REVIEW AND ANALYSIS OF CLIMATE SERVICE MARKET CONDITIONS

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LIST OF ABBREVIATIONS

Abbreviation	Full name and explanation
C3S	Copernicus Climate Change Service
CLIPC	Constructing Europe's Climate Information Portal; former FP7 project
CS	Climate services
CSA	Coordination and Support Action
CSP	Climate Services Partnership
ECCA	European Climate Change Adaption Conference
ECLISE	Enabling CLimate Information Services for Europe; former FP7 project
ECMWF	European Centre for Medium-Ranged Weather Forecast
ECV	Essential Climate Variables
ENHANCE	Enhancing Risk Management Partnerships for Catastrophic Natural Hazards in Europe; former FP7 project
EU-LIFE	LIFE is the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU.
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites; is an intergovernmental organisation with the purpose to supply weather and climate-related satellite data, images and products
EUPORIAS	European Provision of Regional Impacts Assessments on Seasonal to Decadal Timescales; former FP7 project
FP6	Sixth Framework Programme; EU Research Funding 2002 – 2006
FP7	Seventh Framework Programme; EU Research Funding 2007 – 2013
GCOS	Global Climate Observing System; is intended to be a long-term, user-driven operational system capable of providing comprehensive observations required for monitoring the climate system, detecting and attributing climate change, assessing impacts of, and supporting adaptation to, climate variability and change

GEOSS	Global Earth Observation System of Systems; a set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors
GFCS	Global Framework for Climate Services
H2020	Horizon 2020, current research and innovation programme of the European Union
HPC	High-performance computing
IMPACT2C	Quantifying projected impacts under a 2°C warming; former FP7 project
Interreg	European Territorial Cooperation; Interreg is part of the EU's structural and investment policy and supports cross-border infrastructure, job market integration and cultural exchange
MARCO	Market Research for a Climate Services Observatory; currently running project under H2020
n/a	Not available
NB	Nota bene (mind you)
NWS	National Weather Services
SECTEUR	Sector Engagement for C3S: Translating European User Requirements; currently running C3S project
SPECS	Seasonal-to-decadal climate Predictions for the improvement of European Climate Services; former FP6 project
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WP	Work package

GLOSSARY

Term	Explanation
Barrier	A barrier represents a factor or process that makes the (co-) development, provision and / or use of climate services more difficult. Barriers in the context of EU-MACS are assessed in political, economic, social, technological / scientific, ethical and legal / regulatory domain. The terms constraint or obstacle are often used synonymously.
Climate services	In the broad sense, "the transformation of climate-related data — often 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 for the society at large. As such, these services include data, information and knowledge that support adaptation, mitigation and disaster risk management (DRM)" (EC's Climate Services Roadmap)
Climate service provider	An organisation that composes climate service products based on own and/or acquired data from observations and simulations with the aim to serve others in the climate services value chain as pure public good, as controlled open data, or as priced product; often providers are at least to some extent also users when the acquired data encompass climate services from others - yet this use often deals with improving the climate service or widening the scope, but deals with decision making beyond climate services.
Climate service purveyor / intermediary provider	An organisation that largely focuses on mediating of climate services, the value added of these services is largely in improving access and presentation of CS.
Climate service user	An organisation, which uses CS for the purpose of improving its own products and services, as well as for better management of risks.
Innovation	a. Technological: focus on adoption and use of technology (assimilation) b. Non-technological: focus on non-technological innovations (organisational, marketing, etc.) (demarcation) c. Complex/architectural: focus on combinations of technological and non-technological innovations, on convergence between manufactured goods and services (integration)
Market	A medium, physically located or virtual, where supply and demand of near substitutes of products and services meet with the purpose to engage in mutually beneficial transactions between suppliers and demanders; a perfect market is fully transparent for all actors in terms of prices and product features, whereas no actor has a dominating position, and new suppliers and users can easily enter

Value chain	The pathway of processing stages of a product or service through which value is added; a complex product with abundant economies of scope such as a climate service (for a particular purpose) can often evolve through more than one pathway, while more pathways may be added (and others abandoned) over time; how and how strongly value accumulates and to whom it accrues when progressing in the value chain depends not only on the pathway, but also on the degree of regulation of the market, the market position of various actors, and the pace of innovation.
Multi-layer perspective	The multi-level perspective (MLP) is a middle-range theory that conceptualizes overall dynamic patterns in socio-technical transitions." "The MLP views transitions as non-linear processes that results from the interplay of developments at three analytical levels: niches (the locus for radical innovations), socio-technical regimes (the locus of established practices and associated rules that stabilize existing systems), and an exogenous socio-technical landscape.

0. NON-TECHNICAL SUMMARY

Deliverable 1.1 - Review and Analysis of Climate Service (CS) Market Conditions is, among other deliverables of WP 1, one part of the project's baseline and serves as input to the demonstration cases in WP 2 to 4. Deliverable 1.1 aims at providing a snapshot of the current market structures in the following aspects:

- Which actors are parts of the market; market here includes the private and public domains.
- What role do they have in the development, provision and use of climate services?
- What barriers occur in these steps?
- What has been achieved in the past years in terms of scientific progress and innovations?
- What are the main drivers behind these latest developments?

By providing answers to these questions, the recipients of the deliverable are project partners engaged in WP 2 to 4 in the first place. Answers are summarized as key messages in the final chapter of this report.

In brief, many different actors are engaged in the development, provision and use of climate related products. It became clear that there is no clear-cut differentiation between most of the actors as they have hybrid roles.

These actors do have different backgrounds, for instance in science or consulting, that lead to specific strengths and weaknesses and the role they (could or could not) play based on them. This seems to be more important than a clear and straightforward categorization of actors.

Barriers were assessed in six domains, i.e. political framing, economic conditions, social, technical and scientific, and ethical factors as well as legal and regulatory requirements. Basically, economic and technological / scientific barriers seem to be most influential, while ethical aspects are least important.

In terms of scientific progress and innovations major steps forward can be identified. First, the database and the observation facilities to gather these data have been improved significantly. Second, the computing capacities needed to handle these data have been improved. Third, advancements in modelling allow providing information with a higher resolution.

Besides product innovation, process innovation plays an important role. Process innovation include, among others, the implementation of evaluation and quality assurance systems that allow to reflect and improve processes and products and the engagement and integration of users of climate related products.

The main drivers and their roles that steer the whole arena of climate services are identified. These could be either general developments, e.g. there is currently a momentum for environmental and climate issues, or political or politically established actors such as European Commission, JPI Climate or the Climate-KIC.

These aspects are subject to more detailed analysis and include more comprehensive conclusion and results throughout the report.

1. BACKGROUND AND AIM

1.1 Background of EU-MACS

Climate change is among the most important societal challenges of our time (World Economic Forum 2016 and 2017). Responding to the challenge requires immediate action to reduce greenhouse gas emissions and to adapt to those unavoidable changes that are already occurring. To do so, climate services play a major role as being part of the solution, as they support climate-informed decision-making on all levels in public administration and private businesses.

Although climate services play a significant role in this sense the market for these services is still in a very early and premature stage of development. To support further product development and effective widespread uptake of climate services, as a means to boost mitigation of and adaptation to climate change as well as capabilities to cope with climate variability, the European Commission has taken several actions in its current research programme Horizon 2020 (H2020). Essentially these actions follow from the logic to implement the European Research and Innovation Roadmap for Climate Services (European Commission 2015)

EU-MACS and it sister project MARCO (Market Research for a Climate Services Observatory) deal with analysis of the climate services market. In addition demonstration calls were launched on the added value of climate services for supposedly high value added sectors with hitherto little uptake of climate services (SC5-01-2016-2017), while other actions focus more on networking activities interlinking to better connect relevant players (e.g. the ERA-NET for Climate Services (SC5-02-2015), and the project funded under the Coordination and Support Action (SC5-05b-2015), called Climateurope.

An extremely important sub-programme in H2020 is the COPERNICUS Climate Change Service (C3S) programme, which aims to generate a very comprehensive coherent and quality assured climate data set meant to support mitigation and adaptation planning, implementation and monitoring. In due course also coping capabilities of (current) climate variability are addressed.

In this framing, EU-MACS – European Market for Climate Services – will analyse market structures and drivers, obstacles and opportunities from scientific, technical, legal, ethical, governance and socioeconomic vantage points. The analysis is grounded in economic science theories on how service markets with public and private features can develop, and how innovations may succeed.

1.2 Aim of work package 1 and task 1.1

'Work package 1 (WP1) – Current market conditions and innovation prospects in the markets for climate services' will prepare the ground for the analyses and tasks that will be carried out in the other WPs, this means to generate all basic information and insights necessary to identify barriers and enablers on the market for climate services, to understand their interactions and conditional validity so as to enable static and dynamic analysis of the climate services market. The static market analysis, providing a snapshot of current barriers and enablers and their significance, includes – in brief – assessments of climate services market structures (task 1.1), ways and levels of resourcing (monetary and human resources) (task 1.2), principles and practices of quality assurance (task 1.3), and the existing data infrastructures for climate services (task 1.4). In addition, the analysis of innovation and market building dynamics (task 1.5) is a prelude to the dynamic market analysis exercised in WP2-WP5. All this is culminating in the development

of a suite of interactive formats through which business models for climate services are probed from both a provider and user perspective (task 1.6), to be carried out in work packages 2 to 4.

'Task 1.1 – Overview of climate services markets and theoretical framework for market analysis' has the objectives to conduct a market analysis including the following elements:

1. **Mapping the involved actors in terms of providers, intermediaries and users:** this activity aims at getting a better understanding of the mentioned actors on the climate service market. This task will benefit from the MARCO (Market Research for a Climate Services Observatory) project to the extent information is already available (according to slightly different time lines).

2. **Devising a list of definitions of climate service products, sectors and sub-markets: i**n order to ensure comparability and merger of results between EU-MACS and MARCO the same terminology should be applied as far as possible. One connection will be made applying the same categories of climate services. This will be taken from the initial terminology developed in MARCO deliverable 2.1.

3. **Reviewing market failures:** it is at the heart of EU-MACS to better understand impediments influencing development, provision and use of climate services along the value chain on the respective climate services market. This also includes a scrutiny of reasons for non-use of climate services.

4. **Assessing scientific progress and innovations in the value chain: t**he value chain related to climate services covers a whole range including science-driven as well as business-driven perspectives. Both perspectives contribute to the development of new and improved services and, consequently, need to be assessed to identify the leverage points mentioned previously.

5. **Current ways of climate services provision and use:** this objective is closely related to #7 below. Provision and use of climate services along the value chain varies substantially and includes freely available and commercial services, very specific and user-driven services and generic and broad services.

6. **Innovation dynamics:** innovation and their dynamics are dependent on many activities and influences from within and without a certain sector. How the CS market will develop is dependent on the role and strength of key actors in the given domain in comparison to others actors in other domains, the relative importance of the topic, and, whether or not, there is a protected area, in which climate services can be tested and improved.

7. **Product chains and provision modes:** value chain(s) in the climate services market will be assessed in order to identify, which actors are involved (see objective 1) and where specific barriers occur (objective 3).

Some aspects of D1.1 still merit further consideration as the project matures and additional survey results are available. In order to avoid serious disturbance of the EU-MACS timeline, these considerations will be included in an updated version of D1.1. At the time of finalizing this document the update is foreseen at the end of 2017.

2. METHODOLOGY

As outlined above, task 1.1 has several objectives, which cannot be achieved by applying only one method. Thus three different approaches are applied to collect all the information necessary.

2.1 Literature reviews

The first step of task 1.1 was undertaking a literature review covering scientific articles, project reports and grey literature to prepare the ground of the online survey in particular. Literature was scanned on various scientific platforms such as JSTOR, Emeralds Insight, Springer and ECONBIZ, but also Google was used to identify non-scientific publications. Main search terms applied in several combinations were climate services, climate information, barriers, innovation, adaptation, mitigation, provision, development, supply, demand, and use. The goal was to identify barriers and innovations mentioned in the several sources that currently hamper or support the development, provision and / or use of climate services respectively. Reasons for non-use were also investigated in the literature review. This part of the analysis also took into account project reports and deliverables of currently running projects such as SECTEUR (Sector Engagement for C3S: Translating European User Requirements; project funded by the Copernicus Climate Change Service) and MARCO.

Additional literature analysis have been conducted in order to address those objectives of task 1.1 that have not been subject of the survey, which are, in particular, the objectives 1.), 2.) and 4.) to 7.).

2.2 Survey

An online survey was created based on the findings of the literature review. The survey was divided in two paths, one addressing users only, one addressing providers and intermediaries. Both paths consisted of several sections, as indicated in table 1. The whole survey is attached to this document in annex 1. As of May 19th 2017 the number of survey participants amounted to 124, of which 81 stated to be a provider and 43 to be a user. Some participants did not finish the survey.

TABLE 1: STRUCTURE OF EU-MACS SURVEYS

Structure of survey for **providers** of climate services	Structure of survey for **users** of climate services
Section A: Who is offering climate services? 1. Type of organisation 2. Position in value chain 3. Location 4. Networking activities 5. Sectors 6. Quality assurance and evaluation of services	Section A: Who is using climate services? 1. Type of organisation 2. Location 3. Networking activities 4. Sectors 5. Quality 6. Resourcing
Section B: What kinds of barriers and related innovations? 1. Description of service 2. Economic barriers 3. Social barriers 4. Technological barriers 5. Ethical barriers 6. Legal and regulatory barriers 7. Innovations	Section B: What kinds of barriers and related innovations? 1. Description of service 2. Economic barriers 3. Social barriers 4. Technological barriers 5. Ethical barriers 6. Legal and regulatory barriers 7. Innovations
	Section C: Non-use of climate services 1. Reasons for non-use 2. Future innovations to make services more attractive

The survey consisted of mostly closed questions. However, some questions in sections A and all questions in sections B and C also provided the opportunity to add free text. The closed questions were designed to approve or disprove the different barriers and innovations identified in the literature review. In addition, in order to gain deeper insights, providers and users were asked to weigh the importance of different barriers and innovations using a five point Likert scale. In order to increase response rate on the users side, the survey was initially translated to German, Spanish and Finnish, and later also to Italian.

Most partners of WP1 contributed to the design of the survey by adding questions or providing general feedback. In order to ensure harmonized and target-group specific speeches, a cover letter was drafted and agreed on between the coordinator of EU-MACS, WP1 co-lead and task lead.

The survey was launched at the end of March 2017 and was available to participants for six weeks until the beginning of May. Multiple pathways for dissemination were used:

- EU-MACS partners provided contacts to the task leader for centralized dissemination; other partners preferred to disseminate the survey in their networks themselves
- Promoting the survey on the EU-MACS website in the news section and the sector sections
- Promoting the survey in social media as the EU-MACS Twitter
- The project and the survey were introduced to a wider audience at the Climateurope Festival in Valencia (at several occasions, i.e. talks, presentations and posters)
- Multiplier organisations were contacted to disseminate the link to the survey within their networks, e.g. ICLEI, European Climate Services Partnership
- Those contacted directly were encouraged to forward the link to colleagues in other departments of their organisation as well as to other persons they consider relevant

A set of methods was applied to achieve the objectives (see section 1.2), one of which was the development and conduction of this survey. However, as the response rate to the survey was lower than expected, we propose to leave the survey open for another six months in order to increase response rates. Even though we do believe it will not change the overall results it would allow more detailed analysis e.g. for specific types of services, types of providers or stages on the value chain.

2.3 Interviews

Semi-structured interviews were designed and conducted in order to validate or reject the findings of the survey. In order to do so, the semi-structured interviews were, like the survey, divided in three sections with up to four subsequent questions (see table 2):

TABLE 2: INTERVEIW GUIDE

Semi-structured interviews – guiding questions	
Understand **where** specific barriers occur	1. Specify the type of organization you work for 2. What types of data and climate services do you use/provide? 3. Describe the services you provide. 4. Specify the type of users you are providing data/services to.
Understand **which** barriers occur	1. What kind of barriers do you face in your activities related to climate services? 2. How do you deal with these kinds of barriers?
Outlook	1. What changes or improvements do you wish for future-times

The interview guide was prepared based on first results of the survey. It was sent to the interviewees in advance in order to allow preparation. Interviews were conducted in late April 2017.

The interviewees were carefully selected to cover the "simplified" value chain of climate services with reference to the Roadmap for Climate Services (European Commission, 2015).

3. MARKET CONDITIONS ON THE CS MARKET

The following chapter will provide the condensed results to each of the main objectives associated with task 1.1 (see chapter 1.2). As for the "internal logic" of the document the objectives are assembled in another order than outlined in chapter 1.2.

3.1 Involved actors – providers, intermediaries and users

Several activities have been conducted over the past years to get a better understanding of the climate services landscape in terms of the involved actors along the value chain described in 3.1. These previous activities (e.g. the mapping activities in the JPI Climate in 2013 and 2014 as well as the ERA-NET for Climate Services in 2016), and activities that are being carried out in the MARCO project (market assessments by kMatrix) complement each other very well. While the mapping activities in JPI Climate and the ERA-NET (Máñez et al. 2014, Engen Skaugen 2014, Banos de Guasiola 2014, Gøransson 2014, www.climate-knowledge-hub.org 2016[1]) provide better insights into the public and research-oriented part of the value chain, the kMatrix approach (Poessinouw 2016), is more apt to cover this part of the value chain. The MARCO project aims at integrating these two perspectives. The results will not be available in time for this report due to different schedules; however, the results in MARCO will be taken into consideration for the bi-project synthesis.

3.1.1 Providers and intermediaries

The aforementioned activities were designed to identify CS providers and intermediaries in terms of their profiles (e.g. what are targeted sectors and main users, types of services, key competencies etc.) but not explicitly their position in the value chains. So, it is not possible to assign the providers that participated in the previous mappings directly to specific positions in our value chain. Analysing previous inventories of CS providers shows a variety of categorizations. For the purposes of the initial mapping of CS providers in the framework of JPI Climate in 2013 / 2014 a rather detailed (and to some extent overlapping), categorization consisting of 12 different types of CS providers was applied (Máñez et al. 2014). The mapping activities conducted within the ERA-NET for Climate Services were mainly based on the typology developed in the Research and Innovation Roadmap for Climate Services (European Commission 2015), which consists of five categories. While the first approach appeared to be too detailed, the second one was too narrow missing out some important types of providers. Thus, a categorization combining the two approaches was chosen consisting of seven categories of CS providers as indicated in the "EU-MACS column" in table 3.

