Preliminary recommendations for assessments and increase of CS impact, catalogue of best practices and malpractices; foresight of demand evolutions and market developments

Deliverable 4.3

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Glossary

Abbreviation	Explanation
AI	Artificial Intelligence
CE2	Climateurope2
CS	Climate Service(s)
ECMWF	European Centre for Mid-Range Weather Forecasts
FGDs	Focus Group Discussions
ForPAC	Forecast-based Preparedness Action
ISO	International Organisation for Standardisation
KIIs	Key Informant Interviews
MEL	Monitoring, Evaluation, and Learning
PIPA	Participatory Impact Pathway Analysis
WMO	World Meteorological Association

About Climateurope2

Timely delivery and effective use of climate information is fundamental for a green recovery and a resilient, climate neutral Europe, in response to climate change and variability. Climate Services (CS) address this through the provision of climate information for use in decision-making to manage risks and realise opportunities.

The market and needs for climate information has seen impressive progress in recent years and is expected to grow in the foreseeable future. However, the communities involved in the development and provision of CS are often unaware of each other and lack interdisciplinary and transdisciplinary knowledge. In addition, quality assurance, relevant standards, and other forms of assurance (such as guidelines, and good practices) for CS are lagging behind. These are needed to ensure the saliency, credibility, legitimacy, and authoritativeness of CS, and build two-way trust between supply and demand.

Climateurope2 aims to develop future equitable and quality-assured CS to all sectors of society by:

- Developing standardisation procedures for CS
- Supporting an equitable European CS community
- Enhancing the uptake of quality-assured CS to support adaptation and mitigation to climate change and variability

The project will identify the support and standardisation needs of CS, including criteria for certification and labelling, as well as the user-driven criteria needed to support climate action. This information will be used to propose a taxonomy of CS, suggest community-based good practices and guidelines, and propose standards where possible. A large variety of activities to support the communities involved in European CS will also be organized.

Executive Summary

This deliverable D4.3 of the Climateurope2 (CE2) project provides preliminary recommendations for the assessment and increase of climate service (CS) impact, a catalogue of best practices and malpractices, and

a foresight of demand evolutions and market developments. The report is the first version of a recurring deliverable of such recommendations with a focus on the CS market.

Using a two-fold methodology that emphasises gathering insights from stakeholder interviews and contrasts them with a brief analysis of published literature, the goal was to reflect the current realities of the CS market within the objectives of this report. From April to June 2024 13 stakeholder interviews were conducted (7 with users, 3 with providers, and 3 with experts on the CS market). The interviewees were geographically diverse, representing six EU countries: Spain, Germany, Latvia, Belgium, Romania and France. To maintain the participants' anonymity, transcripts and recordings will not be publicly released, and all insights gained will be reported in anonymised form.

The brief analysis of the academic literature on recommendations for the assessment and increase of CS impact highlighted a lack of published research and information on the topic. Information was found on recommendations for increasing the impact of specific components of climate service such as in the case of the co-production of climate services as well as analysis of the impact of the use of CS in specific application domains. General studies providing recommendations on best practices and malpractices related to the impact of climate services are currently lacking. To extend on the findings of this brief analysis, a more thorough literature review will be conducted for the next iteration of the deliverable.
On the other hand, the stakeholder interviews showed that the assessment of CS and climate information impact – both in a qualitative and quantitative manner – is often hindered by several factors, such as the proprietary nature of user data, lack of access to data for risk estimations, and focus on some times when used by the private sector it also affected by financial gains instead of impact on end user communities. To enhance CS impact, the involvement of users in the design of a CS, along with making the collection of user feedback a priority is imperative.

The stakeholder interviews were also used to build a preliminary catalogue of best practices and malpractices, both from the user- and the provider-perspective. Best practices include prioritising user-friendliness of CS tools, standardisation of CS, better integration of users in CS development, knowledge-sharing and cross-sector collaboration, and the upskilling of end users. Malpractices include not prioritising a user-centric CS development, bad internal and external science communication, minimum communication between CS users and providers, lack of common understanding of CS and their usefulness, and the complexity and size of datasets hindering processing and interpretation.

The question of the foresight of demand evolutions and market developments was also posed to the interviewed stakeholders and three main trends driving the CS market in the future were identified: (1) Artificial intelligence and other new and emerging technologies, (2) Policy changes, new policies, and new guidelines for users, (3) More frequent extreme events and changing climate.

This initial set of recommendations will be updated in July 2025 and the final set of recommendations will be published in June 2026. This report will be made available to all interviewed stakeholders with the intention of raising awareness for the best practices and recommendations this report highlights. The hope is that users and providers can learn from each other, which will support the CE2 project's goal of developing an equitable European CS community.

Keywords

Market Development, Market Foresight, Best Practices, Malpractices, Climate Service Impact, Impact Assessment

1. Introduction

The Climateurope2 (CE2) project aims to develop quality-assured and equitable Climate Services to all areas of society, where the term *Climate Services* (CS) describes the provision of climate information such that decision-making is facilitated, including engagement between users and providers, while based on scientifically credible information and expertise, and with an effective mechanism that responds to user needs.

The overall goal of the CE2 project is reinforced in three main pillars: developing standardisation procedures for CS, supporting an equitable European CS community, and enhancing the uptake of quality-assured CS to support adaptation and mitigation to climate change and variability (Fig. 1).

