

Knowledge and information needs of adaptation policy-makers: a European study

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Abstract Across Europe, national governments have started to strategically plan adaptation to climate change. Making adaptation decisions is difficult in the light of uncertainties and the complexity of adaptation problems. Already large amounts of research results on climate impacts and adaptive measures are available, and more are produced and need to be mediated across the boundary between science and policy. Both researchers and policy-makers have started to intensify efforts to coproduce knowledge that is valuable to both communities, particularly in the context of climate change adaptation. In this paper, we present results from a study of adaptation governance and information needs, comparing eight European countries. We identify sources and means for the retrieval of information as well as gaps and problems with the knowledge provided by scientists and analyzed whether these appear to be contingent on the point in the policy-making cycle where countries are. We find that in this early phase of adaptation planning, the quality of the definition of needs, the way uncertainty is dealt with, and the quality of science–policy interaction are indeed contingent on the stage of adaptation planning, while information needs and sources are not. We conclude that a well-developed science–policy interface is of key importance for effective decision-making for adaptation.

Keywords Adaptation · Boundary organization · Europe · Policy cycle · Public policy · Science–policy interface

Introduction

Adapting to the impacts of climate change is a complex endeavor not only for scientists, but also for decision-makers. First, because of the inherent uncertainties in predicting future climate impacts, it is difficult to choose the right adaptation measure for a given problem (e.g., Dessai and Hulme 2004; Fankhauser et al. 1999; Ingham et al. 2007). Second, because adaptation problems operate across multiple scales, they need to be approached in a manner that involves multiple levels of governance (cf. Adger et al. 2005; Amundsen et al. 2010). Third, because adaptation problems do not occur in isolation, but in the context of social, demographic, political and economic change, cross-sectoral negative and positive side-effects need to be considered (O'Brien and Leichenko 2000).

Successful adaptation decision-making needs a broad practical and scientific knowledge base, which requires communication between scientific research communities, policy-makers and stakeholders to be useful (Cash et al. 2006; Patt et al. 2007). In climate change research, this area of overlap between the two domains is known as the science–policy interface (Jones et al. 1999) and the interactions taking place as boundary work (Guston 2000, 2001). While much of this research focuses on normative qualities of these interfaces and of the information provided by the scientific community, this information needs to fit also the practical knowledge needs of the policy community, if it is to be salient to them, and hence of value (Cash and Moser 2000).

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In places such as Europe, a cycle of policy-making to respond to the needs for adaptation is underway. Over the past years, many European countries have started to strategically plan adaptation (Biesbroek et al. 2010; Dreyfus and Patt in press). From the start, scientists were closely involved in these processes to provide the necessary scientific basis. The EU claimed its role in coordinating European adaptation efforts starting in 2007, with the Green Paper on Adaptation (European Commission 2007). Two years later, the White Paper on Adaptation laid out a roadmap to reducing the Union's vulnerability. For the first phase of this road map from 2009 to 2012, the European Commission (2009) defined four aims, the first of which is the constitution of a solid knowledge base on the impact and consequences of climate change for the EU. This aim includes the development of a Clearing House Mechanism for sharing information on adaptation in the member states (European Commission 2009). By formulating this aim and providing adequate incentives, the European Commission gave a clear mandate to the European research community to investigate climate impacts and adaptation in a way that is helpful to policy-makers. Now that adaptation is clearly on the policy agenda in a number of European countries, it is possible to identify, empirically, what information needs of actual decision-makers are.

In this paper, we report on how policy-makers get the information they need and use this to address the particular question of whether this is contingent on the stage of policy-making they are at. The answers have practical implications for the design of institutions at the science-policy interface, what types of information they ought to be providing in the adaptation arena, and the extent to which these design aspects represent a change from current practice. We present results from a study of adaptation governance and information needs, comparing eight European countries. Drawing from document reviews and interviews with decision-makers themselves, we identify sources and means for the retrieval of information as well as gaps and problems with the knowledge provided by scientists.

Background

The policy process for adaptation has been stylized as a circulative model consisting of a number of iterative stages (e.g., Willows and Connell 2003). These stages although different in number and specificity are similar across various models, which have been provided by institutions such as the UK Climate Impact Programme, the UNFCCC and the EU Adaptation Clearing House Mechanism. They include a starting phase of problem identification and definition, an impact—and vulnerability assessment, a phase of

adaptation option generation and assessment, followed by an implementation phase, followed by a monitoring and evaluation phase.

