaptation measures is below the average: Grand Lyon (GL), Sainte Etienne Metropole (SEM), CC Le Gresivaudan (LGR), and CC Vallée de Chamonix-Mont-Blanc (CMB). We believe that these results are explained by the fact that adaptation is defined differently across our sample. In Chapter 1 we have pointed out that views on adaptation change across literature. For UNFCCC there is need to adapt *because* climate is changing, while sustainable development scholars argue for a *broader range* of actions, not limited to climate change.

When analysing PCETs and PCAETs, we came to conclusion that decision makers from several intercommunalities opted for a broader range of actions. Intercommunalities act in sectors where existing mechanisms allow – at least partially – to improve local preparedness for climate change. Therefore, the intercommunalities focus on actions for which objectives and evaluation criteria were quantified previously. For example, as illustrated in Table 15 there are several common adaptation themes found across the latest available PCET or PCAET.

Table 15 Transversality of Adaptation in the latest climate plan

	Theme	Theme	Water resources	Biodiversity	Spatial planning	Sustainable	Knowledge	Risks	Awareness	Construction	Health	Sustainable	Resources	Number of themes/ totals
Group 1	EPCI													
	Grenoble Alpes Metropole													9/11
	Genevois Francais													9/11
Group 2	CA du Pays Voironnais													9/11
	Sainte Etienne Metropole													8/11
	CC Chamonix Mont Blanc													7/11
	Grand Annecy													7/11
Group 3	Clermont Auvergne Metropole													6/11
	CC de l'Oisans													5/11
	Grand Lyon													5/11
														4/11

- *Water resources*: reducing consumption and waste of water, improving distribution networks.
- *Biodiversity*: some of the measures rely on Blue and Green Belt project initiated in 2007 as part of Grenelle de l'environnement policy on environment and sustainable development. Blue and Green Belt is a network of biological corridors, protected areas essential for biodiversity.
- *Spatial planning*: these measures refer to methods of urban development, from the creation of new parks to the design of bioclimatic districts and buildings. These measures rely on local urban plans PLUI and PLUI, which represent main planning documents at municipal and intermunicipal levels.
- *Sustainable agriculture*: this theme regroups silviculture and agriculture and aims at protecting these sectors from negative impacts of climate change. It includes measures on diversification of agricultural production, on the use of heat resistant cultures, but also on the forest's carbon storage capacity.
- *Knowledge*: improving knowledge on climate change and fostering links with local research institutions. Additionally, Grenoble-Alpes Metropole intends to create a local group of experts with University Grenoble Alpes and Ouranos AuRA among others⁵⁵.

⁵⁵ Grenoble won the title of European Green Capital 2022 and created a multidisciplinary Scientific Council to seize “opportunity to take informed decisions based on the results of scientific research” (<https://en.greengrenoble2022.eu/31-une-gouvernance-qui-rassemble.htm>).

- *Risks*: Anticipate the impacts of climate change on natural hazards, their management, improve knowledge and awareness.

All intercommunalities were already engaged in reducing water consumption and improving water distribution networks. For example, Grand Annecy highlights that water and forest stakeholders are already engaged in adaptation and refers to ARTACLIM project carried out in France by the Agence Alpine des Territoires, and supported by the regional parc of Bauges (action nr 63 among others). However, CC Chamonix-Mont-Blanc and Grand Annecy point out the possible conflicts of use due to artificial snow production. CC Chamonix-Mont-Blanc suggested limiting the use of artificial snow in the most vulnerable areas, such as ski stations situated below 1500mt of altitude (PCET, 2012:57). We note that the vulnerability of snowpack is quite a controversial topic in another intercommunality with ski resorts:

Talking about adaptation of the tourism sector is always a delicate task, as tourism activities are focused on skiing. It is paradoxical: there is no political divide on the topic (referring to the need to adapt), but the topic is still somehow “taboo”. Elected officials say that there is nothing to fear, we will always have snow or produce the artificial one. These discourses can be shocking.

In fact, this discrepancy was also highlighted during a public meeting in CC Vallée de Chamonix-Mont-Blanc:

In Chamonix, we are still opting for an “always more” model. We want to save more, to reduce more CO2 emissions, but also, we want more tourists and more fancy residences (CCMB, PCET, 2012:25)

When addressing the transversality of adaptation, we can see that different issues are affected by adaptation measures (Table 15). The second group of topics was covered in half of the PCETs and PCAETs:

- *Awareness*: these actions aim at increasing awareness of citizens and public employees.
- *Construction*: thermal renovation of buildings to improve comfort during summer (also labelled as measure against fuel poverty for Grenoble Alpes Metropole)

Finally, several topics were addressed as adaptation in less than 4 intercommunalities:

- *Health*: improving knowledge on the impacts of climate change on our health (Grenoble Alpes Metropole); preserve health by adapting housing, the urban environment, and human activities to climate change (all intercommunalities). Strong emphasis on heat islands in all intercommunalities.

- *Sustainable economy*: Sainte Etienne Metropole aims at supporting and structuring local companies for innovation sustainable development. CC Chamonix Mont Blanc refers to the measures vulnerabilities of tourism sector.
- *Resources*: measures on creating solidarity mechanisms in case of scarcity of energy, natural and food resources (CA du Pays Voironnais). Genevois Français aims at developing alternative resources, such as hydrogen.

The CA du Pays Voironnais, Grenoble Alpes Metropole and Genevois Français, are among those who label as adaptation actions situated in a larger number of domains – they identify as adaptation activities situated in health, thermic renovation, or mobility domains (9 out of 12). Surprisingly, Grand Lyon is the “less transversal” despite having 2nd largest number of overall actions.

Like for number of actions, the % of adaptation, sorts these intercommunalities according to the number of themes concerned by adaptation measures. It allows us to split the list into 3 groups. Group 1 is the most transversal one (Grenoble Alpes Metropole, Genevois Francais, CA du Pays Voironnais). Group 2 has average transversality (Sainte Etienne Metropole, CC Chamonix Mont Blanc, Clermont Auvergne Metropole, and Grand Annecy). Group 3 is the least transversal one (CC de l’Oisans, Grand Lyon, and CC Le Gresivaudan). Please note that this does not specifically reflect the quality of selected PCETs and PCAETs. It rather highlights the absence of common ground when defining adaptation.

Nonetheless, we find it particularly interesting to trace the development of adaptation in intercommunalities with both PCET and PCAET. Table 16 sums up the weight and content of adaptation measures. We have counted as adaptation only measures labelled as adaptation in selected PCET and PCAETs.

Table 16 depicts the evolution of adaptation in 6 intercommunalities with PCET and PCAET: Grenoble Alpes Metropole, Grand Lyon, Clermont-Auvergne Metropole, Sainte Etienne Metropole, Grand Annecy, and CA du Pays Voironnais:

- The PCET of Grand Lyon, Sainte Etienne Metropole and CA du Pays Voironnais has little (3%) to no adaptation related measures.
- The PCET of Grenoble Alpes Metropole, Grand Annecy and Clermont Auvergne Metropole have between 17 and 25% of measures dedicated to adaptation.

Consequently, those intercommunalities that did not tackle adaptation in their PCET, have seen a significant evolution in their PCAET – an increase between 13% and 28%. While Grenoble Alpes Metropole (GAM) and Clermont-Auvergne Metropole (CAM) registered a slower increase of 4%, and Grand Annecy (GA) a decrease of 3%. However, GA's PCAET has one of the biggest shares of adaptation measures in selected climate plans. Overall, adaptation has made its way into the PCAETs after the second national adaptation plan (PNACC2) but before regional SRADDET.

Besides an increasing share of adaptation, two other evolutions took place between the first and the second generation of local climate plans. Out of six intercommunalities that have both PCET and PCAET, five have highlighted that the new climate plan was built on the experience of the first one. More specifically, they have realized that to actually achieve their goals (mitigation and adaptation), they need to co-construct their strategies with all relevant actors of their territory. Second generation climate plans were built with economic, associative actors, as well as citizens:

I would say that the major evolution is the understanding that intercommunality alone will not be able to carry out all the actions, and to achieve the objectives which are very ambitious, and represent the declination of international, European, and national objectives at the local level. It is necessary that all the actors start moving -the municipalities, the companies, the associative actors, and citizens. The idea of this climate plan is to really work on involving everyone (PV).

In Grand Annecy elected officials decided to apply PCAET approaches used for other policies. More specifically, the co-construction:

According to the elected officials, public policies should be carried out by co-construction. This approach was transposed to the PCAET (GA)

The second evolution refers to the degree of awareness of elected officials. In fact, and this was pointed out by the majority of intercommunalities in our sample – the degree

of awareness increased, as well as the pressure from civil society. For example, a DDT has pointed out that local authorities talk less and do more:

Awareness increased in a gradual way. A lot of people are talking about it (refers to climate change), but I see more and more elected officials engaging in policymaking. Until recently it was just a political discourse, a bit like greenwashing (DDT)

I remember when I started to work I had little political support and then now, as we progress, there is real political support. There the discourse (refers to climate change) is not the same in any case (OIS).

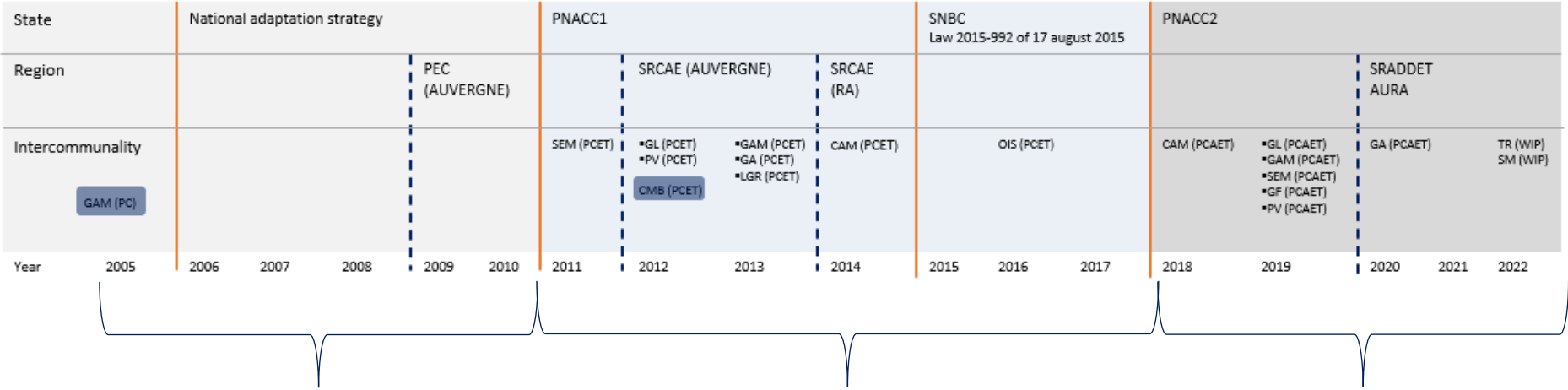
It is worth pointing out that, as PCAETs tackle more sectors than PCETs, we can assume that the transversality of adaptation in selected documents improved. Next section will illustrate the articulation between various climate policies. Based on the timing of implementation of national, regional, and local plans, we will improve our understanding of the governance side of adaptation to climate change in France and in Auvergne Rhône-Alpes region.

5.1.4 Integration of adaptation across scales

Likewise in Chapter 2 dedicated to the climate adaptation policies on the EU, national and regional scales, this chapter follows the same logic but zooms on France. In Chapter 3 we have illustrated the link between decentralization/centralization and the development of climate change adaptation knowledge-action systems. This chapter will go further and include local scale into analysis to depict the articulation of climate adaptation policies in France across different scales. As explained in Chapter 1 (methodology section), we will focus on one region Auvergne-Rhône-Alpes. Figure 29 depicts the timing of the implementation of national, regional, and local climate policies. Portraying adaptation from a multi-scale perspective allows us to shed light on the articulation of these policies and to track when and how adaptation appeared in policy making.

On the national scale we find: National Adaptation Strategy (2006), the two national adaptation plans (PNACC1 2011 and PNACC2 2018), and the national low carbon strategy SNBC (2015). We have also included the law 2015-992 of 17 august 2015, which appoints local authorities as chefs and coordinators of territorial climate-air-energy plans. By lowering the population threshold, this law extended the obligation to elaborate climate plans to smaller intercommunalities (from 50k to 20k inhabitants). Additionally, this law transformed the PCET (territorial climate-energy plan) into PCAET, adding air quality to intercommunalities' domains of responsibility (the elaboration of Atmosphere protection plan, PPA)

Figure 29 Timing of climate and adaptation policies in France



Early Bird (2005-2010)
 First national adaptation strategy and first local climate plan (PC).