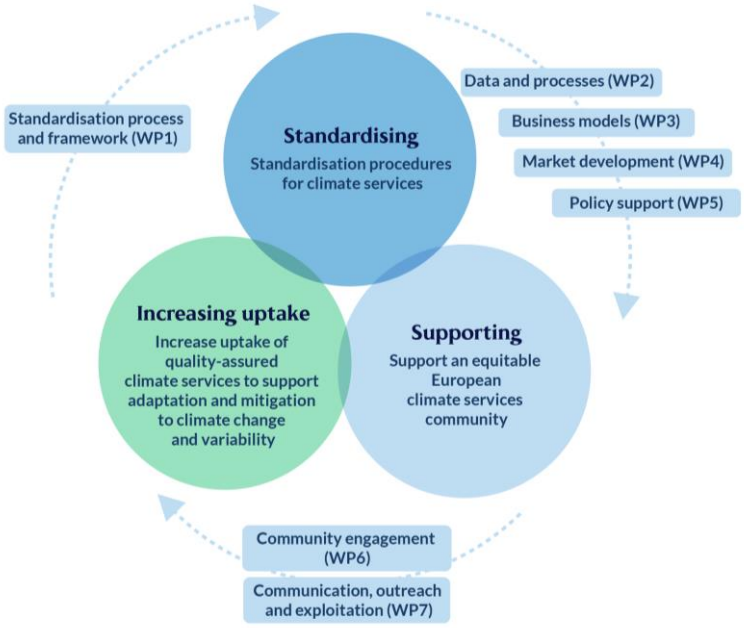

Figure 1. The goals of the Climateurope2 project

Within the project, and specifically to support the goals and Standardising and Supporting, work is being carried out to understand the development of the CS market. As part of these efforts, this document summarises initial recommendations on how to assess and increase the impacts of the use of CS. These recommendations will be based primarily on findings from interviews with stakeholders regarding best practices and malpractices. They will also include stakeholder perceptions on the development of the CS market, including key drivers and trends in future CS demand and supply. The recommendations will be reviewed, contrasted, and updated twice more as the project evolves.

2. Methodology

The methodology employed for this report is two-fold, comprising a series of stakeholder interviews. The outcomes of these interviews, which reflect "on the ground" expertise on the current realities of the CS market, were then contrasted with a brief overview of existing published literature. The predominant emphasis of this deliverable therefore was on harvesting stakeholder perspectives on the topic. To achieve this, interviews were conducted with various types of stakeholders to gather diverse perspectives, as will be outlined below. This mixed method approach aims to gain in-depth knowledge of the CS user experience, understand the perspectives of CS providers, and obtain a holistic view of the market from CS experts.

2.1 Preliminary analysis of scientific and internal publications

While the focus of this report lies in presenting the results of the stakeholder interviews, preliminary research of scientific and project-internal literature was performed between the months of February and June 2024. The focus of this exercise was to conduct an initial analysis of approaches to assess and increase CS impact, as this field was only superficially reported on during the stakeholder interviews. The external literature was identified through Google Scholar using key word searches ("climate services impact", "impactful climate services" etc.). Including the project-internal documents, in total 22 documents were reviewed. The outcomes of the preliminary analysis of scientific and internal publications are summarised in Chapter 3 Recommendations for assessment and increase of climate service impact. Crucially, the results of this initial analysis are limited due to a significant gap in research on the given topic. Only a few relevant publications were identified, and their main findings are discussed in the main body of this document. The report therefore focuses predominantly on the insights gained during the stakeholder interviews. The currently observed lack of literature on the topic will be further studied in the following iteration of the deliverable where a more thorough literature review on the topic will be undertaken.

2.2 Stakeholder interviews

Between the months of April and June 2024, stakeholders, including users, providers, and experts, were engaged in a series of interviews to gather insights into the CS market. A total of 13 stakeholders were interviewed, comprising seven users, three providers, and three experts with a comprehensive understanding of the market. Users of CS were targeted specifically as their perspective is often underrepresented in market assessments. The primary focus was on understanding the requirements and challenges faced by users and providers of CS, while also consulting experts to gain a holistic view of the market.

The interviewees were geographically diverse, representing six EU countries: Spain, Germany, Latvia, Belgium, Romania, and France. The users came from varied sectors, including the finance sector (e.g., a financial institution in Spain), the municipal/public sector (e.g., small municipalities in Germany and Latvia), and the private sector (e.g., a public transport company in Germany and a large global CS provider). An overview of the interviewees is given in the below Table 1.

The interview process involved several steps to ensure the collection of valuable stakeholder data while operating within the CE2 guidelines for engaging stakeholders. Candidates were sourced through existing networks within Work Package 4 and outreach efforts at the CE2 festival, which took place in February 2024. Interview candidates were also asked to recommend additional contacts and this "snowball" technique produced several additional interview contacts.

A tailored question catalogue was developed for each category of interviewee, adhering to the Climateurope2 guidelines for engaging stakeholders, as outlined in the Milestone 6.1 report. These question catalogues can be found in the Annex of this report. Interview questions and an explanation of the interview goals were sent to candidates in advance to prepare them for the discussion. Each interview was recorded and transcribed using Microsoft Teams transcription software. In cases where transcription was not possible due to data protection or technical constraints, an audio recording of the interview was made instead. During the interviews, extensive notes were taken to capture key insights. To maintain the participants' anonymity, transcripts and recordings will not be publicly released, and all insights gained will be reported in anonymized form.