[1] The deliverable to the respective mapping activity conducted in the frame oft he ERA-NET is classified confidential, thus, the insights presented here are based on the publicly available part shown on the Climate Knowledge Hub. This hub is an web-based platform presenting information on providers of climate services. This platform is open to anybody willing to join the network of CS providers by filling in a survey. Based on the entries a profile is created automatically.

TABLE 3: CATEGORIES OF CS PROVIDERS

JPI Climate (2013 / 2014)	ERA-NET for Climate Services (2016)	EU-MACS (2017)
National meteorological and hydro-meteorological service	(Extension of) National weather services	National weather services (or a direct subsidiary)
	Public climate service centre (not from national weather service)	Public climate services centres (not attached to national weather services)
(Federal) State agencies		Public administration / politics (from local to international)
Ministries		
Research institutes	University or research performing organization	University or research institute
Universities		
University networks		
	Non-profit-organization	Non-profit-organization
		Industry or professional body
Private companies	Private business	Private business (from local to international)
Consultancies		
Engineering offices		

Compared to the ERA-NET typology, EU-MACS and MARCO also applied 'public administration / politics' and 'industry or professional body' as CS providers, while reducing redundancies in the science and private business domains of the JPI Climate typology.

Previous mappings within the JPI Climate in 2013 / 2014, and this is supported by the current SECTEUR survey, showed evidence that public bodies should be taken into account as CS providers as significant responses came from that group (i.e. Ministries and (federal) state agencies) (Máñez et al. 2014, Engen Skaugen 2014, Alexander et al. 2016). The private business segment, in contrast, was put together in one group, as the different groups provided almost the same replies in previous mappings, which makes a further differentiation obsolete.

3.1.2 Users

In general, a CS user is considered an individual or organization with **responsibilities for decisions and policies** in climate-sensitive settings, to whom some form of climate information is delivered. According to

this definition, users can be expected to be decision-makers in businesses and the policy area and / or public administrations on various levels from local to international. This notion of a user is also reflected in the value chain depicted in the Roadmap (European Commission 2015). In addition, societal actors are included in the Roadmap called 'public / society'. Societal actors, for instance, could be media, non-governmental organizations or other non-profit-organizations such as industry bodies.

Previous projects and initiatives, such as CLIPC (Constructing Europe's Climate Information Portal) or JPI Climate, assessed user requirements in different respects and, thus, also made stakeholder analysis of different user groups (Lémond et al 2011, Groot, A. et al. 2014, Rössler et al. 2017). The user groups identified in most of these assessments are

- (Climate) Scientists, incl. impact modellers (in some case these two are put together in one user group, sometime they are split up in two)
- Intermediary users such as consultancies
- Societal end users

So, in general the same groups of actors are identified in those projects as well. However, they are considered users of climate services, while in EU-MACS many of them are considered (intermediary) providers. In EU-MACS we applied a user categorization in accordance with the WMO and the Roadmap having included private business and policy-makers. As, for obvious reasons, users can also be expected in the science domain (as identified in previous mappings in JPI Climate), we also included this category.

3.1.3 General findings regarding providers and users

Depending on the purpose of the study, providers and users are considered differently. **However, every segmentation includes the same groups of involved actors being placed at the – more or less – same position in the value chain.**

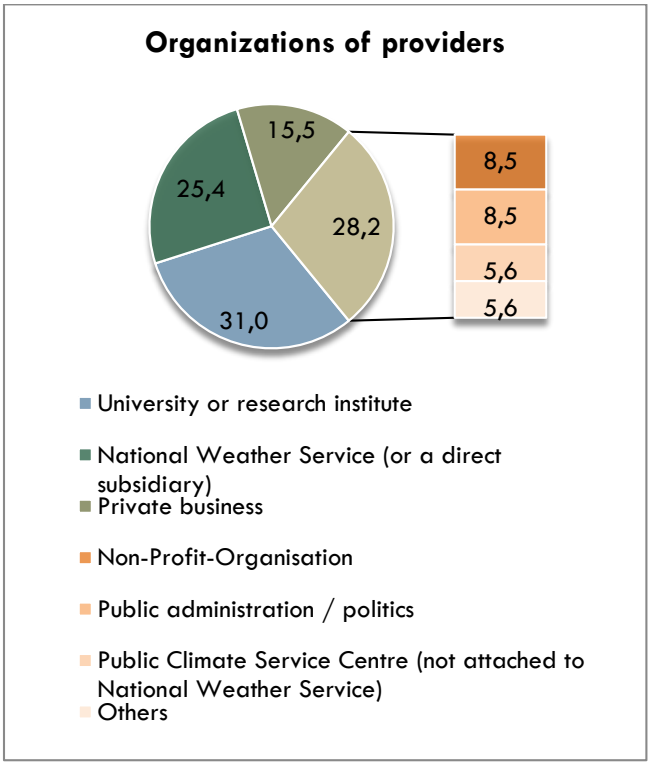
As mentioned above, detailed analysis of the providers and users landscape will be concentrated in MARCO. However, some basic results are:

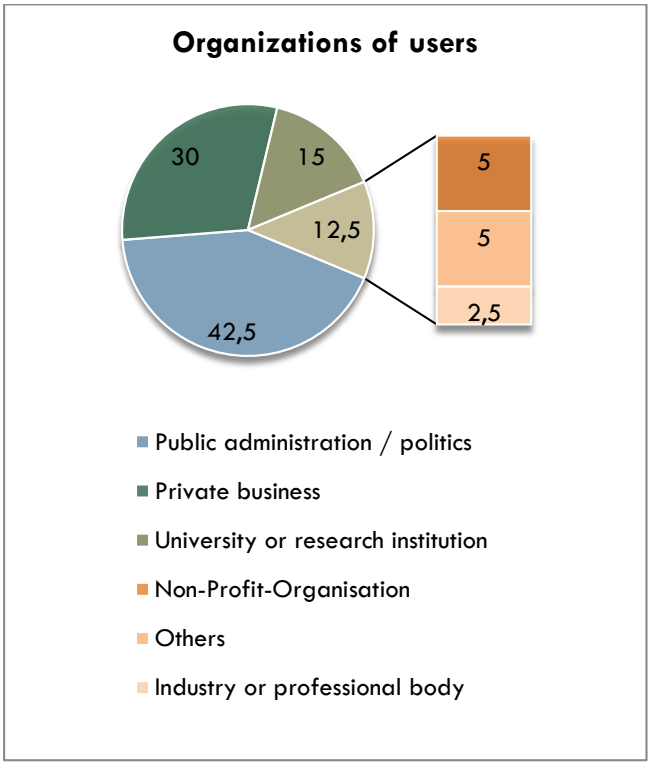
- Overall, it seems to be very difficult to have a clear-cut differentiation between users and providers. As the value chains that are built up in the generation of climate services are typically multi-stage and can take different routes, many organizations in intermediate positions are both providers and users. Depending on their self-perception they consider themselves either as a provider or user of climate services respectively (as we have seen in the survey, some scientists consider themselves as providers, some as 'pure' users).
- The largest groups of users that replied to the survey are public administration / politics (42.5%) and private businesses (30%) and universities or research institutions being the third largest group (15%).
- The largest groups of providers that replied to the survey are universities or research institutes (31%) followed by National Weather Services (25.4%) and private businesses (15.5%).
- As mentioned above, previous mappings showed that some public bodies consider themselves as providers of CS. This finding is also supported by the EU-MACS survey, in which in total 23

participants from public administration / politics responded; of this 23 roughly one fourth (6 in total) indicated to be a (intermediary) provider.

- Other groups of actors that are either (intermediary) providers or 'pure' users are universities or research institutes and private businesses. This is also well in line with previous mapping activities.

FIGURE 1: DIFFERENT PROVIDERS AND USERS PARTICIPATING IN THE SURVEY





There are barely any information on strengths and weaknesses of different types of providers available yet; or none that are based on systematic assessments. Some results could have been drawn from the 2016 mapping of CS providers within the framework of the ERA-NET for Climate Services, but this report and the underlying dataset is classified. A brief characterization of different types of CS providers in terms of their strengths and weaknesses is provided in the Research and Innovation Roadmap for Climate Services (European Commission 2015). Table 4 summarized key strengths and weaknesses of the largest groups of CS providers responding to the EU-MACS survey.

TABLE 4: STRENGTHS AND WEAKNESSES OF LARGEST GROUPS OF CS PROVIDERS

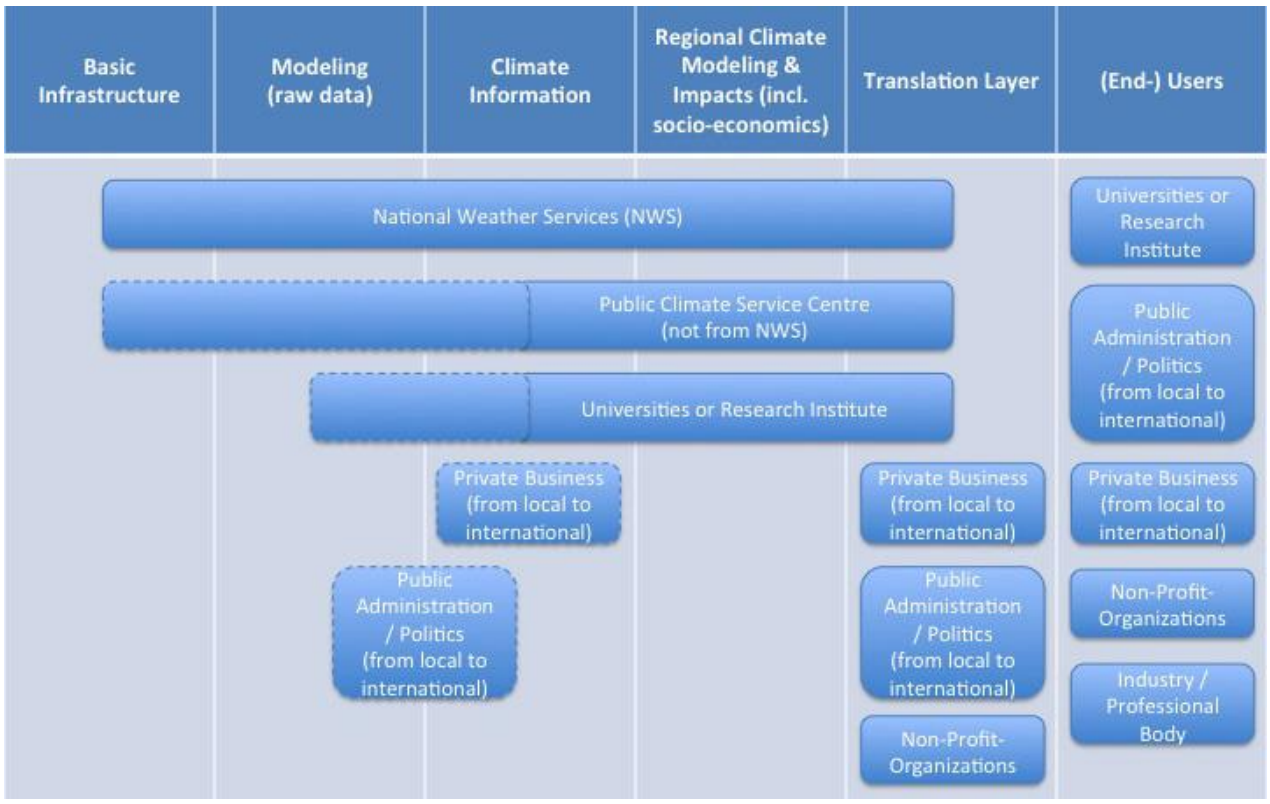
Type of CS provider	Strengths	Weaknesses
National weather services (or a direct subsidiary)	Have traditionally a strong background in meteorology and / or hydrology, a strong infrastructure and (weather) data records of mostly 100 years and more. Very good skills in operational services.	Main focus is on physical data; mostly limited expertise in socio-economic. As mostly operational service they have limited business orientation.
University or research institute	Strong focus on research activities. Even though, a single university institute might only cover one aspect relevant for climate services, the whole 'university' domain includes physical as well as socio-economic expertise.	As universities are research-oriented they lack user knowledge and limited understanding of target sectors and the respective users' needs.
Private business (from local to international)	Strong entrepreneurial orientation and knowledge of users' needs.	Often depended on external climate and impact information.
Public climate services centres (not attached to national weather services)	Most public climate services centres are multidisciplinary, i.e. have expertise in climate and impacts modelling (incl. socio-economics).	Limited entrepreneurial orientation.

3.2 Value chains and provision modes

According to the European Research and Innovation Roadmap for Climate Services (European Commission 2015) a simplified value chain for climate services includes (see figure 2):

- Some **basic infrastructure** such as observational facilities (space, airborne, land-based, sea), high-performance computing and global climate models (incl. model development)
- **Modelling** of (observed) raw data
- Translating the modelled raw data into **climate information and knowledge**
- **Regional climate models and impact modelling (incl. socio-economic impacts**)
- A **translation layer** that translates the outputs of previous steps into useable information and products.

FIGURE 2: SIMPLIFIED VALUE CHAIN FOR CLIMATE SERVICES[2]



These value chains might look different for different types of climate services and / or in different sectors particularly in terms of intermediary providers. These value chains could be 'longer' or 'shorter' depending on the type of intermediaries involved, as some are able to cover more than one step necessary to go from the left to the right side of the chain. National Weather Services, according to the survey (Q2 and Q3), cover almost all parts of the value chain, while private businesses placed themselves mostly in the translation layer (and only very few also provide climate information and knowledge). It is customary to refer to the initial stages of the value chain as 'upstream' (i.e. the left hand ones in figure 2) and later stages (on the right hand side of figure 2) as 'downstream'. Also in this and other EU-MACS Deliverables these terms are sometimes used.

Based on this mapping of providers it can be concluded that there is not "the one" value chain. As summarized in table 4 the different types of providers do have specific strengths and weaknesses. These strengths and weaknesses are also reflected in the simplified value chain above. Private businesses' key competence is strong entrepreneurial orientation and a good understanding of users' needs and target sectors, but they lack climate and impact expertise. Consequently, they primarily position themselves closer to the 'pure' users. This, at the same time, means, they need input from others to develop their services. This could either be universities, public climate service centres or NWS, depending on what they need. But this

[2] Based on replies to the EU-MACS survey. Solid lines indicate the majority of respondents from the respective CS provider types; dashed lines indicate that only some respondents from that group are also active on other stages.

also means that the combination of key competencies of the different providers is needed to create the most effective and efficient climate services.

However, depending on the sector, involved actors, and types of services value chains could be very different. As NWS or public climate service centres are engaged in several steps of the chain it might appear that an "internal" process chain, in which experts from different departments are involved in, is established (which is not necessarily visible outside). On the other hand, there might also be value chains, in which services are delivered from NWS to research performing organizations, which add their expertise, e.g. in hydrological impacts modelling, and provide the new service to a private business, which plans and implements a nature-based solution for flood protection to an urban council. Thus, different pathways through the value chain are possible. It might also happen, that not all steps of this simplified value chain are taken. There are many climate service products available that do not include, for instance, impacts at all. This, however, depends on what a specific user needs.

This makes each step along the value chain unique as the involved actors differ in terms of key competencies, knowledge, field of expertise and many more, which could lead to many potential traps and pitfalls that need to be managed. According to the survey, this also includes internal process chains within institutions acting on several steps of the value chain.

Independent of the length of the chain, it would seem that public providers are typically on the left side of the schematic, operate large research infrastructures such as high-performance computers, observational facilities (airborne, land, sea, and space-based), archive data, and do climate modeling, which requires access to and expenditures for high computer capacities). Further to the right side of the value chain the number of private business providers is increasing. Consequently, the provision modes tend to change accordingly from predominantly generic and publicly available services from public providers on the left side (upstream), to an increasing share of commercial provision of highly customized services from private businesses to the right (downstream). The potential to generate value added by means of climate services tends to increase when moving from upstream to downstream, largely thanks to better connectivity to other (non-climate) data and information (Anderson et al. 2015; Perrels et al. 2013).

3.3 Definition of products, sectors and sub-markets

Even though the climate services market is still in an early stage its development has gained momentum in the past years leading to an ever-increasing number of providers, users, types of products and market segments.

3.3.1 Categories of climate services

The number of climate services products that have been developed over the past years has increased substantially. In order to make this variety somehow manageable in the framework of this study, services are categorized according to their main features. Literature provides different categorizations of services varying in breadth and / or depth. Depending on the purpose and the scope of the respective underlying studies, the number of categories ranges from four, including several sub-categories (Otto et al. 2016), to sixteen (Máñez et al. 2014).

In case the number of categories is chosen too broadly, overlaps between categories might not allow a clear separation which results in a biased picture of the climate services landscape. If the number of

categories is too small and narrow, differentiation between services will be difficult as results might be inconclusive.

The terminology applied in MARCO (Poessinouw 2016), will also be applied in EU-MACS to ensure comparability and merging of results later during the synthesis in WP5. The terminology applied in MARCO consists of eight categories of climate services, which are (see table 5):

TABLE 5: CATEGORIES OF CLIMATE SERVICES APPLIED IN MARCO

Category	Description
Measurement	Instruments and technologies for measurement and calibration, e.g. provision of assistance and advice in the assembly of sensing arrays for ground-based stations.
Operation	Collection and provision of raw data, e.g. provision of raw data to media weather centres.
Modelling	Modelling of data, both certified and non-certified, e.g. modelling of collated data in order to predict the most likely rate of degradation of the polar ice cap.
Data Management	Provision of calibrated data sets, data archiving, data certification and data sales, e.g. provision of validated data sets to consultancies for further analysis.
Processing & Re-Analysis	Provision of data analysis and retrieval services including data mining tools, e.g. provision of essential climate variable models to academia.
Advisory Services	Advisory services, risk assessment and decision support tools provided to public and private sector organizations, e.g. risk assessment for the long-term location of nuclear power stations.
Other Consulting	Consulting services not elsewhere covered, e.g. provision of advice on corporate statements to shareholders on corporate policy towards climate change.
Publication	General publication of analysis findings, e.g. assembly of publications on climate forecasts based on data and analysis for both private and public sector organizations.

There are further categories of climate services that are not well reflected in the terminology presented in table 5. One example would be capacity building and training (as it is not clear, if capacity building is included in 'other consulting').

3.3.2 Definition of sectors and sub-markets

Similar to defining categories of climate services the definition of sectors and sub-markets can follow different approaches. In policy documents such as national adaptation plans and / or strategies the sectors used are of broader nature. Table 6 provides examples for Germany, the UK, and Finland.