First generation (2011-2018)
 First national adaptation plan (PNACC1), regional climate air energy roadmaps (SRCAE) and first local climate energy plans (PCET).

Second generation (2019-2022)
 Second national adaptation plan (PNACC2), first regional strategy for sustainable and equal development (SRADDET) and the second generation of local climate plans (PCAET)

On the regional level we find: Plan Energie Climat (PEC) adopted by Auvergne region in 2009; Regional climate, air and energy roadmap (SRCAE) of Auvergne adopted in 2012 and suspended by administrative court of Lyon on May 3, 2016; SRCAE of Rhône-Alpes of 2014 (RA); Regional strategy for sustainable and equal development (SRADDET) implemented in 2020 after the fusion of Auvergne and Rhône-Alpes into Auvergne- Rhône-Alpes (AuRA).

On local levels we find: Both first-generation 8 climate plans (PCET), elaborated by 8 intercommunalities between 2011 and 2016, and 7 second generation PCAETS adopted between 2018 and 2020. The CC du Trièves' PCAET is work in progress when this chapter was written (WIP).

Based on the timing of implementation of national adaptation, mitigation plans and laws, we have identified 3 major periods, as depicted in Figure 29. The first one refers to the period between 2005 and 2010; the second one is situated between the first national climate plan (PNACC) of 2011 and its newest version adopted in 2018; the third period refers to documents adopted after the PNACC2 (2019-2022).

The “*early bird*” period contains only one document. Grenoble Alpes Metropole (GAM)⁵⁶ is the early bird - with its first “Plan Climat” of 2005, GAM is the first French intercommunality to adopt a climate policy France. In fact, GAM has preceded both national (2006) and regional (2014) policies. The interviews with this intercommunality do not allow us to identify specific reasons behind this. Nevertheless, we can point out several factors that might have contributed to the elaboration of this climate plan. As discussed in chapter 3, the European heatwave of 2003 has pushed France to adopt its first national adaptation strategy. In the case of GAM, this heatwave caused an impressive forest fire on Neron Mountain (Figure 30).

Figure 30 Neron Forest fire (Alain Herrault, <https://france3-regions.francetvinfo.fr>)



The “*first generation*” of local climate plans refers to 8 PCETs adopted by local authorities in the period between the first and the second national adaptation plan (PNACC2). Two intercommunalities of this “first generation” era stand out. More specifically - the CC Vallée de Chamonix-Mont-Blanc (CMB) and the CC de l'Oisans

⁵⁶ agglomeration community at the time.

(OIS). These intercommunalities were not legally obliged to elaborate climate plans, as their population was below 50k inhabitants. What do intercommunalities engaged on voluntary basis have in common? The CC Vallée de Chamonix-Mont-Blanc and CC de l'Oisans have unique locations to admire and practice mountain activities,

Figure 31 Mer de Glace (Marco Bertorello / AFP)



and to observe the impacts of climate change. The CC Vallée de Chamonix-Mont-Blanc and CC de l'Oisans are both situated on high altitudes, where the consequences of climate change are particularly visible. For example, CC Vallée de Chamonix-Mont-Blanc has a privileged spot to observe the impacts of climate change – the Mer de Glace glacier. As pictured in Figure 31, the levels of Mer de Glace are on their historical lows. Additionally, both intercommunalities are surrounded by internationally known ski resorts, such as Les 2 Alpes, Alpe d'Huez, Les Houches, Chamonix, etc:

Skiing is THE economic activity of our territory

We could assume that their dependence on snow and ski tourism encourages them to tackle climate change issues. More specifically, 90% of CC de l'Oisans GDP⁵⁷ come from tourism (www.ccoisans.fr). Other intercommunalities do not have this characteristic – their income does not rely so heavily on one economic sector.

The disappearance of the glacier due to climate change is impressive, but also a communication and a political tool. For example, one of the interviewees from a “mountain” intercommunalities has explained that:

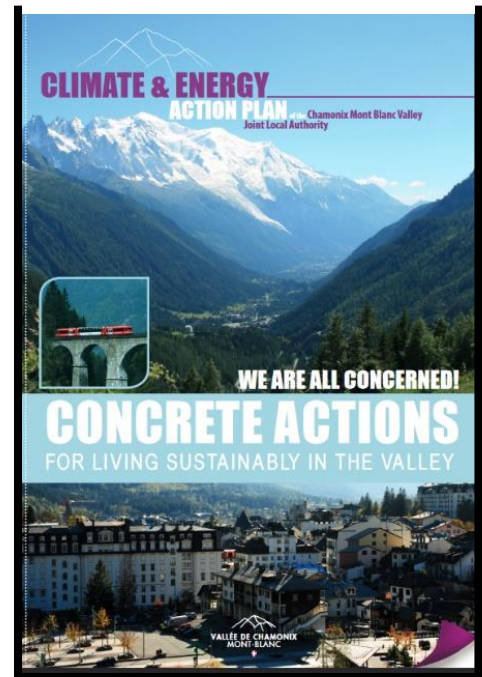
In the beginning I had the impression that they (elected officials) allowed me to work because I had funding, and because that created a good image for the territory (X)

⁵⁷ Gross domestic product

CC Vallée de Chamonix-Mont-Blanc has the only PCET available in English and it is also “*the first PCET in a ski station*” (2012:6; Figure 32). These intercommunalities attract many international tourists: 49% of hotel nights in Chamonix are reserved by foreign guests (Comete, CMB, 2011). It appears that engagement in climate change mitigation and adaptation is also a source of attractivity in the eyes of foreign tourists. Additionally, CC Vallée de Chamonix-Mont-Blanc, and Mont Blanc in general, took part in several European research programs, such as INTERREG (Alcotra, Adapt Mont Blanc)⁵⁸.

The “*second generation*” period contains the 7 local climate plans (PCAET). Not all selected communalities have adopted both PCET and PCAET. Some were not concerned by PCET, others are still working on their PCAET at the moment this chapter was written.

Figure 32 CC Vallée de Chamonix-Mont-Blanc PCET 2012



⁵⁸ <https://www.interreg-alcotra.eu>; <https://www.espace-mont-blanc.com/adapt-mont-blanc>

Figure 12 in chapter 1 has provided a general diagram of climate policies and their articulation in France. We have discussed how local PCETs and PCAETs must be compatible with SRADDET (ex SRCAE), or with the French low carbon strategy (SNBC). At the same time, none of these documents must respect or be compatible with the National adaptation Plan (PNACC). For example:

On an infra-regional scale, the PCET is one of the main tools for local authorities for the implementation of "climate" actions in the territories: it declines on its territory, the orientations, and objectives of the SRCAE, in program of actions, consistent and complementary with other territorial planning tools (SRCAE, 2014:7).

In fact, the Region clearly defines its role vis-à-vis local climate plans, which are seen as territorialized (or downscaled) version of SRCAE. However, when looking at Figure 29 several discrepancies stand out.

1) First of all: 7 out of 9 PCETs were adopted before regional SRCAEs were elaborated. Please note that among the intercommunalities in our sample, only Clermont Auvergne Metropole (CAM) is situated in Auvergne and has elaborated its climate plan after the regional one. The rest of intercommunalities situated in the first-generation period have adopted climate plans before regional SRCAE. For example, Saint Etienne Metropole (SEM) approved its PCET in 2011, or three years before Rhône-Alpes SRCAE (2014). Grand Lyon (GL) and CA du Pays Voironnais (PV) approved their PCETs in 2012, or 2 years before the SRCAE. Grenoble Alpes Métropole (GAM), Grand Annecy (GA), and CC Le Grésivaudan (LGR) adopted PCETs in 2013, 1 year before SRCAE. In fact, we could say that the majority of intercommunalities in our sample did “jump the scale” and did not depend on the regional policies despite:

Local authorities do not have all the levers necessary for broader climate action. This is particularly the case of tax and regulatory levers, the mobilization of which is able to create the conditions for the success of the action of the PCETs (SRCAE, 2014:7).

2) Secondly, SRCAE argues for the need to include climate projections and adaptation in PCETs (“will include”, future tense):

The Météo France study on the climate in Rhône-Alpes for the 2030, 2050 and 2080 horizons revealed a trend, according to which the average temperature was going to increase, with an increase in days of drought, heat waves and a decrease of overall cumulative annual precipitations. It is essential to integrate these parameters into territorial policies today in order to anticipate and

understand the risks associated with these developments. As such, the PCETs will include an “adaptation” section. (SRCAE, 2014:135)

However, 4 intercommunalities out of 9 have already addressed adaptation in their PCETs: Additionally, SRCAE of 2014 provides examples of adaptation measures from the PCETs:

Examples of good regional practices: the development of ecotourism in CC Chamonix Mont Blanc (SRCAE, 2014:83)

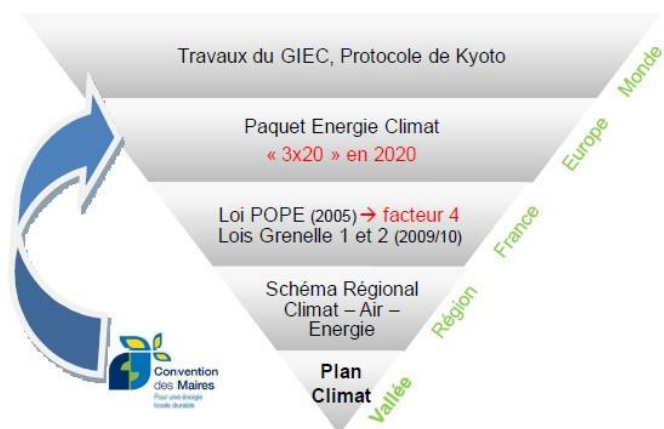
Indeed, when tackling adaptation, intercommunalities refer to several relevant documents on sub-national and national scales. We find references to the EU policies, such as 20-20-20 targets⁵⁹ and to international documents such as Kyoto Protocol:

Adaptation to climate change is a recent concept. The phenomenon of adaptation was mentioned as early as Kyoto in 1992. While greenhouse gases diffuse throughout the atmosphere and produce their effects on the scale of the entire planet, adaptation can only be local. It corresponds to the challenge of reducing the territory's vulnerability to climate change by taking anticipatory measures (Grand Annecy, PCET, 2013:41)

The CC Vallée de Chamonix-Mont-Blanc refers to International, EU, and national objectives, and provides an illustration on how these policies should be articulated (Figure 33). However, although the regional scale is present in Figure 33, the regional scale received no comment:

The PCET: is a tool for implementing international and national objectives on a local scale. In 2007, during the European Energy Summit, the Member States of the Union have decided to set binding targets to fight against climate change, beyond the commitments of the Kyoto Protocol (1997). Thus, at the

Figure 33 CCMB, articulation of climate policies (PCET, 2012:5)



⁵⁹ reducing greenhouse gas emissions by 20% compared to 1990 levels, increasing the share of renewable energy use to 20%, and improving energy efficiency by 20 %.

end of 2008, the “3x20” objective was adopted (CCMB, PCET, 2012:5).

Additionally, when asked about their links and coordination mechanisms with other administrative levels, five intercommunalities talked about territorial coherence scheme (SCoT) described in Chapter 2, or even Switzerland⁶⁰:

We are trying to build a SCoT on our scale, we are trying to increase coordination with Switzerland (GF)

SCoT should “supervise” local policies, so our next SCoT should integrate climate related studies and policies (OIS)

3) Lastly, 8 out of 9 PCAETs were adopted after the second version of PNACC (2019), but before regional SRADDET (2020). The only exception is Grand Annecy, where PCAET was approved in 2020 (same year as SRADDET), and CC du Trièves where PCAET is work in progress.

It appears that these intercommunalities were capable of tackling adaptation without input from the Region. This constat, coupled with the absence of regional committee for adaptation, may be posing non negligible barriers to coherent adaptation in the region. Although the capacity of intercommunalities to engage themselves in climate policies is rather a positive aspect, the necessity of assuring good coordination has been identified in the literature (Chapter 1). Therefore, we believe that improving the links between the state and regional levels represents an important step towards the establishment of robust climate change adaptation knowledge-action system. The need for dialog mechanisms may be dictated by the wickedness⁶¹ of adaptation. Given the complexity of its interactions with other issues, improving connections between different administrative scales is a must. Nonetheless, during the time this thesis took place, several steps were taken in this direction. For example, at the time Chapter 2 was written (2020), there was no national adaptation portal. In 2021, the ministry for ecological transition has put in place a national Resource Center for climate change adaptation (<https://www.adaptation-changement-climatique.gouv.fr>).

