

# Climateurope2

## Advanced guiding principles for high-quality Climate Services

### *Deliverable D4.4*

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# Table of Contents

1	Introduction	8
1.1	Objectives of the work	14
1.2	Structure of this report	15
2	Methodology	16
2.1.1	Survey on Climate Services from User and Provider Perspectives	18
2.1.2	Community engagement in workshops	18
2.1.3	Stakeholder interviews	20
2.1.4	Case studies	20
3	Results	23
3.1	Results from the survey	23
3.2	Results from community engagement in workshops	29
3.2.1	Climateeurope2 Festival	29
3.2.2	3 <sup>rd</sup> Climateeurope2 Webstival	32
3.3	Results from interview series	35
3.4	Results from Case studies	37
3.5	Merging of the results	43
3.6	Other relevant results from Climateeurope2 and other studies	46
4	Conclusions	49
4.1	Next steps:	50
	Acknowledgement	50
5	References	51
	Appendices	56
	Appendix 1: Survey on Climate Services from User and Provider Perspectives	56
	Appendix 2: Case studies	82
	A2.1 Climate Services of Climateeurope2 project-wide case studies	82
	A2.2 CS through public funding (finished projects)	94
	A2.3 Climate Services through public funding (Ongoing projects)	106
	A2.4 Private CS	117

## List of tables

Table 1: Quality criteria related to guiding principles and CS components.....	13
Table 2: Summary of the case studies .....	40
Table 3: Quality criteria and indicators, sources of information and potential measures.....	44
Table 4: Criteria for successful CS and relationship to quality elements .....	48

## List of figures

Figure 1: Guiding principles and major quality criteria of CS.....	10
Figure 2: Climate service components as identified by Climateurope2 (Baldissera Pacchetti and St. Clair, 2023).....	11
Figure 3: Relationships of the guiding principles with the Climate service components. ....	12
Figure 4: Elements and methods of the quality assessment approach used in this study. ....	16
Figure 5: Participants of one of the “deep dive” discussion groups at the Venice Festival (Photo: Daniele Furlanetto).....	19
Figure 6: Sectors covered by the case studies (note that some CS cover multiple sectors).....	21
<b>Figure 7: Providers covered by the case studies.....</b>	<b>21</b>
Figure 8: User groups addressed by the case studies .....	22
Figure 9: Characteristics of CS covered by the survey (Note: this question was only active in the user and provider mode but not for “observers” of CS). ....	23
Figure 10: Positive aspects of user interaction from the provider side.....	24
Figure 11: Barriers of user interaction from the provider side .....	25
Figure 12: Most important quality criteria from the provider perspective. Scale: 1: not important to 7: very important, multiple answers were possible.....	25
Figure 13: Most important quality criteria from the observer perspective. Scale: 1: not important to 7: very important, multiple answers were possible.....	26

Figure 14: Percentage of high-ranked (5-7) quality criteria across all participants of the survey. Note, multiple answers were possible. ....	27
Figure 15: Percentage of partly of fully agreement to the role of standards answered by providers and observers of CS. Multiple answers were possible. ....	27
Figure 16: Summary cartoon illustrating the “deep dive” sessions at the Climateurope2 Festival. Source: Roberto Sitta.....	29
Figure 17: Example of feedback by the participants at the Venice Workshop. Post-it-colours reflect contributions from different user groups, coloured dots indicate priorities (1 <sup>st</sup> : red, 2 <sup>nd</sup> : yellow, 3 <sup>rd</sup> : green). Photo: A. Villwock. ....	30
Figure 18: Summary of the most mentioned keywords at the deep-dive workshop at the Venice festival in form of a word cloud (generated by Wordwolken.com).....	31
Figure 19: Mentimeter results on criteria relevant for the decision context component as rated by the participants of the 3 <sup>rd</sup> Climateurope2 Webstival.....	32
Figure 20: Mentimeter results on criteria relevant for the co-production component as rated by the participants of the 3 <sup>rd</sup> Climateurope2 Webstival.....	33
Figure 21: Mentimeter results on criteria relevant for the knowledge systems component as rated by the participants of the 3 <sup>rd</sup> Climateurope2 Webstival.....	33
Figure 22: Mentimeter results on criteria relevant for the delivery mode and evaluation component as rated by the participants of the 3 <sup>rd</sup> Climateurope2 Webstival. ....	34
Figure 23: Summary of Best- / Malpractices identified by the interview series of Matthies and Ramirez (2024). ....	36
Figure 24: Major quality criteria identified through the stakeholder engagement process in red in relationship to the guiding principles (small coloured dots refer to findings of the different stakeholder processes of this study (blue: survey, green: workshops, yellow: interviews red: case studies).....	43

## 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 address this through the provision of climate information for use in decision-making to manage risks and realise opportunities.**

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

Climateurope2 aims to develop future equitable and quality-assured climate services to all sectors of society by

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

The project **will identify the support and standardisation needs of climate services, 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 climate services, suggest community-based good practices and guidelines, and propose standards where possible. A large variety of activities to support the communities involved in European climate services will also be organised.

## Executive Summary

The market for climate services has developed rapidly over the past decade, originating from seasonal forecasts issued by public and private (weather) services to a crowded landscape with a wide range of applications for climate change adaptation and mitigation. To ensure quality, trust, and usability in this emerging market the Climateurope2 (CE2) project aims to help develop future equitable and quality-assured climate services to all sectors of society by developing standards for climate services, supporting an equitable European climate services community and enhancing the uptake of quality-assured climate services to support adaptation and mitigation to climate change. One of the elements required to achieve these goals is the definition of (high-)quality climate services. What makes up a good climate service? Is there a common ground across the huge variety of providers, products, and users of climate services? Can a climate service or parts of it be standardised to ensure and to improve quality, usability, and trust?

In this deliverable, we refine and enrich the first set of guiding principles for high-quality climate services, which were developed based on a comprehensive literature review (D4.1), by incorporating additional information obtained by Climateurope2 through community engagement, such as a survey, a set of interviews conducted with users and providers of climate services, workshops and a number of case studies.

According to the results obtained from the different sources mentioned above, quality criteria and indicators for high-quality climate services were prioritized and allocated to the guiding principles. Thus, we provide a more in-depth analysis on which indicators and criteria are most important to characterize quality of a climate service and which ones are most relevant to the user (and provider) community. Finally, we assess which of these criteria and indicators are useful and mature for a standardization process of climate services.

As identified in D4.1 guiding principles for high-quality climate services should be science-based, user-centred, designed with transparent and collaborative processes, delivered in a timely and accessible manner, sustainable and equitable.

Throughout the project, this set of guiding principles will be revisited and refined again. Results will be summarized and published in D11 in M48.

### Keywords

Climate services, high-quality, guiding principles, criteria, indicators, standardisation

# 1 Introduction

As Climateurope2 aims to develop future equitable and quality-assured climate services<sup>1</sup> (CS) to all sectors of society, one of the baselines to be accomplished this goal is the definition of guiding principles for high-quality CS. What makes up a good CS and what is meant by high-quality by whom and for whom? What indicators are needed to assess quality and how can quality be measured? What are overarching criteria for all CS across sectors that can support the definition of standards for CS?

Work Package 4 on Market Development of Climateurope2 addresses these issues through Task 4.3 which will elaborate on guiding principles for high-quality CS as a prerequisite for future standardisation, certification, and labelling. In order to accomplish this goal, a phased approach was defined starting with a literature review (see Climateurope2 Deliverable 4.1, (Villwock, 2023)) which has now been continued by involving different user and provider communities in order to prioritise quality criteria across sectors addressed by CS. Furthermore, the results from other work packages, in particular WP2 on Data and Processes (see D2.2, D2.3, D2.4, D2.5) were incorporated in this study. The initial results of this (ongoing) consultation process will be presented in this deliverable. Finally, the consolidated set of guiding principles for high-quality CS will be developed iteratively until reaching D4.11 (M48) to build a broad consensus within the communities involved and, thus, contribute to increase trust and transparency.

The initial set of guiding principles for high-quality CS as defined in Deliverable 4.1 based on an extensive literature review comprises seven major components:

1. **Science-based:** CS should be based on credible science and evidence. Service providers should use the best available scientific data, models, and methods to develop and deliver climate information. References to peer-reviewed literature and / or official certificates (e.g., Certified Consulting Meteorologists of the American Meteorological Society (<https://www.ametsoc.org/index.cfm/ams/education-careers/careers/ams-professional-certification-programs/certified-consulting-meteorologist-program-ccm/>)) can build confidence and trust in the user community.

**Keywords/Criteria:** state-of-the-art methods and data, quality assured data / methods, proven scientific expertise

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<sup>1</sup> Climateurope2 describes climate services as: “The provision of climate information usually in combination with non-climate information and knowledge in such a way as to assist decision makers. The service component involves a demand-driven approach, appropriate engagement with the decision makers, an effective access mechanism and responsiveness to user-needs”.

2. **User-focused:** CS providers should engage with users and stakeholders to understand their needs, priorities, and decision-making contexts. This will help ensure that climate information is relevant, usable, and actionable.

**Keywords/Criteria:** user needs, fit-for-purpose

3. **Transparent:** CS should be transparent about their data sources, methodologies, and assumptions. CS providers should clearly communicate the limitations and uncertainties of climate information to users and stakeholders to build and increase trust. Here standards and guidelines (e.g., such as the FAIR principles (see D2.1 of Climateurope2)) can help the user community to develop trust in the product and to be aware of the limitations.

**Keywords/Criteria:** metadata, uncertainties and limitations, understandable information, standards

4. **Collaborative:** CS should be developed and delivered through collaboration among different stakeholders, including scientists, policymakers, practitioners, and users. Service providers should engage in regular dialogue with users and stakeholders to ensure that climate information is useful and relevant. Feedback by the users provide valuable information to further improve the quality of the product. Thus, feedback and evaluation processes should be a vital part of the CS development.

**Keywords/Criteria:** co-production process, mutual understanding, feedback & evaluation, engagement

5. **Timely and accessible:** CS should be provided in a timely and accessible manner. Service providers should use user-friendly formats and platforms to deliver climate information to users, taking into account differences in literacy levels, languages, and technological infrastructure. Information should be easily locatable and (to the extent possible), be freely accessible.

**Keywords/Criteria:** timely deliverable, easy access, findable

6. **Sustainable:** CS should be designed to be sustainable over the long term. Service providers should ensure that their services are adequately resourced over time, and that they have the capacity to adapt to changing user needs, new scientific developments, and evolving policy contexts.

**Keywords/Criteria:** sustained funding, sustained usage of resources, scalable & transferable

7. **Equitable:** CS products should be freely accessible and usable to the extent possible, to ensure that they are available to users with limited resources. The outcome of a CS should (to the extent possible) take equitable measures into account.

**Keywords/Criteria:** open & free access, understandable information, inclusivity, barrier free

Figure 1 summarizes the relationship of guiding principles and quality criteria. Please note that some of the quality criteria can be related to more than one guiding principle. This is indicated by the overlapping coloured areas. The box at the bottom of the figure entitled “Ultimate goals of a climate service” points towards the goals, a (high-quality) climate service should achieve: 1. The user should trust the information provided by the service, 2. the CS should be usable, 3. provide value for the user and 4. ideally have the (envisaged) impact.

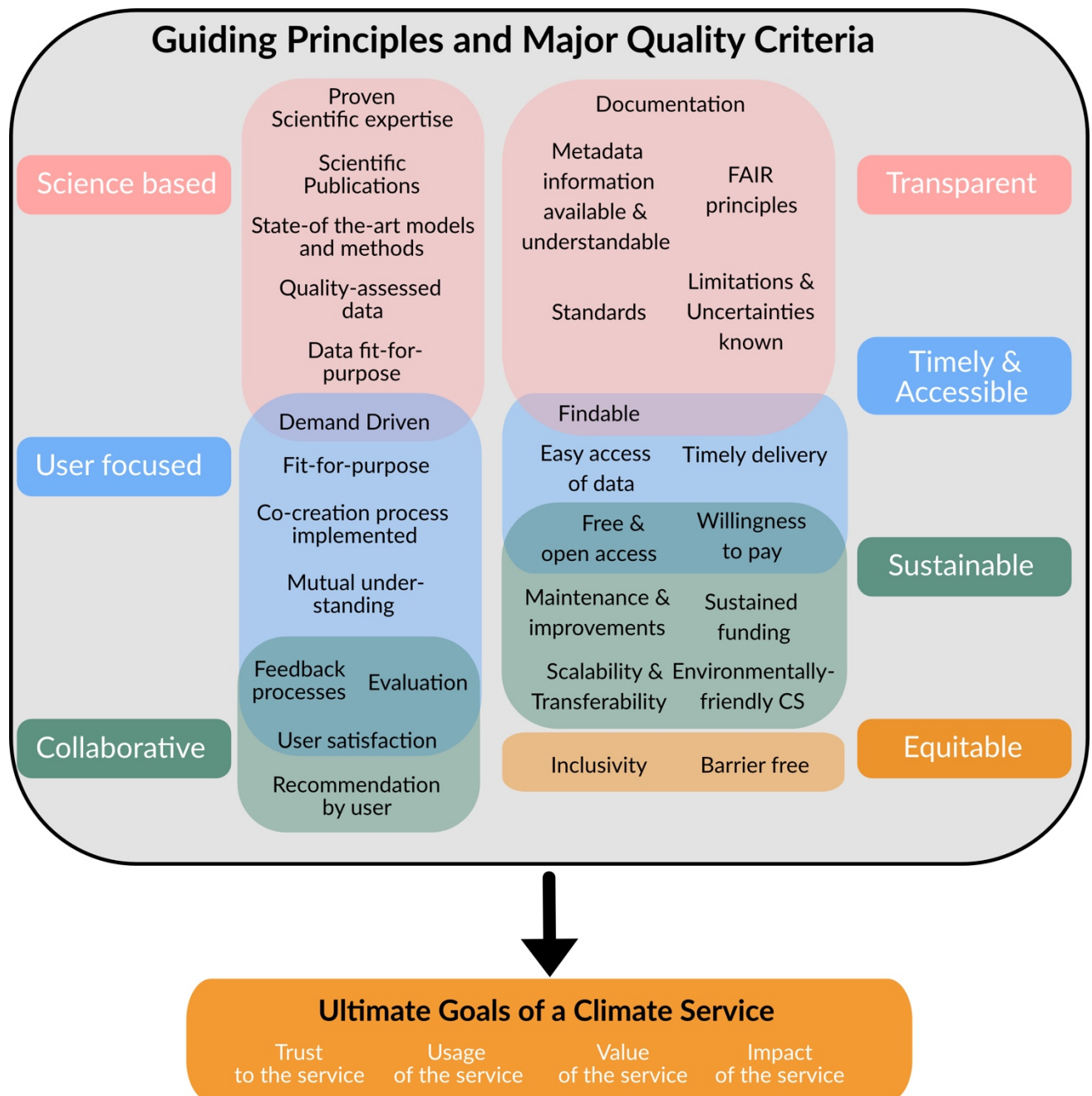


Figure 1: Guiding principles and major quality criteria of CS

In contrast to the “Logic model approach” used for D4.1 we align the guiding principles and quality criteria for this deliverable D4.4 “Advanced Guiding Principles for high-quality Climate Services” along the four components of CS identified by Climateurope2 (see Figure 2):

1. **The decision context:** The decision context refers to the kinds of decisions the CS support, including its geographical and political context. This includes the policy structure and other forms of governance that require and enable CS to develop.
2. **Ecosystem of actors and co-creation processes:** This component identifies the different actors involved in (co)producing, evaluating, and taking up CS, as well as the actors that might become relevant because of a particular decision context (see component 1). This component also addresses the co-production processes that are relevant for different actors and different stages of the climate service development process.
3. **Knowledge systems of different types (quantitative, qualitative, mixed data; local knowledge; etc.) and related selection, evaluation, and translation processes:** This component relates to climate data, but not only. Environmental, social, economic & technical, as well as engineering data and local knowledge to develop and implement local adaptation and mitigation strategies, is relevant here too, as well as all selection, evaluation and translation processes related to this data. Data accessibility, storage and stewardship would also fall under this component.
4. **Delivery mode and evaluation of the delivery mode:** This component regards how a climate service is delivered, and how this delivery is evaluated at various steps. This should include the tailored aggregation and combination of data and processes to match the decision and context of the service client.



Figure 2: Climate service components as identified by Climateurope2 (Baldissera Pacchetti and St. Clair, 2023)

Figure 3 provides a conceptual view how to align the guiding principles to the four components of CS. Note that different elements might contribute to several core components, for example criteria dedicated to the principle “user focused” are relevant for the decision context and for the ecosystem of actors and co-creation processes as well.