Given the nature of adaptation, it is clear that policy-makers, at least intermittently during this policy cycle, require input from the scientific community. Empirical research has demonstrated, however, that the manner in which this input is provided, indeed how this input is generated, can make a large difference as to how it will be taken up and further used by policy-makers. The tenor of this work has been to move from the “loading dock” (Cash et al. 2006) or linear model of communication—whereby scientists dumped a lot of information on policy-makers and expected them to be able to sort it out—to the coproduction of knowledge (Jasanoff 1990), whereby scientists and policy-makers work together both to define and deliver the information that is needed by particular people. Particular institutions and organizations appear to play a key role in this co-production process (Gieryn 1995; Guston 2001). Based on work by Cash (2001), Cash et al. (2003), Guston (2000, 2001) and Miller (2001), Hoppe (2010) summarized the criteria of effective organizations in this area, what people have come to call “boundary organizations” for their role crossing the science-policy boundary: (1) Double participation, i.e., people from both domains need to be involved, (2) Dual accountability, i.e., work needs to confirm to both scientific and policy standards; (3) Use of boundary objects, such as scenarios, assessment reports, models.; (4) Boundary management/coproduction, i.e., communication, translation and mediation between science and policy; and (5) Meta-governance, i.e., orchestration of knowledge across jurisdictional levels.

Both scientists and policy-makers have started to make efforts to better communicate their respective results and needs concerning adaptation. This has shown in several ways: (1) at EU level, the Commission's Science and Society Action Plan (European Commission 2002) as well as a specific focus in the framework programs have reflected the need for more and better communication between scientists and policy-makers by allocating funding to these particular questions (e.g., European Commission 2006, see also the FP6 Waterdiss project as an example). Additionally, adequate dissemination of project results has been required (European Parliament 2006), (2) at national level, different organizations have emerged at the boundaries to facilitate communication between science and policy, such as UKCIP in the UK, ONERC in France, see also “Science-policy interface” of this paper, (3) both policy-makers and the research community have organized joint activities to improve scientific and policy outputs, often by means of stakeholder or expert workshops (e.g., the UNEP, science-policy dialogues, see also Jacobs et al. 2009), and (4) finally, researchers have attempted to make

their results more accessible and user, i.e., policy-maker friendly (e.g., Diedrich et al. 2010; Shaw et al. 2010; Sterk et al. 2009).

At the same time, adaptation planning has incentivized mostly empirical work on the science–policy interface that has been forthcoming for a variety of specific sectors: forestry (e.g., Guldin 2003; Guldin et al. 2004; Janse 2008; Konijnendijk 2004), biodiversity (e.g., Perrings et al. 2011; Watson 2005) and water (e.g., Jacobs et al. 2009; Quevauviller 2010; Vaes et al. 2009), to name just a few. Particularly interesting for our purpose is the work by Tribbia and Moser (2008), who examined the information needs of Californian coastal managers in order to adapt to climate change. The authors conducted 18 in-depth interviews with coastal managers at different jurisdictional levels and followed this up with an extensive survey. They asked questions concerning (1) the kind of scientific information that the respondents used at that time, (2) their problems with available data, (3) information sources the respondents preferred and based their decisions on, (4) the information on global warming, that has been gathered in the respective communities themselves, (5) the respondents desired learning opportunities to better deal with issues of adaptation, and (6) the information and information sources they trusted most. The respondents did not see a lack of available information, but rather wished for better accessibility and user friendliness of existing data, e.g., in the form of a basic structure to integrate available data. An interesting insight was that although scientific information from universities is highly trusted, it is hardly tapped: respondents seemed not to be aware of it or did not use traditional sources of scientific output. Frequent information sources are well-known state agencies as well as interpersonal contacts. The respondents said they would appreciate not simple information, but adequate forums that provide space for discussion and learning.

Vogel et al. (2007), approaching the issue of communicating scientific results on vulnerability and adaptive capacity, investigated what they called the “science–practice interface”. In a case study of southern Africa, they illustrated the evolution of an often complex ‘web’ of different communication pathways and cooperative knowledge production. Although often successful, they identified several problems: (1) difficulties in agreeing on a methodology that could be used by the stakeholders across a wide region; (2) slow delivery of products and results due to time-consuming negotiations to reach common understandings at the science–practice interface; and (3) the absence of an actual organization with the corresponding infrastructure and rules of engagement. The authors highlighted that there is rarely a clearly defined route for science–policy interactions and that more research is needed on the functioning and best position for boundary

organizations. Osmond et al. (2010) suggested a similarly broad framing for “interface organizations”, not only between science and decision-makers but also between science and the general public.