Although tackling different issues is rather a logical outcome, as every territory is unique, the absence of a common view and knowledge base on adaptation may obstruct sharing of experiences and best practices. We have advocated for polycentric governance for adaptation, which is composed of overlapping decision-making units and include

⁶⁰ Please note that Genevois Francais is part of Geneve-Annemasse urban area.

⁶¹ Stand and Ujvari (2015) define wicked problems as “multidimensional challenges that are difficult to resolve due to incomplete or contradictory information, differing views on the nature of the problem, or complex interactions with other issues”.

specific arrangements/special-purpose units that work across multiple jurisdictional levels to ensure sufficient coordination. Indeed, polycentricity is associated with better links to local knowledge, improved information transmission, and enhanced adaptive-management capacity (E. Ostrom 2005; Marshal, 2009).

Hoppe, Vegt, and Stegmaier (2016) have found out that “*localist, multilevel, issue network membership factors...and local capacity building schemes*” have influenced local climate policy action. It appears that vertical coordination of adaptation policies is work in progress in Auvergne- Rhône-Alpes region. In fact, a more horizontal coordination on climate issues was identified:

- When addressing heat islands, one intercommunality has mentioned their links with other French metropolises.
- One intercommunality situated at high altitude has explained that they rely on an international network of Alpine cities and refer to the Alpine Convention.

Eight intercommunalities have mentioned existing mitigations tools:

There is another tool that helps us -it is the cit'ergie⁶² label. So, we also work with indicators developed for this label (GA)

In TEPOS⁶³ we have a regional councilor who helped us during several occasions and specific topics. Not really on climate change, but on energy consumption of our territory (OIS)

We have depicted how adaptation is tackled from a governance perspective and have illustrated how these climate plans are articulated across national and regional scales. The analysis of the contents of selected PCETs and PCAETs enables us to illustrate the views on adaptation, the richness of themes addressed by adaptation measures, and the place these occupy in local climate plans. Splitting the intercommunalities into 3 groups according to number of actions, the % of adaptation, and its transversality, will serve as a guiding tool when analyzing their knowledge needs in the following section. Furthermore, it will allow us to contextualize verbatims while preserving the anonymity of participants.

We will start by illustrating climate products and services found across PCETs and PCAETs, but also discuss available climate products on national and regional scales, such as DRIAS and ORCAE. Secondly, we will try to understand their knowledge needs for adaptation.

⁶² The Climat-Air-Energie, a label developed by ADEME to recognize and encourage intercommunalities efforts in energy transition

⁶³ TEPOS – positive energy territory (territoire à énergie positive) a network created by CLER (Network for Energy Transition) around the idea to cover energy needs with local renewable energies.

5.2 Knowledge and tools for adaptation at local scales

The need for better knowledge was expressed in all PCET and PCAETs. For example, Grand Annecy highlighted that “*improving knowledge is needed to take adequate and pertinent actions*” (Grand Annecy, PCAET 2013:20). Clermont Auvergne Metropole has pointed out that the information on local level is missing, thus it is difficult to depict climate change on local scales to anticipate the impacts (Saint Etienne Metropole, PCAET, 2017).

Consequently, improving the knowledge on climate change represents one of the main actions to be put in place as part of climate plans. Additionally, these intercommunalities aim at spreading relevant climate information on their territory to improve awareness of inhabitants and elected officials (eg.: Grand Annecy, PCAET 2013:20; Clermont Auvergne Metropole, PCAET 2014:48; Saint Etienne Metropole, PCAET, 2017:33).

The need for pertinent knowledge is discussed from different perspectives in the PCAETs. Overall, we have identified 5:

- **Update existing risk management protocols** as new information becomes available. More specifically – thought participation to research programs, such as RISKMAT-ALCOTRA (CC Vallée de Chamonix-Mont-Blanc, 2012).
- **Improve access and acquisition of knowledge** on risks, and to create new monitoring tools when needed. Reinforce strategic partnership between intercommunalities and scientific experts (CC Le Grésivaudan, 2013; Sainte Etienne Metropole, PCAET, 2017; Grenoble-Alpes metropole, 2019). For example, Sainte Etienne Metropole will engage the academics (the “universitaires”) in the elaboration of vulnerability reports to refine them (PCAET, 2017). Grenoble Alpes Metropole is to develop close partnerships with local research institutions as “*the metropole has an excellent university and several internationally known researchers*” (GAM, PCAET, 2019).
- **Involve stakeholders** during problem framing and options appraisal phases to include their expertise and knowledge (Saint-Marcellin-Vercors-Isère-Communauté, 2019). For example, Grand Annecy has created citizen workshops “Espace Citoyen” to allow inhabitants to evaluate PCAET’s propositions. CA du Pays Voironnais work with local association of enterprises Centr’Alp to put in place one of PCAET’s actions (axe A, action 3).

- Coordinate:** climate plans represent a continuation of existing energy transition initiatives. Therefore, there is need for transversality of actions and documents (CC Le Grésivaudan, 2013; Saint-Marcellin-Vercors-Isère-Communauté, 2019; Clermont Auvergne Metropole, PCAET 2014). Although not always expressed as a knowledge need, the idea to coordinate climate policy is present in PCAETs. For example, CA du Pays Voironnais has specific “*governance*” actions, while Sainte Etienne Metropole defines them as “*stakeholders’ mobilisation*”.
- Valorise** and spread information to decision makers, inhabitants, and tourists (CC Le Grésivaudan, 2013; CC Vallée de Chamonix-Mont-Blanc, 2012; Grand Annecy, PCAET 2013, p 20; Clermont Auvergne Metropole, PCAET 2014, p 48; Saint Etienne Metropole, PCAET, 2017). CC Le Grésivaudan’s PCET contains specific action aimed at creating awareness plans (action CC1.3). Similarly, Saint Etienne Metropole has created activities to foster understanding of sustainable development (PCAET, 2017, p.16).

Please note that these are knowledge needs found across climate plans of different generations - PCETs and PCAETs. In fact, they are quite general and do not refer to adaptation specifically. The following paragraphs will portray climate products and services used in existing PCETs and PCAETs. In fact, different climate change adaptation products (CCAPs) were found across these documents. We believe that to shed light on local authorities’ needs, we have to discuss CCAPs they have already used. Only then we can focus on knowledge needs for adaptation.

5.2.1 The use of climate products in local climate plans

Several examples of climate products were found in selected intercommunalities’ climate plans. Usually, these products represented projections of main climate variables, some of which were downscaled by engineering studios. Figure 34 was used by Grand

Figure 34 Grand Lyon, city analogs

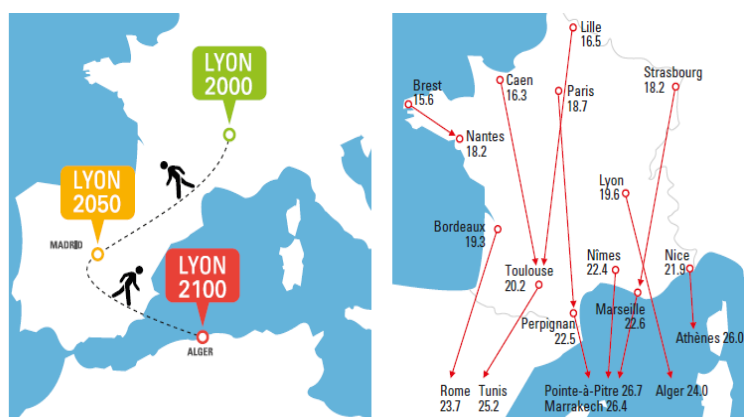
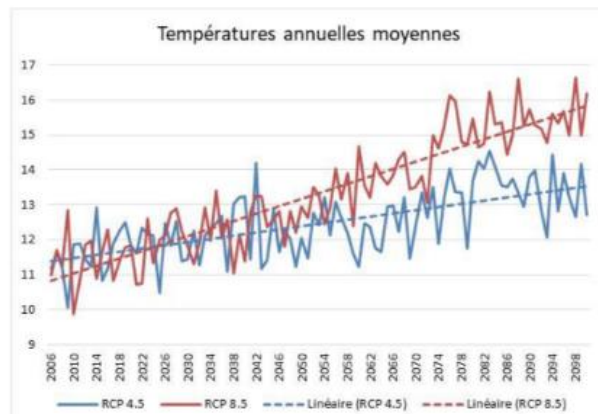


Figure 2 : prévision des températures moyennes à l'horizon 2070-2100. Source : Météo France, 2009.

Lyon to illustrate the future climate of the city. They use city analogs techniques to project themselves into the future.

Climate analogs match the expected future climate at a location with current climate of another location (Fitzpatrick et Dunn 2019). This technique is believed to be more intuitive to the public. Fitzpatrick and Dunn (2019) have used city analogs techniques to illustrate future climate conditions for 540 urban areas in North America. They argue that *“by translating abstract statistical forecasts of future climate into something more akin to personal experience with present-day climates, climate-analog mapping can help communicate what future climate may feel like to urban residents in a broad sense, as well as the potential magnitude and nature of local climate change”* (Fitzpatrick and Dunn 2019:5). While Fitzpatrick and Dunn (2019) used city analogs for awareness purposes, Kellett et al. (2015) inquired on whether this technique informed existing land use planning, housing, infrastructure, health and ecological policies. The authors conclude that *“over the full spectrum of policy, there is insufficient evidence to suggest that analogue approaches are valuable as a policy development tool”* (Kellett et al. 2015:61). In our case, Grand Lyon used city analogs for awareness purposes, not for policy development.

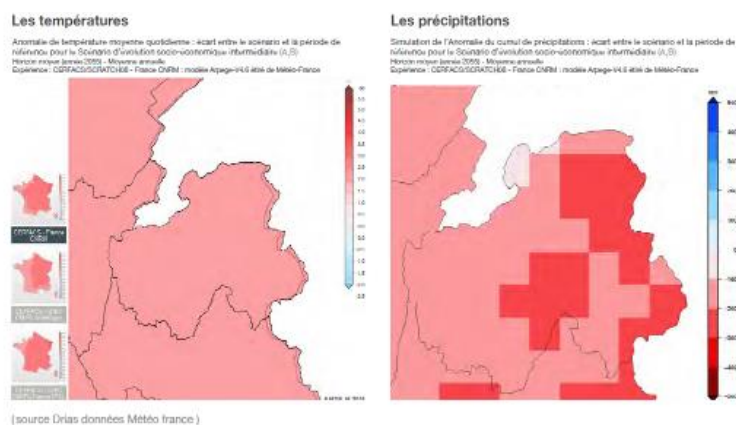
Figure 35 DRIAS, PCAET SMVC



As illustrated by Figure 35, climate change adaptation products (CCAP) were used by Grand Ancey and Saint-Marcellin-Vercors-Isère-Communauté to portray the evolution of specific climate variables (average temperature, precipitations). Figure 35 is taken from vulnerability report of Saint-Marcellin-Vercors-Isère-Communauté. It depicts average temperatures according to different RCP scenarios. In their case, Météo France’s DRIAS climate products were downscaled to local level by an engineering studio.

Figure 36 is taken from Grand Annecy' PCAET. These projections come from DRIAS and represent the anomalies in terms of temperatures and precipitations, downscaled to departmental level. The CC Vallée de Chamonix-Mont-Blanc's PCET also contains DRIAS products.

Figure 36 DRIAS, PCAET Grand Annecy



It appears that DRIAS was mainly used for awareness purposes, regardless of the generation of climate plans or view on adaptation in selected intercommunalities. Besides its use for awareness purposes, Grenoble Alpes Metropole raised the question of costs:

I have used DRIAS and Climat HD for awareness purposes, to show the amplitude of the change. However, it is difficult to recover this data. I had the impression that it costs a lot (GAM)

Grand Annecy pointed out that they are not sure they actually used DRIAS for their second climate plan because the information was regionalized:

We used DRIAS for the first climate plan. I am not sure, but the external contractor might have used it too, or not (refers to second climate plan). Probably because the information on this portal is regionalized. (GA)

From these two citations we can identify several weak points of this CCAP: it is not easily accessible, not of an appropriate scale. Additionally, it is not user friendly. In our sample two interviewees had technical capacities to manipulate data and to work with climate projections. In fact, one interviewee could territorialize the projections:

I used it, but it is complicated. Not that easy to sort excel databases with complicated data. I do not know if this is shared by all my colleagues. I really like to understand data, to manipulate it, sometimes it is just so interesting, it allows us to reshape customize to match our needs (PV)

Even if in the first case the participant “manipulated data”, an exterior expert was asked to “take a look” at the interpretation of the data. Another person had used data from the US:

We tried to map heat islands for our intercommunality, and we used data from Landsat Nasa. Mainly because this data is easy to access, it covers all our territory, has regular updates, good resolution, and it is free of charge (GAM)

Indeed, regardless of the number of adopted climate plans and technical capacities of interviewees, DRIAS simply did not match their needs. Nonetheless, we have observed that those who are elaborating their first climate plan are not interested in very detailed information, like pointed out in Webb et al. (2019) and Stafford-Smith et al (2022). For example, Saint-Marcellin-Vercors-Isère-Communauté prefers “*a global vision of their territory and key indicators allowing to build strategies*” (2019). The CC de l’Oisans pointed out that building a strategy based on climate projections must be their next step because their next PCAET is not voluntary anymore.