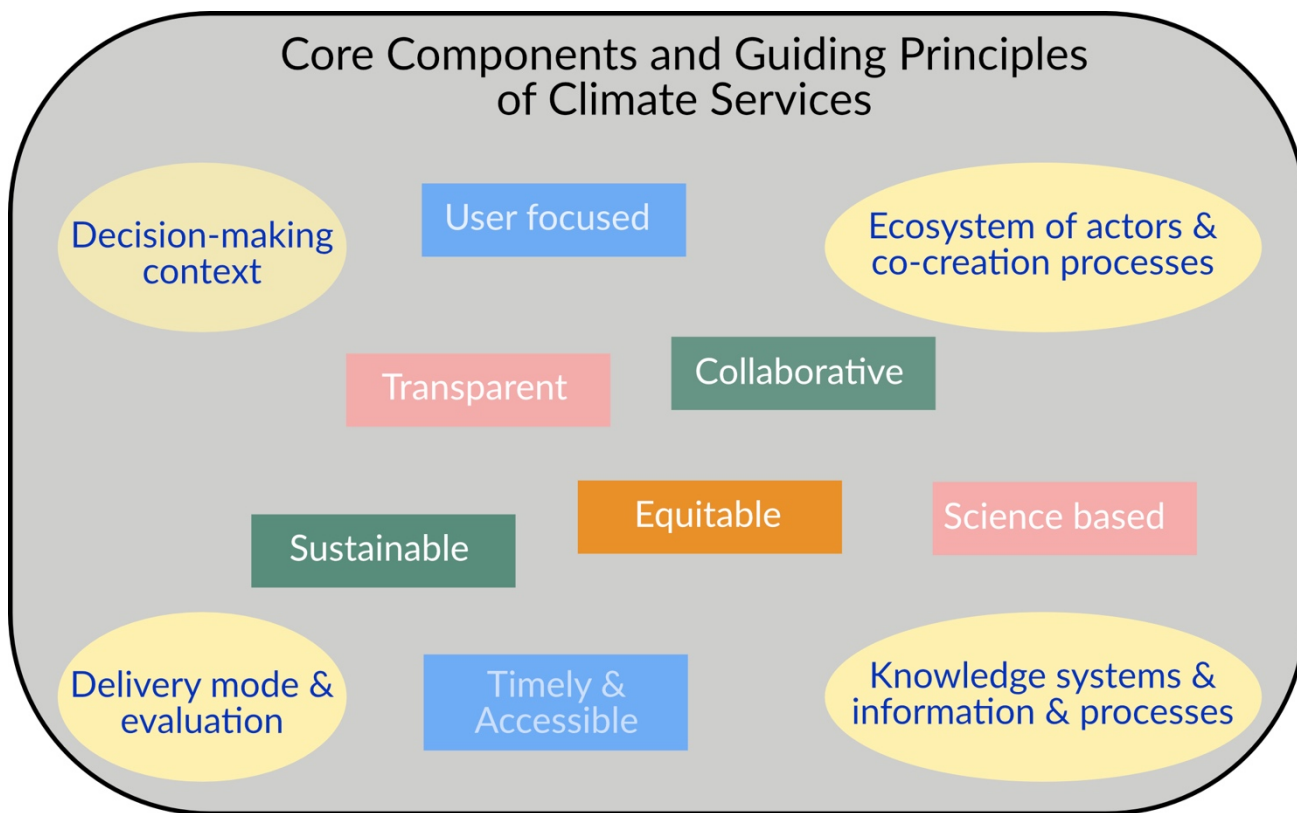


Figure 3: Relationships of the guiding principles with the Climate service components.

Based on this structure we are revisiting in this deliverable the quality criteria which characterize a “high-quality” climate service as described in D4.1 along the logic model approach (Villwock, 2023). Table 1 provides an overview about the most relevant quality criteria and their relationship to the concept of guiding principles and the CS components.

**Table 1: Quality criteria related to guiding principles and CS components**

Quality criteria	Guiding principle(s) supported	Relevant for CS component(s)
Scientific expertise	Science based	Knowledge Systems
State-of-the-art models / methods	Science based	Knowledge Systems
Quality-assured data	Science based	Knowledge Systems
Data source known	Transparent	Knowledge Systems
Data fit for purpose	Transparent	Knowledge Systems
Metadata available	Transparent, Accessible, Sustainable	Knowledge Systems
Metadata information understandable	Transparent, Accessible	Knowledge Systems
Limitations & Uncertainties	Transparent	Knowledge Systems
Demand driven development of CS	User focused	Ecosystem of actors & co-creation processes
Co-creation process implemented	User focused, Collaborative, Equitable	Ecosystem of actors & co-creation processes
Mutual understanding (Language barriers)	Collaborative, Equitable	Ecosystem of actors & co-creation processes
Appropriateness of CS / Fit-for-purpose	User focused, Equitable	Decision context
Findable	Accessible	Delivery mode & evaluation
Barrier free	Equitable, Accessible	Delivery mode & evaluation
Free access	Equitable, Accessible	Delivery mode & evaluation
Willingness to pay	Equitable, Accessible	Delivery mode & evaluation

Quality criteria	Guiding principle(s) supported	Relevant for CS component(s)
Scalability, transferability	Sustainable	Delivery mode & evaluation
Sustained funding	Sustainable	Delivery mode & evaluation
Environmentally friendly CS	Sustainable	Delivery mode & evaluation
Timely delivery	Timely	Delivery mode & evaluation
Usage of the CS	Sustainable	Delivery mode & evaluation
Improvement of expertise (up-skilling)	User focused Collaborative	Delivery mode & evaluation
Satisfaction with the CS	User focused, Equitable	Delivery mode & evaluation
Feedback	Collaborative	Delivery mode & evaluation
Evaluation	Collaborative	Delivery mode & evaluation
Impact of the service	User focused	Delivery mode & evaluation

Using different methods of stakeholder engagement (described in Section 2) we are trying to identify the most important / relevant criteria including the indicators to measure, determine or describe them. Here we also incorporate the results from other work packages, in particular WP2 (D2.3, D2.4. and D2.5 respectively) and WP5 (D5.1). Based on our findings we provide an update which of the criteria are suitable and mature to be included in a standardization process for CS.

## 1.1 Objectives of the work

Task 4.3 “Standardised guiding principles for high-quality climate services” of the Climateurope2 proposal provides the objectives and concept for this deliverable:

“To increase trust and transparency in CS, this task will elaborate on guiding principles for high-quality CS as a prerequisite for future standardisation, certification and labelling. These elements will be clustered in four categories associated with CS: 1) inputs to develop a climate service, 2) output (characteristics of the CS as such), 3) outcome (if and how the climate service is used) and 4) the co-design process. As a result, recommendations for standards and guiding principles for high-quality CS will be shared (at M12 and 24, D4.1 and D4.4 respectively) and developed iteratively until reaching D4.11

(M48) to build a broad consensus within the communities involved and, thus, contribute to increase trust and transparency. These activities will be also linked to task 1.4, task 2.3 and task 2.4 to ensure the traceability of CS and to feed into the development of a pre-standardisation process and the evaluation of future options for certification and labelling that will be performed in WP1.”

This deliverable D4.4. **Advanced guiding principles for high-quality CS** is the second of a set of three deliverables to develop guiding principles for high-quality CS. It complements the findings from the initial deliverable by the findings from community engagement through a survey, interviews, workshops, and case studies.

## 1.2 Structure of this report

The report is divided into four sections. Following this introduction, Section 2 describes the concept and methodology for the update on the guiding principles for high-quality CS. Section 3 summarises the findings and discusses the results. Section 4 provides an overall summary and outlook to the next steps to be taken within this task of the Climateurope2 project.

## 2 Methodology

To identify and prioritise the most relevant quality criteria that characterize a “high-quality” climate service including valuing indicators and to determine their maturity for standardization, a stakeholder engagement process was initiated using various approaches such as a survey, interviews, and workshops. In parallel, several case studies within a broad range of providers, sectors, and products were investigated (Figure 4).

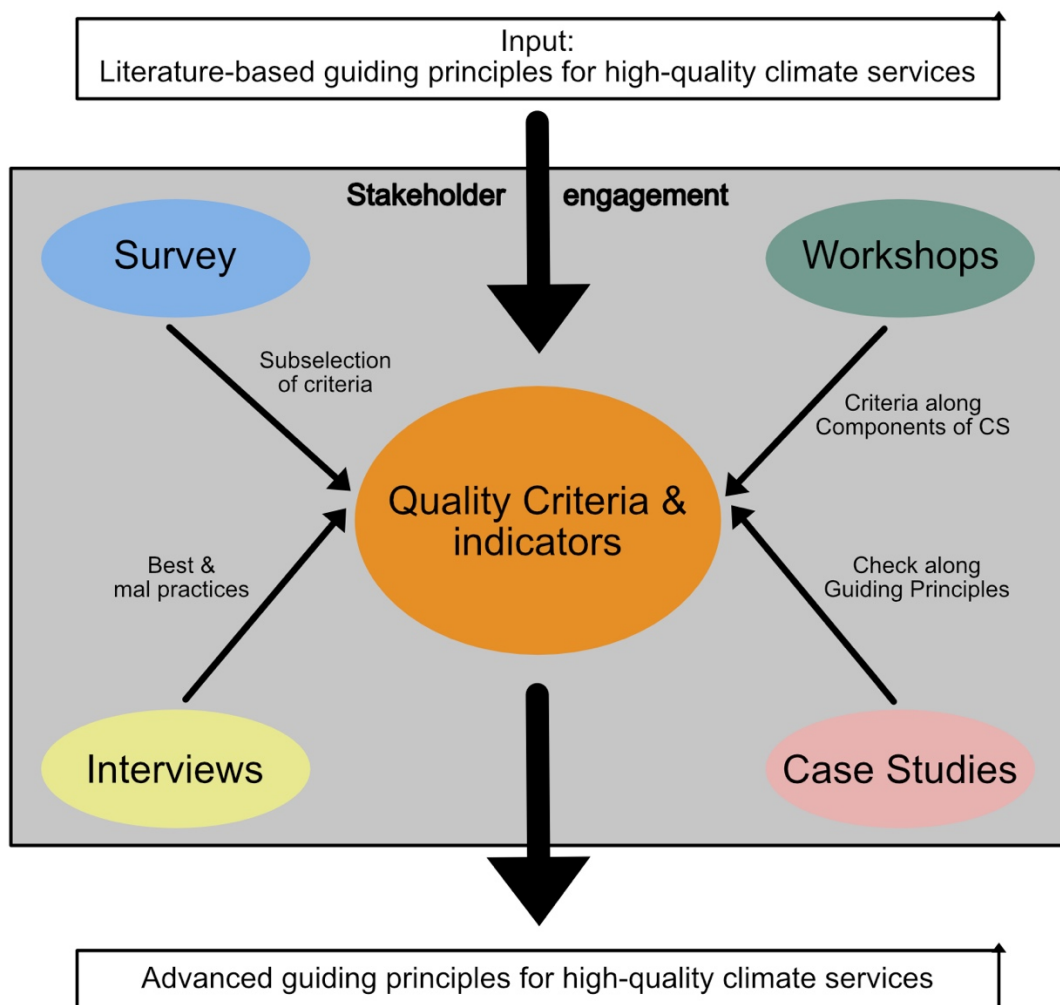


Figure 4: Elements and methods of the quality assessment approach used in this study.

The individual methods used for the different parts of the stakeholder approach differ as described in detail in the following subsections. These different approaches aim to identify and prioritize the quality criteria described in Table 1 from different angles:

- Which of the quality criteria (see Table 1) are most important to users of CS?
- Do providers have different preferences?
- What are commonalities across different types of CS?
- How do public vs private CS differ?

More specifically, some questions in this context are:

- Do different sectors have specific demands in terms of quality? (e.g. agriculture using typically more short-term information vs. construction & infrastructure with long planning horizons or procurement of goods with long lifetime).
- With respect to the users / audience: what are different demands / needs of user groups (e.g. level of complexity, mutual understanding, local vs. regional foci, accuracy of data, importance of co-production processes).
- Which success factors are important for different types of services? (e.g. web-based product vs. consultancy): Data needs, accuracy, co-production processes.
- Public vs. private: transparency, timely delivery, accessibility and availability of information

While there may be commonalities across different types of CS, it is assumed that a “one size fits all” concept may not be applicable to all quality measures, given the highly heterogeneous user context.

By applying different methods of engagement with users and providers of CS and through analysis of a broad range of case studies should help to identify commonalities, differences, and priorities for quality criteria and indicators. To the extent possible a broad range of the CS market and actors should be covered.

Finally, the analysis should help to identify benefits and drawbacks of standardization for each criterion. Which quality criteria are suitable and / or required for the definition of a standard for CS? Which are useful but not suitable for a standardization process?

In the following subsections the different approaches used in this study are described.

## 2.1.1 Survey on Climate Services from User and Provider Perspectives

The scope of a survey on “Climate Services from User and Provider Perspectives” which was conducted by Work Package 4 of Climateurope2, was to assess the present state of the CS market, identify quality criteria, as well as potential gaps, and opportunities for standard procedures to improve CS. As the targeted audience is not familiar with the components of CS nor with the guiding principles, these concepts were not directly applied in the survey. As for the other methods applied in this study the results will be at the end mapped on the concepts of guiding principles and CS components.

Target groups of the survey were initially providers as well as users of CS, finally, a third group, “observers” (interested in CS), was added.

Depending on the background of the participants (provider/user/observer) the survey comprises a different set of questions ranging from 20 (+15 optional) for providers, 18 (+9 optional) for users and 10 (+3 optional) for observers. The complete set of questions in English is available in Appendix 1. The survey was also translated in four major European languages French, Spanish, Italian and German. On average the time needed to complete the survey was about 10 minutes which is in the targeted range of 10-15 minutes.

The survey was active from March to end of June 2024. Information and distribution of the survey took place via presentations at meetings (e.g. Climateurope2 Festival), Climateurope2 mailings and social media posts, as well as individual distribution to partner projects and to international and national groups (e.g., “Copernicus kommunal” or “Klimanavigator” in Germany). More than 500 people have received the information through direct mailings or presentations without taking “snowball”-effects (recommended further distribution by addressed audience) into account. A summary of the results of the survey is provided in Section 3.1.

## 2.1.2 Community engagement in workshops

### 1. Fishbowl and “Deep dive” discussions on quality aspects at the Climateurope2 festival

Climateurope2 organised a 3-day festival entitled: “Bridging science, services and standards for a climate-resilient future”, which took place in Venice, Italy from 11-13 March 2024 (<https://climateurope2.eu/news-events/events/events/climateurope2-festival-1>). About 150 people from a great variety of stakeholder groups covering users, providers of CS as well as “observers” (interested in CS) across different sectors attended.

With respect to quality aspects in particular a fishbowl discussion and an intense interactive brainstorming session (“Deep dive”) were specifically dedicated learning from stakeholders about their needs, priorities and experiences in using CS.



**Figure 5: Participants of one of the “deep dive” discussion groups at the Venice Festival (Photo: Daniele Furlanetto)**

During the so-called “deep dive” session (see Figure 5) the participants provided their favourites and priorities for quality criteria and indicators. The ideas and feedback provided by the participants were structured along the four CS components: 1. The decision context, 2. the ecosystem of actors and co-production processes, 3. Knowledge systems and 4. Delivery mode and evaluation. A summary of the results of the discussions is provided in Section 3.2.

## **2. 3<sup>rd</sup> Climateurope2 Webstival**

The 3<sup>rd</sup> Climateurope2 webstival entitled: “Excellence in climate services for transformational change” (<https://climateurope2.eu/news-events/events/events/climateurope2-webstival-third-edition>) which took place 19-20 September 2024, promoted insightful community discussions on the design, use, quality, business innovation, and policy drivers of CS. This webstival with more than 300 registered participants explored what makes a climate service useful, fit for purpose, viable, equitable, and transparent. Furthermore, it examined how CS can stimulate transformative climate actions - both mitigation and adaptation - to address the climate crisis. The introductory session “What Defines a Good Climate Service?” discussed quality aspects of CS from different perspectives. In thematic breakout sessions different topics and aspects of CS such as climate change impacts, services for the financial, health and urban development sector, tools to facilitate business innovation of CS, and adaptation to climate change were discussed. A summary of the discussions is provided in Section 3.2.

### 2.1.3 Stakeholder interviews

Under the leadership of CLIMATE-KIC<sup>2</sup> interviews (13 in total) with different stakeholders (7 with users, 3 with providers, and 3 with experts / observers on the CS market) were carried out. The interviewees were geographically diverse, covering six EU countries: Belgium, France, Germany, Latvia, Romania, and Spain. Each interview had a length of approximately an hour and comprised a predefined set of questions (see Appendix of D4.3: Matthies & Ramirez, 2024) depending on the audience (user, provider or expert). The primary objective of the interviews was to learn about best practices and malpractices experienced by the interviewees when using CS. The interviews contributed to D4.3 of Climateurope2: “Preliminary recommendations for assessments and increase of CS impact, catalogue of best practices and malpractices; foresight of demand evolutions and market developments” (Matthies & Ramirez, 2024). As some aspects of the discussions were also related to quality aspects of CS, the results are also incorporated in this study. See Section 3.3 for more details.

### 2.1.4 Case studies

Beside the direct community engagement performed via workshops, interviews, and the survey as described in the previous sections, case studies on past and ongoing initiatives and services offered by public and private providers can provide additional insight on quality aspects of CS. Although direct feedback from users (and providers) of these services cannot always be obtained, information available through documents, publications, and other web-based information provides insights about key quality criteria and success of CS.