TABLE 6: SECTORS IN NATIONAL ADAPTATION STRATEGIES

Germany (German Strategy for Adaptation to Climate Change)	Finland (Finland's National Strategy for Adaptation to Climate Change)	United Kingdom (The National Adaptation Programme – Making the country resilient to a changing climate)
Building sector	Construction and buildings	Built Environment (incl. flood and coastal erosion; spatial planning)
Transport and transport infrastructures	Transport and communication	Infrastructure (incl. asset management)
Human health	Health	Health and social care systems (incl. emergency services)
Agriculture		Agriculture and Forestry (incl. water management)
Soil	Natural Resources (incl. agriculture, forestry, fishery, water etc.)	Natural Environment
Trade and industry	Industry	Business (incl. supply chains)
Spatial and regional planning (incl. civil protection)	Land use and communities	Local Governments
Biological Diversity	Biodiversity	
Fishery		
Energy (incl. conversion, transport and supply)	Energy	
Financial services	Insurance	
Water regime (incl. water management, coastal protection)		
Tourism	Tourism and recreational use of nature	

This brief comparison shows that, even though the sector borders are drawn differently, they basically contain the same societal domains, which are also reflected in the chapter on key economic sectors of Working Group III of the latest IPCC Assessment Report (AR5) (IPCC 2014). These sectors, however, are selected to steer adaptation or mitigation activities from a policy point of view, and are to some extent drawn according to political responsibilities.

Sectors, however, could also be separated differently as has been done by Poessinouw (Poessinouw 2016), who differentiated between 24 sectors (see table 7), in which climate services are used. This typology, in contrast to the ones outlined above, is very much business-driven.

TABLE 7: SECTORS DEMANDING CLIMATE SERVICES IDENTIFIED BY POESSINOUW

Sector	Sector
Agriculture	Legal and Financial
Biotechnology (manufacturing and research function)	Logistics (incl. air, land and sea travel of people and goods)
Built Environment (excl. civil engineering and project management)	Manufacturing (excl. food and drink, pharmaceuticals, bio-tech, chemicals processing and project orientated engineering)
Business Services (incl. advertising, marketing, consultancies)	News Publishing and Journalism
Communications	Operational Services
Defence	Pharmaceuticals (manufacturing and research function)
Education and training (incl. schools, universities, commercial training services)	Public and Charitable Bodies
Exploration	Renewable Energy
Food and Drink (from post-agricultural to retail sales)	Research and Development
Forestry and Timber (incl. timber processing)	Retailing and Wholesale
Health Care (incl. hospitals)	Tourism and Leisure (excl. hospitality)
Hospitality (incl. hotels and restaurants)	Utilities (incl. nuclear and non-nuclear power generation and distribution, distribution and recycling of water)

This business-driven approach to distinguish sectors might be appropriate for MARCO, which focuses more on the commercial part of the market. The value chain approach applied in EU-MACS, however, includes commercial and non-commercial providers and users. In order to address both groups of providers a combination of the broader, policy-driven and the more detailed business-driven segmentation of sectors has been applied in EU-MACS (see table 8).

Next to these two approaches to categorise sectors there are others available, e.g. according to national accounts using the globally applied International Standard Industrial Classification (ISIC). In EU-MACS D1.2 – in relation to quality assurance – the distinction between climate services is made in terms of (1) historical observations, (2) seasonal forecasts, (3) long term projections, and (4) consultancy embedded CS. This distinction has to do with key differences in verification options (performance measurement), and data origin tractability. In EU-MACS D1.3 is presented a refinement of this (D1.2) categorisation.

However, all these segmentations are in principle 'fluent'. For the purposes of EU-MACS a combination of the policy-oriented segmentation as shown in table 6 and the business-oriented segmentation by kMatrix as shown in table 7 is applied, which is summarized in table 8.

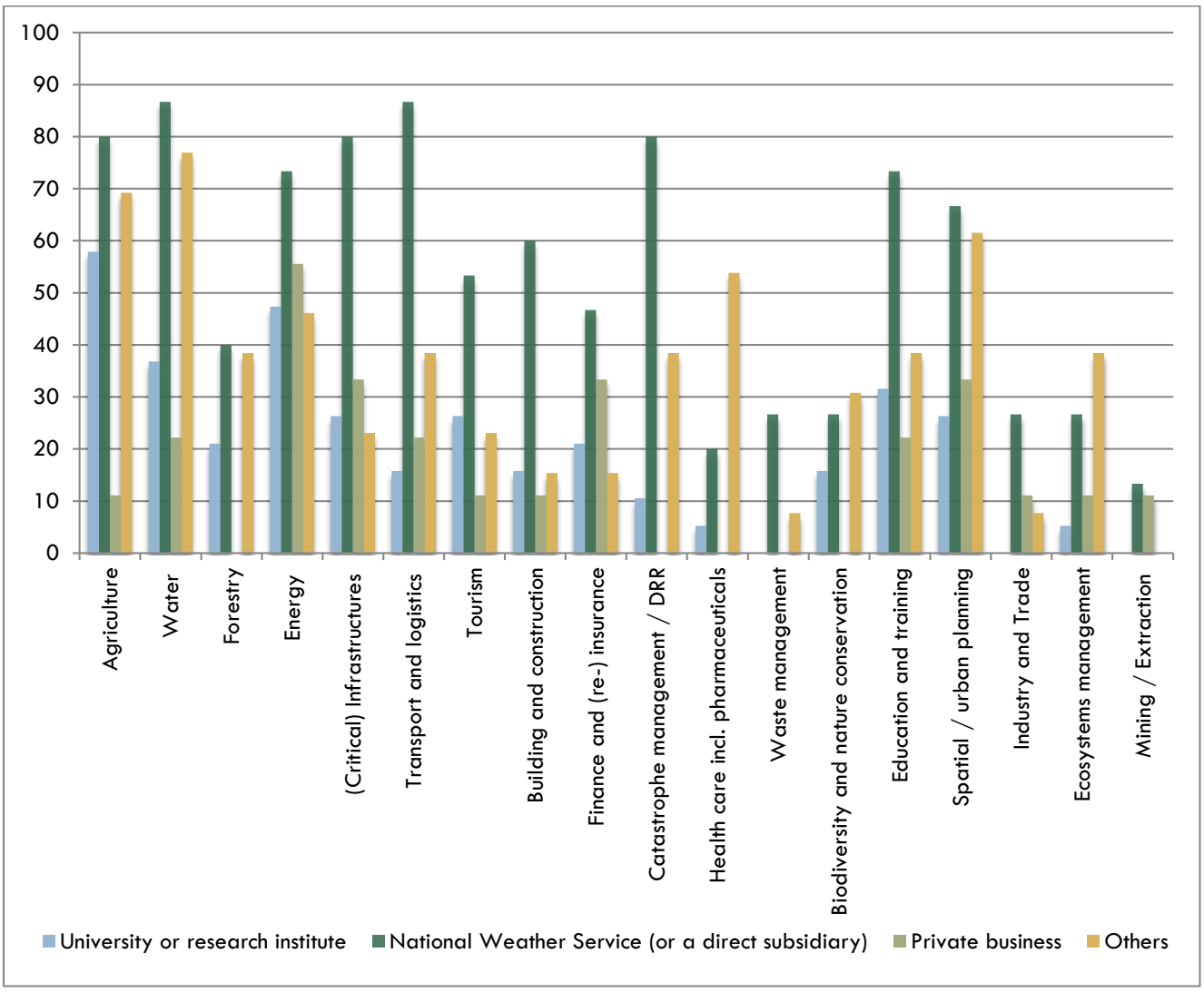
TABLE 8: SECTORS APPLIED IN EU-MACS

Sector	Sector
Agriculture	Health care incl. pharmaceuticals
Water (excl. waterway management and water infrastructures)	Waste management
Forestry	Biodiversity and nature conservation
(Critical) Infrastructures (incl. energy and water supply; excl. roads, rails and waterways)	Education and training
Transport and logistics	**Spatial / urban planning**
Tourism	Industry and trade
Building and construction	Ecosystems management
Finance and (re-) insurance	Mining / extraction
Catastrophe management	

Bold sectors are the ones selected for dynamic analysis in the demonstration cases in WP 2-4)

Figure 3 shows the distribution of the three main types of CS providers to these sectors according to the EU-MACS survey. NWS provide services to almost all 'sectors', which is not much of a surprise as they are typically an operational service provider. Across all sectors, agriculture, water and energy seemed to be those primarily addressed by the participants of the survey. This is the same result as in the ERA-NET mapping of providers (see www.climate-knowledge-hub.org), in which 227 CS providers across 18 countries participated. These three sectors are – in the ERA-NET mapping – followed by spatial / urban planning and education, which are also sectors of high activities in EU-MACS.

FIGURE 3: SECTOR ENGAGEMENT OF DIFFERENT CS PROVIDERS



3.4 Ways of CS provision and use

As outlined in section 3.1, the market of climate services is characterized by different types of providers (public and private) operating on different levels (from local to international) providing numerous different types of services (see section 3.3.1) to a variety of users (from local to international) in different sectors leading to a variety of business models and value chains that are embedded in completely different regulatory framings. The simplified value chain (see figure 2) and the typology of services from section 3.3.1 might serve as a starting point to identify at least some of the features of CS provision and use.

3.4.1 Economic features of climate services

The climate services upstream in the value chain typically require the operation of expensive devices for collecting, archiving, processing and modelling data. Public providers funded by tax money usually do these tasks. Consequently, and in accordance with the latest developments on open data policies, these services are usually **free of any charge**. Examples are the different services provided by the Copernicus Climate Change Service (https://climate.copernicus.eu/services-0) or climate data provided by the EURO-CORDEX initiative (http://www.euro-cordex.net). Intermediary providers develop their own services by taking up these services, adding their expertise to the available non-commercial service and, thus, create a new service with a 'certain' value for users, who then have to pay a price for this added value.

Estimating the size of the **commercial part** of the market is difficult. Even though the methodology applied by Poessinouw should be subject to discussions, there are at least some indications that the commercial market has significantly grown over the past years from 17 billion Euros in 2010 / 2011 to over 24 billion Euros in 2015 / 2016 (globally). The CS market for the European Union has a volume of almost 5 billion Euros in 2015 / 2016. For the European market of climate services the assessment only provided volumes for 2015 / 2016, thus, at least from this report alone, it is not possible to show market growth for the European market. However, the largest share of purchased climate services (almost 24 %[3]) in 2015 / 2016 is advisory services, risk assessments and decision support tools (Poessinouw 2016).

Even though, the commercial part of the (global) market is continuously growing over the past years, the economic benefits of using climate services are still not clear to many potential users. The question to be asked is, how to estimate the **added value** of climate services, why should a user use a climate service at all? This topic is subject to a current (already closed call) of H2020 (SC5-01-2016-2017 – Exploiting the added value of climate services). It is always difficult to assess the benefits of something that might (or might not) happen in the future and that is connected to many uncertainties. Q33 of the survey revealed that the often unclear added value of using climate services could also be a barrier for users. On the one hand, the added value is an argument for users to use climate services – if you use a climate service today (even if you have to pay for it), you can save money in the future – it is also sometimes difficult for providers to demonstrate the added value of their services, as Q12 of the survey showed. Over the course of the EU-MACS project will be explored how a formalized assessment approach of information decay in weather services chains (weather service chain analysis - WSCA; Perrels et al 2012, Nurmi et al 2013, Pilli-Sihvola et al 2016) can be developed into Climate Service Chain Analysis (CSCA). As WSCA CSCA should be able to indicate value added generation potentials and current realizations for designated market segments for different levels of functionality of value chain segments.

Another, even more important barrier, is the step from (co-) developing new climate services prototypes to their operationalization, i.e. to make them marketable. This is not only a question of related technical features of services. It is also a question of **business models**. As the whole climate services market is still premature there are – at least for new service types – no established business models available yet. Business model development, according to Q12 of the survey is the second most important economic barrier for providers. Interestingly, respondents from private CS providers tend to rate this as a more important barrier than those from public providers. This entrepreneurial orientation is also mentioned by Brooks (2013; see also section 3.6.2 for more information) as part of different processes that are currently subject to innovation as well. In addition, it was mentioned during the interviews that providers should establish better

[3] The survey assessment on barriers in chapter 3.5 shows that most respondents also referred to this group of services.

sales skills. A more detailed business model assessment is conducted in D1.2 as well as in WP3 in the sister project MARCO. Results will be integrated in the bi-project synthesis in WP5 of EU-MACS.

Another important economic barrier related to the CS use are the **often limited financial resources** available to users. According to Q33 of the survey, limited financial resources is the most important economic barrier. The same questions showed that human capital in terms of number and proficiency is the second most important economic barrier. These two barriers are interlinked, as financial resources would also be needed to hire new or train existing staff. Financial issues are also addressed in Q27 and Q28. Almost 90% of users stated that the acquisition of climate services entail no or only modest purchase costs. On the other hand approximately 50% stated that the use of climate services requires no or no notable extra resources. Furthermore, so far very few non-users had participated in the survey. It is therefore hard to say whether actual or perceived costs for the user are a significant barrier for uptake.

3.4.2 Technical Features

Closely related to the availability of financial resources is the lack of appropriate technology to use climate services, which is not only the most important technical / scientific barrier for users but also their highest barrier in general (Q35). When technological capacities are limiting CS use and, in addition, user could not invest much in improved technical equipment, provided services should fit in the existing infrastructure.

While the technical equipment is a limiting factor for CS use, the provided climate services are getting more and more advanced in technical terms, e.g. data processing or access to web platforms. This, however, would require some more detailed assessments.

3.4.3 Ethical features

Even though there have been many discussions over the past years, there are no accepted standards available yet that climate services have to meet. According to Adams et al. (2015) CS providers and their services should recognize the following principles[4] (see table 9 and 10):

[4] The CSP has fostered a dialogue on climate services ethics. The results of this dialogue are presented in the white paper ‚Towards an ethical framework for climate services'.

TABLE 9: PRINCIPLES OF CLIMATE SERVICES

Principles of product	What does this mean?
Climate service products should be credible and defensible	Provide information, which data sources, methods, tools etc. have been used or applied to develop a certain service. This information should be well documented and made available to users.
Climate service products should include detailed descriptions of uncertainty	Describe different kinds of uncertainties related to climate services (which includes structural uncertainties, condition uncertainties and parameter uncertainties) and how they 'limit' the usage of CS.
Climate service products should be fit for purpose.	Provide tailored (to geographical and / or temporal) information to the specific decision-makers needs. This also includes an appropriate and understandable language.
Climate service products should be documented	Metadata and version history of certain products should be available to users.

In addition to these principles of products, there are also highlighted some principles of processes that should be followed to develop these products.

TABLE 10: PRINCIPLES OF PRACTICE TO DEVELOP SERVICES

(Selected) Principles of practice	What does this mean?
Communication of value judgments and principles of practice	Provide information that all allow users to better understand and judge the product they receive and whether or not it fits their needs.
Engagement with users and co-exploration	In order to develop services that are fit for purpose providers should engage with their users to understand and continuously update their knowledge of methodologies and context the users is framed by.
Monitoring and evaluation of processes and products	Monitoring and evaluation procedures should allow – users as well as providers – to understand the extent to which a product is delivering intended benefits. The procedures will thus support adjustments to certain products.

3.4.4 Regulatory framing

OPEN DATA POLICIES

The probably most important regulation related to the CS provision are the recent developments in open data policies.[5] In brief, the revised respective EU directive (Directive 2003/98/EC, 2013) aims at making materials held by public sector organizations such as ministries and other public authorities at local, regional and national level, as well as organizations mainly funded by or under the control of public authorities (e.g.

[5] The survey revealed that these developments are considered one of the most important innovations to increase accessibility of information.

meteorological institutes) available for re-use. These materials include written text and databases and other formats. Even though, this Directive explicitly excludes the scientific sector (amongst others), there is a tendency towards open access to research results (e.g. Sancho Reinoso & Helgenberger 2015). Another very important factor related to open data is that open data is by far mostly used to drive innovation as a very recent report by Berends at al. (2017) showed.

QUALITY ASSURANCE

In addition to open data policies, the provision of climate services is mostly influenced by guidelines and principles for quality assurance. These, however, are principles of good conduct rather than actual regulations such as guidelines for good scientific practice (which every organization or institution can define for itself, e.g. DFG 2013) or certified processes (e.g. DIN EN ISO 9001), which aims at improving internal communication and process management and, thus, does not focus on the service specifications as such.

Some critical issues related to quality assurance of services have been mentioned in the previous paragraph on ethical features of climate services. For detailed analysis in this respect also see EU-MACS deliverable D1.2 chapter. In addition, the survey revealed that only a bit more than 60% of the participants have quality assurance process established.

Nevertheless, quality assurance and standards are becoming more and more important and are, to some extent, also discussed in section 3.6.2 – process innovation related to climate services.

REGULATIONS REGARDING THE USE OF CS

Legal institutions and instruments play an important role in climate change adaptation (Cortekar & Groth 2015). Law can facilitate adaptation, using regulation to reduce exposure or sensitivity to climate hazards, establishing the legal architecture for new market mechanisms, and funding arrangements for adaptation costs and liability for climate impacts (McDonald 2011).

Planning for climate change adaptation and the implementation of corresponding measures, thus calls for a strategic approach. The European Commission prepared an adaptation framework for Europe to ensure coherence in adaptation actions across sectors and levels of governance (European Commission 2013). At national level, adaptation strategies and plans provide a general and mostly non-binding policy framework to guide adaptation activities of government authorities and non-state actors.

While national adaptation strategies and policies aim to promote adaptation action, they can also slow down the progress. This includes for example guidance and consistency from higher-level governments, restrictive policies, shifting political ideologies and a lack of regulation and/or funding (Baker et al. 2012, Groth & Nuzum 2016, Porter et al. 2015, Weyrich 2016). Beside these external factors, there are also other reasons for this slowdown that are related to the internal processes of institutions. These include a lack of technical data, unfamiliarity with such data, unclear or ill-defined responsibilities, competing priorities and lack of expertise (Baker et al. 2012, Groth & Nuzum 2016, Measham et al. 2011).

Regulatory and legal context are key determinants of the kind and quality of climate information used. Deliverable 1.2 dedicates attention to the guiding role of legislation and regulation (or lack thereof) regarding CS use, with special reference to the urban sector. It shows how diverse regulations are. In

Germany and the UK, the use of climate projections has not been successfully integrated into local strategic and adaptation planning. In the UK, local governments are aware of the 'best' available climate information but they only use this information in the early process of planning for awareness raising rather than integrating the information throughout the process. German Local Governments make substantial use of past and present climate data. The current regulatory framework requires the use of concrete and accurate information and hence prevents the use of climate projections due to their inherent uncertainty (Lorenz et al. 2013). In addition, as the use of climate projections is not a mandatory requirement for receiving national funding for adaptation, it is difficult to justify any allocation of resources to increase their use (Bubeck et al. 2016, Lorenz et al. 2016).