Table 1. Overview of Interviewees

Nr.	Category	Country	Description
1	User	Spain	Climate Risk Department within Financial Institution
2	Provider	Spain	Data Scientist
3	User	Germany	Public Transport Provider in large German city
4	User	Spain	Municipal Government
5	Expert	Spain	Climate Research Foundation
6	Expert	Germany	Consultancy with focus on Municipal Governments
7	User	Latvia	Municipal Government
8	User	Romania	City Official
9	Expert	Germany	Copernicus Local Office
10	Provider	Belgium	Global Remote Sensing and Climate Service Provider
11	Provider	France	National Meteorological Office
12	User	Germany	City Climate Office
13	User	Germany	Medium-sized Re-Insurance Company

3. Recommendations for assessment and increase of climate service impact

3.1 Assessing climate service impact

The published literature examined for this report represents an initial effort to map the research and academic community's work on assessing and enhancing the impact of CS. Given the importance of ***impact*** in this context, it is crucial to define what constitutes an impactful climate service. The World Meteorological Organization (WMO) defines an impactful CS as one that effectively supports decision-making processes by providing timely, accurate, and relevant climate information (WMO, 2018). Such services lead to tangible benefits in mitigating risks and enhancing resilience to climate variability and change. They integrate climate data with tools, models, and expert guidance to influence policy, planning, and operational decisions across various sectors, resulting in improved societal, environmental, and economic outcomes. The examined literature revealed a significant gap in the existing research on this topic. It is important to note that this analysis of published literature on the

topic is an initial assessment, and subsequent versions of this deliverable will provide a more comprehensive evaluation.

Traditionally, the impact assessment of CS has focused on quantifiable metrics, such as economic gains or elements related to the accuracy of the measurements and predictions. While these metrics are important, a more holistic approach is needed. To further elaborate on the impact assessment of CS, it is essential to consider both quantitative and qualitative metrics, recognising the multifaceted nature of impact. While economic benefits and forecast accuracy provide tangible evidence of success, they do not capture the entire spectrum of influence that effective CS can exert. The integration of qualitative assessments is critical in painting a complete picture of the impact, particularly in terms of human and institutional behavioural changes, capacity building, and long-term resilience.

In theory, each of these methods contributes to a holistic understanding of how CS support decision-making, enhances resilience, and promotes sustainable practices across various sectors. Having concrete "proof" of the effectiveness of a CS would also facilitate investment in CS on the user side and allow providers to improve their CS accordingly. In practice, however, the assessment of CS impact – both in a qualitative and quantitative manner – is often hindered by several factors that were identified in the stakeholder interviews, which will be outlined here.

For the assessment of CS impact with qualitative methods, the process of collecting user feedback often encounters several challenges. One primary issue is the proprietary nature of user data, such as agricultural output data, which restricts access (mentioned in Interview #5). Consequently, it becomes necessary to substitute quantitative data with qualitative user feedback, complicating the assessment of CS impact. Additionally, the multiple layers of interaction between the end users of CS and the high-level data providers further complicate the feedback collection process (mentioned in interview #10). Developing indicators that are specific to the *in-situ* situation is essential to observe the direct impact of CS or of the infrastructure developed using CS, e.g., a new city park (mentioned in interview #1 and #8). However, decisions and actions are frequently based on previous experience, and user feedback is not always systematically collected (mentioned in interview #8).

On the other hand, quantitative assessments – in terms of financial savings attributable to CS – remain a relatively new practice for many user groups, such as small municipalities in Germany (mentioned in interviews #9 and #12). Despite this, financial incentives are a significant driver for decision-makers to invest in CS, highlighting the importance of demonstrating economic benefits through such quantitative impact assessments.

While the insurance sector has a more direct link between the impact of climate data and financial gains or savings, the sector still faces considerable challenges due to the lack of coverage for assets at risk from climate change. This poses a financial risk, particularly for small municipalities, e.g., in Latvia (mentioned in interview #7). Improved access to data for risk estimations would enable insurers to better understand the ratio of losses incurred to premiums collected, enhancing the accuracy of risk assessments. While difficult to measure, better risk quantification could potentially save billions globally (mentioned in interview #13). However, even CS providers with advanced technical skills frequently struggle with the implementation and measurement of CS impacts (mentioned in interview #13).

3.2 Increasing climate service impact

Increasing the impact of CS relates to implementing best practices and avoiding malpractices. A detailed accounting of best practices and malpractices in the CS market will be provided in the subsequent

Chapter 4 Catalogue of best practices and malpractices. Generally, however the following approaches are advisable to increase the impact of CS.

Involving users in the design of CS is essential for ensuring their relevance to key stakeholders and their effectiveness in providing tangible benefits to those stakeholders. By actively involving stakeholders in the CS design process, e.g. as done by one provider with coffee and cocoa farmers in Latin America (mentioned in interview #5), the services could be better tailored to meet their specific needs and conditions. Making the collection of user feedback a priority is another critical aspect, as it provides valuable insights into the effectiveness of CS and areas for improvement.

In line with these practices, one of the few papers offering recommendations on the impact of CS during the literature assessment was by Visman et al. (2022). Their paper, "Defining Metrics for Monitoring and Evaluating the Impact of Co-Production in Climate Services," provided valuable insights into areas requiring further research and development. Some of these elements are discussed below.

Monitoring, Evaluation, and Learning for increasing the impact of Climate Services

Developing Monitoring, Evaluation, and Learning (MEL) frameworks to assess the impact of co-producing CS is key. Effective CS are often the result of co-production processes where climate information producers and users collaborate closely. This collaborative approach ensures that the services are *relevant, user-centric, and actionable*. The proposed framework for monitoring the impact of co-production in CS suggests a set of indicators to track the progress and effectiveness of these initiatives. A framework could, for example, evaluate access, use, and benefits of new and improved CS at the household level, thereby ensuring a comprehensive assessment.
Strengthening MEL capacities within partnering meteorological agencies and research institutions is crucial for sustaining the benefits of CS. This involves developing sustainable systems for *participatory monitoring and evaluation*, which can continuously gather user feedback and adapt services accordingly. National frameworks for CS, when linked with existing national monitoring and evaluation frameworks, can provide a robust basis for demonstrating the value and securing funding for CS. The impact assessment of CS requires a balanced approach that includes both *quantitative metrics and qualitative insights*. By focusing on improved decision-making, enhanced awareness, and behavioural shifts, and by leveraging co-production and robust MEL frameworks, stakeholders can ensure that CS are truly impactful and lead to substantial, long-term benefits across societal, environmental, and economic dimensions.