The 19 case studies<sup>3</sup> selected for this analysis can be divided into four groups:

- 1) **CS from Climateurope2 project-wide case studies:** MED-GOLD, Focus Africa, S2S4E, SMHI, InnovaClimate (Valencia Water case). These five cases studies were selected by the Climateurope2 consortium as project-wide case studies which should always be considered for the analysis of different aspects of the project.
- 2) **Publicly funded CS (finished projects):** Adapter, BlueAction, ClimApp, Indecis, VitiGEOSS. These five projects represented publicly funded services (from national or EU-sources) which are finished due to the end of project funding. Nevertheless, some services are still maintained and usable.
- 3) **Publicly funded CS (ongoing projects):** AGORA, CityPacks, CLIMAAX, PROVIDE, Reachout. The set of these EU-projects comprises initiatives which are very relevant to Climateurope2. They are still ongoing but plans and initial results provide valuable insight how the knowledge how to design successful CS using innovative approaches is applied in these projects.

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<sup>2</sup> CLIMATE-KIC (<https://www.climate-kic.org>) is a project partner in CE2 and co-leader of WP4

<sup>3</sup> See Appendix 2 for full details

- 4) **Private CS:** Climanomics, Fathon, Future Drainage, Repath. As CS are increasingly provided by private (commercial) companies, it is important to assess the quality of these product and to compare commonalities and differences with respect to publicly funded services. Some of these services have developed out of the scientific community and are thematically mostly focusing on risk assessment on climate extremes related to climate change.

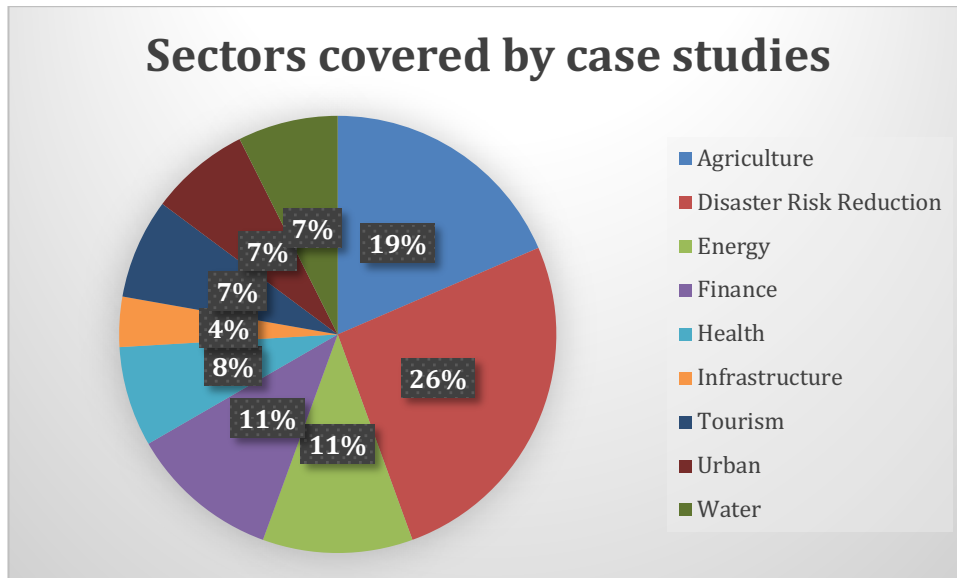


Figure 6: Sectors covered by the case studies (note that some CS cover multiple sectors)

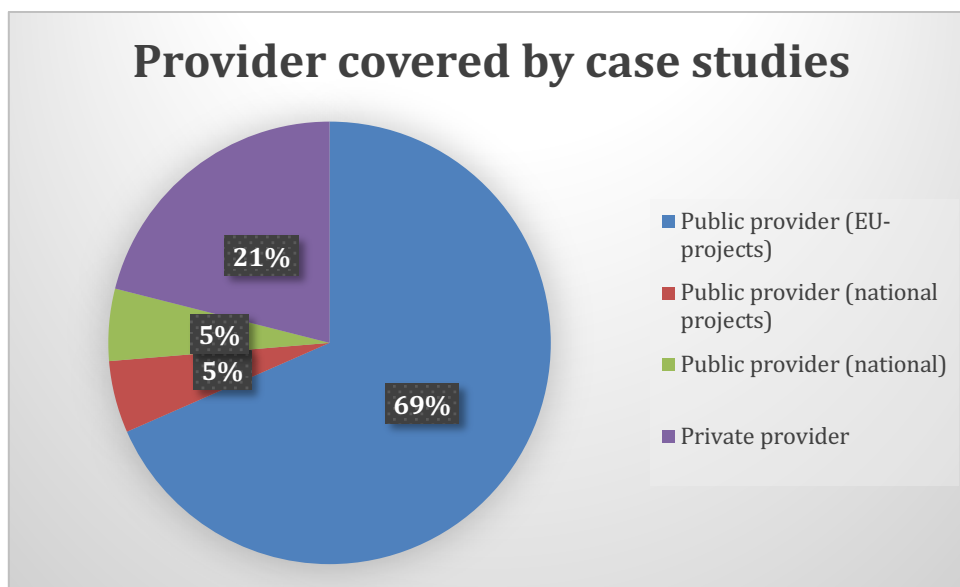


Figure 7: Providers covered by the case studies

The case studies are covering a broad variety of sectors with foci on disaster risk reduction, agriculture, energy and finance (see Figure 6). Note that some CS are supporting more than one sector. On the provider side, the public funded CS, either through EU or national funding are dominating as a broad knowledge base and contacts to private providers of CS are still lacking behind (see Figure 7). The users addressed by the CSs of the selected case studies are mostly either private companies or end users (e.g. wine producers, energy providers or customers in the financial sector) (69%) or public administration of cities or regions working on climate adaptation (27%) (see Figure 8).

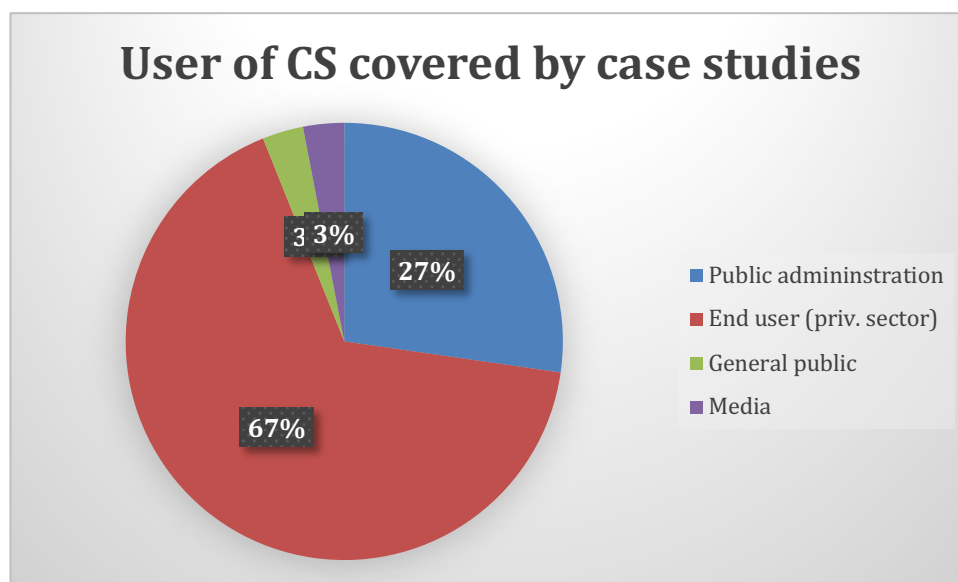


Figure 8: User groups addressed by the case studies

The selected case studies were analysed along the set of guiding principles following the quality criteria and indicators identified in Table 1:

- **Science-based:** state-of-the-art methods and data, quality assured data / methods, proven scientific expertise
- **Transparent:** metadata, uncertainties and limitations, understandable information
- **User-focused:** addressing user needs, fit-for-purpose
- **Collaborative:** co-production process, mutual understanding, feedback & evaluation
- **Timely and accessible:** timely deliverable, easy (and free) access
- **Sustainable:** sustained funding, sustained usage of resources, scalable & transferable
- **Equitable:** open & free access, understandable information

In addition, if available, statements on usability and impact of the service were collected.

The analysis was performed mainly through desk research using web-based sources, project deliverables, scientific publications and, if possible, direct feedback from providers and users. The details for the individual case studies provided in Appendix 2. A summary of the results is provided in Section 3.4.

### 3 Results

Based on the list of quality criteria and indicators identified (see Figure 1, and Table 1) various stakeholder engagements such as interviews, surveys of workshops were used to determine the most important and relevant from the user as well as from the provider perspective. In addition, several case studies were analysed to identify best- (and mal-) practices and to test quality criteria and indicators. The different methods of these approaches were described in Section 2 (see also Figure 4).

#### 3.1 Results from the survey

As described in Section 2.1.1 a survey on “Climate Services from User and Provider Perspective” was conducted and widely distributed amongst providers and users of CS. More than 500 visits on the survey webpage were registered, more than 100 started the survey but in total only 43 stakeholders completed it, of which 25 are from a provider point of view (mostly from the public area (21)), 8 from a user perspective and 10 responded from an observer angle. Most of the replies focus on CS from the public sector (i.e. NHMC, research institutions, or universities). The CS addressed in this survey cover a broad spectrum a broad spectrum of products with a major focus on (climate) modelling output (Figure 9).

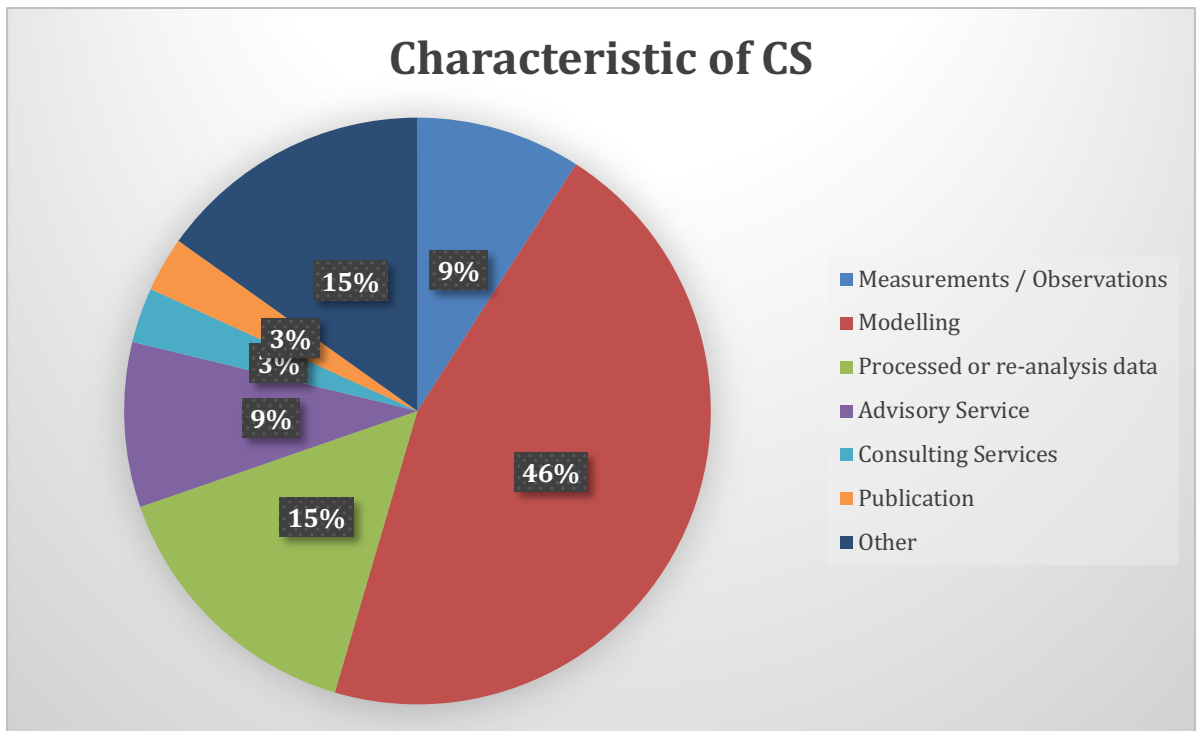
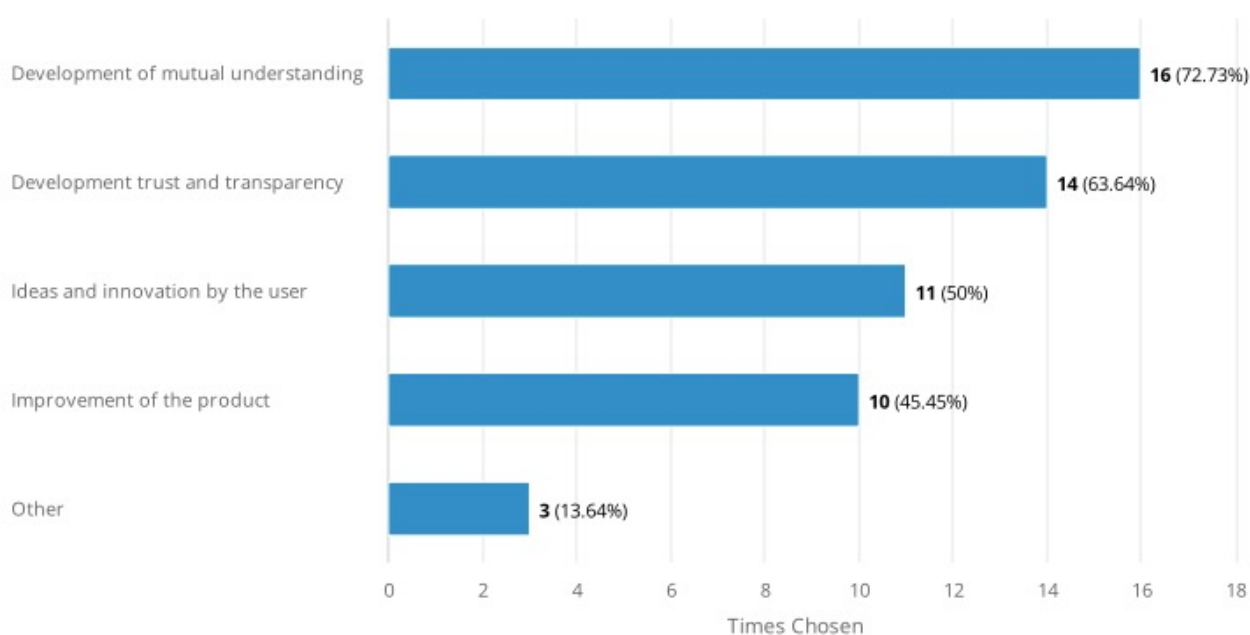


Figure 9: Characteristics of CS covered by the survey (Note: this question was only active in the user and provider mode but not for “observers” of CS).

Most of the participants of the survey stated that ideas for the climate service either came from the provider or were developed collaboratively. Nevertheless, most of the providers developed the service jointly with the users (88%) but not right from the beginning (5%). About 50% had a continuous exchange with the users during the development of the service.

The providers reported that the collaboration with users led to a better mutual understanding (about 73%) and the development of trust and transparency (about 64%) as well as ideas and innovation to improve the product (about 50%) (Figure 10).



**Figure 10: Positive aspects of user interaction from the provider side.**

Different expectations about the product were framed as a major barrier (about 2/3 of the providers, 25% of the users), as well as resources and timeframes (Figure 11). Nevertheless, most of the providers were satisfied with the interaction with users and with the received feedback. The majority of the providers stated that the services were used and had an impact as envisaged. Nevertheless, in more than a third of the answers from providers it was stated that the usage and impact of the CS were either unknown or rated with 3 or lower (scale 1-7).

For both users and providers of CS, user satisfaction and (climate) data are most important in terms of quality, whereas profit / costs and standards received relatively low rankings (Figure 11 & Figure 12). Furthermore, the replies indicate that there seemed to be a lack of knowledge about existing standards (35%) and subsequently the usage of standards with only 20% reporting the use of standards. Although providers would expect more transparency, trust, and quality by applying standards, about 50% are unsure whether they will use standards in future.