For Europe, Swart et al. (2009) identified four institutionalized, i.e., government sponsored, forms of boundary work that emerged in the context of developing national adaptation strategies: (1) boundary organizations, as described above (2) coordinating organizations, (3) advisory organizations, and (4) organizations specifically set up to draft a national adaptation strategy; the last three have only partly the functions of boundary organizations. However, while organizations such as the UKCIP are often praised in their function as boundary organizations, the authors conclude that it is not evident that this is always the best way to organize the science–policy interface. While this study identifies existing forms of institutionalized boundary work for adaptation, it is purely descriptive. Finally, Van der Sluijs (2005) zoomed in on the issue of uncertainty as particularly relevant at the science–policy interface. He used a monster metaphor—where a monster is a phenomenon that fits two categories previously understood to be mutually exclusive—to identify four coping strategies for uncertainty at the science–policy interface: monster-exorcism (ignoring uncertainties), monster-adaptation (trying to fit uncertainty into existing categories), monster-embrace (uncertainty as something unreal or spiritual), and monster assimilation. He suggests that we currently are in a phase of assimilation, i.e., in post-normal science, uncertainty receives an explicit place in managing environmental risks.

Gaps remain, however, in the existing empirical work on the adaptation science–policy interface. First, with the exception of Tribbia and Moser (2008), most of this research focuses on the scientists’ perspective and includes the expressed needs and expectations of policy-makers only to a negligible extent. Second, uncertainty as an issue to be dealt with at the science–policy interface is often not included, although related research highlights this as a core issue (e.g., Bradshaw and Borchers 2000; Funtowicz and Ravetz 1990; van den Hove 2007; van der Sluijs 2010), particularly for adaptation (Patt et al. 2005; Dessai and van der Sluis 2007). Third, the research on boundary work in the adaptation field has not yet been linked to considerations of where particular decision-makers are in the cycle of adaptation policy-making. We designed this research in order to fill some of these gaps.

Methods

First, we mapped the adaptation governance structure in a number of European countries and then identified the challenges to planning and implementing adaptation

measures in general and the knowledge, tools and information needs of the responsible policy-makers in particular. The European Union (EU) represents a good region to study the issue of adaptation governance, because many of its member states already engage in adaptation planning and policy-making. At the same time, they offer a great deal of heterogeneity in terms of the progress they have made. We studied Austria (AT), Finland (FL), France (FR), Italy (IT), Poland (PL), Romania (RO), Spain (ES), and the United Kingdom (UK), which we chose to represent a number of separate regions of Europe (Northern Europe, Western Europe, Southern Europe and Central- and Eastern Europe CEE), each with somewhat homogenous adaptation and impact profiles. Thus, the selection of country-level case studies is a sample of both the diversity of European governance systems and the diversity of the European natural environment as well as different stages and process designs of adaptation planning. Based on our initial assessment and literature review, the case studies are representative for Northern, Western and Southern Europe. Germany, the Netherlands and Denmark, for instance, are on a similar level as Finland and Portugal's efforts can be compared to those in Spain, whereas Italy, having made no effort at all at the national level is certainly an outlier.

The national level was our core unit of analysis. Adger et al. (2009) argue how adaptation is most likely to be constrained by factors endogenous to a society, such as ethics, knowledge and attitudes to risk or culture. Comparing across a range of countries where such factors are different could thus reveal useful insights. While the importance of all levels, regional and local as well as global is emphasized throughout the adaptation literature, the national level is currently a central pivot for adaptation planning (Adger et al. 2005; Amundsen et al. 2010; e.g., Burton et al. 2002). The activities of governments reflect both international efforts to engage in adaptation (UNFCCC, EU) as well as regional and local needs and are a central point for research and policy coordination.