Besides DRIAS, another CCAP is available in the region. We have already discussed the regional observatory on the effects of climate change (ORCAE) and explained why we did not include them in our study of boundary organisations (Chapter 2). More specifically, ORCAE is not a boundary organisation (no scientists on board). We believe that it represents what we defined as first generation of climate services (or CCAP), at least at the time this thesis was written. Additionally, ORCAE’s focus is on mitigation (air and energy), while our core interest lies in adaptation issues:

I think the links with region, ADEME and ORCAE are now structured enough. However, not for adaptation. Energy and CO2 emissions are easier to address (OIS)

However, while recognizing the importance of regional observatory and the fact that its capacities to accompany them might grow in time, intercommunalities in our sample have pointed out that its products and services do not always meet their needs for adaptation. ORCAE’s main product “climate air energy profiles” is available for all intercommunalities of the region and provides standardized information on energy (consumption and production), greenhouse gases emissions (GHG), net carbon sequestration, energy distribution and transmission networks, impacts of climate change. Additionally, the methodology of “climate air energy profiles” was not stable, thus it was difficult for decisionmakers to communicate their progress:

One big downside with energy profiles is that the changed data too often. I think it is because they improve their methodology, but this is not simple to understand for an elected official once the climate plan is approved. I would like something more stable in time (X)

If this verbatim refers to an existing adaptation product, another participant expressed the need for “*precise indicators, calculated in the same way over time*” (GF).

The “climate air energy profiles” provide graphs, figures, and tables. These profiles represent a diagnostic, the 3rd stage of adaptation cycle (risk assessment). Although phrased differently, the need for climate change adaptation service was expressed by different entities. For example, DREAL advocated for operational tools instead of passive data:

We need tools that are operational enough to provide levers for action, to guide the policy of the territory. Climate data must not be passive, it must provide opportunities for action to elected officials (DREAL)

A DDT has also pointed out the need to go beyond the 3rd stage of adaptation cycle:

At the moment, local authorities can only “suffer” from climate change. What we really need, for example, is to have options and to choose between these options based on their expected outcomes. We are not there yet. We are at the diagnosis stage, and almost in fatalism (DDT).

Three local authorities shared similar views:

Climate data is good, but it is not the main thing. Once we have this data, how do we interpret it in a fair and relevant way? What does this mean for the territory? Therefore, we need a climate service which accompanies us in this direction (GA)

We would like to adopt a plan, but what does it mean specifically? What change to put in place? In order to use data in coherent we need to understand it first, so we might need training or guides. In any case, we should never forget the importance of human interactions (GF)

We need something more elaborate (“pre-mâché”) (OIS)

What does this mean for CCAP and CCAS concepts? As a reminder, CCAP is defined as “*data, tools to support decision-making for adaptation, including efforts to identify information needs*” (Weichselgartner and Arheimer (2019)). It appears that CCAP are not enough to guide local policymaking, and that intercommunalities need to be accompanied when addressing adaptation. Based on these inputs, we can suggest that there is need for CCAS, defined as “*activities, consultations, and other forms of interaction that enable decision-makers to make better use of CCAP*” (Weichselgartner and Arheimer (2019)).

Two intercommunalities represented by employees with experience in research pointed out the discrepancies between research and practice when it comes to knowledge transmission:

There is a gap between research, which is so conceptual and our operational reality (GAM)

I think there is a gap between the scientific world and the world of local communities (GF)

Unfortunately, only one person in our sample had maintained close links with research institutions after the completion of PhD. Besides arguing that science-policy gap does exist, this participant also pointed out that creating research projects that aim at accompanying local authorities in their adaptation efforts is not always easy:

Research projects may be problematic in the sense that you have to produce scientific results, which is not always possible on operational level (GAM).

So far, we have illustrated available climate change adaptation products and services and discussed them with intercommunalities. The next section will finally depict their needs.

5.2.2 Adaptation product and/or adaptation service?

In the previous section we have already seen that intercommunalities do need climate data, which in our case represented vulnerability reports (risk assessment), or climate projections (maps, raw data). However, it appears that available adaptation products do not allow intercommunalities to go beyond the 3rd stage of UKCIP's adaptation cycle (section 1.2). There is need to “*understand what this means for a territory*” and to provide with “*levers for action*”. In fact, these correspond to stages 4 and 5. The demand for adaptation products and/or adaptation service will be dictated by several factors. Dilling and Lemos (2011), and Celliers et al. (2021) have pointed out that the uptake of climate information will be influenced by a set of institutional and individual obstacles (discussed in Chapter 2).

The need for adaptation services was expressed by a majority of intercommunalities (7 out of 12). More specifically, the demand for decision-support for option appraisal (stage 4-5) was manifested regardless of the number of climate plans, or the views on adaptation. Whereas 7 intercommunalities expressed difficulties on stages 4 and 5 of adaptation cycle, two intercommunalities pointed out that Stage 8 (evaluation, monitoring) is also a major concern. As Luc Moreau⁶⁴ has pointed during French president Macron's visit to Mer de Glace glacier, the political decisions' have short term logic, while the consequences of these decisions are not perceived during one's political mandate. What could this mean for

⁶⁴ Luc Moreau is a glaciologist at EDYTEM, CNRS/University Savoie Mont Blanc

climate adaptation products and services? What we observe here, is what Sarewitz and Pielke (2007) have described as a mismatch between the supply and demand in science. They argue that the use of climate information will depend on institutional constraints thus, merely producing climate knowledge does mean this knowledge will be used (Sarewitz and Pielke, 2007). Nevertheless, it is not due to the form or the scope of CCAP or CCAS. As DREAL and an intercommunalities have summed up, adaptation policymaking may be discouraging because these policies refer to medium/long term timescales. At the same time, decisionmakers operate within the timescale of his/her terms of office:

Democracies are not fit to tackle climate change (DREAL).

For politicians it is very difficult to accept that the results of their work will be visible then they will not be there. It is very discouraging, as they do like to be able to trace progress (GF)

The citations above describe how short-termism of public policies clashes with long-term consequences of climate change. Regardless of this mismatch between terms of office and the expected positive effects of adaptation policies, the need for evaluation was expressed:

We do need better evaluation (DREAL)

We need a sort of dashboard with main indicators, which should be updated regularly. Like INSEE does with unemployment rates (GF)

The verbatims above illustrate the demand for better evaluation mechanisms, but also highlight difficulties when evaluating outcomes of adaptation strategies. The trials and tribulations when evaluating wicked problems are largely discussed in literature. For example, Termeer and Dewulf argue that “*evaluation methods that compare policy outcomes to previously set promises, targets or budgets do not account for the uncertainty, ambiguity, and complexity characteristic of wicked problems*” (2019:299). Duckett et al. (2016) argue that in case of wicked problems, any positive impact of strategies is extremely difficult to assess in terms of performance and efficiency.

Based on these verbatims, we argue that Stage 8 “Monitoring” (UKCIP, 2003) of adaptation cycles are stymied by evaluation paradox closely related to climate and policy temporal scales. Evaluation paradox is characterized by attempts to judge solutions for problems that have no solution (Termeer and Dewulf 2019). The “outcomes” of adaptation strategies might not be perceived for decades, or their effects might be too difficult to trace back to selected policy solutions. Therefore, the idea to address adaptation, not to solve it. From another perspective, intercommunalities do recognize that adaptation as a long-term process (Grand Lyon, 2015:37). As the climate is changing, so will the knowledge (Grand

Annecy, PCET, 2013:20; Grand Lyon, 2015:37). They are aware that adaptation requires time and iterativity.

5.2.3 What kind of adaptation service?

So far, we have illustrated the demand for adaptation services to support local authorities throughout the whole adaptation cycle (UKCIP, 2003). We have seen that available adaptation products represent an important step towards evidence-based adaptation to climate change. However, adaptation products alone do not enable decisionmakers to complete policy cycles, thus intercommunalities in our sample expressed the need for adaptation services. But what kind of adaptation service? To answer this question, we will use the CRELE framework discussed in chapter 1 (section 1.4.2).

Credibility refers to whether the knowledge and its production are perceived as valid and adequate (trust in science and scientists). In our case, the intercommunalities did not express concerns about their trust in climate information. When asked about “credible” producers, all intercommunalities have pointed to Météo France and universities. Indeed, several PCAETs contain DRIAS or adaptation products based on outputs from DRIAS. According to interviewees, tighter links with universities is one of the main strategies to improve access and quality of knowledge (CC Le Grésivaudan, 2013; Sainte Etienne Metropole, PCAET, 2017; Grenoble-Alpes metropole, 2019). Moreover, the providers of adaptation products and services should be “*indisputable and totally independent*”. One interviewee pointed out that associations (non-profit) may be too perceived as “*too militant*”. In fact, the non-profit sector and research institutions do not share the same level of credibility. When applying the Lacey et al. (2018) model of trust/time to the choice of adaptation services’ provider, we see how the non-zero starting point is confirmed for research institutions (please refer to section 4.4.2). We cannot assume the same for non-profit providers (less credible = a zero-starting point). The issue of trust emerged from a different perspective:

Long-term partnerships are fundamental. When collecting data from the LPO or from the FRAPNA⁶⁵, we realized that we needed a certain level of confidence and a certain habit of working with this type of structures. We had to build trust relationships with them before having access to their data (GAM)

⁶⁵ LPO - League for Birds Protection (Ligue pour la protection des oiseaux). It is a French association funded in 1912 to foster biodiversity protection.

FRAPNA – AuRA federation for nature protection (Fédération Rhône-Alpes de protection de la nature). Created in 1971, Frapna associations aims is engaged in environmental protection.

This citation comes from biodiversity services of an intercommunality. Even if the 'providers' they mention do not produce climate data, the lack of long-term relationships seems to be an institutional barrier to information sharing. The question of trust was raised too. More specifically, when elaborating the second version of PCAET, one intercommunality wanted to work with a specific exterior contractor, and with one person particularly (vulnerability report was outsourced). They explained that persons' contribution to their first PCET was well perceived, thus they wanted to keep working with them. Another person has pointed out that he maintained close contacts with his former lab, and that he is still using climate data elaborated by this lab.

Long term collaboration and trust are issues already discussed in chapter 4. Boundary organisations have pointed out that time was required to achieve a good understanding of local authorities' needs. It appears that to minimize the science-policy gap, both CCAP and CCAS must be stable to allow for trust to be built over time, and to understand users' needs (Chapter 4). Time and trust are also required to build confidence and improve access to data. Unfortunately, we do not have enough elements to assess whether the turnover within policymaking agencies played an important role.

Relevance refers to whether the information matches the needs (when the demand for science matches its supply, as in Sarewitz and Pielke, 2007 and in McNie, 2007). Most of the literature points out that the very first adaptation products were not built on pertinent spatial scales. Therefore, they lacked relevance in the eyes of users and decision-makers. The importance of adequate spatial scales was also highlighted in the interviews, but it did not represent a major obstacle. As illustrated in previous sections, PCAETs contained climate products downscaled to regional or departmental levels. Nonetheless, these scenarios were mainly used for awareness purposes.

Legitimacy is the fairness of knowledge and policy production – whether unbiased or not (Sarkki et al., 2015; McNie 2006; Cash et al; 2003, Reinecke, 2015). From the legitimacy perspective, the question of price was raised on different administrative levels. For example, DDT explained that DRIAS offers free data, but other services are not for free:

Are we talking about public or private research? When you check DRIAS - it is public data, but there are private services. There is a real question behind it: do we want the information to be available to everyone? We are entering into a real democratic debate. I think that there should be at least some access to objective information (DDT).