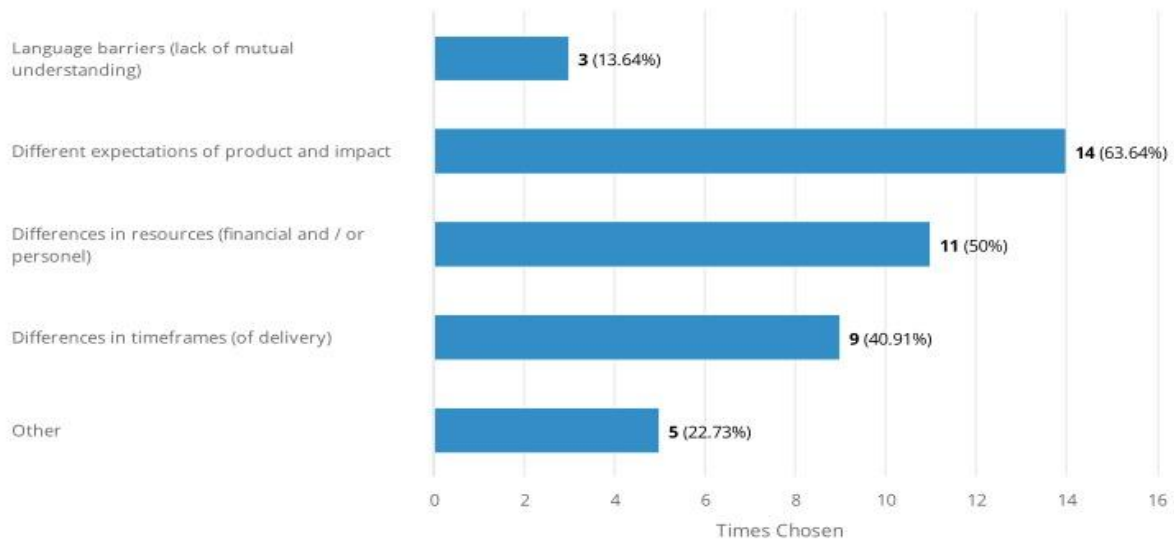


Figure 11: Barriers of user interaction from the provider side

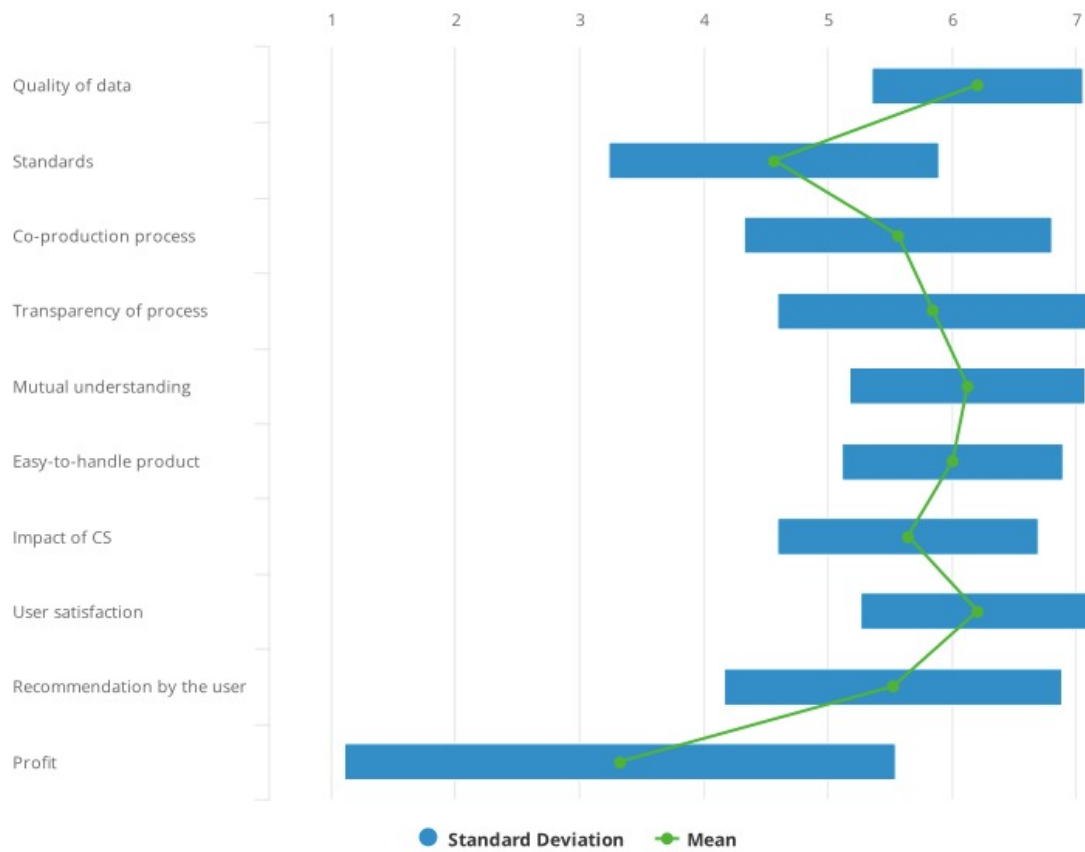
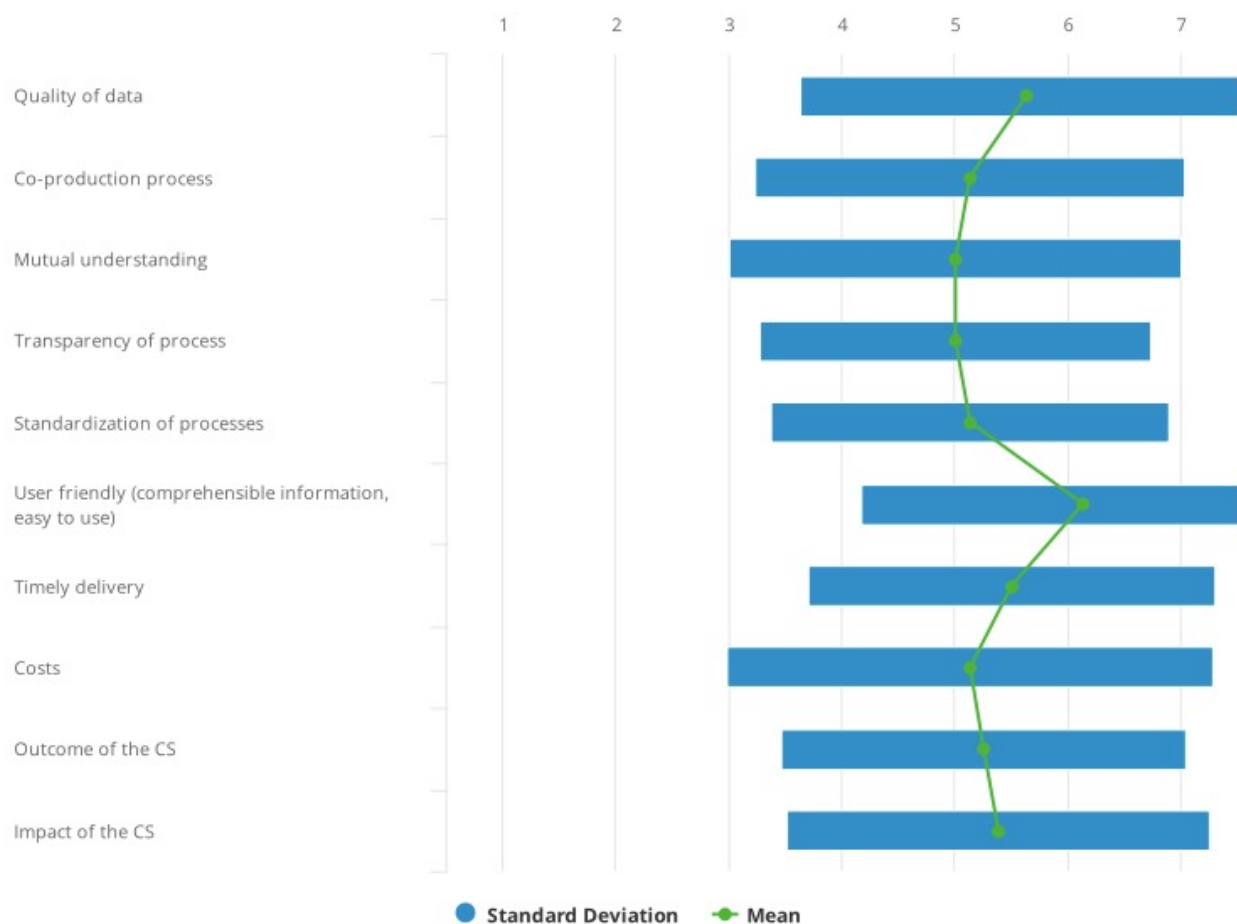


Figure 12: Most important quality criteria from the provider perspective. Scale: 1: not important to 7: very important, multiple answers were possible.

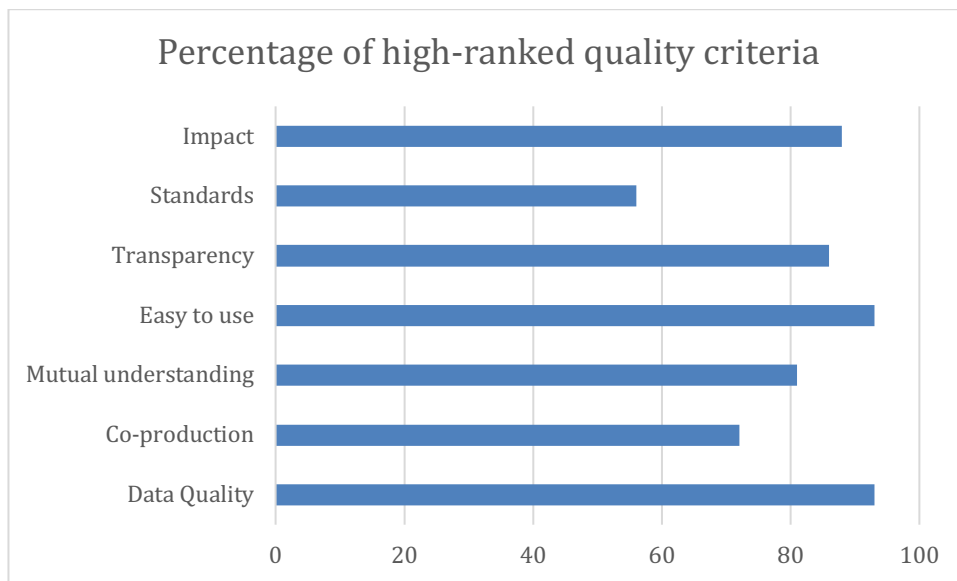


**Figure 13: Most important quality criteria from the observer perspective. Scale: 1: not important to 7: very important, multiple answers were possible.**

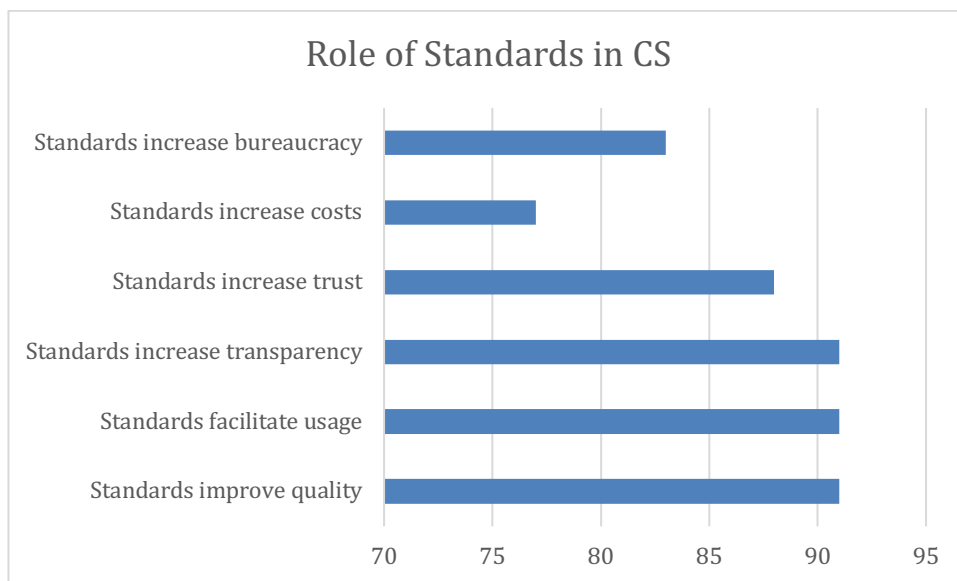
Most of these findings are supported by the third group of participants of the survey, the so-called “observer” or expert group. About 50% of them are scientists conducting research on CS. With respect to quality criteria, user friendliness, data quality, and transparency received higher preferences than co-production, standardization, and costs (see Figure 13).

The percentage of highly ranked quality criteria (scale 5-7) across all answers is shown in Figure 14. Criteria like data, easy to use, mutual understanding, transparency, and impact somewhat stand out. As many of the participants were not using or not even aware of applicable standards it is understandable that this criterium is somewhat lacking behind.

Nevertheless, the participants (here only providers and observers were asked) have in general a very positive view about the role of standards as shown in Figure 15. Positive impacts on quality, transparency, usage, and trust stand out above increase of costs and bureaucracy.



**Figure 14: Percentage of high-ranked (5-7) quality criteria across all participants of the survey. Note, multiple answers were possible.**



**Figure 15: Percentage of partly or fully agreement to the role of standards answered by providers and observers of CS. Multiple answers were possible.**

As the services evaluated in this survey are mostly publicly funded, costs for the service did not play a dominant role. Nevertheless, about 50% of the providers flagged that there is insufficient long-term funding available to operate the CS.

Overall, as the total number of participants in this survey is limited, the results should be interpreted with some caution.

#### Key results of the survey with respect to quality criteria:

- Data quality
- User friendly / easy to use
- Mutual understanding
- Transparency
- Impact

Furthermore, participants expect positive impacts on quality, transparency, usage, and trust through the usage of standards.

## 3.2 Results from community engagement in workshops

### 3.2.1 Climateurope2 Festival

During the Climateurope2 Festival (<https://climateurope2.eu/news-events/events/events/climateurope2-festival-1>) two sessions provided insight in quality aspects of CS: a so-called “deep dive” discussion on quality aspects of CS and a “fish-bowl” discussion with stakeholders (see Figure 16).

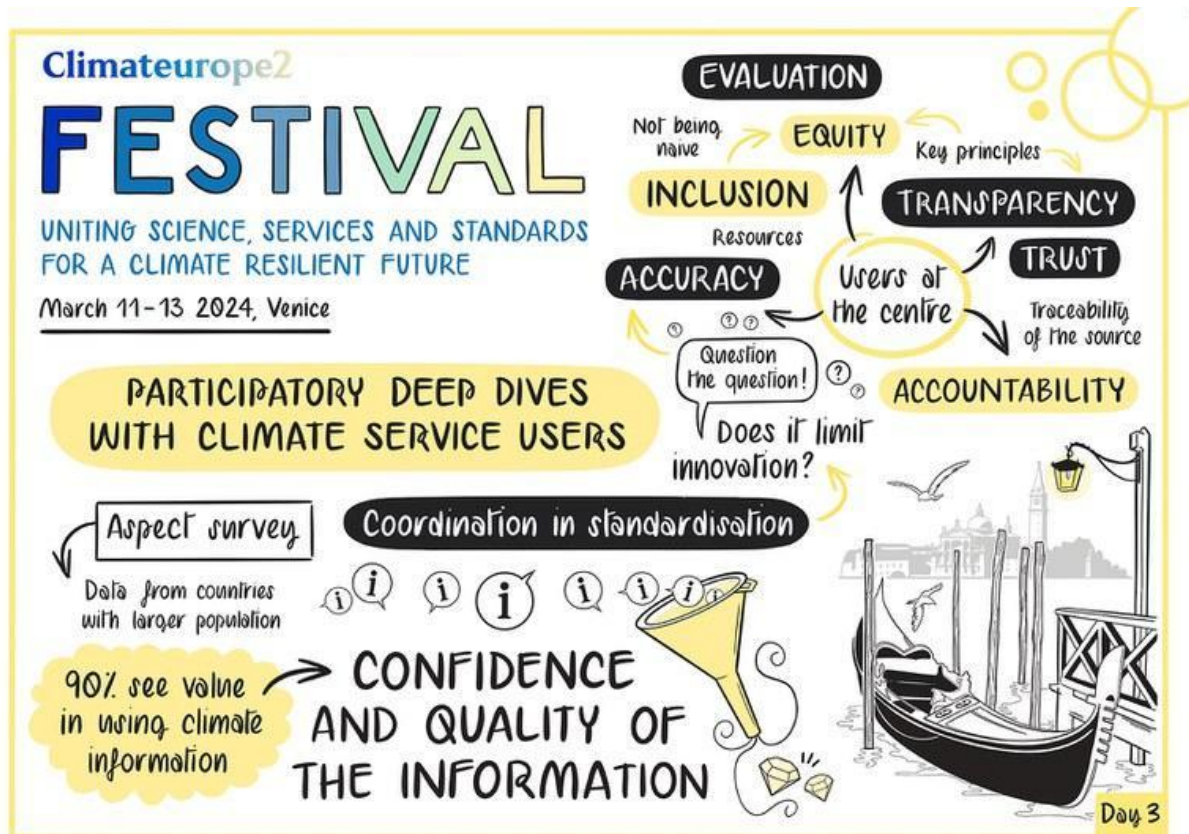
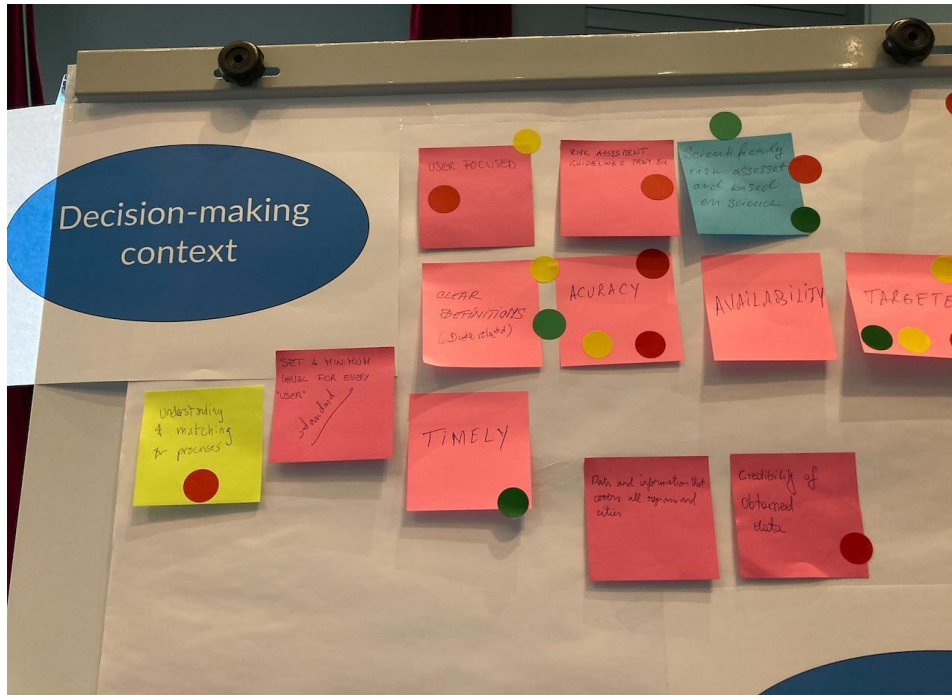


Figure 16: Summary cartoon illustrating the “deep dive” sessions at the Climateurope2 Festival. Source: Roberto Sitta.