We considered regional level policies in our analysis depending on the administrative structure of the countries (e.g., federal states), the evolution of the strategy or the nature of sectoral issues. For each country and the EU as a whole, we analyzed policy documents (national strategies, national legislation, research reports, assessment reports, and official websites). As a result of the progress of adaptation policy and the governance culture in each country, the document analysis provided different output and depth of information. Therefore, the extent to which documents play into the analysis varies. For instance, in the UK, a wide range of research and policy documents exist to be drawn upon, while in Romania, few documents were available beyond a brief non-exhaustive guide on adaptation. The national strategies and other adaptation policy

documents, if available, differed significantly in their comprehensiveness (see therefore Swart et al. 2009). We conducted 30 semi-structured interviews with policy-makers in the case study regions between April and June 2010. This was important to fill information gaps encountered during the document analysis and to specify knowledge and information needs as felt by the policy-makers. As the adaptation community is still comparably small in most countries, representative information on adaptation at the national level can be gained by talking to a few key actors. For the interviews, key players in adaptation policy-making were selected, again keeping in mind the different governance regimes. For example, in the case of Romania, NGO representatives were also interviewed, as their generally important role in environmental education and training also extends to adaptation. In Poland and in Italy, where no official adaptation planning is ongoing, it was difficult to find interviewees that were able and willing to answer our questions. In Poland, we were only able to interview regional policy-makers, while in Italy, we only reached one person at the national level, who was willing to provide some insight.

We adopted a common interview protocol, designed to gain clarity on the perspective of policy-makers and their needs for successful adaptation planning. We asked open questions to fill the gaps remaining from our desk-based review and to gain further insight on (1) the status of adaptation policy-making and, if available, the national adaptation strategy (NAS); (2) the science-policy interface; (3) resources and sources for scientific information; and (4) the scientific and practical information needed to plan and implement adaptation, including the use and need of instruments and tools for adaptation decision-making. Several questions were designed to assess the potential role of the EU. Uncertainty over vulnerabilities, impacts and adaptation options was not explicitly included in the questionnaire, but was discussed in more detail if mentioned as a challenge or need. The advantage of using open questions is that answers are truly genuine and not influenced by pre-categorization or pre-defined options chosen by the researcher. The disadvantage is that answers can only be ranked at an ordinal scale and can only to a limited extent be generalized. This needs to be kept in mind when reading the "Results" section.

Results

The status of adaptation policy-making

The status of current adaptation planning varies significantly across the EU. While some countries have not yet started the planning process (e.g., Italy, Poland), others are

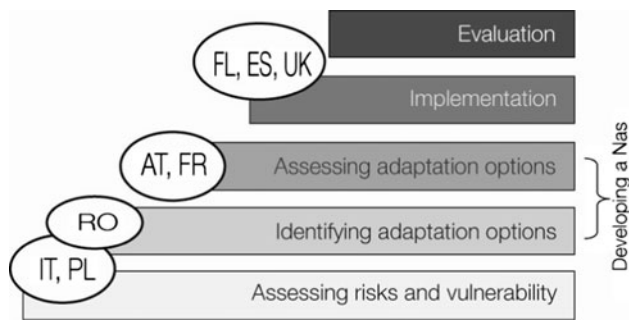


Fig. 1 The case study countries according to their advancement in the adaptation policy process at national level, at least with respect to their first round of strategy development. Factors included in this ranking were: coordinated knowledge production, status and quality of the national adaptation strategy, meta-governance, monitoring and evaluation of the process. The stages of the policy cycle are roughly based on the categories used in the Adaptation Clearinghouse Mechanism, where stages two and three may correspond to the development phase of a NAS

already concerned with issues of implementation and evaluation (e.g., UK, Finland). The selected case study countries reflect this variety (Fig. 1). We ranked the case study countries based on two kinds of criteria:

- Criteria directly related to the stages of the policy cycle:
 - *Existing knowledge on impacts and vulnerability* In almost all countries, we found some form of knowledge on impacts and vulnerability, although this is often quite incomplete, limited to specific sectors and does not always fit policy-makers needs.
 - *National adaptation strategy* Although the existence of a NAS is no guaranty for successful adaptation, it usually accompanies an ongoing awareness-raising process and existing interface structures for adaptation (Biesbroek et al. 2010). The quality of the existing NAS ranks from basic collection of adaptation options (e.g., Romania), to comprehensive plans that include guidelines on implementation and evaluation (e.g., UK, Finland). *Monitoring and evaluation of the process* Some of the case study countries have already begun to evaluate their adaptation work, which is an important step that usually initiates a new iteration in adaptation planning (e.g., Spain, Finland).
- Criteria related to the quality and comprehensiveness of the process:
 - *Meta-governance* refers to the grade to which the planning process included lower jurisdictional levels and relevant interest groups. This is, for example, well achieved and monitored in the UK, and also in Spain and Austria, particularly for

federally structured states this is an important issue from the beginning. However, in several case study countries, the insufficient inclusion of lower level authorities is criticized (e.g., Finland, Poland)

- *Coordinated knowledge production* An important element for creating a broad knowledge base is adaptation research programs, as we find them in most countries with an ongoing NAS process.