Improved decision-making: Beyond the accuracy of forecasts, the utility of CS is fundamentally measured by their ability to inform decisions. For instance, did the information provided lead to more informed and timely decisions by policymakers, businesses, or communities? Evaluating the change in decision-making processes and the quality of outcomes is key to understanding the real-world application of climate services. As highlighted in the document, initiatives like the Towards Forecast-based Preparedness Action (ForPac) and the Participatory Impact Pathway Analysis (PIPA) have been instrumental in aligning forecasts with national drought early warning systems, directly influencing contingency planning and preparedness actions.

Enhanced awareness and understanding: One of the qualitative aspects often overlooked is the role of CS in raising awareness and deepening the understanding of climate risks and vulnerabilities among stakeholders. This involves assessing whether users of CS feel more knowledgeable and equipped to handle climate-related challenges. Projects such as AMMA-2050 have demonstrated the effectiveness

of Key Informant Interviews (KII) scorecards in tracking changes in decision-makers' capacities to integrate climate information into their planning processes.

Behavioural shifts: One of the goals of CS may be to induce behavioural changes that foster climate resilience and mitigation. This can be measured by observing changes in practices, attitudes, and policies among users of CS. For instance, has the provision of climate data led to the adoption of new agricultural practices, better water management, or more resilient infrastructure planning? The qualitative analysis through tools like KIIs and Focus Group Discussions (FGDs) helps in identifying such shifts and understanding the broader socio-economic impacts.

Continuous evaluation and assessment of impact to improve CS is necessary to keep pace with evolving user needs and technological advancements (mentioned in interview #1). The use of new and emerging technologies, particularly Artificial Intelligence (AI), is highlighted as a promising avenue for future enhancements (mentioned in interviews #2, #3, #5, #10). AI can significantly improve CS by enabling the efficient processing of large datasets, thereby providing more accurate and timely information to users. The role of AI in the CS market will be explored further in Chapter 5 Foresight of demand evolutions and market developments.

4. Catalogue of best practices and malpractices

An overview of the best practices and malpractices mentioned during the stakeholder interviews will be given below, both from the perspective of CS users and from the perspective of providers of CS. The catalogue of most frequently mentioned practices was summarised and illustrated in the below Figure 2, which will be updated in the second and third iteration of this deliverable. The figure illustrates which developments and trends the stakeholders reported are related to each other, and may reinforce one another, and which developments oppose or contradict each other.

4.1 Best practices

User perspective

From the user perspective, it is imperative to have highly skilled staff within organisations or municipalities who possess the knowledge of what data is required, where it can be located, how it can be analysed, and how it can inform policy and decision-making processes (mentioned in interviews #1, #4, #8, and #12). Additionally, having personnel at the level of decision-making in the organisation (be it a private sector company or a municipal government) who recognise the value of CS and are committed to prioritising their use is essential (mentioned in interview #5).

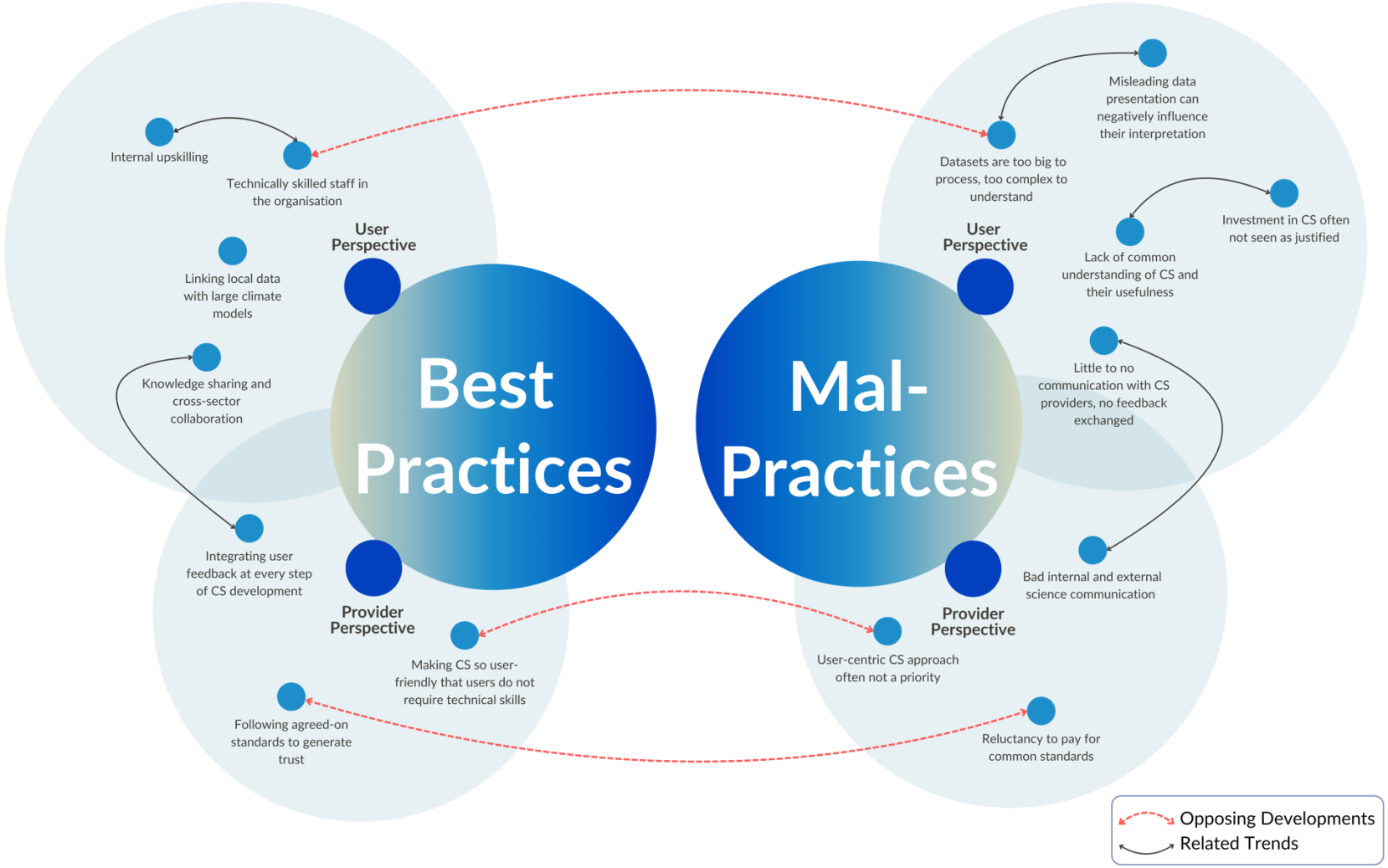
Best Practices
Mal-Practices
User Perspective
Provider Perspective
User Perspective
Provider Perspective
Internal upskilling
Technically skilled staff in the organisation
Linking local data with large climate models
Knowledge sharing and cross-sector collaboration
Integrating user feedback at every step of CS development
Following agreed-on standards to generate trust
Making CS so user-friendly that users do not require technical skills
Misleading data presentation can negatively influence their interpretation
Datasets are too big to process, too complex to understand
Investment in CS often not seen as justified
Lack of common understanding of CS and their usefulness
Little to no communication with CS providers, no feedback exchanged
Bad internal and external science communication
User-centric CS approach often not a priority
Reluctancy to pay for common standards
Opposing Developments
Related Trends