An intercommunality has also pointed out that the question of price non negligible:

It is true that data from Météo France, like Climat HD (CCAP) is not bad. I used it to illustrate the magnitude of change. But it is so hard to get access to this data. I had the impression that you need to pay a lot (GAM)

Additionally, other intercommunalities argue for open access to climate data and knowledge:

It should be an indisputable and totally independent provider, who would share data and knowledge to everyone (refers to adaptation product and service provider) (GF)

It is not only a question of having the data. You should share it with everyone, not keep it between the pairs (OIS)

These verbatims illustrate intercommunalities' views on climate data – it must be open source. As already stated in the previous chapter, we argue for “*public provision of adaptation goods*”, as climate change is “*public risk that requires solutions delivered in a form of public good*” (Tompkins and Eakin 2012, 2012; Berke and Lyles, 2013). Firstly, private businesses have limited access to infrastructure producing climate knowledge. They might lack credibility too. Secondly, private provision of adaptation goods may create distributional inequalities in terms of impacts and costs:

When I talk with my colleague (refers to other intercommunality), I know he/she does not have the same financial resources as me. For him/her it is more difficult to put actions into practice (OIS).

Since the intercommunalities dispose of different material means, distributional inequalities in terms of costs are indeed possible. Adger points out that “*adaptive actions often reduce the vulnerability of those best placed to take advantage of governance institutions, rather than reduce the vulnerability of the marginalized, or the undervalued parts of the social-ecological system*” (2006:277). According to the author, often the most vulnerable are not those best able to mobilize resources. We have already mentioned that only 4 intercommunalities were engaged in research projects at the time this chapter was written. More specifically, the metropolis and one agglomeration of communities with geographical proximity to these research institutions. We believe that, in our case, smaller, less urbanized intercommunalities, such as the “*communities of communes*” do not have the same access to research due to distributional inequalities. However, this hypothesis deserves more systematic inquiry to be confirmed.

Besides the question of cost, there is a lack of efficient communication regarding available products and services. This issue was highlighted by a DDT, which called attention to the fact that climate data is still private and confidential, instead of being free:

If the data is credible, robust, and free – it could contribute to the debate. Currently the data is very private, very confidential, managed in a very technical way (DDT).

Two intercommunalities share similar views:

In fact, we have a lot of data on our territory, but we do not use it. Everyone is using it in their corner, for their needs. There is no real exploitation, no communication of this knowledge on our territory (OIS).

We are more credible when the data is territorialized. We might have this data, but there is lack coordination between data providers. It is essential (GA)

From these citations, it appears that there is no lack of data in AuRA region. As pointed out by Sarewitz and Pielke “*more information does not mean better decisions*” (2007:9). In our case, this knowledge is spread across multiple providers: Météo France, research institutions, national parks, hydroelectricity producers, state agencies, ORCAE, etc. According to two interviewees, gathering data represents an additional task to be performed internally or outsourced:

I tried to look for climate projections and I found various ones on the internet. In fact, you have to visit multiple websites. I ended up on a US university portal that centralizes all these projections (GAM).

We commissioned a design studio to elaborate the vulnerability impact, but also to gather data which was dispersed (GA).

From these two verbatims it appears that there are several obstacles when accessing the data. We have already mentioned the costs, but coordination and dispersion may represent non-negligible barriers too. As one can see, the first intercommunality has privileged a provider that centralizes the data, while the second one asked the design studio to gather it.

These last two citations allow us to confirm Chapter 3’s findings. Climate Change Adaptation Knowledge action Systems are not well developed in France. Not only there is a lack of coordination between different spatial scales (section 5.2). What we observe here is lack of coordination between data producers, leading to barriers for the inter- and intra-organisational mainstreaming of adaptation.

Conclusions

In this chapter we have discussed adaptation governance and knowledge needs of local authorities in Auvergne- Rhône-Alpes region. We have seen that adaptation is framed as national responsibility for several reasons, as no national, regional, and subregional

policy must be compatible with national adaptation plan (PNACC). At the same time local authorities have responsibilities in terms of mitigation and adaptation to climate change and their climate plans must be compatible and coherent with regional policies (SRCAE and SRADDET).

As discussed in Chapter 1, the European Commission argues for better “*coordination and coherence at the various levels of planning and management*” (European Commission 2013:5). In practice, as depicted by Figure 29, local authorities in Auvergne- Rhône-Alpes were able to engage themselves in climate adaptation policymaking without inputs from the region. More specifically, most of the PCETs and PCAETs were adopted before regional strategies SRCAE and SRADDET. Additionally, regional adaptation committees were not put in place as suggested in PNACC. Ergo, adaptation governance (and mainstreaming) from a vertical perspective (state>region>intercommunality) is not well articulated. On the horizontal level, several existing networks are present in the region, but for mitigation issues mainly. Nonetheless, they may represent trampolines for adaptation.

As of September 2022, France did not fully develop the climate change adaptation knowledge-action systems, although some progress was done (national adaptation portal). Adaptation is still a small part of local climate plans, even if there was a significant improvement between the first (PCET) and the second (PCAET) generation of climate plans. Additionally, views on *what is and does* adaptation vary across our sample (Table 15).

Available climate change adaptation products (CCAP) do not support intercommunalities through the whole adaptation cycle, as they focus on the third stage of adaptation planning cycle – risk assessment (Goosen et al., 2014). All the other stages require much more than CCAP. Available CCAPs do not enable local authorities to act (stages 4,5 and 6). Consequently, monitoring and evaluation are also difficult to put in place. Monitoring (Stage 8) is stymied by the so-called evaluation paradox, characterized by attempts to judge solutions for problems that have no solution (Termeer and Dewulf, 2019). Therefore, we argue for managing, not solving adaptation, even if this can pose a major problem for elected officials. The classic metrics of efficiency are not always the most suitable to evaluate outcomes of adaptation policies. In fact, wicked problems such as adaptation cannot be solved because they are continuously changing and involving conflicting values (Churchman, 1967). These types of problems change continuously as new knowledge becomes available; thus, adaptation should not be ‘fixed’ but addressed and managed (Conklin, 2006, p. 5; Head and Xiang, 2016). Phrased differently, adaptation should follow the process of incremental decision-making, defined as: “*decision making*

involving a fragmented political process in which decision makers have limited knowledge, respond to political pressures, engage in limited successive comparisons, and make small tentative adjustments in existing policies “(Carter A. Wilsom, 2000:248).

Based on the findings of this part of study, we can conclude that:

1. There is no lack of data. However, this data is often “private” and “dispersed”.
2. Local authorities in Auvergne- Rhône-Alpes region require climate change adaptation services (CCAS) instead. More specifically, decision-support is required to understand and use climate projections. What does it mean to adapt? What measures to put in place? These questions require answers that are not provided by available CCAPs on national and regional scales. We argue that these CCAPs, more specifically DRIAS and to some extent ORCAE, suffer from the mismatch between the offer and the demand in science (Sarewitz and Pielke Jr., 2007). It appears that local intercommunalities do not suffer from lack of information per se, but this information is dispersed and not easily accessible (in contradiction with PNACC2s).
3. As allegedly pointed out by Krauss and von Storch “*there are significant disturbances in communication between climate change science and the public*” (2012:213). In our case, available CCAPs were lacking CRELE. We have seen that credible, relevant, and legitimate adaptation services are required. The legitimacy, or rather the fairness, is one of the key aspects that needs to be addressed. Adaptation is a wicked problem and its complex interactions with other issues and with other territories may aggravate financial distributional inequalities in the region.

General conclusions and perspectives



This thesis aims to understand climate adaptation services and knowledge needs for adaptation at the local scale. In order to achieve our objectives, several steps have been taken and a funnel approach has been chosen. We have seen that the literature distinguishes between the first and the second (or new) generation of climate services. The first generation of climate services was characterised by a mismatch between the supply and demand of science for adaptation (Sarewitz and Pielke Jr., 2007; Pita Spruijt et al., 2014). More specifically, what was being produced by scientists did not meet the needs of decision-makers. On the contrary, the second generation - or what we call "adaptation services" - provides mechanisms for interaction and knowledge exchange between scientists and actors outside of academia. We have seen that the concept of adaptation services has been taken up not only in the literature (Goosen et al. 2014; Weichselgartner and Arheimer, 2019), but also in practice. The German climate preparedness portal KLiVO makes a clear distinction between products, such as web tools and maps, and services that provide support in selecting and implementing appropriate adaptation measures. This distinction between more 'passive' products and co-designed services is the leitmotif of this research.

Nevertheless, this thesis would be incomplete without taking a few steps back to support a broader perspective. As pointed out by Celliers et al. (2021), decision-making for adaptation requires an integrated, cross-sectoral approach that can capture the complexity of decision processes that are strongly influenced by environmental and social contexts. Therefore, we explored the governance of adaptation and its links to the decentralisation of EU Member States. We have illustrated how country-specific characteristics can influence the emergence of adaptation products and services and the development of knowledge action systems (Chapter 2). In Chapter 2, we identified a possible connection between decentralisation and the emergence of adaptation products, services and systems.

Next, we looked at the 'producer' perspective (Chapter 3). By interviewing boundary organisations from different countries, we were able to shed light on their experiences, the obstacles they face and the techniques they use to work with decision-makers. The final case study presented the 'users' perspective on climate products and services. Chapter 4 was dedicated to a case study in the Auvergne-Rhône-Alpes region in France and looked at the knowledge needs of local authorities. Indeed, our analysis confirmed the general trend in the field - there is a demand for adaptation services (not products). We also identified discrepancies in adaptation governance in France and in the Auvergne-Rhône-Alpes region, where suboptimal vertical integration of adaptation could slow

down evidence-based decision-making. We discuss our main findings in the following sections.

Adaptation governance and systems in the EU

Adaptation to climate change has been on the political agenda for almost two decades. Today, adaptation plans are a common strategy to prepare for future challenges, as any investment or policy is expected to be climate proof. Moreover, as adaptation decision-making is spread across different levels of planning governance, good coordination between different scales is key (European Commission 2013:5).

We have shown that in the EU, the emergence of adaptation on policy agendas has been facilitated by the history of climate and environmental research or by the catastrophic impacts of extreme weather events. Extreme weather events have contributed to the development of the very first adaptation plans in EU Member States. In fact, according to the first French adaptation strategy, the heat wave allowed a shift in the perception of climate and adaptation activities (ONERC, 2007:17). Similarly, the Netherlands, as a low-lying country, launched a coastal management programme after a devastating flood in 1953 that claimed 1836 lives and destroyed 42,000 homes (<https://www.rijkswaterstaat.nl>).

Nevertheless, adaptation has been a taboo subject for some time. It emerged around the world after the publication of the Stern Review on the Economics of Climate Change (2006) and the IPCC's report on Impacts, Adaptation and Vulnerability (2007). These two documents underlined the costs of climate change and, above all, the costs of inaction. In the public health sector climate change “*has gone from a possible concern to what appears to be an actual threat in just over two decades*” (Hess et al 2014:1177).

The 2003 heatwave and the publication of the aforementioned reports contributed to the so-called window of opportunity (or policy window) for adaptation decision-making (Kingdon, 2003). We have seen a flowering of national adaptation strategies and plans across the European Union (Figure 14). The EU Green Paper emphasised that it is at the local level that “*detailed knowledge of natural and human conditions is available*” (2007:11). As many climate-related decisions are taken at the local level, local authorities have an important role to play (European Commission 2007). However, the capacity of local authorities to engage in adaptation decision-making can be influenced by the institutional context, socio-political barriers, and the presence of networks (Dilling and Lemos, 2010; Celliers et al., 2021). Indeed, we have shown that there is a link between decentralisation in EU Member States and adaptation policy making at the sub-national level. More specifically, federal and decentralised countries are those where sub-national administrative units have developed adaptation strategies and plans prior to specific directives from the state (Figure 15). Not surprisingly, the distribution of adaptation

products, services and knowledge action systems followed similar logics. Several decentralised countries, such as Austria, Denmark, Germany, Ireland, the Netherlands, Norway, Spain and Sweden, were able to articulate climate products and adaptation services in knowledge systems (Figure 16). To ensure coherent spatial planning and resource management across scales in relation to adaptation, these countries have 1) established coordination structures at the national level, such as knowledge portals (built in collaboration with multiple stakeholders) or adaptation networks; 2) pursued the integration of climate information into policy and practice through science-policy interfaces and boundary organisations such as BC3, CAS and Climate Ireland. Adaptation services were concentrated in Western European countries (Belgium, Finland, France, Italy). However, the centralised countries in our sample showed varying degrees of integration of climate products and services into their adaptation governance. For example, France has developed adaptation products such as DRIAS (Météo France) or ORCAE (in Auvergne-Rhône-Alpes). Adaptation services have emerged as regional initiatives such as Ouranos AuRA, Grec-Sud, Acclimaterra and RECO. However, at the time this thesis was written, adaptation systems were still a work in progress. From our analysis, we can conclude that decentralised countries with strong coordination traditions and policy networks are the ones where most adaptation knowledge action systems have emerged.