Both Italy and Poland have neither a designated research program nor a national adaptation process; however, adaptation efforts are ongoing implicitly in some sectors such as agriculture, sometimes at the national, but more often at the regional level. Independent sectoral, local adaptation efforts are ongoing in most of the case study countries, but could only be considered to a limited extent in the scope of this study.

Science–policy interface

Table 1 highlights that institutionalized, i.e., government sponsored bodies or organizations fulfill, to different extents, the role of a boundary organization in all case study countries that had an ongoing NAS process. We find that the further ahead in the adaptation process the more boundary work is going on. This is often, but not necessarily happening in institutionalized form.

The UK Climate Impact Programme (UKCIP) provides among other outputs, scenarios and socio-economic projections to policy-makers and stakeholders. The climate scenarios have informed public and private sector activities as well as research across nearly all public and private UK work related to climate change. Meanwhile, UKCIP seeks to improve the accessibility of its results. For instance, increased usage was achieved by packaging its information and tools in an internet wizard. Additionally, UKCIP plays a key role in supporting and consulting the private sector and organizations. It is active on all jurisdictional levels. The UKCIP is principally funded by the government department for environment food and rural affairs (Defra), unlike anywhere else it is not directly integrated with a government body but hosted at the University of Oxford. Recently, its activities have been reduced and most of the work was taken over by Defra.

In Finland, coordinated activities between government agencies and research institutes conduct boundary work, e.g., the online climate guide. The *Coordination Group of Adaptation to Climate Change* oversees adaptation planning and implementation and is responsible for the evaluation of the NAS. This coordination body is headed by a ministry, with members from other ministries and national research institutions. In the interviews, the limited involvement of regional and local authorities was

Table 1 Institutionalized organizations/bodies at the science–policy interface of adaptation; ranked according to the advancement in the policy cycle

Organization/body	Accountability	Main tasks	
		Provision of boundary objects	Coproduction/management/meta-governance
UK UKCIP	Government-funded, hosted by the University of Oxford	Scenarios and socio-economic projections, climate wizard	Communication and consulting with private sector and other stakeholders
ES Oficina Española de Cambio Climático Consejo Nacional del Clima	Ministry of the Environment		Coordination entity
	Participatory body		Debating and approving climate change-related policies and plans
FL Coordination group of adaptation to climate change	Inter-ministerial group involving national research institutions		Evaluation of the NAS
FR ONERC	Government agency	Climate simulator, reports	Organization of workshops and exhibitions
AT s.n. (Umweltbundesamt)	Environment Agency Austria in Cooperation with the Ministry of Environment	Writing the NAS, commissioning of assessments	Coordination of participatory process to set up a NAS
RO s.n. (Inter-ministerial working group)	Coordinated by the Ministry of the Environment		Debating and approving the climate change strategy
PL –	–	–	
IT –	–	–	

The information under ‘main tasks’ corresponds roughly with the boundary objects that these bodies provide as well as at the training, translation and mediation functions they fulfill

criticized. This is particularly interesting as in all countries adaptation is recognized as a regional and local problem. Also in other countries, a neglect to involve lower levels of administration is evident. Particularly in Central and Eastern Europe, this is often an issue, because these countries have no tradition of multi-level governance.

In France, the *National Observatory on Climate Change Effects* (ONERC) was established as a coordinating unit in 2001, to collect and spread information, to study and research risks related to global warming and disasters and to formulate recommendations on potential preventive and adaptive actions. ONERC is a government agency and cooperates with different research institutions. It plays an important role in providing boundary objectives, such as a climate simulator, as well as providing reports, aimed at informing policy-makers and other stakeholders at different levels.

The *Environment Agency Austria* was the responsible coordinating body in cooperation with the Ministry for Agriculture, Forestry, Water management and the Environment to initiate and implement a broad participatory process for the development of a NAS. This NAS process was closely accompanied by Austrian climate change

scientists who initiated the interdisciplinary cooperation AustroClim, with the aim to address the challenges of climate change and to support decision-makers and stakeholders. The Agency provides a website with detailed documentation of the process, synthesized information on adaptation and a database of ongoing adaptation measures and research.