3.5 Barriers in CS development, provision and application

Research on barriers occurring in development, provision and use of climate services is in a very pre-mature phase. The literature review revealed that barriers related to the processes of adaptation planning and strategy development in different sectors and settings are the dominating topics and have been subject to a whole set of assessments and analysis (Hulme et al. 2007, Biesbroek et al. 2009, Klein et al. 2014, Leichenko et al 2015). An impressive number of barriers has been reported already with a list of possible additional barriers that seems to be almost endless.

In contrast, only very few projects and reports are specifically assessing barriers that impede the process of developing and / or applying climate services, e.g. the FP7 funded project SPECS (Seasonal-to-decadal climate Predictions for the improvement of European Climate Services) or the currently running C3S project SECTEUR. Thus, insights and understanding of barriers in CS development, provision and use is very limited at the moment. However, some of the barriers that are of high relevance in adaptation planning and strategy development could also be of relevance for CS development, provision and application.

In order to identify current barriers and innovations to overcome them for actors being engaged in the CSs market, a market analysis was carried out. The PESTEL tool was used to systematically assess the influences of **p**olicies, **e**conomy, **s**ocial, **t**echnology, **e**thics, and **l**egislation on CS development, provision and use. Table 11 gives an overview of the different types of barriers and what is included in the framework of EU-MACS. However, there are other typologies available. Nevertheless, it is more important to identify barriers and to understand how they interfere the process of (co-) development, provision and use of climate services instead of clearly assign them to a specific category.

TABLE 11: BARRIERS ASSESSED IN THE EU-MACS PESTEL FRAMEWORK

Type of barrier	Explanation
Political barriers	The political setting might hamper the availability or accessibility of services. While open data policies, for instance, could support the use of climate services, other policies can support the development of climate services (e.g. the European Union's HPC Strategy).
Economic barriers	Economic barriers include a variety of aspects such as human capital, institutions in terms of rules for decision-making or distribution of responsibilities, business model development, property rights, demonstrating benefits of using climate services, or simply financial resources.
Social barriers	Social barriers are related to people and processes between them, e.g. different 'languages' in science and practice, expectations, priorities, how to address and integrate them, understanding the framing / regulations of "others"
Technological / scientific barriers	Technological barriers also include scientific barriers as these two types are somehow interlinked. The current computing capacities limit to some extent the resolution of models, which leads to limited understanding of localized processes and impacts. This type of barriers also includes standardization and / or accuracy of information, e.g. bandwidth of uncertainties.
Ethical barriers	Ethical barriers are related to CS products (e.g. provide sufficient information on data sources or methods to develop a product) and processes to (co-) develop products (e.g. stakeholder participation, communication and evaluation).
Legal / regulatory barriers	Regulation and legal obligations are more important for users. They can stimulate or (unintentionally) impede use of climate services. Legal obligations for users do only influence CS providers indirectly as the magnitude of regulations are difficult to understand. This aspect, however, is covered by "incomplete understanding of targeted users and sectors" (which in the EU-MACS framing is a social barrier).

3.5.1 General findings

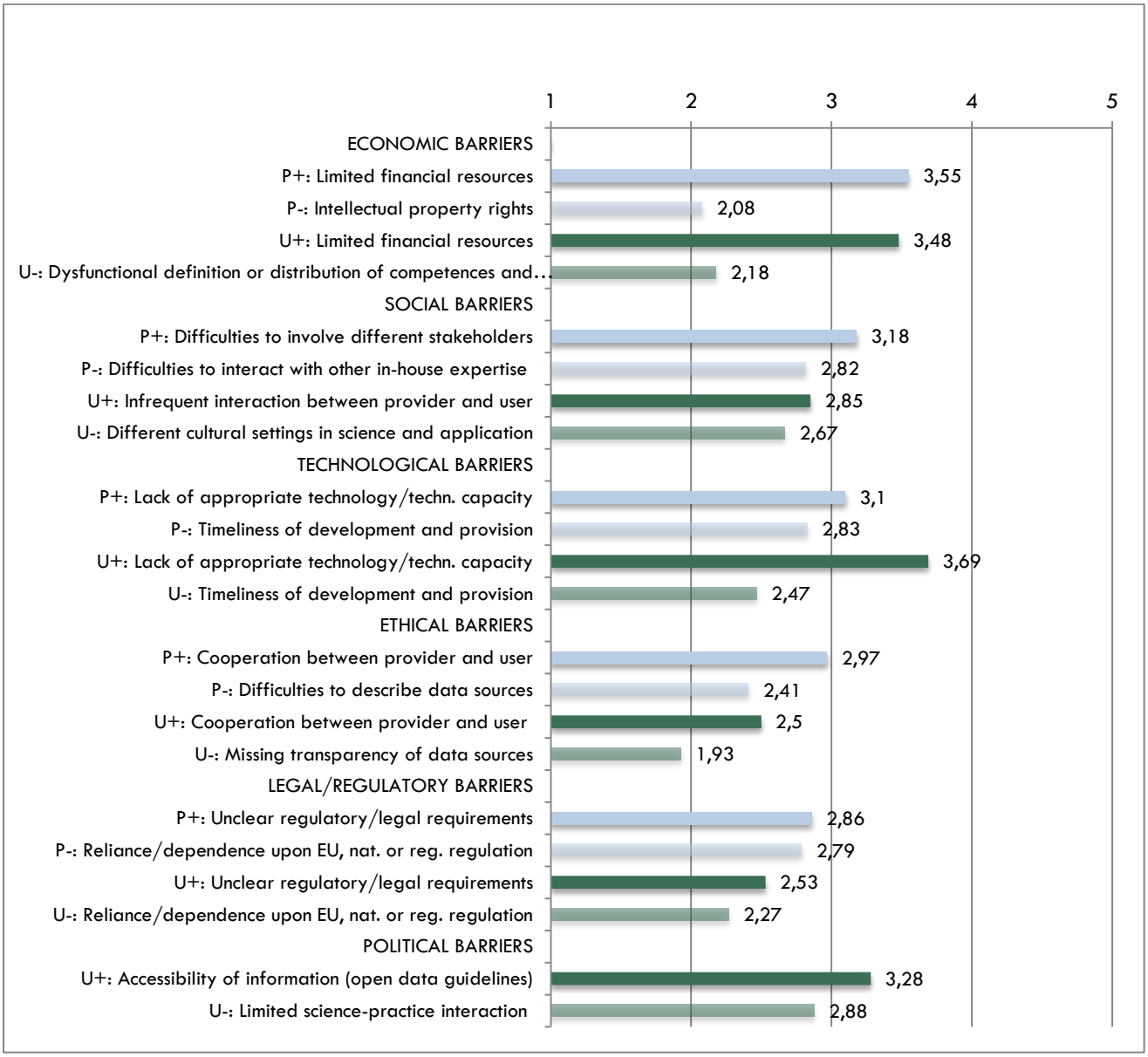
Consequently, participants of the survey got requested to report on the barriers, which they have faced when (co-) developing, providing and / or using climate services within the six fields mentioned above and to rate their importance.

Figure 4 visualizes the six different tested groups of barriers and out of these groups the barriers that either have the highest or the lowest impact on both, providers and users. Providers and users were asked

to rate the importance of barriers and innovations on scale from 1 (low importance) to 5 (high importance). The analysed findings – based on 43 or 44 answers given from providers and 24 or 25 answers given from users – show that there seems to exist a tendency on the providers side to evaluate barriers in total higher than users.

First results of the survey show that providers of CS on average rate limited financial resources as most prominent. This impression differs somewhat from feedback in the Task 1.2 and Task 1.3 interviews (see Deliverable 1.2), in which *public* CS providers tended to regard financial resources not as the primary limiting factor. Both users and providers have rated "limited financial resources" as the one barrier out of all possible economic barriers with the highest negative impact on their climate service activities, with a slightly bigger impact for providers.

FIGURE 4: APPLIED PESTEL ANALYSIS – HIGHEST (+) AND LOWEST (-) BARRIERS FOR PROVIDERS (P) AND USERS (U)



While this is surprising, it is less of a surprise that of all possible barriers tested by the applied PESTEL tool "limited financial resources"[6] was also seen as the overall main barrier for providers. Users, however, identified the "lack of appropriate technology/technological capacity" as the most influential barrier on their climate service activities, thus, a technological one. On average, they also have to face technological barriers first, followed by political, social, economic, legal and ethical barriers. This finding is very well in line with – yet unpublished – findings from the Urban Climate Under Change (Stadtklima im Wandel; http://www.uc2-program.org) project. Users consistently stated that the new climate service under development – i.e. a new urban climate model – has to meet the users' technical requirements as they are not willing or not able to buy new computers to run the model. In comparison to that, providers are on average clearly confronted with economic barriers first, followed by social, technical, legal and ethical barriers.

This different order of groups of barriers show that the applied PESTEL tool on average uncovers different influences of policies, economy, social, technology, ethics, and legislation on the use of climate services for users and providers. Still, also the main barrier for users – "lack of appropriate technology/technological capacity" – goes hand in hand with the second most influential barrier "limited financial resources".

Interviews with experts along the CS value chain provided valuable insights about key barriers and enablers for the European CS market. Interviews have been conducted with a variety of professionals in the CS field, including consultants, researchers and public administrators for governmental organizations. The primary barrier specified across all sectors described a general lack of awareness about the importance of CS data on the customer side and the potential value of climate information related to commercial applications. To resolve this limitation, CS providers need to improve in two key areas:

1. Developing improved communication methods and sales skills when interfacing with clients.
2. Presenting better quality scientific data and determining ways to convert climate information into an easily understandable format free of difficult-to-understand scientific jargon for target clients.

Both points support the results of the survey and are closely related to each other. Even though, improved methodologies for science-stakeholder interactions are considered the second most important innovation by providers (Q17), cooperation between providers and users are also considered the most important ethical barrier by both providers (Q15) and users (Q36). In addition, difficulties to involve different stakeholders is the most important social barrier for providers (Q13). This is also in line with Q14, in which providers state that limited / incomplete understanding of the targeted sector is the second most important technological / scientific barrier. Even though, considerable improvements have been made in stakeholder engagement, there still seems to be room to make the cooperation between CS providers and users more effective and efficient.

By refining efforts in these areas, CS providers will be better able to convince potential users about the importance of including climate data into long-term strategic decision making processes, instead of only short-term risk-reduction planning. Finally, through on-going internal evaluation on the provider side, best practice examples and a profound understanding of CS user needs can be obtained. This systematic monitoring will add to the continued development of policies and regulations that drive positive commitment to the CS sector.

[6] Issues of resourcing are discussed in Deliverable 1.2.

These overall findings of the survey and the interviews are in large part very well in line with the results of the literature review (see table 12). Most barriers reported in recent relevant publications are belonging to the 'economic' domain followed by technological / scientific barriers. Ethical barriers have not been subject to any systematic analysis so far; the referenced publication is a white paper developed by a Climate Services Partnership working group, from which potential barriers have been deduced reversely from ethical requirements that CS should fulfil.

In detail, the literature survey (in comparison with the survey) showed, that at least some attention has been paid to 'accuracy and reliability of services', while the survey showed no evidence that accuracy and reliability is a major barrier.

TABLE 12: SUMMARY OF BARRIERS RELEVANT TO CS DEVELOPMENT, PROVISION AND USE REPORTED IN LITERATURE

Type of barrier	Specification	Source(s)
Political	Not specifically mentioned in literature with respect to CS development, provision or use	
Economic (incl. organizational / institutional issues)	• Organizational setting, practices and routines, i.e. flexible decision-making processes, in-house expertise	Lemos et al. 2012; Bruno Soares & Dessai 2016;
	• Added-value (true value) of CS often unclear / difficult to measure	Lourenco et al. 2015
	• Business Modelling	Brasseur & Gallardo 2016
	• Insufficient human or financial resources	Bulkeley et al. 2011; Lemos et al. 2012; Oberlack & Eisenack 2014; Matasci et al. 2014; Balaban & Senol Balaban, 2015
	• Dysfunctional definition or distribution of competencies and responsibilities	Bulkeley et al. 2011; Oberlack & Eisenack 2014; Eisenack et al. 2014; Balaban & Senol Balaban 2015

Type of barrier	Specification	Source(s)
Social	• Differences in attitudes, priorities and expectations between providers and users	Bruno Soares & Dessai 2016; Brasseur & Gallardo 2016
	• ‚Language' in science and practice	Lourenco et al. 2015
	• Understanding targeted users and their regulatory setting	Lourenco et al. 2015
	• Difficulties involving different stakeholders	Burch 2010; Matasci et al. 2014
Technological / scientific	• Missing standardization of information (forecast type, verification type, layout, terminologies)	Measham 2011; Davis et al. 2015
	• Accuracy and reliability of information	Measham 2011; Lemos et al. 2012; Bruno Soares & Dessai 2016
	• Technical capacity	Bruno Soares & Dessai 2016
	• Inappropriate format of CS	Measham 2011; Brasseur & Gallardo 2016
	• Availability and accessibility	Bulkeley et al. 2011; Davis et al. 2015
Ethical	• Provision is corrupted by personnel / institutional interests	Adams et al. 2015
	• Missing meta information on data sources, methods etc. used to develop services	Adams et al. 2015; Davis et al. 2015
	• Missing or limited collaboration between providers and users (co-design)	Adams et al. 2015
	• Present ‚true' value of a service (show strength and weaknesses)	Adams et al. 2015
Legal / regulation	• Reliance and/or dependence upon national policies and regulations	Oberlack & Eisenack 2014
Others	• Conflicting time-scales or priorities (i.e. short- term interventions based on a long-term vision)	Bulkeley et al. 2011; Eisenack et al. 2014

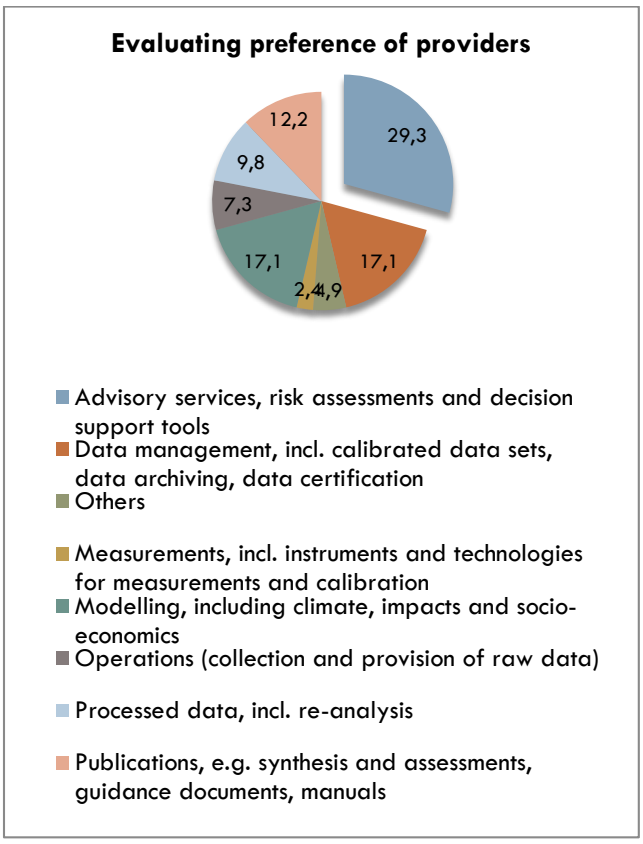
3.5.2 Barriers related to advisory services

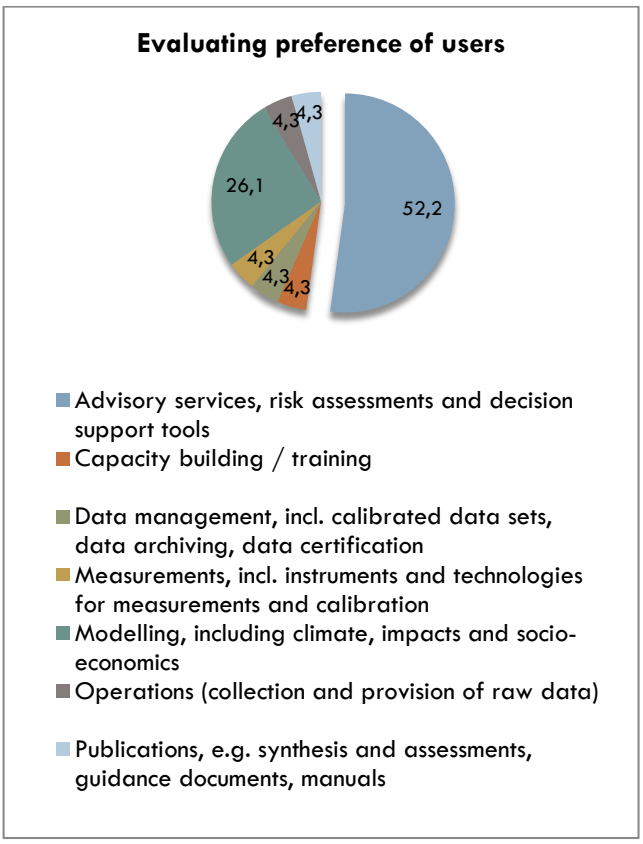
Besides these overarching perspectives on barriers related to climate services in general, a closer look at the CS category 'Advisory services, risk assessments and decision support tools' reveals that (see figure 5):

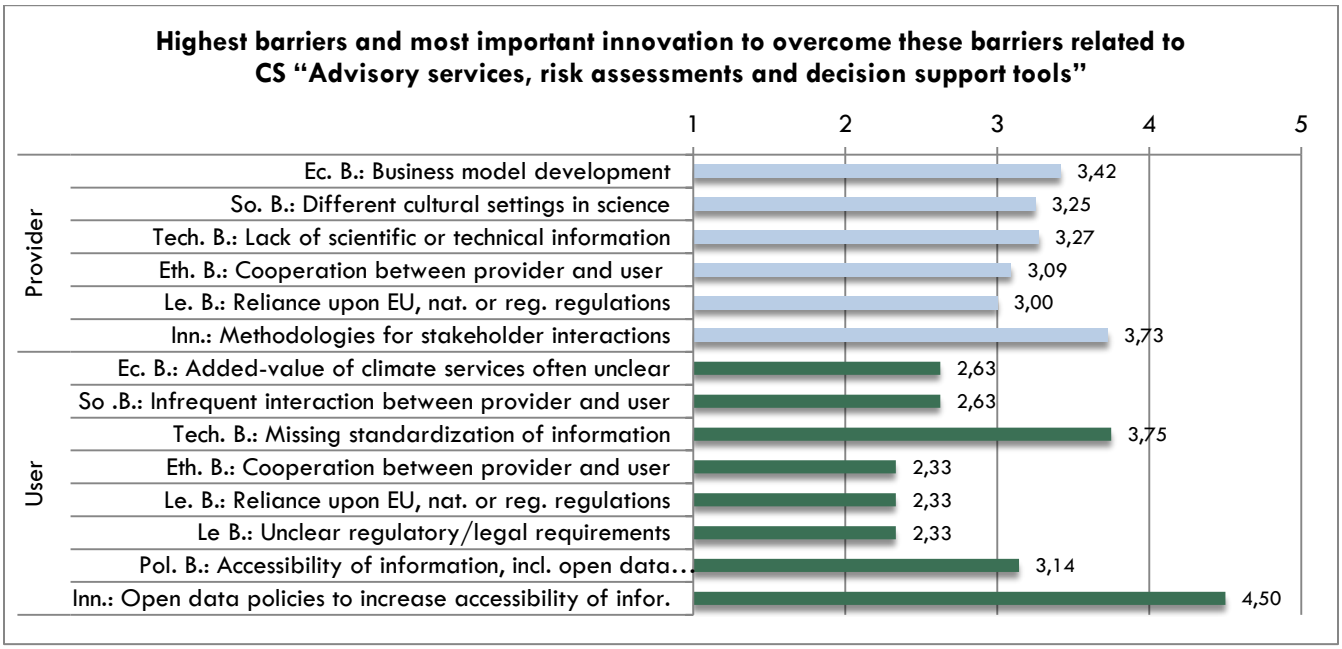
- 'Advisory services, risk assessments and decision support tools' were selected the most by both providers and users of climate services. The second largest types of CS are – also in both groups – modeling (climate, impacts and socio-economics) (see figure 5, upper left and upper right graphics).
- On average there seems to be the tendency that barriers are percieved as being more influencial by providers'.
- Users rate 'missing standardization of information' (technical-scientific barrier) and 'accessibility of information, incl. open data policies' (political barrier) as main barriers related to advisory services, while, at the same time, enhancements in open data policies in order to improve accessibility are considered the most important innovation (see figure 5, lower graphic).
- Providers, in contrast, rated 'methodologies for stakeholder interaction' the most important innovation. This is also reflected by the fact that 'cooperation between providers and users' is among the least interfering barriers; users also rate this barrier as least influential.
- Providers rated business model development the highest among the economic barriers related to advisory services, while overall this barriers is rated the least important economic barrier.
  (NB: The reference related to business model development given in table 12 relates to CS provider organizations, not CS products. However, business model development is also relevant for specific products; as the findings of the survey showed).