“Deep-dive” on quality aspects:

The contributions from the participants in the “deep dive” session covered a wide range of quality criteria, amongst them e.g. accuracy and user friendliness but also accessibility and timely delivery were mentioned and prioritized amongst others (see Figure 17).



**Figure 17:** Example of feedback by the participants at the Venice Workshop. Post-it-colours reflect contributions from different user groups, coloured dots indicate priorities (1<sup>st</sup>: red, 2<sup>nd</sup>: yellow, 3<sup>rd</sup>: green). Photo: A. Villwock.

In summary, the feedback from the participants characterized a high-quality climate service as follows: *It delivers a transparent, user-friendly product which is easily, freely, and timely accessible and useable based on high quality data with benefit and impact to the society.*

**Fish-bowl discussion:**

In discussion entitled “*Climate adaptation in urban regions - How can climate services support decision-making*” organized in a fish-bowl forma<sup>4</sup>t jointly organized by WP4 & WP5. Major outcomes with relevance to quality aspects of CS were:

- There is often a mismatch between the data provided by services like Copernicus (regional level) and local data which is often collected on-site through downscaling.
- The implementation of climate information into decisions is a social process that must be politically implemented and socially accepted.

<sup>4</sup> [https://en.wikipedia.org/wiki/Fishbowl\\_\(conversation\)](https://en.wikipedia.org/wiki/Fishbowl_(conversation))

- Practitioners and public administration are the central interface in the implementation of climate data. There is a great need for the transformation of data into information for decision-making.

Overall, both sessions showed that transparency, building of trust, and value of the products to the user are key elements to pave the way for an impactful climate service. Furthermore, participants stated that standards would help to set a minimum level of quality, increase transparency, and facilitate comparability of products. Figure 18 illustrates the broad range of answers / key words that were provided by the participants during the workshops.



Figure 18: Summary of the most mentioned keywords at the deep-dive workshop at the Venice festival in form of a word cloud (generated by Wordwolken.com).

### 3.2.2 3<sup>rd</sup> Climateurope2 Webstival

The discussion at the 3<sup>rd</sup> Climateurope2 webstival<sup>5</sup> entitled: “Excellence in climate services for transformational change” (see Section 2.1.2) had a major focus on “What Defines a Good Climate Service?” In the introductory session the importance of tailored approaches according to user needs was highlighted (e.g. by Roberto Mezzalama (WSP)). Furthermore, communicating and understanding uncertainties is of crucial importance for the usage of CS. Successfully bridging the so-called “valley of death” (e.g. Swart et al., 2021) between (scientific) knowledge and users needs, in particular when reaching out to local stakeholders, still is an issue in the design and application of CS.

In a mentimeter questionnaire participants of the webstival were asked to prioritize quality criteria contributing to the different components of CS.

For the decision context (Figure 19) being aware of the complete context a CS is used and “fit-for-purpose” attributes like appropriate timescales, data and methods” stand out. Implementing an adequate co-production process with all relevant stakeholders is key for mutual understanding, increasing of transparency and trust in a climate service (Figure 20). Understandable, transparent and comprehensive communication of data sources, limitations and uncertainties was mentioned with respect to the knowledge system (Figure 21), i.e. climate data and information used in a CS. Timely delivery and accessibility stand out as the highly rated criteria for the delivery mode (Figure 22) but also (visualisation) methods to easily understand and use CS as well as evaluation and feedback processes.

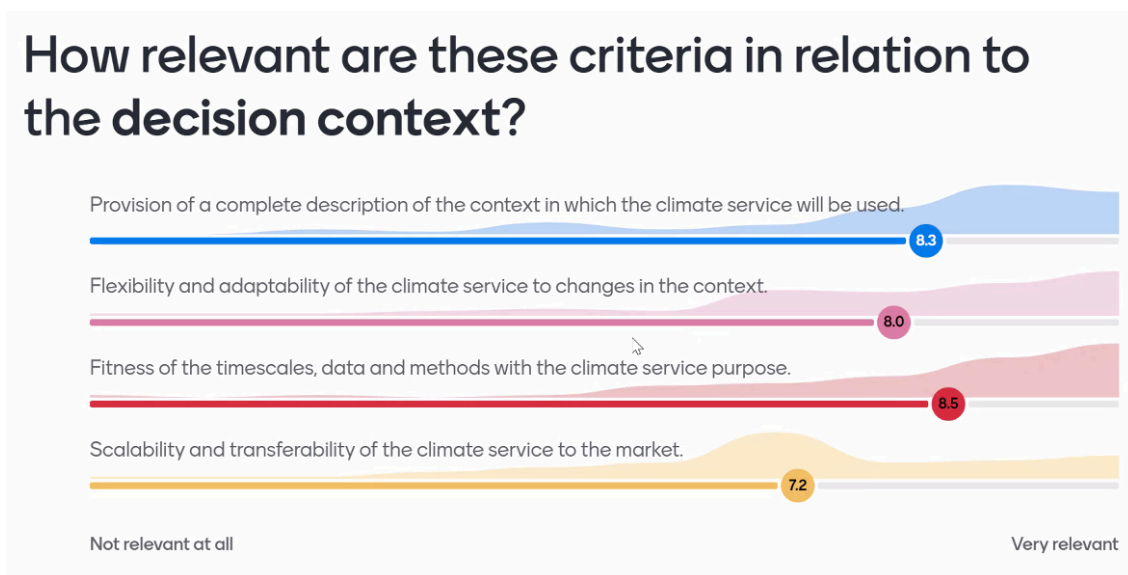


Figure 19: Mentimeter results on criteria relevant for the decision context component as rated by the participants of the 3<sup>rd</sup> Climateurope2 Webstival.

<sup>5</sup> <https://climateurope2.eu/news-events/events/events/climateurope2-webstival-third-edition>

## How relevant are these criteria in relation to the co-production processes?

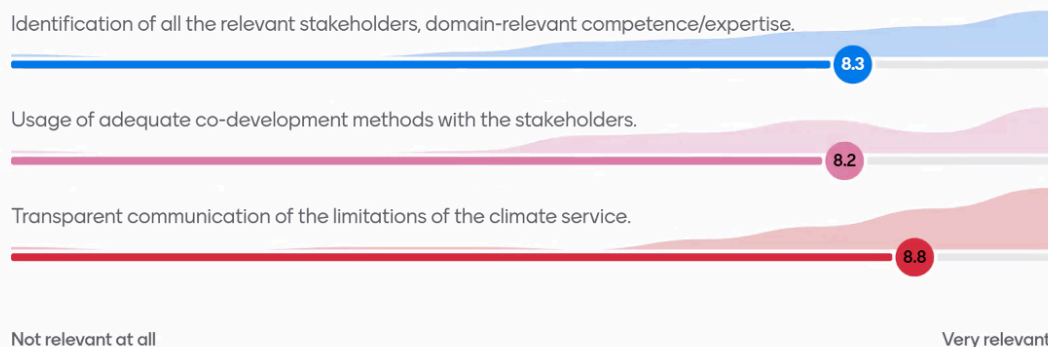


Figure 20: Mentimeter results on criteria relevant for the co-production component as rated by the participants of the 3<sup>rd</sup> Climateurope2 Webstival.

## How relevant are these criteria in relation to the knowledge systems?

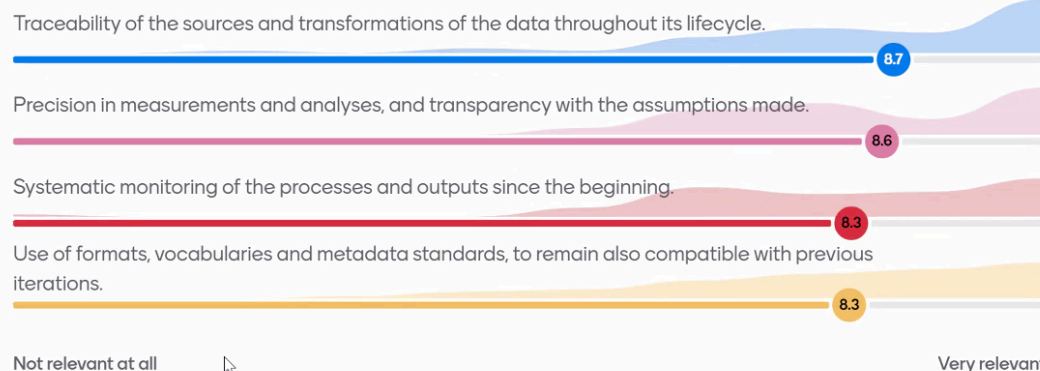


Figure 21: Mentimeter results on criteria relevant for the knowledge systems component as rated by the participants of the 3<sup>rd</sup> Climateurope2 Webstival.

## How relevant are these criteria in relation to the delivery mode and evaluation?

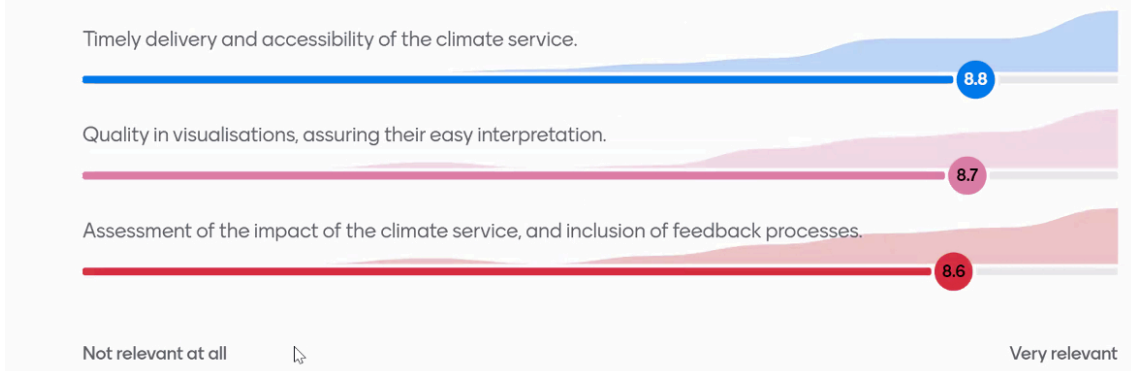


Figure 22: Mentimeter results on criteria relevant for the delivery mode and evaluation component as rated by the participants of the 3<sup>rd</sup> Climateurope2 Webstival.

As mentioned at the beginning, bridging the gap between scientific findings and user needs by better collaboration, information and communication was identified as key for a successful CS. Building of trust by transparent and understandable information and processes along with accessible and appropriate data sets of high quality facilitate an uptake and implementation of adaptation measures and thus pave the ground for the envisaged impact of CS.

### Key results of the workshops with respect to quality criteria:

- Data quality and transparency
- Fit-for-purpose
- Communication of limitations (and uncertainty) of CS
- Timely delivery and accessibility

Furthermore, participants stated that standards would help to set a minimum level of quality, increase transparency, and facilitate comparability of products.

### 3.3 Results from interview series

The 13 stakeholder interviews conducted for D4.3 (see Section 2.1.3) focused on harvesting best practices and malpractices experienced by users and providers of CS as well as reflecting the perspectives of experts on the CS market, i.e. those who are not active participants in the market, but have knowledge of it, such as scientists researching CS.

The feedback from both users as well as providers of CS showed that typical bottlenecks are the availability of suitable data in formats that users e.g. city administration can use and interpret it for their climate adaptation needs. Therefore, often intermediaries such as engineering offices or consultant companies assist to provide the information needed for the end user. “Bridging the technical skill-gap and building up capacities internally is a vital best practice for end user organisations to implement”, Matthies & Ramirez (2024) summarized.

In addition, shortage in qualified personnel on the user side often limits the ability to participate in an intense co-production process to derive custom-made products. Nevertheless, regular communication and feedback processes are regarded to be very important and helpful to develop mutual understanding and improvement of the products.

Due to legal regulations, public administrations and authorities are often not free in choosing providers of CS but have to use data and products developed by National Hydrological and Meteorological Services (NHMSs). Some participants in the interview series stated that the indicators provided by the services do not always fulfil their needs. One example referred to typical indicators for heat stress which are days with maxima above 30°C (hot days) or nighttime minima above 20°C (tropical nights). With respect to long-term investments in infrastructure these indicators do not reflect critical thresholds, such as for instance if maximum temperature exceeds 40°C (e.g. relevant for air conditioning systems or electronics). This type of information would be an important boundary condition in a procurement process for infrastructure or buildings.

In Figure 23 (from Matthies and Ramirez, 2024) best practices and mal practices from the user and provider perspective as mentioned in the interview series are summarized. Technical and data aspects were often mentioned but also the importance of co-production and mutual understanding was raised frequently. Financial as well as personnel resources often limit the duration and intensity interaction between providers and users.

The figure shows how best practices and malpractices are at times opposing each other. For example, using standards was mentioned as a best practice, as it generates trust, but the reluctance to pay for the use of these standards, despite their usefulness was a reported prevailing malpractice in provider communities.

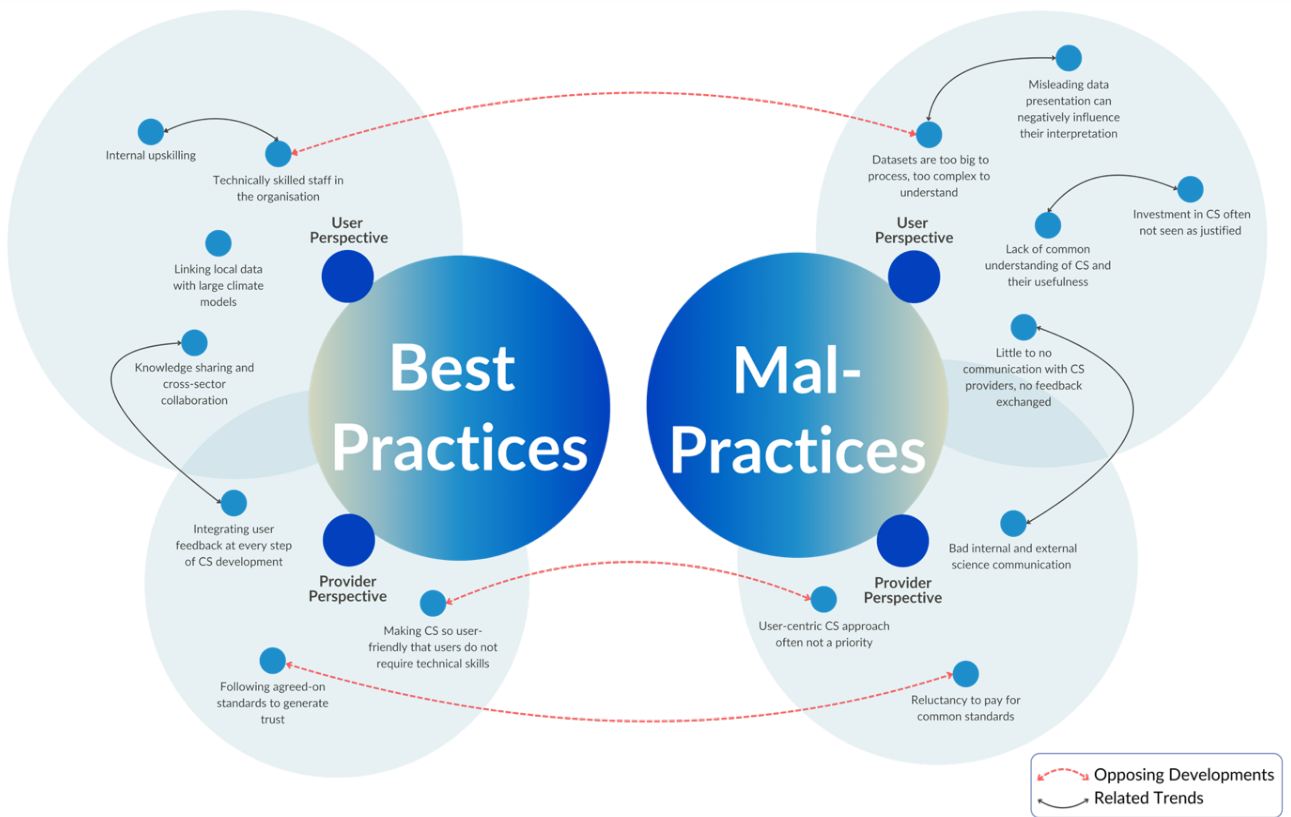


Figure 23: Summary of Best- / Malpractices identified by the interview series of Matthies and Ramirez (2024).