Spain has several bodies operating at the science–policy interface of climate change. Particularly important for adaptation are the *Spanish Climate Change Office* a coordinating entity within the Ministry of Environment and the *National Climate Council*, an open and participatory body for approving climate change related programs, policies and plans, where representatives from autonomous regions, municipalities, scientists, and a wide range of stakeholders are represented.

In Romania, an inter-ministerial working group including experts from national research institutes was organized to support the ministry department responsible for the writing of the national climate strategy. However, some competencies such as awareness-raising and education have been outsourced to NGOs, who have limited resources to do boundary work. Italy and Poland at present have

no government sponsored forms of boundary work that could be detected. However, we are aware that other organizations, such as NGOs and research institutes, conduct boundary work to some extent, e.g., in the context of research projects with stakeholder involvement. In Italy, also the UNESCO National Italian Commission is responsible for awareness-raising about climate impacts and adaptation options among stakeholders.

Resources and sources for scientific information

In all countries that have advanced in adaptation policy-making, governments fund and prioritize relevant research programs and projects (Table 2). The generated information is supposed to feed directly into public adaptation efforts. In the UK, several major programs and activities are funded through the UK research councils (publicly funded agencies responsible for funding research). One example is the “Building Knowledge for a Changing Climate” program for the built environment. The UK has a large government-funded climate research base with the Met Office and its Hadley Centre, a number of trans-disciplinary, cross institute research partnerships, including the Tyndall Centre, and there are now many academic institutes which have a climate change focus (e.g., the Walker Institute), including donor funded institutes (e.g., the Grantham institutes). Austria, Finland, and France also have structured climate research programs although less comprehensive than the UK. The French government-funded program ‘Management and Impacts of Climate Change’ (GICC—Gestion et Impacts du Changement Climatique) was initiated as early as 1999. In Finland, FIN-ADAPT and the Climate Change Adaptation Research Programme ISTO are two programs that were particularly important in bringing science into the adaptation planning process. The Austrian Climate Research Program (ACRP)

is a special funding line addressing specifically adaptation with a partial focus on supporting Austrian policy-makers. Also in Austria, the StartClim program, which was initiated in 2002, introduced adaptation as a funding priority in 2008. In Spain, adaptation research was designed as part of the first Spanish NAS. Other ongoing research has only recently been better coordinated through national funding priorities, but here too, research needs are generally covered nationally. In most of these countries, the responsible authorities for adaptation planning, apart from the research programs, often contracted scientists and consultancies to conduct specific assessments that were needed for the decision process.

In Italy, Romania and Poland, but also in other Eastern European member states, no structured research programs are in place (cf. Massey 2009). Italy has research on adaptation ongoing within existing climate change and sustainability research programs (e.g., the Strategic Programme “Sustainable development and climate change”). In Romania and Poland, ongoing research is still much concerned with mitigation and climate change impacts and only little has been done exclusively on the national level. If national projects exist, they are often funded through EU programs. Important research projects are usually conducted in transnational consortia of the EU Framework Programs as well as INTERREG, ESPON and similar programs, which are available for all EU member states. Relevant projects in Poland are the project KLIMAT led by the Institute for Meteorology and Water Management researches future climate change influence on environment, economy and society in Poland (2009–2011), and the INTERREG-funded project ASTRA—Developing Policies and Adaptation Strategies to Climate Change in the Baltic Sea Region. In Romania, similarly to Poland, only vague information could be gained as to nationally conducted research, important research projects mentioned were

Table 2 Resources and sources for scientific information

	Adaptation research program	Uncoordinated research	EU funded research	Assessments	Workshops/ forums	Informal information sources
UK	✓	–	–	✓	✓	✓
FL	✓	–	–	✓	✓	n/f
ES	✓	✓	–	✓	✓	n/f
FR	✓	–	–	n/f	n/f	n/f
AT	✓	–	–	✓	✓	✓
RO	n/f	✓	✓	n/f	✓	n/f
PL	n/f	✓	✓	✓	n/f	n/f
IT	n/f	✓	–	n/f	n/f	n/f

Legend: ✓ source mentioned in the interviews, – existing sources that were not mentioned in the interviews, n/f no information found

Table 3 Knowledge and information needs

	Better structured and accessible data	Regionally explicit information	Vulnerability/socio-economic data	Costs of adaptation	Best practice
UK	✓				✓
FL	✓	✓	✓		✓
ES	✓	✓	✓		
FR		✓		✓	
AT	✓	✓	✓	✓	
RO	✓		✓		✓
PL			✓	✓	✓
IT	✓	✓	✓	✓	✓

The checked boxes reflect knowledge needs mentioned by decision-makers in the case study countries according to their advancement in the national adaptation policy cycle

international ones such as the FP6 projects CLAVIER (Climate Change and Variability: Impact on Central and Eastern Europe) and CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment).