The findings displayed in the lower graphics of figure 5 look very different for other types of climate services. However, due to limited replies to the other types of services these analysis will be subject to the updated version later.

FIGURE 5: ASSESSMENT OF BARRIERS AND INNOVATION RELATED TO ADVISORY SERVICES, RISK ASSESSMENTS AND DECISION SUPPORT TOOLS







3.5.3 Reasons for non-use of climate services

Non-use of climate services is difficult to assess in a survey that addresses CS providers and users. So, only a few participants (n = 7) responded to the respective questions in the EU-MACS survey. However, there are at least some indications. The three most important reasons for not using climate services are:

- Users do not know where to get the service or it is not available
- The service is available but provided inappropriately
- The services are not understandable (too scientific).

Even though the response rates are far too low to allow any reasonable conclusion, there are some points to be made.

Firstly, all three reasons have – similarly – also been identified in the SECTEUR survey as important reasons for not using climate services (Alexander at al. 2016).

Secondly, the reasons for not using climate services seem to be related to some important barriers of using climate services. The second most important barrier related to advisory services (see figure 5, lower graphic) for instance is the accessibility, which is somehow linked to the "do not know where to get the service". Q35 of the survey revealed that the inappropriate format of services (arithmetic average 3.47), difficulties to find suitable services (arithmetic average 3.24), and difficulties to access suitable services (arithmetic average 3.37), are barriers to some users. It might occur, that, while for some users these are barriers they can handle, these barriers lead to non-usage of available services by a small fraction of other users.

3.6 Scientific progress, innovation and innovation dynamics

Climate services involve the generation and provision of information and knowledge derived from climate research for decision-making. The transformation of climate (and climate-related) research into practical applications results in climate services.

Scientists around the world are now working to produce climate information on timescales from seasons to decades and to contextualize this information for purposes of adaptation, mitigation and disaster risk reduction. To date, climate services focus primarily on forecasting forthcoming seasons to inform decision making; projecting long-term trends to guide policy making and strategic planning; and monitoring and predicting climate-related hazards for disaster risk management (Vaughan & Dessai 2014).

Yet, state-of-the-art climate information often remains unused because it is seen to be too complex, not sufficiently relevant or unusable. The focus of both scientists and decision makers has shifted to solutions derived from cross-disciplinary and transdisciplinary user-oriented research (Kirchhoff et al. 2013). In this way, climate scientists and service providers now strive to work closely with sectorial experts, practitioners, and policy makers in a process of joint problem solving. In theory at least, the 'co-production' of climate services leads to services that are more effective, more usable, and more suited to user needs.

Consequently, the need for the 'co-production' between scientists and practitioners has been highlighted as the central approach adopted by international programmes such as Future Earth (http://www.futureearth.org), and H2020 to develop a more effective participation process (bottom-up approach). Yet the success of these interventions is intricately linked to the level and quality of scientist-user interactions achieved. To foster new or lasting dialogues between science and decision making, knowledge

brokers, boundary organizations, and most recently climate service specialists (Brugger et al. 2016), are increasingly asked to bridge the cognitive and institutional gap between science and decision making.

This, in brief, is the framing in which scientific progress and CS innovations are embedded. Scientific progress and CS innovations should, in the end, lead to improved, easier to understand, fit-for-purpose climate services that support decision-makers making better-informed decision.

3.6.1 Progress in climate science

IMPROVED MODELLING

In the last half-century more sophisticated climate models were developed to describe the individual components of the Earth system. Due to the rapid scientific, technical and algorithmic evolution of the models and the available enhanced computer power, the horizontal resolution of climate models increased. Climate impact assessments and the development of regional to local-scale adaptation strategies require high-resolution climate change scenarios, including an assessment of their robustness and their inherent uncertainties. The CORDEX initiative 'COordinated Regional Downscaling Experiment' (http://cordex.org) of the World Climate Research Programme (WCRP) provides a framework to improve regional climate scenarios with harmonisation of model evaluation activities in the individual modelling centres (Jacob et al. 2014). Important objectives were to better understand relevant regional and local climate phenomena and to generate ensembles of regional climate projections worldwide, but especially for the regions not covered with high-resolution climate change scenarios. Special effort was dedicated to the communication and knowledge exchange with users of regional climate information. In general the resolutions of CORDEX areas are of the order of 50 km. For Europe, where particularly the EURO-CORDEX collaboration is very active, an integration area of 12.5 km resolution has also been used. Currently developments have started to further increase the resolution of regional climate models to 1 to 2 km horizontal resolution.

The CMIP (Coupled Model Intercomparison Project) activities are another important cornerstone improving modelling activities. With CMIP a standard experimental protocol for studying the outputs of coupled atmosphere-ocean models has been implemented in 1995 (Washington 2012). It allows model assessments and comparison of model outputs.

Besides improved (global and regional) climate modelling there have also been considerable improvements in impact and socio-economic modelling (e.g. agent-based modelling) and, in recent years, in coupling of these models. This means that different models should not run sequentially, i.e. the output of a regional climate model serves as input to an impact model and so on, but integrated, i.e. direct feedbacks between different model types.

Even though progress has been made in these respects the following has to be kept in mind. Firstly, scientific progress in (regional) climate modelling is outpacing developments in impacts and socio-economic modelling so that the knowledge gap is still increasing. Secondly, these so-called integrated assessment models (IAM), however, are mostly used on lower spatial resolutions. As climate change adaptation requires very localized information, IAMs are – for the time being – too rough.

IMPROVED OBSERVATION AND INFRASTRUCTURES[7]

In addition to advancements in spatial resolution of climate information there have also been considerable efforts to improve the available database covering the GCOS (Global Climate Observing System) 50 essential climate variables (ECV). GCOS (http://www.wmo.int/) is a joint effort of major global actors in the field of climate science among others the WMO, UNESCO, UNEP. GCOS aims at providing comprehensive information on the climate system as a whole including physical, chemical and biological properties, and atmospheric, oceanic, hydrological, cryospheric and terrestrial processes. It is based on several domain-based and cross-domain operational observing systems intended to meet the full range of national and international requirements for climate and climate-related observations and, thus, is the climate observing component of the Global Earth Observation System of Systems (GEOSS).

On a European scale it is the European Space Agency, EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites), the ECMWF including the Copernicus Services (including the C3S) that have to be mentioned in this respect.

Improving our understanding of key processes behind and impacts of climate change (which are needed for CS innovation) does not only require better models and better data to run the models. Models that are able reconstruct actual processes better inevitably rely on improved High-Performance Computing (HPC) capacities. These capacities have consequently been improved over the past decades and will further be improved in the future as the European Commission considers HPC as a strategic resource for Europe's future (European Commission 2012).

[7] The infrastructures behind climate services is subject to task 1.4 and a specific deliverable D1.3.

HOW DOES PROGRESS IN CLIMATE SCIENCE ENTER CLIMATE SERVICES?

An example of national climate projections

The latest development of climate model simulations have encouraged national activities to investigate into national climate scenarios. National climate projections are a set of government approved descriptions of future climates in a specific geographical area covering one whole nation. Such national climate projections become influential tools for informing adaptation planning and decision-making in the United Kingdom (UKC09, Jenkins et al. 2009), Switzerland (CH2011 2011), the Netherlands (KNMI 2014) but also outside of Europe, like in Australia (CSIRO and Bureau of Meteorology 2015), and other countries (Skelton et al. 2017).

Two main reasons were cited why the experts felt it was important to produce and disseminate national climate projections (Skelton et al. 2017). First, in order to take well- informed adaptation and mitigation decisions, a single coherent body of locally relevant scientific evidence is needed. Second, such exercises can help advance scientific understanding through the development of new methods, computing power, and working relationships. The British scientists assumed that if users want to make 'reliable, robust, and relevant' decisions, 'they need the best science' available.

The example of the British government centralized investment in national climate projections (UKCP09) resulted in a scientifically sound climate product. Where multi-model ensembles have conventionally been used to assess uncertainty, the UKCP09 scientists felt this method failed to capture the full range of uncertainties. By developing their own method, not only would they make a significant intellectual contribution to quantifying model uncertainties but they could also meet the institutional and political goals set by the Met Office and to produce world-leading science (Skelton et al., 2017).

3.6.2 Innovation in climate services

The previous section described major scientific progress, i.e. improved modelling capacities (global and regional climate models, impact models (incl. socio-economics), integrated assessment models), high-computing capacities, availability of observed data and so on. This is one part of innovations in climate services. The other part is innovations in **products and processes** underlying the (co-) development, provision and use of climate services.

PROCESS INNOVATION

The innovation process by Brooks consists of three elements for developing climate services – engagement, entrepreneurship and evaluation.

Brooks (2013) defines the interaction between CS providers and users as **engagement** that paves the way to innovation. Different levels, ranging from attracting users to long lasting partnerships, characterize this

engagement. This call for intense interaction between providers and users of climate services has become (Lemos & Morehouse 2005, Brasseur & Gallardo 2016) a firm component in climate services. Central pillars for enabling and maintaining an open-minded exchange between the different climate service actors are internationally organized events such as the annual International Conferences for Climate Services[8] (which are organized under the umbrella of the Climate Services Partnership) or bi-annual conferences such as the ECCA or Adaptation Futures, which are explicitly designed to attract science and practice. In addition, there is a coordination and support action (CSA) funded under Horizon 2020 that aims a bringing together different stakeholders of climate services. Within this CSA called Climateurope (http://www.climateurope.eu) several festivals will be organized to facilitate networking.[9] These examples are also highlighting the roles of the major organizations / institutions mentioned above and how they act structuring the innovation regime. This engagement aspect is also reflected in the ethical features related to climate services (see tables 9 and 10).

When leaving the meta level and looking more on interactions between single providers and users when developing new climate services two things seem to be important. Firstly, users are only willing to engage to a certain extent. Their time is also limited and they are facing a trade off between costs (time invested) and benefits (savings based on the used service). So innovations in stakeholder engagement, e.g. new forms of two-way dialogue or new methodologies entering from social sciences such as Living Labs or the Constructive Technology Assessment, could help to address barriers related to stakeholder integration or interaction, to better understand users' needs and so on.

An **entrepreneurial orientation** of climate services encourages innovation (Brooks 2013). This includes creating an environment that encourages people to experiment with product ideas, while being tolerant of failure and project ambiguity. How entrepreneurial concepts are implemented in an organization depends on the type of climate service providers. Entrepreneurship in private sector climate service providers is rooted in direct support of a company's success and wealth creating for its shareholders. Whereas profit is the motivator in the private sector, the creation of social capital or value is the motivation of public entrepreneurship (Brooks 2013). For all climate service providers, the interdisciplinary role of climate services is essential. This is achieved by the development of sustained relations with staff representing different disciplines in the distributed academic world and by an internal effort to synthesize knowledge and to turn it into practical implementation (Brasseur & Gallardo 2016).

The use of **evaluation metrics** will enhance the provision of climate services. This is a new field that calls for innovation as there are no established ways how to track the performance of climate services and to

[8] The ICCS5 brought together a diverse set of researchers, CS providers, intermediaries, users, and sponsors of climate services. The agenda surveyed the theme 'Innovation in Climate Services and Capacity Building' whereby the theme 'innovation' resonated strongly throughout the conference (Viktor et al., 2017). This reflects a widely held belief that there is much more to be learned in designing and operating successful climate services, and that climate service providers are called upon to continually promote and pursue innovation, accepting inevitable failures that will accompany it.

[9] The main theme of the discussions among European climate science communities, funding bodies, climate service providers and users was that sharing knowledge and expertise is key for the creation of a successful climate service market. Moreover, it became apparent that private providers of climate services are already pushing the climate services market and that businesses are ready to use climate services, because they profit from cost savings, business continuity, competitive advantage and a stronger reputation.

evaluate processes and products (Vaughan & Dessai 2014). The identification and implementation of stringent and transparent evaluation procedures are important, as well as quality assurance mechanisms within the climate service community. Separate methodologies should be developed for the range of climate services (public and private) and methodological guidelines should be tailored toward different types of evaluations (Vaughan & Dessai 2014).

A critical reflection of processes and products could reveal leverage points for improvements in both respects, e.g. why cooperation between providers and users is not as effective as it could be (which is an important ethical barrier for providers). The survey, for instance revealed, that among the participants only a bit more than 60% have established quality assurance processes within their organizations. Further insights to common practices of quality assurance and evaluation are provided in D1.2 Part C and D.

PRODUCT INNOVATION

Major relevant projects such as ECLISE, ENHANCE, EUPORIAS or IMPACT2C funded from 2007 onwards (i.e. FP7 and H2020) were assessed[10] in order to identify latest product innovation in climate services.

The majority of projects analysed climate data and trying to make climate change more visible and understandable to public, also helping a variety of stakeholders (in industry, politics, etc.) in their decision-making processes by showing the negative effects of climate change. Summed up, in the last 10 years there has been an increased awareness concerning climate change, and the long term negative consequences (such as economic losses, among other things) as well as an increase in the awareness of negative consequences associated with ignoring climate change in the decision making process.

These two points combined result in the need for Big Data Analysis and the translation of scientific data into added value for users. Subsequently, the most evident CS product innovations are Big Data Analysis per se and customer specific prototypes (software as well as hardware/sensors) based on Big Data Analysis. Furthermore, the access to recent, readable data has to be available for a wider public through reliable platforms. Additionally, users want to use the acquired data for their specific areas. In the zoo of climate data portals, there is a strong need for innovative prototypes. On the one side, these prototypes need to provide an easy access to data but also in a user-specific way. The C3S aims to fulfil these requirements (https://climate.copernicus.eu/), and in particular the Climate Data Store and the different data services. For instance the IMPACT2C web atlas (https://www.atlas.impact2c.eu/en/) is an existing successful prototype (see box below) for the dissemination of high level multidisciplinary projects. An increasing number of start-ups are using these provided climate data and related products – this way start-ups can function as a link between science and future climate data users.

[10] There have been more and more were assessed as well. ECLISE (Enabling CLimate Information Services for Europe), ENHANCE (Enhancing Risk Management Partnerships for Catastrophic Natural Hazards in Europe), EUPORIAS (European Provision of Regional Impacts Assessments on Seasonal to Decadal Timescales), IMPACT2C (Quantifying projected impacts under a 2°C warming).

The IMPACT2C web atlas

The EU-FP7 IMPACT2C project drew on different innovative methods and tools to quantify the impact of a 2 °C global warming compared to the preindustrial period. The project's targeted regions of interest lay within the pan-European level as well as including some of the world's most vulnerable hot-spot regions. The key sectors tackled within the project were energy, water, tourism, health, agriculture, ecosystems and forestry, as well as coastal and low-lying areas.

The IMPACT2C web-atlas Preuschmann et al. 2017) is an innovative way to present the project results to the public. The web-based climate service product serves as an information source to raise awareness for a wide audience and to help decision makers in policy negotiations.

The web-based tool allows the users to access information on the impacts of climate change along different sectors. Single research topics are logically connected to other topics and may belong to multiple sectors at the same time. Within the web-based framework these links help the user to orient themselves within this scientific environment.

For the implementation, a new combination of Content Management System and Geographical Information System was established. The diverse range of interdisciplinary and transdisciplinary results of the project, the "storyline concept" was developed 'telling' the project's results within key sectors. To enhance the comprehensibility for the user, the tool consequently applies concepts for harmonization in data analysis, visualization and text structure.

The IMPACT2C web-atlas is an open access information tool, designed to serve as a prototype to enable the dissemination of current and upcoming interdisciplinary projects and their results.

Innovative visualization

A major part of delivering climate service information works through graphics and visualizations. They can enable discovery, create engaging and robust reporting, or support online resources. Producing accessible and unbiased visualizations from complicated, uncertain data requires expertise and knowledge not only from science but also computing and design. Mutual co-working between these fields and climate services is a source for producing innovative products. For instance, the Project Ukko (http://project-ukko.net/) developed a novel way to spot patterns in seasonal wind prediction data. The aim was to support users to better understand the future variability in wind power resources and bridge the gap between energy practitioners and the climate science community. This interactive and smart data visualization was an outcome of the successful mutual work between scientists and a data visualization designer[11] within the FP7 EUPORIAS.