Figure 2: Catalogue of Best Practices and Malpractices from the Provider and User Perspective

Enhancing cross-sector collaboration and knowledge sharing are additional crucial measures mentioned in interviews #5 and #6). These can also help in upskilling the end users, by providing technical support where technical knowledge is lacking. The lack of capacity often means that users are a lot less ready than they anticipated when beginning to work with CS providers (mentioned in interview #10). Bridging the technical skill-gap and building up capacities internally is a vital best practice for end user organisations to implement.

Additionally, the integration of locally measured or collected data with large-scale climate projections and models would constitute a significant advancement, facilitating the processing and understanding of data for end users, even in the absence of technical expertise (mentioned in interview #12). For this integration, either good communication between the providers and users would be needed, or a high level of technical skill on the user side would be required.

Imagining the" ideal" Climate Service

Some interviewees (CS users) were asked to imagine their "ideal" CS, i.e. the CS that would meet their needs best. They were asked to consider this as a hypothetical scenario, without any financial or data constrains. Three concrete and thought-provoking suggestions are listed here:

- **Interview #3:** A tool that helps the end user identify the CS that they need, where they could enter the end user's needs and the tool prescribes a best-fit CS. This would be a kind of CS "search tool".
- **Interview #4:** An AI tool where the end user can enter their assets and the tool then gives information on the (climate) risk to those assets over at least 3 scenarios. The AI then produces a risk assessment of the listed assets, can suggest measures to reduce the risk, and can generate reporting on the assets.
- **Interview #8:** A website or tool that integrates the types of data the end user needs and automatically generates graphs and datasets for common parameters (e.g. temperature, precipitation) to be used in proposals and for reporting.

The main aspects of the "ideal" CS mentioned were the ***integration of AI***, the ***integration of end user needs***, and the ***automatic generation of reporting materials***.

Furthermore, standardised CS are particularly important for end users in heavily regulated industries, such as the insurance and reinsurance sectors (mentioned in interview #13). Implementing standards across the board would represent a paradigm shift for the industry (mentioned in interview #13) and the use of agreed-on and common standards generates trust within end user communities and would make it easier for end users to report under new regulations (mentioned in interviews #2, #5, and #6).

Provider perspective

From the provider perspective, the integration of user feedback at every stage of CS development is essential (mentioned in interview #5). Ideally the design of a CS combines data timeseries from the past with input from the end user to generate a model for the future (mentioned in interview #5). In line with the end-user focus, the CS should be designed in a way that does not require the users to possess any technical skills, e.g. expertise in Earth Observation.

CS should be designed to be highly user-friendly, eliminating the need for highly technical expertise on the user side; users should not be expected to comprehend remote sensing data or its processing (mentioned in interview #10). This should include presenting the CS information in a user-friendly way. For example, colour coded, or through direct and clear recommendations (e.g. "irrigate now", "harvest in 30 days"). User-friendly communication ensures that the prediction will be translated into concrete actions or recommendation (mentioned in interview #5).

Adhering to agreed-upon standards foster trust among users and standards are critically important for providing cohesive information to users (mentioned in interview #2). The use of agreed-on standards should therefore be encouraged on the provider side (mentioned in interviews #2 and #10). Furthermore, soliciting feedback from the end-user community, as well as from stakeholders such as citizens, regarding new developments made with the consultation of CS, is vital for improving the overall effectiveness and acceptance of these services (mentioned in interviews #5 and #8). It is also important that CS providers support the upskilling of the end user community to ensure the service can be used to its full potential (mentioned in interview #10).

Furthermore, Earth Observation data – or any data type – should ideally not be utilised in isolation; it should be combined with various types of data to maximise value for the end user community (mentioned in interview #10). It may be necessary to involve multiple layers of companies building on each other's data and products between Copernicus and the end user to make this integration possible (mentioned in interview #10).