Information needs

Furthermore, we looked for and asked about the kind of information adaptation policy-makers lack in order to plan and implement successful adaptation measures (Table 3). As indicated by the literature, there are gaps that have or cannot be filled even by coordinated research efforts. Interestingly enough the most important need of policy-makers at all stages of adaptation planning was not a lack of information but the need for better filtered and accessible information, this corresponds to the findings of Tribbia and Moser 2008 (cf. “Background”). Too much research results are available and policy-makers feel overwhelmed processing them and usually do not have the necessary time and resources. They need the information to be better synthesized and filtered. In Finland, the necessity for easy and timely accessibility was highlighted. In this particular case, the problem has been solved through an online climate guide. In the UK, general difficulties in accessing certain climate data were mentioned.

In Italy, where local initiatives lack national coordination, any sort of structured provision of information would be helpful to support policy-makers in deciding on adaptation options. In this context, it is important to highlight the repeatedly voiced need for best practices, which policy-makers deem very important for making their own choices. Finnish policy-makers underpin this need by emphasizing that adaptation is a learning-by-doing experience. However, they also note that not all tools can simply be transferred from one country to another. The Austrians argue similarly that best practices from other European countries

might not be applicable in the very specific Austrian natural environment which is dominated by the Alps. In most case study countries, the interviewees did not specify the kind of filter or synthesizing tool that could help most in answering this need, but they agreed that this might be a role that should be taken up by the EU—even the countries that did not think exchange of best practices would be particularly useful to them.

The request for better-filtered information does not mean that there is no need for more research. Generally, policy-makers, with the exception of the UK representatives, agree that more regionally explicit information on impacts is needed. In Austria, this was exemplified through the case of catchment areas, while in the other cases, it was largely left undefined. In Spain, this was listed as part of the knowledge needed to improve the yet patchy scientific basis. Furthermore, there is broad consensus that more research on vulnerability and socio-economic implications of adaptation are needed. Particularly, research in Eastern European country still focuses on mitigation and climate impacts, while adaptation measures are under-researched. Austria and France, but also Poland explicitly mentioned the need for better cost estimations for adaptation measures. Unlike their UK counterparts, policy-makers in the other case study countries have little experience with cost-benefit analysis, which is not a commonly established tool in public administration.

Dealing with uncertainty

Uncertainty in scientific knowledge about climate change, impacts, and adaptation options is one of the core issues in science–policy communication. Interestingly enough, in most of the conversations with policy-makers “coping with uncertainty”, although always mentioned, was not highlighted as a major need. Furthermore, the way uncertainty

Table 4 Dealing with uncertainties

	Not mentioned	Uncertainty as unreliable research results	Uncertainty as barrier to adaptation investments	Hiding uncertainties	Embracing uncertainties	Uncertainties in decision preferences
UK					✓	✓
FL				✓		
ES			✓			
FR			✓			
AT			✓			
RO		✓				
PL	✓					
IT	✓					

The categories result directly from the answers received from the interviewees in each case study country, and the checked boxes reflect how these answers best described the issue of uncertainty

is perceived seems to change with the progression of adaptation policy-making (Table 4). In the countries that have no ongoing planning process, uncertainty was not mentioned at all by the policy-makers we interviewed. In Romania, it was only mentioned in the context of unreliable and diverging research results. In countries that have started more comprehensive planning processes such as Austria, France, and Spain, uncertainty is an issue because of the unwillingness to finance measures based on uncertain information. In these contexts, policy-makers voiced the need to reduce uncertainties. Finnish policy-makers who have dealt with adaptation for almost a decade see a danger that research is tailored to the demands of users by hiding underlying uncertainty. Finally, in the UK, policy-makers, although still recognizing the need to further reducing uncertainties, suggest embracing them too and to try and make good decisions in the context of uncertainty when dealing with climate change. Also new questions of uncertainty are arising in terms of decision preferences. For example, questions about moving settlements versus improving defenses, or sacrificing the natural environment versus adapting to radically changed surroundings.