[11] See for more information about Moritz Stefaner: http://truth-and-beauty.net/ . The visualisation received an ‚Information is beautiful award 2016' in the category ‚data visualisation' http://www.informationisbeautifulawards.com/news/188-2016-the-winners.

3.6.3 Innovation dynamics

As these innovations are embedded in a complex framework of many drivers such as organizations, technologies, regulations, sector dynamics and many more it is important to understand the innovation dynamics behind them. A multi-layer perspective is a suitable tool to assess these dynamics in terms of regime, niche and landscape (see table 13; taken from EU-MACS glossary):

TABLE 13: MULTI-LAYER PERSPECTIVE ON INNOVATION DYNAMICS

Layer	What does this mean?
Multi-layer perspective (MLP)	A multi-layer perspective helps to "inquire how the context of innovation journeys influences the dynamics of innovation" (Rip 2012).
Landscape	Backdrop of opportunities and constraints for technology, service, market, and policy development.
Niches	In a multi-layer perspective referring to protected spaces for vulnerable novelties, shaped by requirements for protection and some boundary maintenance; carved out in selection environments, e.g. by benevolent selectors (sponsors of start-up firms); lead to mini-paths and a lock-in.
Regime	In a multi-layer perspective referring to a set of rules, practices and institutions structuring the further development of a technology (and service, market, policy).

INNOVATION LANDSCAPE

According to the Global Risk Report 2015 (World Economic Forum 2015) failure of climate change adaptation is among the largest risks mankind is facing (and the largest environmental risk). The Research and Innovation Roadmap for Climate Services (European Commission 2015) starts the foreword with a very similar statement. In order to decrease CO_2 emissions and increase resilience respective products, services and information are needed. Thus, "climate services have the potential to become the intelligence behind the transition to a climate-resilient and low-carbon society", and consequently, "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" (European Commission 2015). Even though, the (commercial) market is still in a very premature phase being fragmented it has significantly risen over the past years (Poessinouw 2016).

There has been considerable discussion about how to drive innovation and bridge knowledge across the "Valley of Death" between research, development, market orientation, and commercial exploitation of technological products (Brooks 2013) . Some of these approaches have been discussed in the context of environmental problems, and specifically to narrow the gaps between providers and users of climate knowledge (Lemos et al. 2012). This means that whilst it is essential to improve our understanding of the climate and its impact on our activities, this cannot occur in isolation and should instead ensure that users and producers of climate information effectively work together (Buontempo et al., 2014).

This is important as capacities, capabilities and priorities might be different for providers and users of climate services. The survey results showed that in many cases, e.g. the most influential barrier for users so

far is lack of technological capacity (see figure 4). This means that services (co-) development needs to take the technical equipment on the users side into account because the best service is not applicable if it does not fit into existing infrastructures or processes.

INNOVATION NICHES

The **innovation niche** relates to protected spaces for vulnerable novelties carved out in selection environments, e.g. by benevolent selectors (sponsors of start-up firms), that results in mini-paths and lock-in effects.

The probably most important niche, in which commercial CS products could be tested, is the public-private-partnership EIT Climate-KIC, which has been established in 2010. This network brings together dynamic companies with innovative ideas, scientific expertise from major research performing organisations and public sector organizations, thus, integrating education, entrepreneurship and innovation leading to economically viable products. Even though the focus of Climate-KIC in the past has been on technical innovations mostly related to climate mitigation, there is a tendency of shifting more to climate adaptation lately. This, at least, is reflected in the mission statement of Climate-KIC (http://www.climate-kic.org/about/). The Climate-KIC has several programmes in place to identify promising innovative ideas that could then be tested and further developed.

However, the climate services market is still very fragmented and real mini-pathways or lock-in effects are not yet visible.

The development of such a climate services market, even though it has gained some momentum, is difficult as the providers and users side is very fragmented. The providers of services have to understand and learn more about users' actual needs, their framing conditions, decision-making processes, cultural behavior, their competencies and capacities and so on. As this alone is already easier said than done, this does not only change from sector to sector, it also changes from one user to another within the same sector. Only very generic patterns remain the same. On the other side, users that are aware of their specific needs are sometimes lost, as they do not know what services are out there, which format is suitable, where to purchase a respective service, how to judge on quality and so on.

The following are important elements in order to (co-) develop highly customized climate services that provide added values to users:

- Better understanding of the climate system
- Better integration of disciplines
- Localized climate information (where required) → improved regional climate modeling
- Localized impact information (where required) → e.g. improved integrated assessment models
- Improved HPC capacities to run models with higher spatial and temporal resolution
- Better access to and availability of climate information (e.g. processed or bias corrected data) that allow private sector CS providers to develop their services
- Agreed quality standards, e.g. with regards to processes or uncertainties
- Process innovation for co-development of climate services
- Capacity-building for users in terms of human capabilities and technical capacities

- Guidelines for non-scientific communication of information.

All of this needs some sort of structuring and guidance to avoid duplication of activities and to make sure all are heading in the same direction. One key document – i.e. the European Research and Innovation Roadmap for Climate Services – framing all this has been mentioned several times and will be introduced in the next section.

INNOVATION REGIME

Some **major institutions / organizations** that could be considered as structural elements, and thus forming the innovation regime, have already been mentioned such as the WCRP, Future Earth and GCOS on a global scale. Additional ones to be mentioned are the Global Framework for Climate Services (GFCS) or the (international) Climate Services Partnership (CSP), which both were very early initiatives to bring experts in the field of climate services together to share experiences and to learn from each other.

In Europe similar institutions have been established, some of which have already been mentioned, e.g. the Copernicus Climate Change Service as an operational (data) provider. In addition, the JPI Climate (which was referred to several times in sections 3.1) was established in 2011 by 14 countries. It aims at aligning research activities in the participating countries and also provides a 'fireplace', where experts could meet and exchange (JPI Climate 2016). To link the European activities to global ones, the Belmont Forum was established. The European Climate Services Partnership as regional pendant to the CSP was established in 2014. One very important player is the European Union that stimulates research and innovations via its funding programmes (e.g. FP6, FP7 and currently running H2020, EU LIFE, InterReg and many more).

Q7 of the survey showed, that respondents are engaged in or in other ways connected to international and / or European networks or initiatives such as the C3S, the ERA-NET for Climate Services, the GFCS, CORDEX, EUMETNET or JPI Climate.

On national and sub-national levels there is an almost endless list of activities and organizations. Public climate service centres have been established, e.g. in Germany (in addition, four regional climate services have been established as well) or Austria. In other countries climate services centres have been established at NWS (e.g. in Sweden or Finland).

Another important player is the Climate-KIC (Knowledge and Innovation Community), which is a public-private-partnership that supports SMEs, start-ups and university spin-offs to develop new ideas, test and improve CS prototypes, offer programmes to train business skills needed to run a business successfully and so on.

There are no **legal regulations or common practices** specifically for innovations in climate services yet. As briefly outlined in chapter 3.4.4 regulations could set very different incentives for using climate services; and it was stated in the interviews as well that legal obligations could lead to positive commitment. Some other elements that are discussed to become common practices have been mentioned in the previous section on process innovation.

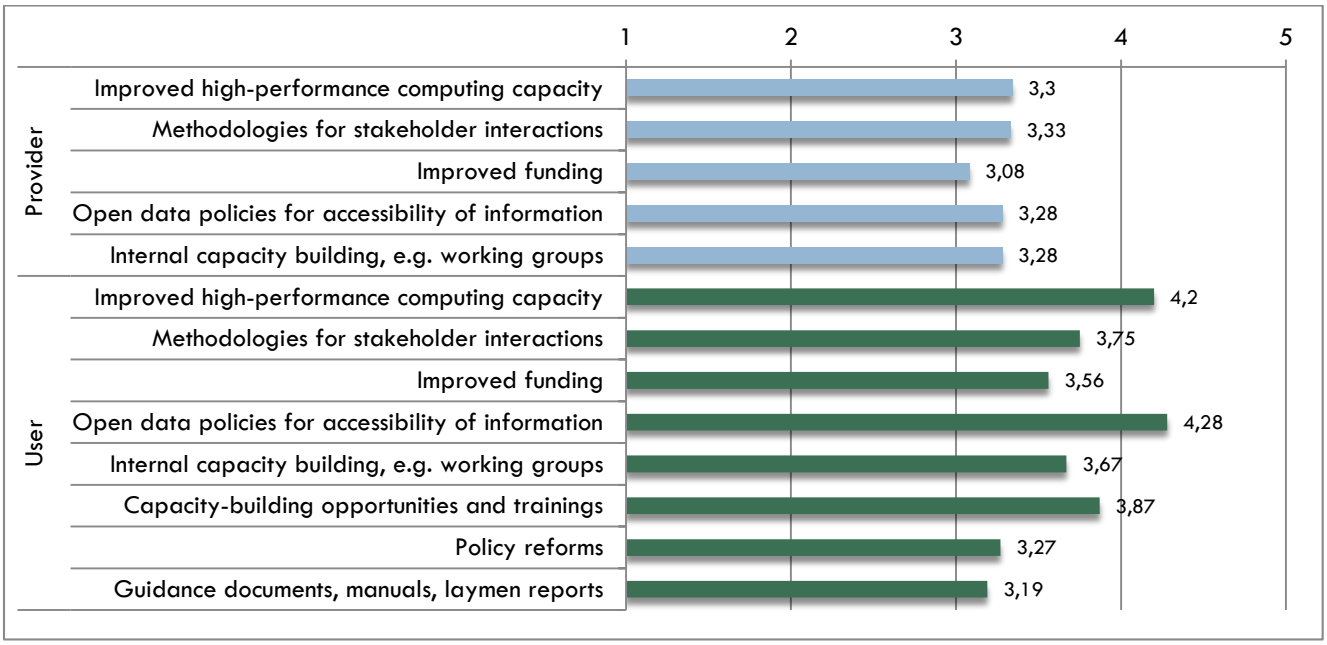
Even though there are no specific regulations addressing climate services yet, two developments should be highlighted that are indirectly linked to climate services. Firstly, the relevance of open data policies has been mentioned quite often. Berends at al. (2017) showed that open data are primarily used for some reasons, of which innovation is the most important (followed by reduced costs and increased efficiency, data harmonisation, business model improvements, and reliability). Even though the underlying study has a very broad focus there is no reason to doubt the importance of open data for the development of climate services.

Secondly, the HPC strategy. HPC was mainly planned and organised on national levels. Similar to other activities (e.g. via the JPI Climate to align and bundle national research activities related to climate change), the European Commission has adopted its HPC strategy (European Commission 2012) consisting of three pillars, which are:

- Develop next generation HPC to exascale
- Access to supercomputing facilities to academia and industry
- Establishment of Centres of Excellence in HPC applications.

This seems to be an important development. The survey showed that both CS providers **and** users consider improved HPC capacities and open data policies among the most important innovations to them (see figure 6).

FIGURE 6: IMPORTANCE OF INNOVATION



While the previous developments are of indirect relevance for the CS market, the probably most important document framing the future development of climate services is the Research in Innovation Roadmap for Climate Services (European Commission 2015).

A European Research and Innovation Roadmap for Climate Services

The 'Roadmap', as this important document is typically been referred to, is the result of a stakeholder consultation process. It includes participation of (intermediary) provider and users from several domains, e.g. policy, science, private business, professional bodies, civil society and more. The aim of this process was the identification of key challenges in order to facilitate the development of the European market for climate services. The three main challenges identified in this large consultation process are:

1. Enabling market growth
2. Building the market framework and
3. Enhancing the quality and relevance of climate services.

For each of the three main challenges activities have been identified that should help achieving this goal. Conducting these activities requires sustained research and innovation funding and thus, the Roadmap is guiding or structuring the most relevant research and innovation activities related to climate services.

These activities, however, will mainly be implemented via EU's research and innovation framework Horizon 2020, the European Institute of Innovation and Technology (EIT) climate-knowledge and innovation community (Climate-KIC) and other transnational (e.g. EU LIFE, JPI Climate, Belmont Forum; all have been mentioned above), national and regional programmes.

4. KEY MESSAGES

The static assessment of market characteristics in task 1.1 included different views on the market as a whole in terms of involved actors, market segments, types of climate services and ways of provision and use. In addition, framing conditions have been assessed in terms of progress made including science and process innovations as well as innovation schemes. This allows us to create a generic understanding of processes and procedures on the CS market.

It is often said that climate services should be demand-driven and science-informed. This notion can be found in several documents including the Research and Innovation Roadmap for Climate Services. This implies that the whole market develops, as users are increasingly demanding climate services for several purposes. To increase usability of services and, thus, contribute to the CS market development it is important to understand impediments and identify innovations to overcome them.

Previous assessments of barriers were mostly related to barriers in the adaptation process, not climate services development, provision and use. Thus, there is not much evidence EU-MACS can build on. However, most important results of the initial market assessment are (according to the structure of chapter 3):

Involved actors – providers, intermediaries and users
The assessment of the involved actors was based on previous mapping activities and stakeholder analysis, e.g. those of the JPI Climate (2013/14), the ERA-NET (2016), SECTEUR (2016). The results of EU-MACS confirmed the findings of previous activities. In contrast to the Roadmap, in which public administration and politics is seen as CS user, other activities clearly showed that public administration / politics consider themselves as CS (intermediary) providers as well. All providers do have specific strengths and weaknesses (e.g. good infrastructure or data sets, multidisciplinary expertise, entrepreneurial orientation etc.) that make them unique to find their role in the climate services landscape.

Value chains and provision modes
Even though there have been previous mappings and stakeholder analyses of CS providers and users, there have not been much effort to derive value chains. A CS value chain reflecting the CS market can only be very simplified as the competencies, capacities and capabilities of the involved actors are very different. In addition, types of climate services and targeted sectors influence the shape of the value chain substantially. Provision modes change accordingly from free of charge (e.g. publicly available data from C3S or EURO-CORDEX; assessment reports such as the IPCC) to commercial products from private businesses. In addition, there might also be in-house provision in case that climate information is processed to impact modellers. However, one common feature seems to be that there is a dominance of public CS providers upstream in the chain operating HPC infrastructures, observation facilities, run global models, making re-analysis etc. The number of private providers is increasing further to the 'right side', where entrepreneurial orientation is needed to sell services on a commercial market.

According to their specific strengths and weaknesses, different types of providers find their niche in the CS landscape. This, at the same time, requires cooperation between different types of providers along the simplified value chain. This cooperation might in some cases be interfered by some of the barriers identified in this report (e.g. funding, stakeholder engagement etc.)

Several of these topics are taken up in Deliverable 1.2, which deals with business models, resourcing and quality assurance.

Definition of products, sectors and sub-markets

There have been several typologies of products, sectors and (sub-) markets that are all to some extend 'fluid' and subject to changes.

The kMatrix typology of products was applied; mainly for strategic reasons that allow integrating the results of EU-MACS and MARCO later on.

Sectors can be separated following an either policy-driven or market-driven approach. For the purposes of EU-MACS, which is somehow integrating these two perspectives in order to apply the value chain, a combination was chosen. This should reflect the policy-driven segmentation (which is sometime to narrow), e.g. from national adaptation strategies, as well as the market-driven segmentation from kMatrix (which seems to be to detailed).

Features of CS provision and use

Economic and regulatory features seem to be most influential for CS provision and use.

Economic features include free vs. commercial provision modes, business model development, availability of financial resources to purchase commercial services, or to improve the in-house capacities (either technically or staff).

Regulatory features include open data policies to increase accessibility of climate information and policy improvements that aim at stimulating CS use. This is an ambiguous / ambitious task, as regulations could have contradicting incentives that lead to non-use of climate services at all. There is no accepted quality assurance system / process in place yet, even though this would be helpful.

Ethical features, as outlined by the Climate Services Partnership, are more like principles of good conduct but no standards at all.

Barriers in CS development, provision and application

Barriers were assessed in six domains, i.e. political, economic, social, technological / scientific, ethical, and legal / regulatory barriers, by a literature review, a survey, and some interviews.

The literature review was conducted in order to identify possible barriers, the survey aimed at assessing the relative importance of barriers for providers and user. In literature mostly economic, technological / scientific, and social barriers are reported. The survey, more detailed, showed that economic barriers are particularly important

for providers (i.e. limited financial resources and business model development), while technological barriers are more important for users (i.e. lack of technological equipment / technological capacities) followed by economic barriers such as limited financial resources. For both groups, ethical barriers seem to be least important.

More detailed analysis, e.g. most relevant barriers related to specific providers / users, sectors, or types of services will be part of the updated version later during the project.

Scientific progress, innovation and innovation dynamics

Scientific progresses differently when looking at climate modelling and impacts modelling. While in both domains considerable progress in terms of spatial and temporal resolution has been made, progress in (regional) climate modelling still outpaces progress in impacts and socio-economic modelling.

Innovations are distinguished by process and product innovations. Process innovation takes mainly place in the three domains engagement (to better integrate users and understand their needs), entrepreneurial orientation (understanding the market and value chains, business model for climate services), and evaluation of products and process (to reflect on them and to develop new processes and products). This leads to innovation in products. The better users understand how they might be affected by climate change (as a result of better users' engagement) the better they can articulate their needs and can be served with better and improved services.

This whole development is framed by the **innovation dynamics** in terms of landscape, regime, and niche. Main actors, such as the European Commission, EIT Cliamte-KIC, JPI Climate but also the WCRP or Future Earth, and their roles are outlined in chapter 3.6.3.

The success of CS market development will not only be influenced by the strength of the actors pushing it and the will of users to purchase climate services. It will, to a large extend, also be depended on other markets and the possibilities to earn money in them.

The results of Deliverable 1.1 are providing a snapshot of the market, its structure, and underlying processes and, thus, preparing the ground for the dynamic analyses of CS supply and demand, barriers in matching these two and innovations to overcome the identified barriers.