With respect to quality aspects of CS the stakeholder interviews showed that:

- 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;
- 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.

### Key results of the interviews with respect to quality criteria:

- Data fit-for-purpose and accessibility
- User friendly tools
- User engagement and feedback processes
- Standards for CS
- Knowledge sharing and upskilling

As stated above the usage of standards was regarded as a positive aspect to improve the quality of climate services.

## 3.4 Results from Case studies

As pointed out in Section 2.1.4, in total 19 case studies were used to investigate to what extent quality criteria along the seven guiding principles are fulfilled and whether the services are usable and lead to an (envisaged) impact. For every case study a detailed summary is available in Appendix 2: Case studies.

### What are commonalities and differences of the different along the guiding principles?

#### Science-based:

As the majority of services covered by the case studies is based on scientific projects or disseminated from National Hydrological and Meteorological Services there is a profound scientific basis and high-quality climate data as the backbone for almost all CS. This is also valid for the services of private providers as they use high-quality state-of-the-art data from actual climate change scenarios for their risk assessments.

#### Transparent:

Most of the CS products provide background information about data, metadata and methods used for the service. Nevertheless, sometimes the information is not easy to find or requires a certain level of background knowledge to understand and to interpret. In particular, web-based information which is freely available and accessible should be understandable for non-expert users. Although the CS offered by private providers provide information about the climate data used (s. above) some details (e.g. which model output was used) and methods (details about the product) are not publicly available. Since they offer commercial products, this may not be expected.

#### User-focused:

Most of the services of the case studies were designed for a specific purpose or targeted user group (Exception perhaps SHMI). Nevertheless, the services are not user-driven in the way that the scope of

the service is defined by the user demand. Although stakeholder groups are often involved in the design and creation of the climate service, the agenda setting either comes from the scientific community, the private provider or externally (e.g. by legislation). In order to ensure that the CS products meet user requirements a collaborative approach was chosen by the services observed in this study. (see next item).

#### **Collaborative:**

As mentioned above, interaction with the user during the creation of a CS, the development of a mutual understanding, and feedback processes are essential to adjust a CS to user needs. Successful examples are for instance the MED-GOLD and ADAPTER projects where a close and intensive interaction with the stakeholders was performed. As for private providers profit is essential, they will develop products which are successfully applicable on the market. Thus, even though products might not be custom-made for individual users, user interaction and collaboration are mandatory. Nevertheless, some differences in the strategy and intensity of collaboration exist.

#### **Timely and accessible:**

Accessibility of data but also findable and easy to use data sets or products as well as timely delivery were often mentioned in interviews and stakeholder exchange. The majority of the case studies are publicly funded projects where the delivery of the CS (product) is predefined in the project outline. Of course, timely delivery is part of the project goals, the emphasis might not be to deliver a product within a short timeframe. In the private sector timely delivery of a product receives in general a much higher importance, as costs and revenue are closely bundled to that.

As many of the CS scanned in the case studies originate from specific projects, the dedicated users are often partners in the projects. Thus, for these types of services, no wider advertisement is planned as they are limited in terms of audience and time. This is different for services with sustained funding, e.g. from NHMS or from the private sector. Private companies have an inherent interest that their services are well-known and accessible, e.g. through advertisements to their potential user community.

#### **Sustainable:**

Are the CS in the case studies scalable, transferable and/or are they be sustained by long-term funding? Here, the services offered by private providers are potentially in advantage as they are financed by revenues obtained selling the services to customers. Project-funded services e.g. through EU or national funding schemes are typically limited to the lifetime of the projects. This often limits their availability and transferability and products after the end of the project. A third category are CS offered by National Hydrological and Meteorological Services (NHMS) which can be sustained due to long-term funding.

#### **Equitable:**

Free and open access to climate data, information and services is of course the ultimate goal. Nevertheless, this can only partly be achieved, in particular for publicly funded CS. Private providers will not be able to meet these goals, as they require revenue for their investments and costs. Another facet of this topic is to provide the information in an understandable fashion for all targeted groups. Here a

number of CS within the case studies make explicit or implicit reference that their services are freely available, understandable, and useable by a wide range of user groups (e.g. AGORA).

Beside the guiding principles, as formulated in D4.1, we tried to assess the usability and impact of the CS in the case studies. Although both factors are important for the successful application of a climate service, they are strongly context dependent and have limited significance to validate quality in an objective way.

#### **Useable:**

Are the products fit-for-purpose? If available, provider and user feedback and evaluation results were taken into account to estimate whether the CS products are useable for the desired purpose. Overall, the feedback available was positive, nevertheless, for instance for services based on seasonal forecasting, the limitation of forecast skill can limit the usability of the products. E.g. if a forecast skill is below a certain threshold this might not be sufficient for user to adopt or trust in the forecasts. Other drawbacks can occur due to lack of mutual understanding or different expectations in the CS product. For a number of services which are currently being developed, no final evaluation about their usability could be made yet due to the lack of user feedback.

#### **Impact:**

Has the CS lead to envisaged improvements and / or changes? To assess the impact of a climate service is not easy unless direct feedback from users or a self-assessment of the provider can be obtained. For some case studies this was possible. Limitations can occur due to different expectations of providers and users so that the results / information of a CS are not applicable in the way expected.

Table 2 summarizes how the individual CS of the case studies comply with the guiding principles documenting strength and weaknesses of the services. Please note that such ratings are to some extent subjective and are based on the information which was available or provided.

Overall, all services reviewed in this study use high-quality climate data and state-of-the-art models and methods. Slight differences may occur in the resolution of the data and whether IPCC scenarios from the 5<sup>th</sup> or 6<sup>th</sup> assessment report (AR5 or AR6) were applied.

Transparency is also regarded as an important cornerstone for a high-quality climate service. There are slightly different methods to achieve this, e.g. whether the meta data and information about limitations and uncertainties is actively communicated or just provided through weblinks of (scientific) publications.

Even though most of the CS were not initiated or driven by the users, a user-focussed approach was applied in almost all examples. Most of the services engage very effectively with user groups which are in part partner in projects. Private providers have an even more inherent interest to build their services according to user needs as they would otherwise not be successful to sell their products.

Table 2: Summary of the case studies

CS	Science based	Trans-parent	User focused	Collabo-rative	Timely & acces-sible	Sustain-able	Equita-ble	Usabil-ity	Impact
MED-GOLD	Light Green	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Light Green
Focus Africa	Dark Green	Dark Green	Dark Green	Dark Green	Light Grey	Light Green	Dark Green	Light Grey	Light Green
S2S4E	Dark Green	Light Green	Dark Green	Dark Green	Light Green	Light Green	Light Grey	Light Green	Light Green
SMHI	Light Green	Light Green	Light Green	Light Green	Dark Green	Light Green	Dark Green	Dark Green	Dark Green
Valencia Water	Dark Green	Dark Green	Dark Green	Dark Green	Dark Green	Light Green	Light Grey	Dark Green	Dark Green
Adapter	Dark Green	Dark Green	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green
Blue Ac-tion	Dark Green	Light Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Light Green
Clim-App	Dark Green	Light Green	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green
Indecis	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Grey
ViteGE-OSS	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Grey
AGORA	Dark Green	Dark Green	Dark Green	Dark Green	Light Grey	Light Green	Dark Green	Dark Green	Light Grey

CS	Science based	Trans-parent	User focused	Collabo-rative	Timely & acces-sible	Sustain-able	Equita-ble	Usabil-ity	Impact
City Packs	Very good = 1	Very good = 1	Very good = 1	Average = 3	Average = 3	Very good = 1	Very good = 1	Average = 3	Average = 3
CLI-MAAX	Very good = 1	Very good = 1	Very good = 1	Very good = 1	No rating	Average = 3	Average = 3	No rating	No rating
PRO-VIDE	Very good = 1	Very good = 1	Very good = 1	Very good = 1	No rating	Average = 3	Average = 3	Average = 3	No rating
Reach-out	Very good = 1	Very good = 1	Very good = 1	Very good = 1	No rating	Average = 3	Very good = 1	Very good = 1	No rating
Clima-nomics	Very good = 1	Very good = 1	Very good = 1	Average = 3	Average = 3	Very good = 1	Average = 3	No rating	No rating
FATH-OM	Very good = 1	Very good = 1	Very good = 1	Average = 3	Average = 3	Average = 3	Average = 3	Average = 3	Average = 3
Future Drainage	Very good = 1	Very good = 1	Very good = 1	Very good = 1	Average = 3	Average = 3	Average = 3	Average = 3	Average = 3
repath	Very good = 1	Average = 3	Average = 3	Average = 3	Average = 3	Average = 3	Average = 3	No rating	No rating

**Legend:**

Very good = 1	Good = 2	Average = 3	Acceptable = 4	Poor = 5	No rating
Very good = 1	Good = 2	Average = 3	Acceptable = 4	Poor = 5	No rating

More differences occur in the areas of accessibility, sustainability and equitability of the services. Mainly services which are funded through projects are not able to provide long-term perspectives to maintain or transfer their products. Thus, products are either frozen or discontinued after the end of the project. A commercialization of CS products is sometimes envisaged but seldom implemented.

Nevertheless, many products from public providers are freely available but sometimes only for registered users. Equitability is rarely explicitly mentioned, nevertheless in particular examples of more recent projects keep more focus on free and open access, and availability to a broader user community.

Finally, the case studies selected in this study were evaluated with respect to their usability (fit-for-purpose) and (potential) impact. For some studies user feedback could be used documenting limits for some products. For example, even though the CS products were developed in close cooperation with users their usability was limited because of limited forecast skill. Thus, users are not using / applying the products as the uncertainties or limitations are too high for their decision-making.

#### **Key results of the case studies with respect to quality criteria:**

- Scientific background and data quality are well established
- Transparency through a co-production process
- User engagement and feedback processes are commonly used to increase transparency and trust
- Free and open access to data is well established in the public sector
- Project-based CS are often lacking long-term perspectives due to funding limitation.
- Usability can be hindered due to limitations and uncertainties

For many cases more user feedback is required to determine usability and impact of the CS.

### 3.5 Merging of the results

According to the different approaches of engagement with stakeholders and the insights obtained from the case studies, a number of quality criteria were mentioned more frequently than others. Re-visiting quality criteria with respect to the guiding principles as introduced Figure 1, in Figure 24 the criteria which were frequently mentioned in the stakeholder engagement process are highlighted in red and coloured dots refer to the different methods applied in this study.



Figure 24: Major quality criteria identified through the stakeholder engagement process in red in relationship to the guiding principles (small coloured dots refer to findings of the different stakeholder processes of this study (blue: survey, green: workshops, yellow: interviews red: case studies))

Overall, the results of the different stakeholder methods show no major differences across sectors. In terms of stakeholder engagement however, the greater the distance between climate science and application, the more important mutual understanding and collaboration between providers and users becomes.

A follow-up question is “How can the quality criteria for CS identified in this study be determined either qualitatively or even quantitatively?”

As a first approach Table 3 provides ideas for indicators, sources of information and potential measures in reference to the different quality criteria. Those criteria which were frequently referenced in the results of the stakeholder engagement of this study are highlighted in red. Please note that the potential measures should be regarded as suggestions with respect to further investigations and discussions.

**Table 3: Quality criteria and indicators, sources of information and potential measures.**

Quality criteria	Quality indicators	Primary source(s) of information	Potential Measure(s) & Methods
Scientific expertise	References, “H”-index	Publications, scientific profile of provider	“H”-index, Subjective: CV
State-of-the-art models / methods	Actual model version / method	Documentation	Subjective: Yes/no or scale (1-5)
Quality-assured data	QC methods applied / Standards (used, referenced)	Documentation	QC methods following guidelines: FAIR, WMO, see D2.4
Data source known	User knows data source	User (survey, interview)	Yes/no
Data fit for purpose	User confirms usability of data	User (survey, interview)	Subjective (e.g. scale 1-5)
Metadata available	FAIR principles applied	Documentation	Yes/no
Metadata information understandable	User feedback, documentation	User (survey, interview)	Subjective (e.g. scale 1-5)
Limitations & Uncertainties	Communicated and understood	Documentation & user (survey, interview)	Yes/no or scale (1-5) see Otto et al., 2016
Demand driven development of CS	CS development is demand (user) driven	User (survey, interview)	Yes/no

Quality criteria	Quality indicators	Primary source(s) of information	Potential Measure(s) & Methods
Co-creation process implemented	Start /duration / intensity	Provider and/or user (survey, interview)	Subjective (e.g. scale 1-5) or according to WMO Guidelines for user engagement (WMO, 2018a)
Mutual understanding (Language barriers)	Feedback from user / provider	User & provider estimate	Subjective (e.g. scale 1-5)
Appropriateness of CS / Fit-for-purpose	Usage & user feedback	User (survey, interview)	Subjective (e.g. scale 1-5)
Findable	Web searches, databases, user feedback	User (survey, interview)	Web-search results, advertisements
Barrier free	Accessibility of web-pages, level of language	Web-based content	Tools for checking of web-based content
Free access	Documentation	Documentation	no fees, no passwords
Willingness to pay	Provider information, user feedback	Provider / User (survey, interview)	Survey results, no. of subscribers
Scalability, Transferability	CS applied for other cases	Provider information	Subjective (e.g. scale 1-5)
Sustained funding	Long-term funding available	Provider information / Funding scheme	Yes/No
Environmentally-friendly CS	Low consumption of resources, Low CO <sub>2</sub> -footprint Recyclable material	Provider information, documentation	Assessment of consumption of resources
Timely delivery	Delivered in time User satisfaction	User (survey, interview)	Yes/no or scale (1-5)
Usage of the CS	Frequency / Duration	User / provider feedback	Statistics of provider or user feedback
Improvement of expertise (upskilling)	Trainings, User feedback	User (survey, interview)	Subjective (e.g. scale 1-5)
Satisfaction with the CS	User appreciation, recommendations	User (survey, interview)	Statistics on Web or user feedback

Quality criteria	Quality indicators	Primary source(s) of information	Potential Measure(s) & Methods
Feedback	Feedback mechanism implemented	Provider, documentation	Yes/no
Evaluation	Evaluation mechanism implemented	Documentation of evaluation	E.g. Schuck-Zoeller et al. (2022)
Impact of the service	Target achievements	User (survey, interview)	Subjective (e.g. scale 1-5)

### 3.6 Other relevant results from Climateurope2 and other studies

In addition to the findings of the literature review performed in D4.1 (Villwock, 2023) and the different methods of stakeholder engagement applied for this deliverable (see Section 3.5), key findings from other parts of the Climateurope2 project (e.g., D2.2, D2.3, D2.4, D2.5, D5.1) are available.

Pascoe et al. (2024) summarized in D2.3 of Climateurope2 a set of best practices in climate uncertainty quantification and communication (see box below) underpinning the importance of mutual understanding and close cooperation with the designated user groups.

**D2.3 Uncertainties: Preliminary best practices in climate uncertainty quantification and communication (Pascoe et al., 2024)**

1. Always start with the most relevant risks for the target population
2. A standard approach to uncertainty assessment and communication is needed
3. Use language the audience is familiar with (don't say uncertainty)
4. There are multiple ways to evaluate and communicate uncertainty
5. Communication about uncertainty builds trust
6. Precision of information should be relevant to the situation
7. Understand existing narratives
8. Be aware of deep uncertainties

Deliverable D2.4 of Climateurope2 (Domingo et al., 2024) provides an overview of procedures for data verification, including FAIRness and quality management of climate service data sources and processing methodologies. The main lesson learned from the analysis is that extensive documentation already exists, including ISO standards, WMO guidelines, and community conventions.

Loyer et al. (2024) stated in D2.5 of Climateurope2 that although “access to quality-controlled data on climate change and climate indicators has greatly improved in recent years, some background knowledge on climate science will still be required to properly evaluate and use these data. In many cases further data processing may still be necessary to ensure the saliency of the climate data in a specific risk assessment“. The following knowledge gaps have been identified by the authors:

1. **Quality assurance:** Few CS provide readily accessible information on data quality, such as validation details for impact simulations.
2. **Addressing and mitigating uncertainties:** While most climate data-oriented portals provide information from one or more ensembles of climate models, it is sometimes left to the user to ensure that this uncertainty information is taken into account.
3. **Vulnerability indicators:** More research may be necessary to guide vulnerability analyses.