As weather extremes typically manifest on small spatial and temporal scales, high-resolution data becomes a necessity to supply data with the highest-possible accuracy to end users (mentioned in interview #10). In the context of future climate change, extreme weather impacts, and the translation of these impacts into risk estimations, substantial progress has been made in the resolution of models. The European Centre for Medium-Range Weather Forecasts (ECMWF) and other large organisations are advancing towards finer scales for their datasets and models. Further refinement in scale would significantly enhance the industry's ability to understand and characterise these events, which is of high value to the end users (mentioned in interview #10).

4.2 Malpractices

User perspective

From the user perspective, several challenges hinder the effective application and uptake of CS. Datasets provided by sources such as Copernicus are often too large, leading to extended processing, downloading, and downscaling times (mentioned in interview #1, #5, #6, and #7). Despite these datasets being available to users free of charge, their processing demand is a big hurdle especially for those end users who lack technical skills and knowledge of the availability of the data (mentioned in interviews #6). -This contributes to the potential of CS frequently not being recognised, also on the political level. The use of CS is therefore often deemed unnecessary, as there is a significant lack of understanding and technical knowledge to fully recognise their potential in many end user communities (mentioned in interviews #6, #7, and #8). This situation is exacerbated when there is a lack of a common definition and understanding of what CS are (mentioned in interview #8). Due to the lack of internal capacity, end users often have to rely on companies specialising in modelling data, who are closer to their position in the value chain, making it easier to outsource data processing (mentioned in interview #10). This outsourcing, however, reduces the likelihood of internal upskilling and adds an additional financial burden on the end user.

Similarly, the relatively high investment in purchasing CS tools is often viewed as unjustified when these tools are only needed or used on an *ad hoc* basis (mentioned in interview #7 and #8). This this perceived unnecessity makes it easy to justify inaction and shows that CS are generally not thoroughly integrated into decision-making in end user communities (mentioned in interviews #7 and #8). This is especially detrimental as the "low-risk, low regret" measures are no longer enough to sufficiently support adaptation and resilience measures (mentioned in interview #6).

Furthermore, responsibility for using and integrating CS often falls on a few or even single individuals within the end user organisation who possess the required technical knowledge (mentioned in interviews #1, #7 and #8). Due to high workload and short delivery timeframes, these individuals often only have limited time to generate reports or proposals that integrate CS, and their full potential is therefore often not represented (mentioned in interview #1 and #8). The quality of data analysis and presentation in proposals to decision-makers, however, directly influences the likelihood of the proposal being accepted (mentioned in interview #7). The lack of support for the individuals championing the use of CS in their organisations decreases the likelihood that CS will be integrated in decision-making, creating a negative feedback loop.

Lastly, the communication with CS providers is minimal, making it difficult to give feedback or request specific types of data or models (mentioned in interviews #8 and #12). Especially the communication of uncertainties in the models is challenging and end users often struggle to understand the implication of uncertainties in data and the actual meaning behind the data (mentioned in interview #3 and #6). Misleading representation of data can negatively impact its interpretation, especially when used to support or disprove specific political agendas (mentioned in interview #12).

Provider perspective

From the provider perspective, there are significant issues with science communication both internally and externally, as well as a lack of scientific collaboration across borders (mentioned in interviews #2 and #5). This hinders the data and knowledge sharing that should be implemented as a best practice and could support the upskilling of end users. Moving towards a user-centred CS approach is not always prioritised by provider organisations. Even Copernicus and other open-source data providers do not make their web pages sufficiently user-friendly (mentioned in interview #3).

The primary issue, therefore, is not the provision of data but the downstream application and adoption of solutions (mentioned in interview #10). These are often hindered because solutions are not sufficiently tailored and often demand too much technical expertise from the end user. Data is also not sufficiently centralised, but rather spread across several platforms, and there is no single publicly accessible data portal that provides precisely the information end users need (mentioned in interview #13).

Furthermore, there are financial incentives that hinder the implementation of best practices from the perspective of CS providers. For instance, providers are often required to pay for standards, such as ISO standards, which can be a barrier to the implementation and use of such standards (mentioned in interview #2). The standards can also be perceived as very complicated and difficult to understand for providers (mentioned in interview #2). Additionally, the implementation of open-data policies can significantly affect the revenue model of CS providers (mentioned in interview #11). Providers rarely offer figures on the cost-effectiveness of using CS data, which would demonstrate the usefulness of CS for a given user or stakeholder community (mentioned in interview #9). Moreover, it is often more cost-effective for private CS providers to use only one model, projection, or variable in their CS, despite the comparison different models being the scientifically suitable approach (mentioned in interview #5).

Generally, in Europe the issues lie not in the amount of data available, even though the user-friendliness of this data can be improved, but the slow downstream uptake of the information. This slow uptake is reinforced by a lack of urgency in communicating the risks of climate change impacts and how to best adapt to them, which can be attributed to political and societal effects (mentioned in interview #1 and #5). Following best practices and avoiding malpractices therefore often comes down to "a question of vision" (mentioned in interview #4).

5. Foresight of demand evolutions and market developments

When considering the future demand evolutions and market developments for CS, three key trends and drivers of future demand were identified in the stakeholder interviews (Figure 3). These will be explained in detail in this chapter. Generally, it was agreed that the demand for CS will grow in the future (mentioned in interviews #3, #4, #5, #10, and #12).