Central and Eastern European Member States have at best developed adaptation products. Looking at the distribution of adaptation products, services and systems, we can see that there is a separation between the Western and Eastern European countries. Not surprisingly, real GDP per capita follows a similar distribution (Figure 19). As pointed out by several authors (Adger et al., 2005; Amundsen et al., 2010) and the European Commission itself (European Commission, 2013), the impacts of climate change will not respect borders. In fact, the spatial distribution of adaptation products, services and systems raises concerns about inequalities in the EU. In the context of climate change, these inequalities could hinder cohesion between the West and the East. However, resource availability alone cannot explain the distribution of adaptation products, services and systems, and this was not one of our research objectives.

Promoting climate change adaptation and risk prevention was one of the goals of the EU strategic framework of 2012, where the principle of solidarity among states was reiterated “*if the cost of measures to protect the environment are deemed disproportionate for the public authorities of Member States, the Treaty on the Functioning of the European Union provides for financial support from the Cohesion Fund*” (European Commission, 2012). Furthermore, one of the objectives of the ERDF and the Cohesion Fund is to support adaptation policies at national and sub-national levels, as well as to improve the knowledge base, data observation capacity and information exchange mechanisms (European

Commission, 2012:17). (European Commission, 2012:17). We have illustrated in Chapter 3 that several EU member states have benefited from these funds. For example, Croatian national adaptation plan was partially funded by the Purchaser Central Finance and Contracting Agency for European Union Programs and Projects (SAFU); the Estonian adaptation plan was funded by an EEA grant and driven by the Stockholm Environmental Institute (Tallinn); Bulgaria and Poland made use of the EU's Cohesion Funds; Cyprus' adaptation strategy was formulated within the CYPADAPT project, which was co-financed by the EU through the LIFE+ program. Adaptation services, products and systems should follow the same path, as they represent “*data observation capacities, and mechanisms for the exchange of information*” – a sine qua non condition for evidence-based decision making. It would be interesting to inquire on the role of ERDF and Cohesion Fund in their development.

Vertical and horizontal integration of adaptation in France and Auvergne-Rhône-Alpes region

To further explore the governance of adaptation, we conducted a study in France and the Auvergne-Rhône-Alpes (AuRA) region. As discussed in Chapter 1, the European Commission argues for better “*coordination and coherence at the various levels of planning and management*” (European Commission, 2013:5). We have tackled vertical and horizontal integration of adaptation policies on national, regional, and local scales.

The vertical dimension refers to the relationship between the local and the national, where the local scale functions within legal and institutional frameworks implemented at higher scales (Corfee-Morlot, J. et al., 2009). In practice, adaptation governance (integration) from a vertical perspective is not well articulated between the state AuRA region. Firstly, no climate adaptation policy on regional and local scales must be compatible and respect national orientations (PNACC). Additionally, the coordination between the state and AuRA is not complete, as regional adaptation committees are yet to be put in place. In fact, the creation of these committees is one of the adaptation measures proposed in French National Adaptation Plan of 2018 (PNACC2, 2018). Yet, in 2021 these committees were still non-existent in AuRA.

Secondly, vertical coordination between regional and local policies is also suboptimal. Regional policies (SRCAE and SRADDET) are supposed to provide general orientations and to guide adaptation policymaking at local scales (intercommunalities). As depicted by Figure 29, local authorities in Auvergne Rhône Alpes were able to engage themselves in climate adaptation policymaking without inputs from the region - most of the PCETs and PCAETs were adopted before regional strategies SRCAE and SRADDET. Additionally, while PCAETs (ex PCETs) must be compatible with SRADDET (ex

SRCAE), none of these documents have legal obligations towards the national adaptation plan (PNACC). These discrepancies may represent a significant obstacle to coherent adaptation in the AuRA region, but also between regions in France. Although the capacity of intercommunal authorities to engage in climate policy is a rather positive aspect, the need to ensure good coordination has been identified in the literature (chapter 1). The horizontal dimension refers to formal and informal networks that extend across borders. In fact, horizontal integration is less problematic as local authorities in the AuRA region of France rely on existing mitigation networks, personal connections with other cities or research institutions. These can act as trampolines for adaptation.

We therefore believe that improving the links between the state and regional levels is an important step towards building robust adaptation knowledge-action systems in AuRA, but also in France. On the one hand, we argue that a greater degree of decentralisation is needed to enable local levels to act, and we have shown how decentralised countries perform better in terms of adaptation knowledge-action systems. On the other hand, we believe that there is a need for a balance between centralisation and decentralisation and, most importantly, for better coordination to avoid maladaptation, negative spillovers and exacerbation of inequalities between territories and populations. This "balance" has already been described in the literature as "hybrid governance" because it combines central and local authorities (Sydney Halpern, 2008). In fact, numerous and diverse climate institutions have shifted adaptation governance from monocentric structures, such as the Kyoto protocol and the Paris Agreement, towards more polycentric systems, where subnational governments and actors have expanded their commitments and roles (Abbott, 2017). Nonetheless, although in general polycentric governance *theory* organisations can emerge and coordinate their actions spontaneously, in climate governance such organisations are created thanks to facilitation operated by the state and other actors. Ergo our call to foster coordination between the state and the region, and in the region itself. Please note that we argue for better *coordination*, not for a bigger role of the state in *defining* adaptation. We believe that the role of the state is to create dialog mechanisms for vertical integration of adaptation policymaking to assure coherency between regional adaptation policies.

A sound coordination is necessary to assure coherence between scales, but also to avoid maladaptation, defined by IPCC as “*actions, or inaction that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future*” (2014:857). The absence of a regional committee for adaptation in AuRA, but also lagging in the elaboration of adaptation policies on regional scales may have a noteworthy impact on the vulnerabilities in the region. Firstly, the absence of such committees may increase the possibility of negative spillovers between

various sectors. We have seen that the management of water resources is a key priority for AuRA and its intercommunalities - as water resources become scarcer, conflicts over their use can arise. Several local authorities have expressed concerns about the viability of snowmaking as a strategy for economic development in their areas. Unfortunately, the topic of artificial snow is quite controversial in the region, as winter tourism represents 8% of regional GDP (SRADDET, 2020:23). Additionally, similar concerns were also expressed in the latest SRADDET, where artificial snow was identified as one of the causes of biodiversity loss. However, regional investments in “the first sustainable mountain of Europe” mainly refer to artificial snow production.

Secondly, discrepancies in coordination may lead to negative spillovers between territories and aggravate inequalities between regions, or between intercommunalities with different financial resources. From this perspective, we have seen that regions and/or intercommunalities have unequal access to adaptation services. In fact, France has several regional adaptation services’ (AS) providers, discussed in Chapter 3. However, not all regional AS have sufficient institutional stability. Institutional barriers linked to political awareness represented the first and the major challenge for several non-profit boundary organisations in our sample. In their case, a lack of awareness among policy-makers rhymed with insufficient political support. Fortunately, the electoral cycles at regional level did not affect their activities, as their funding contracts were renewed. However, all were concerned about financial stability. Acclimaterra was able to expand its knowledge transfer activities, engage in research projects and support regional policies. Unfortunately, this was not the case for other non-profit boundary organisations.

Once again, the unequal access to adaptation products and services brings into question the nature of adaptation. Mees et al. (2012) point out that adaptation often addresses impacts to public goods, such as safety peace and security, national defence, fire, and flood protection. Similarly, Berke and Lyles (2013) classify climate change as “*public risk*” which requires solutions delivered in the form of public good. When knowledge and adaptation services are treated as a private good, they are owned by the organisation and can be exchanged like any other good. This implies additional costs for decision makers, while financial resources are not equally distributed between territories and populations. Therefore legitimacy, or rather fairness, is one of the key aspects that needs to be addressed. Adaptation is a wicked problem and its complex interactions with other issues and with other territories may aggravate financial distributional inequalities in the region.

We have illustrated the West/East divide in the EU: climate change adaptation knowledge action systems, but also services were mainly developed in Western European countries. Similar logics can be applied to regional or local scales. Wealthier territories

have an important advantage today and thus become less vulnerable in the future. According to us, public distribution of adaptation services may alleviate inequalities in terms of costs and access to relevant data in France and in AuRA. Or phrased differently – the absence of public adaptation services represents a form of inaction, which may lead to increased vulnerabilities and diminished welfare in the future (IPCC definition of maladaptation).

While the available adaptation products delivered by public entities, such as ORCAE can only be beneficial, we have seen that they do not fully match the demands of intercommunalities. We argue that available adaptation products, more specifically DRIAS and to some extent ORCAE, suffer from the mismatch between the offer and the demand in science (Sarewitz and Pielke Jr., 2007). It appears that local intercommunalities do not suffer from lack of information per se, but this information is dispersed and not easily accessible (in contradiction with PNACC2). As allegedly pointed out by Krauss and von Storch “*there are significant disturbances in communication between climate change science and the public*” (2012:213). In fact, local authorities in Auvergne Rhône Alpes region require decision-support to understand and use climate projections. These disturbances in communication have led to a situation where available climate change adaptation products (CCAP) do not support intercommunalities throughout the whole adaptation cycle, as they focus on the third stage of adaptation planning cycle – risk assessment (Goosen et al., 2014). The intercommunalities in our sample do recognise the importance of these products, but they expressed the need for adaptation services instead: decision-support and capacity building activities to allow them to use existing adaptation products.

Towards the emergence of adaptation services

Adaptation should follow the process of incremental decision-making, defined as: “*decision making involving a fragmented political process in which decision makers have limited knowledge, respond to political pressures, engage in limited successive comparisons, and make small tentative adjustments in existing policies*” (Carter A. Wilsom, 2000:248). Likewise for evidence-based decision making, the key aspect of incremental decision-making is access to data and services. To enable policy adjustments there is need for institutionally stable adaptation products and services providers. In chapter 3 we have illustrated how stable adaptation services managed to evolve in time, expand their activities and improve their understanding of policy domain. For example, Ouranos Inc. was established in 2002. Nowadays, it is composed of 450 researchers, experts, practitioners, and policymakers from a variety of disciplines. Ouranos Inc. has more than 10 research programs from climate simulation and services to vulnerability assessments and climate

adaptation (from general to sector and context specific). Climate Ireland has started as a research project but successfully got over the project stage. As they pointed out, long term collaboration with local authorities enables them to anticipate users' needs. Acclimaterra started with public outreach activities and reports on climate in Nouvelle Aquitaine region. Nowadays, they are also part of the regional “*NeoTerra*” roadmap for energy transitions.

We have seen that credible, relevant, and legitimate adaptation services are required. However, as outlined in Dilling and Lemos (2011), the usability of climate adaptation products and services can be negatively influenced by a set of constraints linked to the political context, or to intrinsic features of climate information. The obstacles adaptation services providers faced are numerous. Some are connected to the “*valley of death*” which separates scientists and decision makers (Buontempo et al., 2014). Others are linked to institutional rigidity in academia, which poses important barriers to interdisciplinary and transdisciplinary approaches. Organising successful interactions between scientific and non-scientific stakeholders is quite a challenging task. Disciplinary approaches in climate sciences are not the most suitable for adaptation on local scales. At the same time, the “*publish or perish*” metric is still predominant when evaluating scientific careers, which might create double burden for scientists engaged in AS production. There are no doubts on the need for sound information and knowledge delivered by research institutions. However, scientists and academia must reconsider their roles: do they do science of adaptation (disciplinary) or science for adaptation (transdisciplinary)? The answer to this question will have huge consequences on the methods and goals of research.

When doing science for adaptation, structural stability enables learning by doing between scientists and decisionmakers. The participants explained that decisionmakers are not climatologists and complicated graphs and figures are not an adequate form of knowledge transfer. As pointed out in Porter and Dessai, “*it is assumed that users either have the same capacity, resources, and time needed to make sense of technical knowledge*” (2017:10). In fact, assuring a stable relationship enabled stakeholders to clarify several aspects of adaptation services, such as time and spatial scales, but also allowed decisionmakers to acquire expertise in using them. The role of shared history of knowledge exchange between users and producers of knowledge was identified in the literature (Saarela et al., 2015), but also during our field work. Trust, better connections, and joint re-thinking of socially constructed boundaries between science and policy are believed to foster the appropriation of new tools. As illustrated by Lacey et al's (2018) trust/time model, institutional challenges, such as grant-based research, or short-term research contracts, do not allow for trust to build gradually over time (Figure 24). Moreover, the understanding of decision-making processes allowed boundary organisations to anticipate “users” needs.