REFERENCES

Adams, P., Eitland, E., Hewitson, B., Vaughan, C., Wilby, R., Zebiak, S. (2015): Towards an ethical framework for climate services, White Paper of the Climate Services Partnership Working Group on Climate Services Ethics, www.climate-services.org/ethics, 15.05.2017

Alexander, M., Bruno Soares, M., Dessai, S. (2016): Multi-sector requirements of climate information and impact indicators across Europe: Findings from the SECTEUR survey – Part 1. Deliverable 2.3 for the "SECTEUR" project: Sector Engagement for the Copernicus Climate Change Service (C3S) - Translating European User Requirements

Baker, I., Peterson, A., Brown, G., McAlpine, C. (2012): Local government response to the impacts of climate change: an evaluation of local climate adaptation plans, in: Landsc Urban Plan, Vol. 107, pp. 127–136, doi:10.1016/j.landurbplan.2012.05.009, 06.05.2017

Balaban, O., Senol Balaban, S. (2015): Adaptation to Climate Change – Barriers in the Turkish Local Context, in: TeMA – Journal of Land Use, Mobility and Environment, Special Issue ECCA (2015), Smart and Resilient Cities – Ideas and Practices from the South of Europe, pp. 7-22, DOI: 10.6092/1970-9870/3650, 15.05.2017

Banos de Guisasola, E. (2014): Mapping of Climate Services Providers in Italy – Summary Report, CMCC Research Papers Issue RP0213, http://www.jpi-climate.eu/media/, 09.05.2017

Berends, J., Carrara, W., Engbers, W., Vollers, H. (2017): Re-using Open Data – A Study on Companies transforming Open Data into Economic and Societal Value, https://www.europeandataportal.eu/, 02.06.2017

Biesbroek, G.R., Klostermann, J.E.M., Termeer, C.J.A.M., Kabat, P. (2013) On the nature of barriers to climate change adaptation, in: Regional Environmental Change, pp. 1119-1129, DOI: 10.1007/s10113-013-0421-y, 15.05.2017

Biesbroek, G.R., Termeer, C.J.A.M., Kabat, P., Klostermann, J.E.M. (2009): Institutional governance barriers for the development and implementation of climate adaptation strategies, Working Paper for the Internattional Human Dimensions Programme (IHDP) conference 'Earth System Governance: People, Places, and the Planet, http://library.wur.nl/WebQuery/wurpubs/387218, 16.05.2017

Brasseur, G.P., Gallardo, L. (2016): Climate Services – Lessons learned and future prospects, Earth's Future, Vol. 4, pp.79-89, doi:10.1002/2015EF000338, 13.05.2017

Brooks, M. S. (2013): Accelerating innovation in climate services: The 3 e's for climate service providers, Bull. Am. Meteorol. Soc., 94(6), 807–819, doi:10.1175/BAMS-D-12-00087.1, 14.05.2017

Brugger, J., Meadow, A., Horangic, A. (2016): Lessons from first-generation climate science integrators, Bull. Am. Meteorol. Soc., 97(3), 355–365, doi:10.1175/BAMS-D-14-00289.1, 16.05.2017

Bruno Soares, M., Dessai, S. (2016): Barriers and enablers to the use of seasonal climate forecasts amongst organisations in Europe, Sustainability Research Institute Paper No. 91, SRI Papers, http://www.see.leeds.ac.uk/sri, 15.05.2017

Bubeck, P., Klimmer, L., Albrecht, J. (2016): Klimaanpassung in der rechtlichen Rahmensetzung des Bundes und Auswirkungen auf die Praxis im Raumordnungs-, Städtebau- und Wasserrecht, in: Natur und R., Vol. 38, No. 5, pp. 297-307, doi:10.1007/s10357-016-3003-1, 16.05.2017.

Bulkeley, H., Schroeder, H., Janda, K., Zhao, J., Armstrong, A., Chu, S.Y., Ghosh, S. (2011): Cities and Climate Change – The role of institutions, governance and urban planning, Report prepared for the World Bank Urban Symposium on Climate Change, http://elibrary.worldbank.org/, 15.05.2017

Buontempo, C., Hewitt, C.D., Doblas-Reyes, F.J., Dessai, S. (2014): Climate service development, delivery and use in Europe at monthly to inter-annual timescales, in: Climate Risk Management, Vol. 6, pp. 1—5, doi:10.1016/j.crm.2014.10.002, 17.05.2017

Burch, S. (2010) Transforming barriers into enablers of action on climate change: Insights from three municipal case studies in British Columbia, Canada, in: Global Environmental Change, Volume 20, No. 2, pp. 287-297, http://dx.doi.org/10.1016/j.gloenvcha.2009.11.009, 15.05.2017

Capela Lourenço, T., Swart, R., Goosen, H., Street, R. (2016): The rise of demand-driven climate services, in: Nature Climate Change, Vol. 6, pp. 13-14

CH2011 (Eds.) (2011): Swiss climate change scenarios CH2011. C2SM; MeteoSwiss; ETH; NCCR Climate; OcCC, Zürich

Cortekar, J., Groth, M. (2015): Adapting energy infrastructure to climate change - Is there a need for government interventions and legal obligations within the German "Energiewende"?, Energy Procedia, No. 73, pp. 12-17, doi:10.1016/j.egypro.2015.07.552, 06.05.2017

CSIRO, Bureau of Meteorology (Eds.) (2015): Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report. CSIRO; Bureau of Meteorology, Australia

Davis, M., Lowe, R., Steffen, S., Doblas-Reyes, F., Rodó, X. (2015): Barriers to using climate information – Challenges in communicating probabilistic forecasts to decision makers, SPECS Technical Note 4, http://www.specs-fp7.eu/SPECS/Dissemination.html, 15.05.2017

Déandreis, C., Pagé, C., Braconnot, P., Bärring, L., Bucchignani, E., de Cerff, W.S., Hutjes, R., Joussaume, S., Mares, C., Planton, S., Plieger, M. (2014): Towards a dedicated impact portal to bridge the gap between the impact and climate communities - Lessons from use cases, in: Climate Change, 125(3–4), 333–347, doi:10.1007/s10584-014-1139-7, 16.05.2017.

DFG (Ed.) (2013): Safeguarding Good Scientific Practice, Wiley-VCH Verlag, ISBN 978-3-527-33703-3 Weinheim

Directive 2003/98/EC of the European Parliament and of the Council of 17. Nov. 2003 on the re-use of public sector information, http://eur-lex.europa.eu/, 16.05.2017

Eisenack, K., Moser, S.C., Hoffmann, E., Klein, R.J.T., Oberlack, C., Pechan, A,. Rotter, M., Termeer, C.J.A.M. (2014): Explaining and overcoming barriers to climate change adaptation, in: Nature Climate Change, Vol. 4, pp. 867-872, DOI: 10.1038/NCLIMATE2350, 15.05.2017

Engen Skaugen, T. (2014): Mapping Climate Services Providers in Norway, Deliverable to JPI Climate Working Group 2 "Research for Climate Services Development and Deployment", http://www.jpi-climate.eu/media/, 09.05.2017

European Commission (2012): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – High-Performance Computing: Europe's Place in a Global Race, http://eur-lex.europa.eu/, 17.05.2017

European Commission (2013): http://ec.europa.eu/clima/policies/adaptation/what/documentation_en.htm, 04.05.2017

European Commission (2015): A European Research and Innovation Roadmap for Climate Services, DOI: 10.277/70215

Gøransson, T., Rummukainen, M. (2014): Climate Services – Mapping of Providers and Purveyors in the Netherlands and Sweden, CEC Report No 01, Centre for Environmental and Climate Research, Lund University, ISBN 978-91-981577-3-4

Groot, A., Swart, R., Hygen, H., Benestad, R.E., Cauchy, A., Betgen, C., Dubois, G. (2014): ClipC deliverable User requirements, Part 1. Strategies for user consultation and engagement and user requirements: synthesis from past efforts, http://www.clipc.eu/media/, 18.05.2017

Groth, M., Nutzm, A.-K. (2016): Informations- und Unterstützungsbedarf für Kommunen zur Anpassung an die Folgen des Klimawandels, GERICS-Report 25, http://www.climate-service-center.de/, 16.05.2017

Hulme, M., Adger, W.N., Dessai, S., Goulden, M., Lorenzoni, I., Nelson, D., Naess, L.-O., Wolf, J., Wreford, A. (2007): Limits and barriers to adaptation – four propositions, Tyndall Briefing Note No. 20

IPCC (Eds.) (2014): Climate Change 2014 – Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Jenkins, G.J., Murphy, J.M., Sexton, D.M.H., Lowe, J.A., Jones, P.D., Kilsby, C.G. (2009): UK Climate Projections: Briefing report, 2nd edition, Met Office Hadley Centre, Exeter

JPI Climate (Ed.) (2016): Joint Programming Initiative Connecting Climate Knowledge for Europe (JPI Climate) – Strategic Research and Innovation Agenda 2016-2025, http://www.jpi-climate.eu/, 23.05.2017

Kirchhoff, C.J., Lemos, M.C., Dessai, S. (2013): Actionable Knowledge for Environmental Decision Making - Broadening the Usability of Climate Science, in: Annu. Rev. Environ. Resour., Vol. 38, No. 1, pp. 393-414, doi:10.1146/annurev-environ-022112-112828, 16.05.2017

Klein, R.J.T., Midgley, G.F., Preston, B.L., Alam, M., Berkhout, F.G.H., Dow, K., Shaw, M.R. (2014): Adaptation opportunities, constraints, and limits, in: Climate Change 2014: Impacts, Adaptation, and Vulnerability.Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J.

Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 899-943.

KNMI (Ed.) (2014): KNMI '14 climate scenarios for the Netherlands: A guide for professionals in climate adaptation

Leichenko, R., McDermott, M., Bezborodko, E. (2015): Barriers, Limits and Limitations to Resilience, in: Journal of Extreme Events, Vol. 2, No. 1, DOI: 10.1142/S2345737615500025, 17.05.2017

Lémond, J., Dandin, P., Planton, S., Vautard, R., Pagé, C., Déqué, M., Franchistéguy, L., Geindre, S., Kerdoncuff, M., Li, L., Moisselin, J. M., Noël, T., Tourre, Y. M. (2011): DRIAS - A step toward Climate Services in France, Adv. Sci. Res., Vol. 6, pp. 179-186, doi:10.5194/asr-6-179-2011, 18.05.2017.

Lemos, M.C., Kirchhoff, C.J., Ramprasad, V. (2012): Narrowing the climate information usability gap, in: Nature Climate Change, Vol. 2, No. 11, pp. 789–794, doi:10.1038/nclimate1614, 18.05.2017

Lemos, M.C., Morehouse, B.J. (2005): The co-production of science and policy in integrated climate assessments, in: Global Environmental Change, No. 15, pp. 57-68, doi:10.1016/j.gloenvcha.2004.09.004, 06.05.2017

Lorenz, S., Dessai, S., Forster, P.M., Paavola, J. (2016): Adaptation planning and the use of climate change projections in local government in England and Germany, in: Regional Environmental Change, Vol. 17, No. 2, pp. 1-11, doi:10.1007/s10113-016-1030-3, 06.05.2017

Lourenço, T. C., Swart, R., Goosen, H., Street, R. (2015): The rise of demand-driven climate services, in: Nature Climate Change, Vol. 6, No. 1, pp. 1-2, doi:10.1038/nclimate2836, 13.05.2017.

Máñez, M., Zölch, T., Cortekar, J. (2014): Mapping of Climate Service Providers – Theoretical Foundation and Empirical Results: A German Case Study, http://www.climate-service-center.de/imperia, 09.05.2017

Matasci, C., Kruse, S., Barawid, N., Thalmann, P. (2014): Exploring barriers to climate change adaptation in the Swiss tourism sector, in: Mitigation and Adaptation Strategies for Global Change, Vol. 19, No. 8, pp. 1239-1254, DOI 10.1007/s11027-011-9301-2, 15.05.2017

McDonald, J. (2011): The role of law in adapting to climate change, Wiley Interdiscip. Rev. Clim. Chang., Vol. 2, No. 2, pp. 283-295, doi:10.1002/wcc.96, 07.05.2017

Measham, T.G., Preston, B.L., Smith, T.F., Brooke, C., Gorddard, R., Withycombe, G., Morrison, C. (2011): Adapting to climate change through local municipal planning – barriers and challenges, in: Mitigation and Adaptation Strategies for Global Change, Vol. 16, pp. 889-909, DOI 10.1007/s11027-013-9471-1, 15.05.2017

Mills, A., Huyser, O., v.d. Pol, O., Zoeller, K., Snyman, D., Tye, N., McClure, A. (2016): UNDP Market Assessment – Revenue-generating opportunities through tailored weather information products, http://www.adaptation-undp.org/, 16.05.2017

Morgan, B. (2014): Income for outcome, in: Nature, No. 511, pp. 72-75, doi:10.1038/511S72a, 18.05.2017

Nurmi, P., Perrels, A., Nurmi, V. (2013), Expected impacts and value of improvements in weather forecasting on the road transport sector, *Meteorological Applications*, Vol.20, pp.217 – 223., DOI: 10.1002/met.1399

Oberlack, C., Eisenack, K. (2014): Alleviating barriers to urban climate change adaptation through international cooperation, in: Global Environmental Change, http://dx.doi.org/10.1016/j.gloenvcha.2013.08.016, 15.05.2017

Otto, J., Brown, C., Buontempo, C., Doblas-Reyes, F., Jacob, D., Juckes, M., Keup-Thiel, E., Kurnik, B., Schulz, J., Taylor, A., Verhoelst, T., Walton, P. (2016): Uncertainty – Lessons learned for climate services, in: Bull. Am. Meteorol. Soc., BAMS—D-16-0173.1, doi:10.1175/BAMS-D-16-0173.1, 16.05.2017

Perch-Nielsen, S., Oberpriller, Q., Holthausen, N., Locher, P. (2016): Analyse der Nutzerbedürfnisse zu nationalen Klimaszenarien, http://www.meteoschweiz.admin.ch, 17.05.2017.

Perrels, A., Nurmi., V., and Nurmi, P. (2012), *Weather service chain analysis (WSCA) - An approach for appraisal of the social-economic benefits of improvements in weather services*, SIRWEC Conference, Helsinki, 23-25/5/2012, paper 0081

Pilli-Sihvola, K., Nurmi, V., Perrels, A., Harjanne, A., Bösch, P., and Ciari, F. (2016), Innovations in weather services as a crucial building block for climate change adaptation in road transport, *European Journal of Transport Infrastructure Research*, Vol.16, issue 1, pp.150-173

Poessinouw, M. (2016): Initial definition, taxonomy and report, Deliverable 2.1 for the MARCO project: Market Research for a Climate Services Observatory

Porter, J.J., Demeritt, D., Dessai, S. (2015): The right stuff? Informing adaptation to climate change in British Local Government, in: Global Environment Change, No. 35, pp. 411-422, doi:10.1016/j.gloenvcha.2015.10.004, 06.05.2017

Preuschmann, S., Hänsler, A., Kotova, L., Dürk, N., Eibner, W., Waidhofer, C., Haselberger, C., Jacob, D. (2017): The IMPACT2C web-atlas - Conception, organization and aim of a web-based climate service product, in: Climate Services, doi:10.1016/j.cliser.2017.03.005

Rössler, O., Fischer, A.M., Huebener, H., Maraun, D., Benestad, R.E., Christodoulides, P., Soares, P.M.M., Cardoso, R.M., Pagé, C., Kanamaru, H., Kreienkamp, F., Vlachogiannis, D. (2017): Challenges to link climate change data provision and user needs - perspective from the COST-action VALUE, in: Int. J. Climatol., doi:10.1002/joc.5060, 18.05.2017

Sancho Reinoso, A., Helgenberger, S. (2015): Guidelines on Open Knowledge - Improving the societal benefit of climate research activities, http://www.jpi-climate.eu/, 16.05.2017

Schneider, T., Teixeira, J., Bretherton, C.S., Brient, F., Pressel, K.G., Schär, C., Siebesma, A.P. (2017): Climate goals and computing the future of clouds, in: Nature Climate Change, Vol. 7, No. 1, pp. 3 5, doi:10.1038/nclimate3190, 16.05.2017

Sigel, M., Fischer, A., Zubler, E., Liniger, M. (2016): Dissemination of climate change scenarios – a review of existing scenario platforms, (257), 15.05.2017

Skelton, M., Porter, J.J., Dessai, S., Bresch, D.N., Knutti, R. (2017): The social and scientific values that shape national climate scenarios: a comparison of the Netherlands, Switzerland and the UK, in: Regional Environmental Change, doi:10.1007/s10113-017-1155-z

Vaughan, C., Dessai, S. (2014): Climate services for society: Origins, institutional arrangements, and design elements for an evaluation framework, Wiley Interdiscip. Rev. Clim. Chang., Vol. 5, No. 5, pp. 587-603, doi:10.1002/wcc.290

Viktor, E., Ehlert, S., Haensler, A., Bolaños, T.G., Blome, T., Máñez Costa, M. (2017): The 5th International Conference on Climate Services (ICCS5) – "Innovation in Climate Services and Capacity Building", in: Climate Services, Vol. 1, No. 4, pp. 4-5, doi:10.1016/j.cliser.2017.04.002, 16.05.2017

Washington, R. (2012): Progress in Climate Science Modeling – A Look Forward, CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), www.ccafs.cgiar.org, 23.05.2017

Weyrich, P. (2016): Barriers to Climate Change Adaptation in Urban Areas in Germany. Report 26. Climate Service Center Germany, Hamburg.

World Economic Forum (2015): The Global Risk Report 2015 – Part 2: Risks in Focus, http://reports.weforum.org/global-risks-2015/, 18.05.2017

World Meteorological Organization (Eds.) (2015): Valuing Weather and Climate – Economic Assessment of Meteorological and Hydrological Services, https://sustainabledevelopment.un.org/, 16.05.2017

ANNEX 1 – SURVEY

Questionnaire on Barriers and Enabling Conditions
on the European Market for Climate Services

This survey aims at identifying barriers in the European market for climate services. According to the IPCC, barriers are obstacles to reaching a certain potential – they make a situation more difficult than it needs to be. In addition, we aim to identify enhancements that enable innovations in order to improve development and use of climate services.

The survey addresses both providers and users of climate services. It does not focus on specific sectors or types of climate services and it does not distinguish for which purposes climate services are provided or used.

The survey is divided into three sections. Questions in the first section address you and your organisation, the second part addresses the barriers and enabling innovations, and the last section focuses on identifying reasons for non-use of climate services.

We do not ask for any personal information. Participation will be completely anonymous. The replies will be stored in an anonymized way, in a password protected storage capacity.

For more information see: http://eu-macs.eu http://eu-macs.eu/

In case of questions about the survey, please email joerg.cortekar@hzg.de

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A. Who is providing / using climate services?

In this first section of the survey we would like to learn more about you as a provider or user of climate services.

1. **I am / I work for an organisation that is**

☐ Providing climate services (please also tick this box if you are providing and using climate services)

☐ Using climate services only.