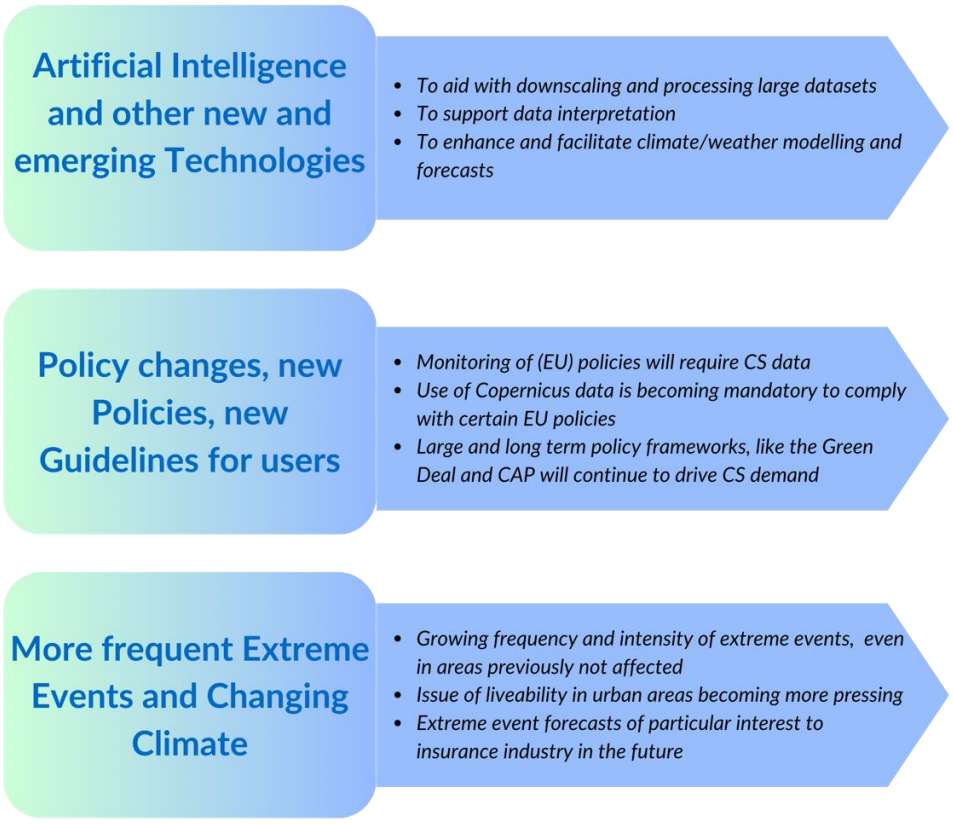

Figure 3. The main trends and drivers for demand for CS in the future, as identified through the interviews

One major area identified throughout the interviews is the role of AI and its applications for data processing. There is a strong desire for AI-driven CS tools that simplify the process of finding appropriate CS, automatically downscale large datasets, present data in a user-friendly manner, and potentially suggest policy decisions based on the data (mentioned in interviews #2, #3, #5, and #10). The capacity to better serve user needs with the vast amounts of data being generated is expected to improve significantly with new AI systems. This is already becoming evident in the Earth Observation sector, where AI is being leveraged to handle large quantities of Earth Observation data (mentioned in

interview #5). Additionally, AI is used to support data interpretation, however this raises internal debates about whether AI is replacing human decision-making abilities and the potential consequences of AI being incorrect (mentioned in interview #11).

Policy changes and the implementation of new policies are another significant driver of demand for CS in the future (mentioned in interviews #3, #4, #6, #7, and #10). New standards, norms, and regulations for reporting will require the use of CS and climate data by companies and organisations (mentioned in interview #3). Those able to support such reporting while meeting regulatory standards will be in high demand (mentioned in interview #3). The European Union has increased its climate policy output, necessitating monitoring of policy targets using Earth Observation and national adaptation plans will require regular reporting on climate trends (mentioned in interview #3). This is an essential part of the European Green Deal, for example, which extends until 2030 and ensures that these objectives remain a priority (mentioned in interview #10).

CS market drivers and trends in the insurance industry – Resilience vs. Uninsurability

When looking at the insurance industry in particular, there is a level of inhibition among insurance companies to take initial steps towards better resilience, partly due to a lack of political will. Progress is more evident in the industrial or commercial insurance sectors, where customers are more willing to enhance the resilience of their operations. In these sectors, new business models are emerging that incorporate resilience into their insurance offerings (mentioned in interview #13). In contrast, the private property market stands to face challenges due to the substantial costs of retrofitting buildings for resilience, which could drive many people out of the insurance market. Consequently, several insurers are withdrawing from high-risk areas, negatively impacting both the at-risk regions and the insurance industry. As a result, implementing resilience on a large scale remains distant. In Europe, governments often step in to provide subsidies and act as the ultimate risk taker to prevent areas at high risk from becoming uninsurable (mentioned in interview #13).

Lastly, the increasing frequency and intensity of extreme events due to climate change are further driving demand for CS and will continue to do so in the future (mentioned in interviews 3, #4, #5, and #8). Even regions not currently affected by extreme weather events will see a growing need for CS, such as early warning systems, in anticipation of future risks (mentioned in interview #1). Urban areas facing issues of liveability, for example, will require long-term temperature and heat models to assess their viability (mentioned in interview #8). Datasets tracking the accumulation and frequency of extreme events will be crucial for future decision-making at the local municipal level (mentioned in interview #3).

To support this increased use of and demand for CS, an important aspect is the need for increased upskilling of the end-user workforce to enable them to fully understand and exploit the potential of CS, as mentioned previously under Chapter 4.1 Best practices. There is also a significant demand for CS in other parts of the world, particularly in the development of climate finance to support and reward regions for protecting natural resources like forests (mentioned in interview #10).

6. Conclusion and next steps

This report represents a cohesive assessment of the current state of the CS market, comparing insights gained during in-depth interviews with key players in the CS market with the relatively few scientific publications on the topics.

A catalogue of best practices and malpractices was provided and summarised (Fig. 2), along with recommendations for increasing and assessing the impact of CS. Additionally, the key trends and drivers that will steer the demand for CS in the future, and therefore have significant influence on the market as a whole, were identified and presented.