Krauss et al. (2024) investigated in D5.1 of Climateurope2 knowledge needs for maintaining trust in standardised CS. The authors stated that CS must extend beyond merely providing climate data and information. “Integrating place-based knowledge and contextual narratives is essential for ensuring that CS are relevant, credible and trusted by communities“. They recommended a couple of steps for the interaction with stakeholder such as:

1. Enhance engagement with local communities;
2. Promote flexibility in standardization and guidelines;
3. Situating CS;
4. Establish systematic feedback;
5. Encourage interdisciplinary approaches.

Finally an important new study in the context of (high-quality) CS that was not captured in the literature review of D4.1 is the paper by Boon et al. (2024). In a comprehensive Delphi study, involving more than 30 international experts, 12 elements were identified that characterize successful CS for adaptation. These elements can be related to criteria used in this study and correspond to a large extent with the findings of the stakeholder engagement carried out in this study (see Table 4).

**Table 4: Criteria for successful CS and relationship to quality elements**

No.	Elements of a successful CS (Boon et al., 2024)	Criteria (this study)
1.	The climate service has tangible or intangible benefits for the user	Impact, value
2.	Timely delivery	Timeliness
3.	Climate service increases users' understanding of an issue	Transparency
4.	Users build the capacity for using services	Value, transparency
5.	Acknowledgement and communication of uncertainty	Transparency
6.	Communication format is tailored to users	User focused, collaborative
7.	Accessible climate service	Accessible
8.	Credible information	Science based
9.	Establishment of trust between users and producers	Collaborative, trust
10.	Interaction between users and producers is tailored to context	Collaborative
11.	Relevant information	Value
12.	Better decision-making for adaptation	Impact, value

The ASPECT project (<https://www.aspect-project.eu>) conducted a large survey amongst users of CS. More than 1,800 replies were collected. Preliminary results (Grainger, pers. Communication) show that areas of improvement of CS comprise “easier to understand” information, an enhanced reliability and accuracy of forecasts as well as accessibility and timeliness of information. Thus, also these findings correspond very good with the other stakeholder feedback received for this study.

## 4 Conclusions

Taking the findings of the stakeholder dialogue carried out with CE2 and other more recent and relevant studies into account, the quality criteria for high-quality CS could be further sharpened and prioritized (see Figure 24 and Table 3). With reference to the guiding principles, the following points summarize the findings within this study:

1. A sound scientific basis with state-of-the-art quality assured climate data provided by re-known scientific institutions or organization is essential for any high-quality CS (*Guiding principle: Science-based*).
2. Strongly connected to the data basis and quality is the appropriate knowledge about data sources (metadata), limitations and uncertainties for the user. This information has to be a) available and b) understandable to increase transparency and trust. In particular, b) is strongly context dependent as amount of information, level of detail and complexity depends on the user skills and interests. Here the interaction with the user of CS plays an important role (*Guiding principles: science-based, transparent, collaborative*).
3. User needs and interest should be key in the design, production and implementation of a climate service. For most of the examples monitored in the case study section this is clearly stated (and applied). Nevertheless, user often express that the climate data or information is not always complying with their expectations and needs. Here an interaction with the user right from the beginning in the development process of a CS can avoid misunderstandings and wrong expectations (*Guiding principles: user focused, collaborative*).
4. Closely connected on the user-centric focus in the development of CS is a collaboration with the user. Mutual understanding was mentioned repeatedly as a key criterion on the way to a product which is fit for purpose. User interaction comprises feedback loops at all stages as well as an appropriate evaluation whether the usage of the service let to *the desired impact or, for instance, to maladaptation* (*Guiding principles: user focused, collaborative*).
5. Whether a CS product can finally successfully be applied depends on a number of aspects as already mentioned above. In addition, timely delivery and accessibility were frequently mentioned by users. Free and open access to data and products in usable formats were often notified as barriers. (*Guiding principles: timely & accessible, equitable*).
6. In principle, users as well as providers would welcome standards for CS as they can facilitate the comparison and usage of products and increase quality, transparency, and trust (*Guiding principles: transparent, sustainable, equitable*).

Finally, which of the quality criteria discussed in this deliverable are suitable to be included in a standard for CS?

As the European Commission has tasked CEN and CENELEC (<https://www.cencenelec.eu>) in early 2024 to develop a standard for CS, Climateurope2 will provide input to this process. Therefore, a process has been started by WP1 to assess existing or required governance structures for important elements of CS including quality criteria and indicators. This will be done along a number of decision trees as described in D1.2 of Climateurope2 (Baldissera Pacchetti & St. Clair, 2023).

## 4.1 Next steps:

The community engagement, in particular with the private sector but also sectors and regions which are currently underrepresented (e.g. eastern and southeastern Europe) or emerging (e.g. financial sector, risk assessment), will be intensified in the next two years of the project. The results of further discussions and workshops will be funnelled in the Deliverable D4.11 (Month 48) which is the third and last one of a set of three deliverables to develop guiding principles for high-quality CS. It will integrate the findings from the first two deliverables and the final set of workshops. It will also integrate relevant findings from other tasks in WP4, but also WP1 and 2 where relevant.

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WMO, 2020: Global Framework for Climate Services: Progress Report 2009–2019, GFSC-2, [https://library.wmo.int/doc\\_num.php?explnum\\_id=10294](https://library.wmo.int/doc_num.php?explnum_id=10294)

WMO, 2022: Guidelines for Communicating Climate Science and Services, WMO No. 1288, ISBN 978-92-63-11288-0, [https://library.wmo.int/doc\\_num.php?explnum\\_id=11319](https://library.wmo.int/doc_num.php?explnum_id=11319).

# Appendices

## Appendix 1: Survey on Climate Services from User and Provider Perspectives

### Survey on Climate Services from User and Provider Perspectives

Dear reader,

The demand and use of climate information for adaptation to climate change is rapidly increasing. This results in a growing number of different kinds of information services and products, so-called Climate Services (CS). CS use climate-related data, together with other relevant information, to develop customized products for climate adaptation and transformation.

Within the EU-funded project Climateurope2 ([www.climateurope2.eu](http://www.climateurope2.eu)) we aim to build and strengthen the climate services community by, amongst others, co-developing improved quality measures and standards for climate services.

With this survey we want to assess the present state of the climate services market, identify quality criteria, potential gaps and opportunities for standard procedures to improve climate services.

Therefore, we would greatly appreciate if you could spend about 10-15 minutes of your time and help to improve climate services.

Thank you very much for your participation!

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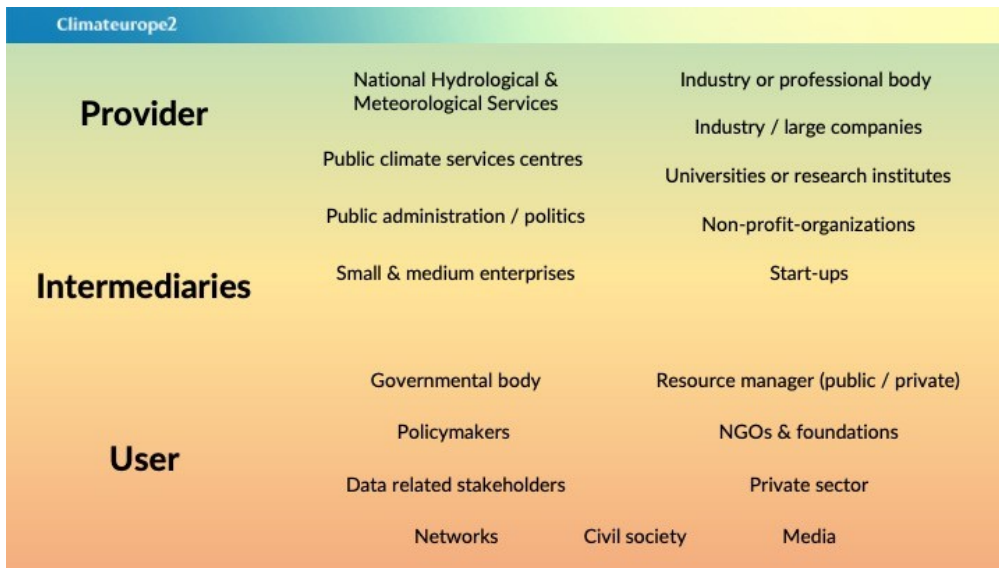
### Privacy Policy Statement

Note: This survey is anonymous!

Your responses and the data collected will be stored in accordance with General Data Protection Regulation Guidelines. Please tick the box below if you agree with this.

I agree with the Privacy Policy Statement \*

<input type="checkbox"/>	Yes
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**1. Who are you? - What is your function with respect to climate services? \***

The boundaries between providers and users of climate services are somewhat fluent. If you take a look at the image above (classifications adopted from MARCO, 2018), how would you classify yourself?

<input type="radio"/>	Provider
<input type="radio"/>	User
<input type="radio"/>	Both (Intermediary)
<input type="radio"/>	None, but interested in climate services for other reasons

**1.1 Please take a role\* (Note: only applicable if both was selected)**

Even though you have selected "both" in the previous question, please select one of the two options which better characterizes your experience and expertise.

<input type="radio"/>	Provider
<input type="radio"/>	User

## 2. Provider of Climate Service

### 2.1 Which climate service (CS) is being evaluated in this survey?

We would like to concentrate in this survey on one climate service that you provided. Thus, please tell us which climate service will be part of this survey. (Of course, you can repeat this survey for other services you have provided). Note, that this question is not mandatory!

--

### 2.2 Please specify the type (basis) of the climate service evaluated in this survey \*

Please select the option that characterizes the service most appropriate!

<input type="radio"/>	Measurements / Observations
<input type="radio"/>	Modelling (Sub-)Seasonal predictions to climate change projections)
<input type="radio"/>	Processed or re-analysis data
<input type="radio"/>	Advisory Service
<input type="radio"/>	Consulting Services (e.g. sustainability, decarbonization and climate neutral strategies, etc.)
<input type="radio"/>	Publication
<input type="radio"/>	Other

### 2.3 How did the idea for the climate service that you offer come about? \*

<input type="radio"/>	My own (Provider)
<input type="radio"/>	User idea
<input type="radio"/>	Idea was developed in collaboration with the user
<input type="radio"/>	Idea was defined jointly with other partners
<input type="radio"/>	Other

**2.4 What kind of climate data (base) have you used? \***

<input type="radio"/>	Own data (e.g. model output, forecasts, projections, etc.)
<input type="radio"/>	Data from a public service or research institute
<input type="radio"/>	Data from a private provider
<input type="radio"/>	Data source unknown

**2.5 Did you obtain the data used in the climate service free of charge? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
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**2.5.1 If not, how much do you spend for data usage (once or per month or year)? (voluntary answer)**

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**2.6 Did you process the data any further? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
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**2.6.1 If so, please briefly describe how the data was processed?**

--------------

**2.7 Are you using established standards (ISO, DIN, etc) for your climate service? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

### 2.7.1 Please tick the standards that you are using for your climate service?

You can select multiple options\*

<input type="radio"/>	ISO 9001 Quality management systems - Requirements
<input type="radio"/>	ISO 14002-1 Environmental management systems
<input type="radio"/>	ISO 14090 Adaptation to climate change - Principles, requirements and guidelines
<input type="radio"/>	ISO 14091 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment
<input type="radio"/>	ISO 14092 Adaptation to climate change - Requirements and guidance on adaptation planning for local governments and communities
<input type="radio"/>	ISO 14093 Mechanism for financing local adaptation to climate change
<input type="radio"/>	ISO 19115-2 Geographic information - Metadata - Part 2: Extensions for acquisition and processing
<input type="radio"/>	ISO 19131 Geographic information - Data product specifications
<input type="radio"/>	ISO 19156 Geographic information - Observations, measurements and samples
<input type="radio"/>	ISO 19157 Geographic Information - Data Quality
<input type="radio"/>	ISO 19158 Geographic Information - Quality assurance of data supply
<input type="radio"/>	ISO 32210 Sustainable finance - Guidance on the application of sustainability principles for organizations in the financial sector
<input type="radio"/>	Other

**2.7.2 Why are you not using standards for your climate service? \***

<input type="radio"/>	Existing standards are not applicable to the CS product
<input type="radio"/>	Application of standards requires additional efforts
<input type="radio"/>	Lack of knowledge of existing standards
<input type="radio"/>	Other

**2.7.3 Please indicate with which of the following statements you agree or not. \***

	disagree	partly disagree	partly agree	agree
Standards are improving quality of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards facilitate usage of CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards increase transparency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards increase trust	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards are increasing costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards increase bureaucracy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**2.7.4 Are you planning to adopt (more) standards to improve your CS in the future? \***

<input type="radio"/>	Yes, definitely
<input type="radio"/>	I am not sure
<input type="radio"/>	No, standards are not suitable for my climate service

**2.8 Did you collaborate with users to create the climate service? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

**2.8.1 At which point did the collaboration start? \***

<input type="radio"/>	Right at the beginning
<input type="radio"/>	During the development & test phase
<input type="radio"/>	After the product was finished
<input type="radio"/>	Not sure

**2.8.2 What form of interaction did you had with the users? \***

<input type="radio"/>	Continuous interaction with workshops, etc.
<input type="radio"/>	Few feedback loops during the development process
<input type="radio"/>	Only feedback on the final product
<input type="radio"/>	No feedback from users

**2.8.3 What were the positive aspects of the interaction with the users? \***

You can select multiple options

<input type="radio"/>	Development of mutual understanding
<input type="radio"/>	Development trust and transparency
<input type="radio"/>	Ideas and innovation by the user
<input type="radio"/>	Improvement of the product
<input type="radio"/>	Other

**2.8.4 Did you experience barriers in the interaction with the user? \***

You can select multiple options

<input type="radio"/>	Language barriers (lack of mutual understanding)
<input type="radio"/>	Different expectation of product and impact
<input type="radio"/>	Differences in resources (financial or personnel)
<input type="radio"/>	Differences in timeframes (of delivery)
<input type="radio"/>	Other

**2.8.5 Was a moderator or neutral person involved in the user-provider interaction? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

**2.8.6 From your impression, how well did the users understand: \***

	poor	medium	well	completely
Scientific background	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Limitations of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Uncertainties of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**2.8.7 How satisfied are you overall with the user-interaction?**

very unsatisfied

very satisfied

1	2	3	4	5	6	7

**2.8.8 If not, why has there been no interaction with the user? (only if 2.8. no)**

--

2.9 Did you receive feedback from the users? \*

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

2.10 Has there been some kind of evaluation process of the climate service? \*

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

2.10.1 Could you please describe briefly the evaluation process? (only applicable if 2.10 "yes")

--

2.11 Is the climate service used as envisaged? \*

"0" = not known, "1": no, not at all

"7": yes, absolutely

0	1	2	3	4	5	6	7

2.12 Has the usage of the climate service led to the envisaged impact? \*

"0" = not known, "1": no, not at all

"7": yes, absolutely

0	1	2	3	4	5	6	7

2.13 Are there any updates planned for the product? \*

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

**2.14 How would you like to change / improve your product?**

**2.15 Is there sufficient (long-term) funding available to operate the climate service? \***

<input type="radio"/> Yes	<input type="radio"/> No
---------------------------	--------------------------

**2.16 In general (not specifically this climate service): What is most important for you in terms of quality of a climate service? \***

1: not important -> 7: very important

	1	2	3	4	5	6	7
Quality of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Co-production process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Transparency of process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mutual understanding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Easy-to-handle product	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Impact of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
User satisfaction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recommendation by the user	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Profit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## General background information

### 2.17 Type of provider \*

<input type="radio"/>	National Hydrological or Meteorological Service
<input type="radio"/>	Public Climate Service Center
<input type="radio"/>	University or research institute
<input type="radio"/>	Public administration
<input type="radio"/>	Non-Governmental Organization
<input type="radio"/>	Large industrial / commercial provider
<input type="radio"/>	Small-to-medium enterprise (SME)
<input type="radio"/>	Start-up
<input type="radio"/>	Other

### 2.18 Number of employees of your company/institution

--

### 2.19 Number of CS products offered? \*

<input type="radio"/>	1
<input type="radio"/>	2-10
<input type="radio"/>	> 10

### 3. User of Climate Service

#### 3.1 Which climate service (CS) is being evaluated in this survey?

We would like to concentrate in this survey on one climate service that you used. Thus, please tell us which climate service will be part of this survey. (Of course, you can repeat this survey for other services you have used). Note, that this question is not mandatory!

#### 3.2 Please specify the type (basis) of the climate service evaluated in this survey \*

Please select the option that characterizes the basis of the service most appropriate!