As illustrated in chapter 3, Incentives for inter- and transdisciplinary approaches, shared history of knowledge exchange, shared steering groups, coherent material conditions, immunity to legislative turnover are key ingredients for adaptation services' providers. Unfortunately, these characteristics were not observed in all boundary organisations in our sample. Those who were established as a public service, or nested in universities, had better institutional stability. Institutionally stable boundary organisations went through the process of learning by doing and have identified solutions to existing institutional barriers. For example, a university-based BO argued that it is better to "*make an evolution, not a revolution, it will be more solid*". Similarly, a public service BO suggested using existing channels, as new tools can be perceived by policymakers as additional work.

On the contrary, non-profit boundary organisations in our sample face challenges related to the political context. All non-profit boundary organisations in our sample are located in France, and work on regional (and sub-regional) scales. All of them depend on regional funding for their operations, thus they are not immune to legislative turnover. Indeed, the political context had a direct impact on the breadth and scope of their activities. This, in turn, raises questions about the distribution of adaptation as a public good and inequalities between regions in terms of preparedness for climate change.

The issue of institutional rigidity, "*institutional inertia*" or "*the stickiness of institutions*", has been largely discussed by political scientists (Lustick, 2011). Although stable institutions allow our communities to take effective action, institutional rigidity could also lead to suboptimal decisions (Lustick, 2011). Sydney Halpern's (2008) so-called "*hybrid model*" was discussed as an interesting solution for adaptation governance. However, a governance model can be hybrid from different perspectives. For example, it can bring together governmental and non-governmental controls, it can combine central and local authority, or engage a multiplicity of policy actors (Halpern, 2008:85).

Although respondents highlighted the existence of institutional rigidities, they also pointed out that there are feasible solutions to this barrier. The thematic analysis shows that most of the institutional barriers linked to interdisciplinary and transdisciplinary work can be solved with learning by doing. However, this learning by doing is only possible if scientific and non-scientific actors take the time to learn from each other. In turn, taking time is possible in the presence of well-established boundary organisations. Adaptation cannot be 'fixed' but can be addressed and managed, since managing adaptation is more realistic than solving it (Conklin, 2003).

Perspectives

Before discussing suggestions for future research, it is essential to point out that this thesis was characterized by challenges and limits of different nature – linguistic and methodological.

Besides the issues related to “zoom field works” dictated by COVID restrictions, language barriers could have impacted the mapping of adaptation products, services, and knowledge-action systems in the EU. In fact, some information was not available in English, and this represented an important challenge during desk research phase. On the contrary, knowledge of Italian and French did facilitate interactions with boundary organisations from Italy and Quebec. Ergo, we believe that it would be interesting to investigate the emergence of adaptation products, services, and systems in specific countries (eg.: Denmark or Hungary) with native speakers. An additional investigation of other countries (like we did in France) may open multiple possibilities to comparative studies. Moreover, depending on the number of countries involved (few or many), different methodologies may be applied (qualitative, mixed, or quantitative). An additional inquiry may provide more details on the role of decentralization (or other country-specific features) in the development of adaptation systems. Nonetheless, one of the most important limitations of this work refers to samples.

Boundary organisations - small sample (13 BO), composed of organisations working in different countries. Half of these organisations were established in France, introducing an important bias in our results. However, we believe that there is need to conduct an additional study on boundary organisations in France. Our field work took place between 2018 and 2019, thus it is interesting to see how these institutions evolved or have emerged. In fact, at the time the interviews took place, several BOs did not exist. It is the case of HCBC, GREC Francilien, GIEC Pays de la Loire, GIEC Normandie. Conducting an extensive study on boundary organisations in France may improve our understanding on how to improve the uptake of climate information, but also may allow us to propose an “ideal type” of institution capable of dealing with wicked problem such as adaptation. Moreover, a similar approach may be applied to other countries, where adaptation services emerged at various scales. Additionally, Pascale Bosboeuf has recently completed her PhD research on AcclimaTerra and its interactions with GA Greater Châtelleraut and CC Grands Lacs. We can imagine a similar approach to be applied to other boundary organisation in France or in other countries.

Intercommunalities - the size and the homogeneity of the sample is less problematic. The sample is representative for some types of intercommunalities, such as metropolises. However, communities of agglomerations (CA, interviewed 2 out of 27) and communities

of communes (CC, out of 132 federation of communes, only 11 have more than 50k habitants, and we have interviewed 6). Additionally, our sample is slightly biased towards intercommunalities surrounding Grenoble because of COVID restrictions. To complete our results and to repair the limits of our research design, we see 2 possibilities:

1. conduct a larger case study in France. Our investigation into the knowledge needs of local authorities provides good grounds for additional research. Based on the themes identified for semi-structured interviews, and on the themes that emerged during the discussions with local authorities, we can imagine a larger scale research deploying quantitative methods with additional variables. We have pointed out that adaptation to climate change should be treated as public good, and as consequence adaptation products, services and systems should be delivered as public service. We have argued that private services may aggravate inequalities between territories. Several authors have empirically illustrated that income per capita generally reduces the impact of weather shocks (Kahn 2005; Dell, Jones, and Olken 2012). Others have depicted the correlation between Adaptive Capacity, GDP per Capita and Exposure Indice (Bellon and Massetti, IMF, 2022). Generally, these studies inquire on the differences between developed and developing countries, while we suggest analysing inequalities within a country or a region. In the interviews a couple of their intercommunalities pointed out that financial resources influenced the scope of climate plans. However, we do not have sufficient empirical material on the impacts of GDP per capita and adaptation capacities of intercommunalities in AuRA.
2. Focus on a few intercommunalities and scrutinize all stages of their adaptation cycles. Unfortunately, we did not have the opportunity to observe how local climate plans (PCET and PCAET) have been elaborated. For example, Palermo and Hernandez (2020) have studied how to implement a participatory process in climate adaptation planning of different municipalities in Malaysia and illustrated the different levels of citizen participation assigned to each step of the climate adaptation planning cycle. We suggest an additional study on the role of adaptation services throughout the adaptation cycles may represent an important advancement in increasing adaptive capacities of local authorities.

“I hate the term ‘user’” (Skelton et al. 2019:2)

The *user/producer dichotomy* is not always straight forward and sometimes it does not make sense. In other cases these terms dangerously simplify the picture on “*more data-hungry scientists and qualitative practitioners*” (Skelton et al. 2019). According to Skelton et al. (2019) the *user/producer dichotomy* makes sense when describing the aims

(relevance), but it does not offer an adequate description of users. In fact, the authors point out that the term ‘user’ is ambiguous and vague, as it can equally refer to climatologists, public servants or interested public. As the literature on first generation of climate services have been increasingly arguing for service co-production with relevant stakeholders, this vague term became problematic. Although understanding the nuances of user/producer terminology was not among our research objectives, we believe that it deserves further discussion.

Finally, this PhD work focused on climate adaptation governance and services, which might create an impression of polarization between adaptation and mitigation. We argue that adaptation versus mitigation is a false dichotomy. Some measures can be labelled as both, depending on the views of decision makers. We have seen in Chapter 4 that some intercommunalities have included thermic renovations in their adaptation actions. Interestingly, other intercommunalities are also engaged in renovation, but classify it as mitigation. For example, the city of Basel in Switzerland combines these two strategies. Basel authorities have implemented an incentives program to promote green roofs to save energy and reduce emissions (mitigation), but also to lower the indoor temperatures and absorb rainwater (adaptation)⁶⁶. These strategies are complementary and should not be seen as rivals.

⁶⁶ <https://climate-adapt.eea.europa.eu/en/metadata/case-studies/green-roofs-in-basel-switzerland-combining-mitigation-and-adaptation-measures-1/>

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Annex 1: Interview guide -boundary organisations

Thematic questions (after mutual presentations)

Historical evolution, context.

- What factors contributed to the creation of X?
- What perception of climate change in X?
- Who are the central actors in adaptation to climate at [the territorial level concerned]
- What does [the territorial level concerned] implement to promote this adaptation?
- Who are the partners? Have they changed over time?
- What factors contributed to the expansion of activities?
- What place for co-production (in general, perceptions over time). What is the definition of co-production?

Governance and funding

- Funding?
- Source of funding?
- Sustainability of funding?
- Other "non-monetary" sources?
- Who are the partners? What is their place in governance? *power relationships*
- What role in networking? *How is the network articulated and animated? By whom?*
- Who decides the research priorities, the research questions? *Top-down, bottom -up, hybrid?*
- What disciplines are involved in the decision-making process? *Balance between hard science, SHS? Between researchers and facilitators?*

Product/service level

- What are the main products? What target audience? Which sector?
- Has the program evolved over time? How?
- What disciplines are involved?
- What role for "users"? What connections with users?
- Who initiated project X? Who decided on the methods, the objectives? Consensus on methods/objectives ?
- What socio-economic challenges does it respond to?
- What climate information? Other data? Source ?
- Who's tailoring the information / products?

Climate adaptation services

- What does the notion of climate service mean to you?

If a service were to be developed to provide this support for the territories in terms of adaptation:

- Where should it be? On what scale? in which institution?
- what form could it take: external service? internal department? ...
- To bring what?

Evaluation

- How would you rate the impact of xxx on "climate change adaptation"?
- Do you have feedback and evaluation mechanisms in place?
- Can you think of some successful actions/activities/achievements? In your opinion, what were the key elements of this success?
- Can you think of an unsuccessful practice? What led to failure?
- Have there been positive or negative secondary impacts of your activities?
- Can you think of factors that promote the effectiveness of your organisation?
- What about barriers and obstacles? What was your response to obstacles? What can help overcome them?

Annex 2: Interview guide: intercommunalities in AuRA

(Thematic questions after mutual presentations)

Role in adaptation

- What are the issues related to Climate change? Negative/Positive Aspects and impacts
- What is the role of your department in the development of climate policies (and adaptation specifically)?
- What aspects of climate change have been included in the strategies and why?
- What evolution between the first and the second version of climate plan (when possible)?
- What spatial scale are you working on? Time scale?
- How do you ensure coordination between the different strategies of the territory? Eg what are the links with the SCoT, the PLU?

Transversality (organisational cohesion, cooperation; institutional issues and incentives)

- Which other metro services are you working with to implement the adaptation?
- What issues are you working on together?
- How do you ensure consistency between services?
- What organisational factors contributed to the implementation of the climate plan? The obstacles?

Specific needs (Information capacity: availability of info, access to info, relevance and communication, decision-support)

- Do you have specific needs in terms of data? (PCAET 2018: mapping of potential tiger mosquito breeding sites, real-time observatory of temperature and urban humidity, knowing and anticipating the impact of heat on renewable energies, on ground movements, varieties of species, outbreaks ambrosia/mosquito)
- of knowledge? (PCAET 2018: need to improve knowledge on ICU) know-how? (PCAET 2018: train services and elected officials in adapting to climate change)
- partnerships with research labs? If yes, for what?
- How are these needs met today? Who are your contacts?
- In what form should this data and knowledge be transmitted to you to meet your needs? How often does this data/knowledge need to be refreshed/updated to meet your needs?
- Do you have specific expectations that are not currently covered in terms of data, knowledge, know-how to ensure the adaptation of territories to climate change?
- Can you identify barriers/levers in the use of climate information?
- Do you have other needs to elaborate climate plans (adaptation specifically)?

Adaptation services

- What does the notion of climate service mean to you?

If a service were to be developed to provide decision-support for the territories for adaptation,

- Where should it be? On what scale? in which institution?
- What form could it take: external service? internal department? ...
- to bring what?

Annex 3: EU, from CCAP to CCAKAS.