6.1 Next steps

As this report marks the first iteration in a recurring series of deliverables, the recommendations and the catalogue presented here will be continuously updated until the next deliverable (July 2025) and eventually the final set of recommendations (June 2026) are published. The aim is to build on the knowledge base that was built up for this report, as well as the network of contacts within the CS market that were established and grown during the interview process. Follow-up interviews with certain candidates as well as an additional round of the "snowball" technique for gathering additional contacts from existing networks may be conducted. The following iterations will also build up on the preliminary literature analysis conducted for this report.

This deliverable will also be shared with the cohort of interviewees with the intention of raising awareness for the best practices and recommendations this report highlights. The hope is that users and providers can learn from each other, which will support the development of an equitable European CS community.

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8. Annex

8.1 Question Catalogue USERS

Many thanks for accepting to participate in this interview. Below we will provide a short overview of the Climateurope2 project, the goals of conducting these interviews, as well as the question catalogue that will guide the interviews. You will not be required to respond to all listed questions.

Introduction:
Climate-KIC is part of the Climateurope2 project, which has three main objectives:

1. **Standardising:** Development of standardisation procedures for CS
2. **Supporting:** Support of an equitable European CS community
3. **Increasing uptake:** Enhancement of the uptake of quality assured CS to support climate adaptation and mitigation.

CS involve the generation, provision, and contextualization of information and knowledge derived from climate research for decision making at all levels of society.
Within the Climateurope2 project, Climate-KIC is active in Work Package 4, which focuses on the Development of the CS market. More specifically, Climate-KIC is currently working on drafting recommendations for the assessment and increase of the impact of CS, as well as a catalogue of best practices and malpractices. Furthermore, we aim to provide foresight of demand evolutions and market developments. To inform this work, we are conducting interviews with active participants in the CS market, both on the demand and supply side. The questions asked during the interviews aim to gather insights from both perspectives, allowing for a comprehensive and balanced report on climate service impact, best practices, and future market developments.

Question Catalogue:

1. User experience:
   - Which types of CS are you currently using, or have you used in the past and for what purpose?
   - What are your thoughts about the CS you have experience with?
   - Can you share more details/background/information on the experiences you've had with CS with us?
2. Challenges and limitations:
   - What challenges or limitations have you encountered in accessing or utilising CS?
   - Have there been instances of dissatisfaction or unmet expectations with climate service offerings?
3. Impact assessment:
   - How do CS impact your decision-making processes?
   - Is there a way to measure this impact? If so, how?
4. Best practices:
   - Are you integrating CS into how your organisation operates?
5. Areas of improvement:
   - Are there (specific) areas or aspects of the CS you have used that you believe could be enhanced or improved?
6. Future demand:
   - How can you imagine that the future demand for CS might evolve in your sector or industry?
   - Which future challenges or opportunities do you think CS can address?

8.2 Question Catalogue PROVIDERS

Many thanks for accepting to participate in this interview. Below we will provide a short overview of the Climateurope2 project, the goals of conducting these interviews, as well as the question catalogue that will guide the interviews. You will not be required to respond to all listed questions.

Introduction:
Climate-KIC is part of the Climateurope2 project, which has three main objectives:

2. **Standardising:** Development of standardisation procedures for CS
3. **Supporting:** Support of an equitable European CS community
4. **Increasing uptake:** Enhancement of the uptake of quality assured CS to support climate adaptation and mitigation.

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Question Catalogue:

1. Service offerings:
   - What specific CS does your organisation provide, and how do they meet user needs?
   - Can you share some user experiences with CS with us?
2. Success stories and case studies:
   - Do you have success stories or case studies showcasing the successful implementation of your CS?
3. Challenges faced:
   - What challenges or obstacles have you encountered in delivering effective CS?
   - Are you aware of instances of a need for improvement or lessons learned from less successful implementations in the CS domain?
4. Climate service quality:
   - How does your organization gather user feedback, and how is it utilised?
   - What strategies are in place to enhance your CS over time?
5. Foresight and market developments:
   - How do you foresee the demand for CS evolving in the coming years?
   - Are there emerging policies, trends, or technologies that are influencing the development of CS?
6. Collaboration and partnerships:
   - How does your organization collaborate with users and stakeholders?
   - Can you share with us some ongoing or past partnerships or collaborations with stakeholders beyond users (e.g. governments, NGOs, private companies, …)?

8.3 Question Catalogue EXPERTS

Many thanks for accepting to participate in this interview. Below we will provide a short overview of the Climateurope2 project, the goals of conducting these interviews, as well as the question catalogue that will guide the interviews. You will not be required to respond to all listed questions.

Introduction:
Climate-KIC is part of the Climateurope2 project, which has three main objectives:

3. **Standardising:** Development of standardisation procedures for CS
4. **Supporting:** Support of an equitable European CS community
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Question Catalogue:

1. Service offerings:
   - What specific CS does your organisation work with, and how are they linked to user needs?
   - Can you share some experiences with CS with us?
2. Success stories and case studies:
   - Do you have success stories or case studies showcasing the successful implementation of CS?
3. Challenges faced:
   - What challenges or obstacles have you observed in delivering effective CS?
   - Are you aware of instances of a need for improvement or lessons learned from less successful implementations in the CS domain?
4. Climate service quality:
   - How does your organization gather user feedback, if at all, and how is it utilised?
   - What strategies are in place to enhance CS you have observed over time?
5. Foresight and market developments:
   - How do you foresee the demand for CS evolving in the coming years?
   - Are there emerging policies, trends, or technologies that are influencing the development of CS?
6. Collaboration and partnerships:
   - How does your organization collaborate with users and stakeholders?
   - Can you share with us some ongoing or past partnerships or collaborations with stakeholders beyond users (e.g. governments, NGOs, private companies, …)?