→ if 'provider' then continue with Q2

→ if 'user only' then continue with Q18

2. Please specify the type of organisation you work for:

☐ National Weather Service (or a direct subsidiary)

☐ University or research institute

☐ Private business

☐ Public Climate Service Centre (not attached to National Weather Service)

☐ Non-profit organisation

☐ Industry or professional body

☐ Public administration / politics

☐ Other:

3. **To better understand where specific barriers occur, please position your organisation in the value chain of climate services.**

☐ Data collection

☐ High-performance computing

☐ Model development

☐ Modelling and re-analysis

☐ Climate information and knowledge

☐ Regional downscaling

☐ Impact modelling (incl. socio-economic impacts)

☐ Consultancy services (translation layer)

☐ National government / administration

☐ Regional / federal government / administration

☐ Local government / administration

☐ Civil society, e.g. foundations, associations

☐ International corporations

☐ SME

☐ Other:

4. In which country (or countries) is your organisation located?

- ☐ Austria
- ☐ Belgium
- ☐ Bulgaria
- ☐ Croatia
- ☐ Cyprus
- ☐ Czech Republic
- ☐ Denmark
- ☐ Estonia
- ☐ Finland
- ☐ Germany
- ☐ Greece
- ☐ Hungary
- ☐ Ireland
- ☐ Italy
- ☐ Latvia
- ☐ Lithuania
- ☐ Luxembourg
- ☐ Malta
- ☐ The Netherlands
- ☐ Poland
- ☐ Portugal
- ☐ Romania
- ☐ Slovakia
- ☐ Slovenia
- ☐ Spain
- ☐ Sweden
- ☐ United Kingdom
- ☐ other, where:

5. In which city are you located?

6. For what sector(s) do you mainly provide climate services? (check all that apply)

- ☐ Agriculture
- ☐ Water (excl. water way management and water infrastructures)
- ☐ Forestry
- ☐ Energy (excl. grids)
- ☐ (Critical) Infrastructures (incl. energy and water supply, and telecommunication but excl. roads, rails and waterways)
- ☐ Transport and logistics (incl. land, water and air)
- ☐ Tourism
- ☐ Building and construction
- ☐ Finance and (re-) insurance
- ☐ Catastrophe management / Desaster Risk Reduction
- ☐ Health care incl. pharmaceuticals
- ☐ Waste management
- ☐ Biodiversity and nature conservation
- ☐ Education and training
- ☐ Spatial / urban planning
- ☐ Industry and Trade
- ☐ Ecosystems management, incl. soil
- ☐ Mining / Extraction (incl. oil, gas, coal)
- ☐ Other:

7. Are you engaged in or connected to one or more of the following networks? (Check all that apply)

☐ ERA-NET for Climate Services	☐ Climate Services Partnership	☐ Global Framework for Climate Services (GFCS)
☐ Copernicus Climate Change Service (C3S)	☐ Climate Knowledge Brokers	☐ World Climate Research Programme
☐ EUMETNET	☐ Water JPI	☐ Future Earth
☐ ECRA	☐ JPI Oceans	☐ Belmont Forum
☐ CORDEX	☐ JPI Climate	☐ EIT Climate KIC
☐ CMIP	☐ JPI Urban Europe	☐ GCOS
☐ GEOSS	☐ JPI FACCE	☐ Others:

8. Does your organisation operate a quality assurance process in relation to the supplied climate information?

☐ yes ☐ no

→ if 'yes' continue with Q8a

→ if 'no' continue with Q9

8a. Does this process include

☐ Statistical properties of datasets

☐ Declaration of the sources of the datasets (observation and/or model simulation)

☐ Declaration of post-processing steps (bias corrections, interpolation, etc.)

☐ A systematic production and maintenance of metadata per dataset

☐ Some kind of certification

8b. Do you provide meta-data on datasets and other information to (prospective) users?

☐ Upon request ☐ Standard practice ☐ Usually not

9. Do you offer advice and/or tools to users to evaluate the fitness-for-purpose of climate information?

- ☐ Yes
- ☐ Yes, but evaluation is a joint effort of provider and (prospective) user
- ☐ No, that is to say we do that in house, without involvement of the user
- ☐ No

B. What kinds of barriers do you face in your activities related to climate services?

In this section we would like to learn about the barriers and enabling conditions you face when developing and providing climate services.

10. Over the past years, numerous different types of climate services have been developed. How would you classify the climate service product you will relate all subsequent questions to? (check what fits best)

- ☐ Advisory services, risk assessments and decision support tools
- ☐ Data management, incl. calibrated data sets, data archiving, data certification
- ☐ Measurements, incl. instruments and technologies for measurements and calibration
- ☐ Modelling, including climate, impacts and socio-economics
- ☐ Operations (collection and provision of raw data)
- ☐ Processed data, incl. re-analysis
- ☐ Publications, e.g. synthesis and assessments, guidance documents, manuals
- ☐ Capacity building / training
- ☐ Other:

11. What type(s) of climate data and information is needed for the selected service?

- ☐ Observational data
- ☐ Seasonal forecasts
- ☐ Climate projections and models
- ☐ Paleoclimatology
- ☐ Mapping and analysis tools
- ☐ Not applicable

12. Please let us know, which economic barriers you have already faced in relation to the selected type of service. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Limited financial resources	☐	☐	☐	☐	☐	☐
Human capital (incl. number and proficiency of staff)	☐	☐	☐	☐	☐	☐
Organisational setting, incl. established practices and routines, decision-making processes	☐	☐	☐	☐	☐	☐
Added-value of climate services often unclear (differences between expected and actual costs)	☐	☐	☐	☐	☐	☐
Timeliness of development and provision	☐	☐	☐	☐	☐	☐
Intellectual property rights	☐	☐	☐	☐	☐	☐
Business model development (from prototyping to operationalization)	☐	☐	☐	☐	☐	☐

Would you like to add anything?

13. Please let us know, which social barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Difficulties to involve different stakeholders (lack of social capital)	☐	☐	☐	☐	☐	☐
Difficulties to interact with other in-house expertise / other disciplines	☐	☐	☐	☐	☐	☐
Different cultural settings in science and application, incl. attitudes, priorities and expectations, 'language'	☐	☐	☐	☐	☐	☐
Infrequent interaction between provider and user	☐	☐	☐	☐	☐	☐

Would you like to add anything?

14. Please let us know, which technological and scientific barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Lack of appropriate technology / technological capacity	☐	☐	☐	☐	☐	☐
Missing standardization of information, incl. layout, terminology etc.	☐	☐	☐	☐	☐	☐
Lack of scale (both, temporal and spatial) of relevant scientific or technical information	☐	☐	☐	☐	☐	☐
Timeliness of development and provision	☐	☐	☐	☐	☐	☐
Coupling of climate and impact models	☐	☐	☐	☐	☐	☐
Limited / incomplete understanding of target sector	☐	☐	☐	☐	☐	☐

Would you like to add anything?

15. Please let us know, which ethical barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Difficulties to describe data sources, methods used to develop services etc.	☐	☐	☐	☐	☐	☐
Difficulties to provide meta information, strength and weaknesses / limitations of a service, uncertainties	☐	☐	☐	☐	☐	☐
Cooperation between provider and user during service development	☐	☐	☐	☐	☐	☐
Short-term relationship - missing trust between provider and user on reliability and quality of services	☐	☐	☐	☐	☐	☐

Would you like to add anything?

16. Please let us know, which legal / regulatory barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Reliance and / or dependence upon EU, national or regional policies and regulations	☐	☐	☐	☐	☐	☐
Unclear regulatory / legal requirements	☐	☐	☐	☐	☐	☐

Would you like to add anything?

17. What innovations of the past years would you consider most relevant to overcome the indicated barriers?

Innovation	1	2	3	4	5	Not applicable
Improved high-performance computing capacity	☐	☐	☐	☐	☐	☐
Improved methodologies for science-stakeholder interactions, e.g. to foster two way dialogue	☐	☐	☐	☐	☐	☐
Improved funding	☐	☐	☐	☐	☐	☐
Open data policies to increase accessibility of information	☐	☐	☐	☐	☐	☐
Internal capacity building, e.g. setting up working groups, hiring / capacitating staff	☐	☐	☐	☐	☐	☐

Are there any other important innovations that helped to overcome barriers in relation to your climate services activities?

18. Would you like to add another type of service?

☐ yes ☐ no

→ if 'yes' then continue with Q10 (and go through section B again; max. three times, then loops end automatically)

→ if 'no' survey ends for providers.

→ Section A continues for users! (followed, if answer to Q1 is 'user')

19. Please specify the type of organisation you work for :

☐ University or Research Performing Organization
☐ Private business
☐ Non profit organisation
☐ Public administration / politics
☐ Industry or professional body
☐ Other:

20. In which country (or countries) is your organisation located?

☐ Austria
☐ Belgium
☐ Bulgaria
☐ Croatia
☐ Cyprus
☐ Czech Republic
☐ Denmark
☐ Estonia
☐ Finland
☐ Germany
☐ Greece
☐ Hungary
☐ Ireland
☐ Italy
☐ Latvia
☐ Lithuania
☐ Luxembourg
☐ Malta
☐ The Netherlands
☐ Poland
☐ Portugal
☐ Romania
☐ Slovakia
☐ Slovenia
☐ Spain
☐ Sweden
☐ United Kingdom
☐ other, where:

21. In which city is your organisation located?

22. In which sector(s) do you work? (check all that apply)

- ☐ Agriculture
- ☐ Water (excl. water way management and water infrastructures)
- ☐ Forestry
- ☐ Energy (excl. grids)
- ☐ (Critical) Infrastructures (incl. energy and water supply, and telecommunication but excl. roads, rails and waterways)
- ☐ Transport and logistics (incl. land, water and air)
- ☐ Tourism
- ☐ Building and construction
- ☐ Finance and (re-) insurance
- ☐ Catastrophe management / Desaster Risk Reduction
- ☐ Health care incl. pharmaceuticals
- ☐ Waste management
- ☐ Biodiversity and nature conservation
- ☐ Education and training
- ☐ Spatial / urban planning
- ☐ Industry and Trade
- ☐ Ecosystems management, incl. soil
- ☐ Mining / Extraction (incl. oil, gas, coal)
- ☐ Other:

23. Are you engaged in or connected to one or more of the following networks? (Check all that apply)

- ☐ ERA-NET for Climate Services
- ☐ Climate Services Partnership
- ☐ Global Framework for Climate Services (GFCS)
- ☐ Copernicus Climate Change Service (C3S)
- ☐ Climate Knowledge Brokers
- ☐ World Climate Research Programme
- ☐ EUMETNET
- ☐ Water JPI
- ☐ Future Earth
- ☐ ECRA
- ☐ JPI Oceans
- ☐ Belmont Forum
- ☐ CORDEX
- ☐ JPI Climate
- ☐ EIT Climate KIC
- ☐ CMIP
- ☐ JPI Urban Europe
- ☐ GCOS
- ☐ GEOSS
- ☐ JPI FACCE
- ☐ Others:

Would you like to add another network or initiative?

25. Do you use climate services in your work?

☐ yes ☐ no

→ if 'yes' continue with Q26

→ if 'no' continue with Q40.

26. What, in your opinion, does 'quality' refer to in your choice of climate service providers, and how would you rate it in terms of importance from 1 (low) to 5 (high)?

Quality characteristics	1	2	3	4	5	Not considered
The usefulness of the information in our own processes (better results or output)	☐	☐	☐	☐	☐	☐
The serviceability of the provider regarding information transfer, applicability, and further advice	☐	☐	☐	☐	☐	☐
The fitness-for-purpose of the provided data for joining with our own data and information (e.g. spatial and temporal resolution, statistical properties, proximity to variables of interest, etc.)	☐	☐	☐	☐	☐	☐
The cost of acquisition and use of the climate services	☐	☐	☐	☐	☐	☐

27. Did the acquisition of climate services entail:

☐ No purchase cost ☐ Modest purchase cost ☐ Significant purchase cost

28. Did the use of climate services entail:

☐ No or no notable extra resource use

☐ Moderate, yet notable extra resource use for HR

☐ Moderate, yet notable extra resource use for equipment/ software

☐ Moderate, yet notable extra resource use for HR and equipment / software

☐ Significant extra resource use for HR

☐ Significant extra resource use for equipment/ software

☐ Significant extra resource use for HR and equipment / software

29. Would your organisation see benefits in joint acquisition (and post-processing) of climate services (e.g. with other organisations in the same area, with others from the same sector, etc.)?

☐ No, because our climate services acquisition happens irregularly

☐ No, because it mixes with confidential or commercially sensitive information

☐ No, because our climate service needs are quite specific

☐ Yes, with organisations from same area

☐ Yes, with organisations from same sector

☐ Yes, in order to share costs / save resource use

☐ Yes, in order to better exploit the potential of climate services

B. What kinds of barriers do you face in your activities related to climate services?

In this section we would like to learn about the barriers and enabling conditions you face when using climate services.

30. Over the past years, numerous different types of climate services have been developed. How would you classify the climate service product you will relate all subsequent questions to? (check what fits best)

- ☐ Advisory services, risk assessments and decision support tools
- ☐ Data management, incl. calibrated data sets, data archiving, data certification
- ☐ Measurements, incl. instruments and technologies for measurements and calibration
- ☐ Modelling, including climate, impacts and socio-economics
- ☐ Operations (collection and provision of raw data)
- ☐ Processed data, incl. re-analysis
- ☐ Publications, e.g. synthesis and assessments, guidance documents, manuals
- ☐ Capacity building / training
- ☐ Other:

31. What type(s) of climate data and information are needed for the selected service?

- ☐ Observational data
- ☐ Forecasts
- ☐ Climate projections and models
- ☐ Paleoclimatology
- ☐ Mapping and analysis tools
- ☐ Other:
- ☐ Not applicable

32. Please let us know, which political barriers you face when using climate services. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Limited science-practice interaction (availability of relevant information)	☐	☐	☐	☐	☐	☐
Accessibility of information, incl. open data guidelines	☐	☐	☐	☐	☐	☐

Would you like to add anything?

33. Please let us know, which economic barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Limited financial resources	☐	☐	☐	☐	☐	☐
Human capital (incl. number and proficiency of staff)	☐	☐	☐	☐	☐	☐
Organisational setting, incl. established practices and routines, decision-making processes	☐	☐	☐	☐	☐	☐
Added-value of climate services often unclear	☐	☐	☐	☐	☐	☐
Timeliness of development and provision	☐	☐	☐	☐	☐	☐
Dysfunctional definition or distribution of competences and responsibilities	☐	☐	☐	☐	☐	☐
Missing definition or distribution of competences and responsibilities	☐	☐	☐	☐	☐	☐
High search costs to find a suitable service	☐	☐	☐	☐	☐	☐

Would you like to add anything?

34. **Please let us know, which social barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).**

Barriers	1	2	3	4	5	Not applicable
Difficulties to involve different stakeholders (lack of social capital)	☐	☐	☐	☐	☐	☐
Difficulties to interact with other in-house expertise / other disciplines	☐	☐	☐	☐	☐	☐
Different cultural settings in science and application, incl. attitudes, priorities and expectations, 'language'	☐	☐	☐	☐	☐	☐
Infrequent interaction between provider and user	☐	☐	☐	☐	☐	☐

Would you like to add anything?

35. Please let us know, which technological and scientific barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Lack of appropriate technology / technological capacity	☐	☐	☐	☐	☐	☐
Difficulties to find suitable services (availability)	☐	☐	☐	☐	☐	☐
Difficulties to access suitable services	☐	☐	☐	☐	☐	☐
Missing standardization of information, incl. layout, terminology etc.	☐	☐	☐	☐	☐	☐
Lack of scale (both, temporal and spatial) relevant scientific or technical information	☐	☐	☐	☐	☐	☐
Timeliness of development and provision	☐	☐	☐	☐	☐	☐
Inappropriate format of available services	☐	☐	☐	☐	☐	☐

Would you like to add anything?

36. Please let us know, which ethical barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Missing transparency of data sources, methods used to develop services	☐	☐	☐	☐	☐	☐
Completeness of information incl. metadata, strength and weaknesses / limitations of a service, uncertainties	☐	☐	☐	☐	☐	☐
Cooperation between provider and user during service development	☐	☐	☐	☐	☐	☐
Short-term relationship - missing trust between provider and user on reliability and quality of services	☐	☐	☐	☐	☐	☐

Would you like to add anything?

37. Please let us know, which legal / regulatory barriers you have already faced. Please rate their importance from 1 (low) to 5 (high).

Barriers	1	2	3	4	5	Not applicable
Reliance and / or dependence upon EU, national or regional policies and regulations	☐	☐	☐	☐	☐	☐
Unclear regulatory / legal requirements	☐	☐	☐	☐	☐	☐

Would you like to add anything?

38. What innovations of the past years would you consider most relevant to overcome the indicated barriers? Please rate their importance from 1 (low) to 5 (high)

Innovation	1	2	3	4	5	Not applicable
Improved high-performance computing capacity	☐	☐	☐	☐	☐	☐
Improved methodologies for science-stakeholder interactions	☐	☐	☐	☐	☐	☐
Improved funding	☐	☐	☐	☐	☐	☐
Capacity-building opportunities and trainings	☐	☐	☐	☐	☐	☐
Open data policies to increase accessibility of information	☐	☐	☐	☐	☐	☐
Policy reforms	☐	☐	☐	☐	☐	☐
Internal capacity building, e.g. setting up working groups, hiring / capacitating staff	☐	☐	☐	☐	☐	☐
Guidance documents, manuals, laymans reports etc.	☐	☐	☐	☐	☐	☐

Would you like to add anything?

39. Would you like to add another type of service?

☐ yes ☐ no

→ if 'yes' continue with Q30 (and go through section B again; max. three times, then loops ends automatically)

→ if 'no' survey ends for users

C. Why do you not use climate services?

You indicated that you do not use climate services. In this section we would like to learn a bit more about the reasons and what, if possible, needs to be done in order to make the use of climate services more attractive or helpful.

40. What are the main reasons for not using climate services? Please rate their importance from 1 (low) to 5 (high).

	1	2	3	4	5	Not applicable
Do not need them / is not required	☐	☐	☐	☐	☐	☐
Is not available / do not know where to get them	☐	☐	☐	☐	☐	☐
To expensive	☐	☐	☐	☐	☐	☐
Provided inappropriately	☐	☐	☐	☐	☐	☐
Not understandable (to scientific)	☐	☐	☐	☐	☐	☐
Not accessible (due to technical constraints)	☐	☐	☐	☐	☐	☐
Need customized solution (no generic ones)	☐	☐	☐	☐	☐	☐
Timeliness of provision	☐	☐	☐	☐	☐	☐

Are there other reasons for not using climate services?

41. What climate services that are not yet available would help you to fulfil your job?

42. In which way could services already available be improved to better fit your purposes?

You have completed the survey. Thank you very much for your participation.

You can now close the window.