Discussion

We examined information needs and sources across European countries and analyzed whether these appear to be contingent on the point in the policy-making cycle where countries lie. We found out that in this early phase of adaptation planning, the quality of the definition of needs, the way uncertainty is dealt with, and the quality of science-policy interaction are indeed contingent on the stage of adaptation planning, while information needs and sources are not. Our findings indicate that a well-developed

science-policy interface is of key importance for effective decision-making for adaptation. Several insights support this conclusion:

Across the board, information and research needs—particularly the needs concerning decision support tools—are poorly defined. The main reason for this is most likely the early stage of strategic adaptation planning in Europe combined with the inherent uncertainties of adaptation. In many of our case study countries that have a NAS (e.g., Austria, Finland, and France), mitigation is still clearly prioritized over adaptation and financial and human resources are scarce.

The quality of the definitions of needs goes hand in hand with the progress in adaptation planning. UK policy-makers, who have been working on their country’s adaptation since the 1990s, are able to voice very specific research needs, potential areas for improvement (e.g., information barriers to certain data sets need to be reduced and UKCIP scenario extensions clearly communicated to non-expert users) and redefined or emerging challenges (e.g., embracing uncertainty; moving away from climate-driven approach to a vulnerability-driven approach). At the same time, they use the largest variety of tools (including cost-benefit analysis and sophisticated online instruments). Outside the UK, by contrast, policy-makers were vague about current knowledge needs. One can speculate that in these countries other needs—administrative, communicative, political, and financial—are more urgent at the time. Research needs are expressed very broadly as, for example, “more impact assessments”, “more vulnerability assessments”, “more socio-economic implications of adaptation measures”, “more information on the costs of adaptation measures”, “reduce uncertainty”. In terms of decision-making tools, it appears that beyond workshops, working groups, expert elicitation of various forms and online

platforms of different quality, policy-makers do not yet have a clear picture about what kind of tools might be helped in making adaptation related decisions.

Our findings with respect to uncertainty in the adaptation field are consistent with other research, such as suggested by van der Sluijs (2005), and yet suggest that even countries at relatively advanced stages may find the issue daunting. Policy-makers in the UK have arrived at a stage where uncertainties try to be embraced. Those countries, where “dealing with uncertainty” was also mentioned as an issue, were still in a stage of what van der Sluijs (2005) called “monster-adaptation”, i.e., trying to fit uncertainty into existing categories. While scientists advance in research on uncertainty and have a continuously better pronounced idea of how to deal with it, policy-makers are still very much in the dark. Consequently, our results suggest a continued need to support policy-makers in dealing with uncertainty through boundary work.

We found that in all case study countries that had actively started to plan adaptation, some, in most cases institutionalized form of interaction at the science–policy interface was established right at the beginning of the emerging adaptation efforts, albeit with varying levels of comprehensiveness and government oversight. If we use the criteria for an effective boundary organization introduced in the “[Background](#)” section, the only boundary organization that at the time of the interviews fulfilled all criteria is the UKCIP. In all other countries studied, existing organizations at the science–policy interface conform to the other types of organizations at the science–policy nexus as identified by Swart et al. (2009) or have even a lesser status. Although these bodies operate at the interface of science and policy, many are clearly biased toward the policy side, being sub-units of government departments, or less tightly bound and less obviously biased, such as projects or groups coordinated by government agencies. In these cases, dual accountability is not clearly given. Moreover, such bodies often do not have the necessary capacities to fulfill the roles of a boundary organization as identified in the literature. This is explicitly an issue in Austria, France, and Romania. Admittedly, most of them were probably not set up with the intention to be a full-fledged boundary organization. However, looking at the encountered needs and information mismatches, which exist despite existing efforts (e.g., extensive adaptation research programs, workshops and seminars with participants from both sides), we see the need for an improved science–policy interface.

At the moment, the farther ahead countries appear to be in adaptation planning and implementation, the better developed is the science–policy interface and the more refined and specific are both the expressed needs for information and the handling of uncertainty. Policy-makers

in these countries simply understand the problem better. Given the early phase of adaptation policy in general, this may yet change with the consolidation of the knowledgebase. Nevertheless it appears to be the case that bodies at the science–policy interface of adaptation should fulfill all the criteria of a fully fledged boundary organization, which in turn will help to improve and potentially speed up national adaptation planning. This might not be easily possible in all current settings, as bodies too closely linked to governments may be too biased toward the policy community, too dependent on political good will, and might in turn have not enough resources to live up to the expectations of such an organization. This is one argument for the European Union to foster pan-European boundary work directed toward the member states. Work has already been initiated through the Adaptation Clearing House Mechanism, but not yet yielded any definite results.

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