<i>Country</i>	CCAP <i>Data, tools, maps produced by CCAS or by national meteorological services</i>	CCAS <i>Boundary organisations involved in CCAP production or selected adaptation services offered by CCAS</i>	CCAKAS <i>Adaptation knowledge-action networks. Presence of coordination mechanisms built by at least 2 different entities/networks (institutional, research, professional)</i>
<i>Austria</i>	Fact sheets, Data portal, Literature Database by CCCA and ZAMG	KLAR! k.i.d.Z.21-Austria	CCCA – Climate Research Network Austria; The Disaster Competence Network Austria
<i>Belgium</i>	Adapt2Climate		N/A
<i>Bulgaria</i>	N/A	N/A	N/A
<i>Croatia</i>	DHMZ, Prilagodba-klimi (portal)	N/A	N/A
<i>Czech Republic</i>	CHMI, Perun project (projections)	N/A	N/A
<i>Cyprus</i>	Department of Meteorology Ministry of Agriculture, Rural Development and Environment (but no tools or maps were found)		N/A
<i>Estonia</i>	<i>Riigi Ilmateenistus</i>	N/A	N/A
<i>Denmark</i>	Klimaatlas (DMI)	Klimatilpasning (collaboration between Danish Regions, Danish Road Directorate, Local Government Denmark, DMI and several ministries and organisations)	
<i>Finland</i>	Climate-Proof City	Finland Climate Guide	N/A
<i>France</i>	DRIAS; TerriSTORY	AcclimaTerra ; Grec-Sud ; Ouranos AuRA ; RECO ; Creseb	ONERC (work in progress)
<i>Germany</i>	KomPass	Gerics	KliVo Portal; KlimAdapt and DKD networks
<i>Greece</i>	Hellenic National Meteorological Service (HNMS, but no maps or tools were found)	N/A	N/A (A beta release of the national online adaptation hub is planned for the end of 2021)
<i>Hungary</i>	NAGiS	N/A	N/A
<i>Ireland</i>	Met Eireann; Adaptation Tool Box (Climate Ireland)		Climate Ireland
<i>Italy</i>	ISPRA	CMCC	N/A
<i>Latvia</i>	Klimatariks, LEGMC	N/A	N/A
<i>Luxembourg</i>	MeteoLux (but no maps or tools were found)	N/A	N/A
<i>Lithuania</i>	LHT, klimatokaita.lt	N/A	N/A
<i>Malta</i>	The Climate Research Group (CRG), part of the Department of Geosciences at the University of Malta (but no tools or maps were found)		N/A
<i>Netherlands</i>	Climate Atlas (CAS); Climate-Proof City Toolbox (Kennisportaal)	Climate Adaptation Services (CAS);	Kennisportaal The Delta Plan on Spatial Adaptation and Delta Programme Steering Groups.
<i>Poland</i>	Klimada	N/A	N/A
<i>Portugal</i>	Portal Do Clima (IPMA)	N/A	N/A
<i>Romania</i>	<i>Meteo Romania</i>	N/A	N/A
<i>Slovakia</i>	<i>SHMU</i>	N/A	N/A
<i>Slovenia</i>	<i>Meteo.si</i>	N/A	N/A
<i>Spain</i>	AEMET	BC3	AdapteCCa
<i>Sweden</i>	Climate scenarios for the sea by SMHI	SMHI (Adaptation center)	Klimatanpassning Governmental agency network for climate change adaptation

Source: The European Climate Adaptation Platform Climate-ADAPT

Annex 4: Adaptation policies in EU and its member states

COUNTRY	NAS	NAP	SUB-NATIONAL STRATEGIES AND PLANS
AUSTRIA	2012	2012	2009 Wien and 2011 Niederösterreich, 2012 Tyrol, Oberösterreich, 2013; Steiermark, 2015; Vorarlberg, 2016; Salzburg, 2017
BELGIUM	2010	2017	2014 Wallonne; 2013 Bruxelles-Capitale (further developed in 2016); 2013 Flemish Region
BULGARIA	2019	x	x
CROATIA	2017 draft	2017 draft	x
CZECH REPUBLIC	2015	2017	2017 Prague territorial self-governing unit (Urban region)
DENMARK	2008	2012	2015 South Denmark, 2016 North Jutland, 2015 Region Zealand and the 2011 Capital Region
ESTONIA	2017	2017	x
FINLAND	2005	2014	16/18 by 2012
FRANCE	2006	2011	2012 IDF, 2012 Centre Val de Loire, 2012 Grand Est, 2012 Franche-Comté, 2012 occitanie, 2013 H & B Normandie, 2013 Bretagne, 2013 Nouvelle Aquitaine, 2013 PACA, 2014 Pays de la Loire, 2014 AuRA,
GERMANY	2008	2011	2009 Bavaria, 2009 Mecklenburg Western Pomerania and Schleswig-Holstein, 2012 Lower Saxony, 2013 Hambourg, 2013 Brandenburg, 2015 Baden-Württemberg, 2017 Hessen
GREECE	2016	x	2016 LIFE-IP AdaptInGR - Boosting the implementation of adaptation policy across Greece
HUNGARY	2008	2010	x no regional, but county level
IRELAND	2012	2014	In January 2018 the Government established four Climate Action Regional Offices (CAROs).
ITALY	2015	2017 draft	2015 Lombardy; 2019 Sardegna
LATVIA	2019*	2019	NAP and NAS represent one document. Regional level has not been very relevant in Latvia, as sub-national level has no defined role in climate adaptation. Nonetheless, Salacgriva urban region has adopted a plan in 2011 (a declaration)
LITHUANIA	2012	2013	Municipalities, together with relevant national-level ministries, are responsible for the implementation of the Strategy for National Climate Change Management Policy.
NETHERLANDS	2007	2017	Duch provinces had to elaborate strategies by 2015 (law 2009). DELta project is at the hearth of adaptation processes.
POLAND	2013	x	x
PORTUGAL	2010	2015	2011 Azores, 2015 Madeira, 2017 Alentejo, 2020 de adaptação às alterações climáticas do Algarve (Plano Intermunicipal)
ROMANIA	2013	2016	Region Centre implemented a project aiming to develop a set of good practices on adaptation to climate change, "Greenways for Sustainable Development" in February 2015 – April 2016.
SLOVAKIA	2014	2018	2015 Horná Ondava, 2017 Bratislava Self-Governing Region 2017 (Urban region).
SLOVENIA	2016		x
SPAIN	2006	2009	2008 Basque country (upd 2015), 2009 Aragon, 2009 Canarias, 2009 Castilla y Leon, 2010 Andalusia, 2011 Navarra 2011 Castilla-La Mancha, 2013 Catalunya, 2013 Baleares, 2013 Comunidad Valenciana, 2014 Extremadura, 2014 Madrid, 2016 Galicia, Principality of Asturias, Cantabria, Murcia, La Rioja (work in progress)
SWEDEN	2018	x	County administrative boards responsible for coordination of adaptation since 2006, while municipalities are responsible for comprehensive and detailed plans for local development (bill 2009)

Annex 5: Boundary organisations, type, funding, activities, etc

Institution	Est*	Fund**	Type***	Compiling	Knowledge needs and research gap	Networking and coordination	Decision support tools	Policy development	SP***
BC3	2008	MIX	URES	<u>Policy Briefings</u> ;	promoting integrated interdisciplinary and transdisciplinary research	Klimagune workshop (or a science-policy forum) 50+ research and stakeholder networks	economic- energy-environment model for the Basque Country; project RESIN on city Adaptation (Bilbao)	participated in the elaboration of the Spanish Adaptation Plan.	Y
CAS	2008	MIX	URES	The Knowledge Portal for Climate Adaptation Climate Impact Atlas for the Netherlands	climate ateliers for researchers, policy makers and relevant stakeholders to support spatial planning or strategy development		Interactive Climate Atlases; rapid assessment tool;		Y
CCCA	2011	RES	URES	Fact sheets Literature database	27 research-performing/ coordinating organisations ACRP Dialogue K3 Congress	Annual Austrian Climate Day; https://www.climate-knowledge-hub.org . International Networking Platform for European and International Climate Change Research	COIN - Cost of Inaction	KLAR! Project (elaboration of regional adaptation plans)	Y
CMCC	2005	MIX	URES	Foresight : the synthesis of knowledge produced by CMCC Foundation and its partner organisations.		bilateral and multilateral agreements for scientific and technological cooperation	Map of Resilient Italy; AdriaClim (adaptation in Adriatic Coastal areas)	BLUE AP – Bologna Local Urban Environment Adaptation Plan for a Resilient City;	Y

Institution	Est#	Fund**	Type***	Compiling	Knowledge needs and research gap	Networking and coordination	Decision support tools	Policy development	Sp****
Climate Ireland	2011	PUB	URES	website provides a directory of online resources; Case Study Driectory		coordinate the All Ireland Adaptation Knowledge Exchange Network	Climate Status Tool; Adaptation Tool Box; Local Authority Adaptation Wizard	seminars focused on planning for adaptation on local levels and its links to the national plan. seminars for The Climate Action Regional Offices (CAROs) which took place in Kork, Mayo, Dublin, Kildare. These seminars “reviewed policy and information requirements relating to climate change	Y
Ouranos Inc.	2002	MIX	PCS	numerous reports and factsheets for consortium members (Synthesis on climate change knowledge in Quebec, 2015 edition).	co-financing interdisciplinary and multi-institutional projects that act as bridge between researchers, practitioners and policy-makers; multiple seminars for researchers and non-scientific stakeholders, such as Webinar on GHG scenarios	coordinate climate-change research in Québec;	Climate scenarios and services for regional, national and international stakeholders: mapping tool of climate impacts for Quebec (Climate Portraits)	Climate governance program (Portrait climatique régional en soutien à l’analyse des impacts et de l’adaptation sur le territoire Eeyou Istchee Baie-James	Y

Institution	Est*	Fund**	Type***	Compiling	Knowledge needs and research gap	Networking and coordination	Decision support tools	Policy development	Sp****
MedECC		PUB	NONP	MedECC booklet, report on the current state and risks of climate and environmental changes in the Mediterranean, Atlas of projected temperature and precipitation changes		MedECC is an open and independent network of scientists working towards a regional science-policy interface. UfM Member States rely on MedECC for the assessment of climate and environmental impacts on the Mediterranean			N
SMHI	2012	MIX	ENWS	The klimatanpassning.se online portal: Case studies		Governmental agency network for climate change adaptation	Climate scenarios; Climate scenarios for the sea; Climate Adaptation Game	Knowledge Centre has arranged workshops and drawn up guidelines, guidance and reports to support Sweden's climate change adaptation work; Expert support to the Ministry of the Environment and participating in development internationally.	Y
Accimaterra	2012/2016	PUB	NONP	report « Anticipate climate change in Nouvelle-Aquitaine »		Climate Train (awareness initiative); AclimaCampus, Semaine du Climat (schools and highschools)	Projet "Retour réflexif sur le suivi des PCAET"	Regional Energy Transition roadmap Néo Terra	N

Institution	Est#	Fund**	Type***	Compiling	Knowledge needs and research gap	Networking and coordination	Decision support tools	Policy development	Sp****
Creseb	2011	PUB	PCS	reports and factsheets, case study and literature database	promotes and co-constructs interdisciplinary projects; cycle of webinars dedicated to the deployment of Hydrology, Environment, Uses and Climate analyzes	brings together around fifty members, such as : representatives of public institutions, scientists from Breton research establishments and water management actors		French State and Brittany Region have solicited Creseb's scientific support for elaboration of a regional plan against the proliferation of green algae (PLAV2)	Y
Grec-Sud	2015	PUB	NONP	Books, reports, and web articles		organizes events to raise awareness and foster collaboration between scientific and non-scientific stakeholders (conferences, thematic days, etc.), co-organised national Adaptation Conferences in 2018 and 2021			N
Ouranos AuRA	2014	MIX	URES	involved in the Trajectories Project of Grenoble-Alpes University and - set up a climate data platform	Surveys on users' needs; seminars for researchers and non-scientific stakeholders;	co-construction of scientific projects with operational stakeholders; involved in the Climat-Metro project co-built with Grenoble-Alpes Municipality; organised a photo exhibition "Alpine Anthropocene" to raise awareness on impacts of climate change in the French Alps	traineeships to increase the capacities of local actors (climate datalabs)		Y

Institution	Est*	Fund**	Type***	Compiling	Knowledge needs and research gap	Networking and coordination	Decision support tools	Policy development	SP****
RECO	2017	PUB	NONP	report on climate change in Occitanie in 2021, tool for mapping climate action in the region (research projects, public actions, non-profit initiatives, etc); summary sheets	Surveys on users' needs				N

*Est – year of establishment.

**Fund- funding: PUB – public; MIX- mixed (public + research).

***Type: URES – university and research; NONP – Non Profit (eg.: association not nested at university); PCS - Public climate service, not related to national weather service; ENWS – extension of national weather service.

**** SP – scientific production, refers to direct involvement in research projects. Y -Yes; N- No.

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