<input type="radio"/>	Measurements / Observations
<input type="radio"/>	Modelling (Sub-)Seasonal predictions to climate change projections)
<input type="radio"/>	Processed or re-analysis data
<input type="radio"/>	Advisory Service
<input type="radio"/>	Consulting Services (e.g. sustainability, decarbonization and climate neutral strategies, etc.)
<input type="radio"/>	Publication
<input type="radio"/>	Other

#### 3.3 Who is the provider of the climate service? \*

**3.4 How did you become involved with this climate service? \***

<input type="radio"/>	It was our own (user) idea
<input type="radio"/>	A provider of a climate service approached us
<input type="radio"/>	The idea was developed jointly (e.g. in a project)
<input type="radio"/>	Recommendation
<input type="radio"/>	Advertisement
<input type="radio"/>	Web search
<input type="radio"/>	Other

**3.5 Do you know the data source (basis) of the climate service product? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

**3.6 Is the metadata information available to you? \***

<https://community.wmo.int/en/climate-metadata#:~:text=Metadata%20is%20the%20descriptive%20data,can%20also%20be%20a%20specification>

<input type="radio"/>	Yes	<input type="radio"/>	No
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**3.6.1 Is this information sufficient and understandable? \***

not at all							yes, absolutely
1	2	3	4	5	6	7	

**3.7 Are there any (financial) costs implied in the use of this climate service? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

**3.7.1 How much did you pay for using this climate service? (per usage or per month/year)**

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**3.8 Did you work / cooperate with the provider to design & create the climate service? \***

<input type="radio"/> Yes	<input type="radio"/> No
---------------------------	--------------------------

**3.8.1 When did the cooperation started? \***

<input type="radio"/>	Right at the beginning
<input type="radio"/>	During the development & test phase
<input type="radio"/>	After the product was finished
<input type="radio"/>	No cooperation at any time

**3.8.2 What form of interaction did you have with the provider? \***

<input type="radio"/>	Continuous interaction with workshops, etc.
<input type="radio"/>	Few feedback loops during the development process
<input type="radio"/>	Feedback on the final product only
<input type="radio"/>	Other

**3.8.3 Was enough time provided for interaction with the provider?**

<input type="radio"/> Yes	<input type="radio"/> No
---------------------------	--------------------------

### 3.8.4 What were the positive aspects of the interaction with the provider? \*

You can select multiple options.

<input type="radio"/>	Development of mutual understanding
<input type="radio"/>	Development trust and transparency
<input type="radio"/>	Partnership on equal footing
<input type="radio"/>	User ideas were taken up to improve the product
<input type="radio"/>	Other

### 3.8.5 Did you experience barriers in the interaction with the provider? \*

You can select multiple options

<input type="radio"/>	Language barriers (lack of mutual understanding)
<input type="radio"/>	Different expectation of product and impact
<input type="radio"/>	Differences in resources (financial or personnel)
<input type="radio"/>	Differences in timeframes (of delivery)
<input type="radio"/>	Other

### 3.8.6 How well did you understand: \*

	poor	medium	well	completely
Scientific background	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Limitations of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Uncertainties of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**3.8.7 What is your overall level of satisfaction in terms of cooperation with the provider? \***

not satisfied at all

fully satisfied

1	2	3	4	5	6	7

**3.8.8 If not, why?**

**3.9 How would you rate the following criteria with respect to the CS that you used? \***

1: poor -> 7: very good

	1	2	3	4	5	6	7
Quality of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Co-production process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mutual understanding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Transparency of process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fit-for-purpose product	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
User friendly comprehensible information, easy to use)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Customer service	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Timely delivery	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	1	2	3	4	5	6	7
Overall quality of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outcome of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Impact of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**3.10 What would you change or how would you improve the product?**

**3.11 Has the usage of the climate service led to the envisaged impact? \***

"0" = not known, "1": no, not at all

"7": yes, absolutely

0	1	2	3	4	5	6	7
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.11.1 Could you please briefly explain the impact of the CS or why there was no impact \***

**3.12 How would you rate your trust in the provider of the CS? \***

Very low

Very high

1	2	3	4	5	6	7
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**3.13 Would you use the CS again or continue to use it in future?\***

Very low

Very high

1	2	3	4	5	6	7
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### 3.14 How likely is it that you would recommend the CS to a friend or colleague?\*

Not at all							Very likely
1	2	3	4	5	6	7	

### 3.15 In general: What are for you the most important quality criteria of a CS from your point of view?\*

1: not important -> 7: very important

	1	2	3	4	5	6	7
Quality of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Co-production process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mutual understanding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Transparency of process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standardization of processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
User friendly comprehensible information, easy to use)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Timely delivery	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outcome of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Impact of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

## General background information

### 3.16 Type of user (please characterize yourself) \*

<input type="radio"/>	Policymaker (Local, subnational, national, and supranational level)
<input type="radio"/>	Governmental body (Environmental and conservation agencies, climate change offices, and funding agencies)
<input type="radio"/>	Resource manager public (Local, regional, and national authorities or resource authorities (e.g., river basin management authorities), public utilities, and resource suppliers)
<input type="radio"/>	Resource manager private (Landowner associations, professionals, mediators, and practitioners)
<input type="radio"/>	Consulting Services (e.g. sustainability, decarbonization and climate neutral strategies, etc.)
<input type="radio"/>	Data related stakeholder (Data provision, supplier, purveyor, developers, and manager)
<input type="radio"/>	Civil society, community representative (Citizen associations, local communities (hybrid), consumer associations Citizen representatives, social movements, and youth representatives)
<input type="radio"/>	NGO and other foundations (Local, regional, and national NGOs)
<input type="radio"/>	Private sector (Companies, industry representatives, and associations)
<input type="radio"/>	Resource manager private (Landowner associations, professionals, mediators, and practitioners)
<input type="radio"/>	Networks (Transnational networks, global initiatives, and umbrella organizations)
<input type="radio"/>	Media (Journalists and specialized media)
<input type="radio"/>	Other (Non-project-related scientists, technologists (vendors, computing centers, etc.), and experts; educators)

### 3.17 How often have you already used climate service products? \*

<input type="radio"/>	1
<input type="radio"/>	2-10

<input type="radio"/>	> 10
-----------------------	------

#### 4. "Friends" of Climate Services

##### 4.1 Why are you interested in climate services if you are neither a user nor a provider? \*

<input type="radio"/>	I am doing research on climate services
<input type="radio"/>	I am funding climate services
<input type="radio"/>	I am planning to use climate services in future
<input type="radio"/>	I am planning to become a climate service provider
<input type="radio"/>	Other

##### 4.2 What type of climate services are of most interest to you? \*

You can select multiple options

<input type="radio"/>	Products addressing seasonal prediction
<input type="radio"/>	Products addressing climate change
<input type="radio"/>	Advisories
<input type="radio"/>	Consultancies
<input type="radio"/>	Other

**4.3 What are the most important quality criteria of a CS from your point of view? \***

1: not important -> 7: very important

	1	2	3	4	5	6	7
Quality of data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Co-production process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mutual understanding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Transparency of process	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standardization of processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
User friendly comprehensible information, easy to use)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Timely delivery	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Outcome of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Impact of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**4.4 If there would be costs using a climate service, would you pay for it? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

**4.4.1 How much would you pay for using a climate service? (per usage or per month/year)**

**4.5 What are the positive aspects of a user-provider interaction from your point of view? \***

You can select multiple options.

<input type="radio"/>	Development of mutual understanding
<input type="radio"/>	Development trust and transparency
<input type="radio"/>	Partnership on equal footing
<input type="radio"/>	User ideas were taken up to improve the product
<input type="radio"/>	Other

**4.6 What kind of barriers do you expect in the interaction between user and provider? \***

You can select multiple options.

<input type="radio"/>	Language barriers (lack of mutual understanding)
<input type="radio"/>	Different expectation of product and impact
<input type="radio"/>	Differences in resources (financial or personnel)
<input type="radio"/>	Differences in timeframes
<input type="radio"/>	Other

**4.7 Are you aware of standards used in the area of climate services? \***

<input type="radio"/>	Yes	<input type="radio"/>	No
-----------------------	-----	-----------------------	----

#### 4.7.1 Which of the following standards do you know?

You can select multiple options\*

<input type="radio"/>	ISO 9001 Quality management systems - Requirements
<input type="radio"/>	ISO 14002-1 Environmental management systems
<input type="radio"/>	ISO 14090 Adaptation to climate change - Principles, requirements and guidelines
<input type="radio"/>	ISO 14091 Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment
<input type="radio"/>	ISO 14092 Adaptation to climate change - Requirements and guidance on adaptation planning for local governments and communities
<input type="radio"/>	ISO 14093 Mechanism for financing local adaptation to climate change
<input type="radio"/>	ISO 19115-2 Geographic information - Metadata - Part 2: Extensions for acquisition and processing
<input type="radio"/>	ISO 19131 Geographic information - Data product specifications
<input type="radio"/>	ISO 19156 Geographic information - Observations, measurements and samples
<input type="radio"/>	ISO 19157 Geographic Information - Data Quality
<input type="radio"/>	ISO 19158 Geographic Information - Quality assurance of data supply
<input type="radio"/>	ISO 32210 Sustainable finance - Guidance on the application of sustainability principles for organizations in the financial sector
<input type="radio"/>	Other

4.7.2 Please indicate with which of the following statements you agree or not. \*

	disagree	partly disagree	partly agree	agree
Standards are improving quality of the CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards facilitate usage of CS	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards increase transparency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards increase trust	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards are increasing costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Standards increase bureaucracy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4.8 How would you overall rate the impact of the climate services in contributing to climate action?

very low

very high

1	2	3	4	5	6	7

## General background information

### 4.9 How would you characterize yourself? \*

<input type="radio"/>	Policymaker (Local, subnational, national, and supranational level)
<input type="radio"/>	Governmental body (Environmental and conservation agencies, climate change offices, and funding agencies)
<input type="radio"/>	Resource manager public (Local, regional, and national authorities or resource authorities (e.g., river basin management authorities), public utilities, and resource suppliers)
<input type="radio"/>	Resource manager private (Landowner associations, professionals, mediators, and practitioners)
<input type="radio"/>	Consulting Services (e.g. sustainability, decarbonization and climate neutral strategies, etc.)
<input type="radio"/>	Data related stakeholder (Data provision, supplier, purveyor, developers, and manager)
<input type="radio"/>	Civil society, community representative (Citizen associations, local communities (hybrid), consumer associations Citizen representatives, social movements, and youth representatives)
<input type="radio"/>	NGO and other foundations (Local, regional, and national NGOs)
<input type="radio"/>	Private sector (Companies, industry representatives, and associations)
<input type="radio"/>	Resource manager private (Landowner associations, professionals, mediators, and practitioners)
<input type="radio"/>	Networks (Transnational networks, global initiatives, and umbrella organizations)
<input type="radio"/>	Media (Journalists and specialized media)
<input type="radio"/>	Other (Non-project-related scientists, technologists (vendors, computing centres, etc.), and experts; educators)

Do you have any further comments about this survey? Please tell us how to further improve the survey!

Thank you for taking the time to participate in this survey!

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### Stay in touch with Climateurope2

If you wish to sign up for our information about Climateurope2, please sign up [here](#). Then, we will keep you updated about our project.

In the follow up of this survey we are planning a series of workshops to discuss these issues in more detail. If you are interested in attending one of these events, please leave your email address in the box below.

By entering your e-mail address, you consent to the processing of your contact details for the purpose and duration of the workshop planning and implementation (Art. 6 para. 1 lit. a GDPR). You can revoke your consent at any time by sending an email to [datenschutz@hereon.de](mailto:datenschutz@hereon.de). In this case, your data will be deleted from our system immediately.

Important note: Providing your e-mail address is voluntary and is not related to the survey. The survey can also be completed without providing your e-mail address and ended by clicking on the "Finish" button.

Further information on the data protection policy can be found [here](#).

Contact: Dr. Andreas Villwock ([andreas.villwock@hereon.de](mailto:andreas.villwock@hereon.de))

## Appendix 2: Case studies

### A2.1 Climate Services of Climateurope2 project-wide case studies

#### 2.1.1 MED-GOLD: Turning climate-related information into added value for traditional MEDiterranean Grape, OLive and Durum wheat food systems

##### Overview

MED-GOLD (EU H2020 funded project, 2017-2022, 16 partner, <https://www.med-gold.eu>) aimed to develop novel pilot climate services focusing on three staples of the Mediterranean food system: grape, olive and durum wheat. The long-term objective of MED-GOLD is to make European agriculture and food systems more resilient, sustainable and efficient in the face of climate change, by using climate services to minimize climate driven risks/costs and seize opportunities for added value.

##### Knowledge-holders

Climate information and background provided by several research partners (BSC, CNR, MetOffice, NOAA, UNMG, U Leeds and UTH), matched with expertise in the above-mentioned agricultural sector from several companies (Barilla, DCOOP, SOGRAPE). Advanced decision support systems and digital platforms were developed by HORTA, EC2CE, BEETOBIT, GMV).

##### Quality assessment

- *Science based:* The project is using state-of-the-art model simulations, including climate-predictions (seasonal) and climate projections. The work is carried out by renowned research institutions and scientists and the results are well-documented in the scientific literature. Nevertheless, for the users the quality of the forecasts was not always sufficient (see usability).
- *Transparent:* The data and methods used are well-documented as well as uncertainties. Workshops were also organised with potential new users to present the information provided on the dashboard (online tool developed to deliver information to end-users). Some of these workshops were directly run by the users involved in the project, which could much better empathize with the audiences' needs. Nevertheless, the question is whether or not all end-users understand the abilities and limitations of the climate information serving as the basis of the decision support tool (dashboard) of the CS.
- *User focused:* The project was initiated through a public funded project from the climate and SHH<sup>6</sup> research communities but involving the user community as partners in the project. Thus,

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<sup>6</sup> Social sciences and humanities

the user community influenced the design of the project and the envisaged climate services. Thus, the project was not user driven but co-produced (see next item)

- *Collaborative*: The development of the service was collaborative with user interaction from the beginning. Intense co-production with continuous feedback from the user side. Terrado et al. (2023) stated: “Lessons learned are that repeated interaction between scientists and users allow to better frame research questions, jointly decide how to address these questions, and test the outcomes with feedback from real-world decision-makers. Furthermore, having a user who co-developed the service and helped assess its added value was key to ensure that it could truly inform decision-making needs and to promote its broader uptake by the wine sector community.”
- *Timely and accessible*: The main climate service product (dashboard) was created and applied. Access is limited to partners within the project as this is designed as a prototype service available to the project partners only and during the duration of the project.
- *Sustainable*: The dashboard is still accessible and not maintained or updated with actual predictions. Without additional funding or revenues through subscription fees, the dashboard cannot be maintained, either the data is publicly available. Nam et al. (2024) provided an estimate on a realistic revenue from users with respect to potential savings or losses using seasonal predictions for the wine sector to finance the maintenance of the dashboard. In principle, the CS can also be applied to other regions but this would require adjustments and additional information input.
- *Equitable*: Statement by Werner Krauss WP5: “The development of climate services (within MED-GOLD) do not question power relations, unequal market practices, ethical behaviour, questions of equity / environmental justice.”
- *Usability of the service (Fit-for-purpose)*: Results from user feedback / evaluation

**Olive**: “The result shows that participants believe that the Olivia platform<sup>7</sup> has been designed for only one pest (Olive fly fruit) which is not harmful in all areas, and it needs to consider other pests as well. Regarding the dashboard added value assessment, they discussed that this version of the dashboard will be only useful for a minority of users in the olive sector as it is not intuitive enough for some users especially farmers. Therefore, they suggested simplifying the tool can increase its usability by different user profiles”. (MED-GOLD, D2.4, 2021a)

**Wine** “Although seasonal forecasts and climate projections are hardly used by participants, they believe that using these types of timescales could add value to their medium-term planning (e.g., stock management, seasonal labour scheduling) and long-term planning (e.g., purchasing land/vineyard, vineyard installation)”. (MED-GOLD D3.4, 2021b)

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<sup>7</sup> Note that Olivia is a commercial service developed by a Spanish SME that existed prior the MED-GOLD

**Wheat:** “The assessment reveals that the new functionality of Granoduro.net (<https://www.horta-srl.it/en/granoduro-net/>) is salient enough for the users as they believe the tool is easy to access, and they have the variables, indicators and the lead time they need to make decision in their roles. However, regarding the data understandability, five users out of eight agreed that the data is easy to understand, and some users have mentioned that they need training to be able to use and apply the information provided in the tool in their decision-making. Reliability of the climate information is the factor that users are not completely sure about it”. (MED-GOLD D4.4, 2021c)

- Impact of the service: Actually, the service was not really applied in practice/reality (we are not aware that the users involved in the project changed any of their BaU practices in the face of the predictions available) but it certainly entrained discussion within the staff of the companies involved and between the companies and scientists. We really saw an increase in the level of understanding/users’ learning of climate information at longer time scales than the usual weather forecasts and awareness on the potential usefulness of the climate services.

**Summary/conclusions:**

The climate service products developed within the MED-GOLD project based on renowned scientific expertise, state-of-the-art and innovative methods and reliable data. Although the products were developed in close cooperation with the user communities through an intensive co-production process, the usage and impact of the services was limited mainly due to the quality of the forecast products vs. the expectations and needs of the users. Also, because the project was aimed to be a ‘proof of concept’ of climate services for Mediterranean agriculture, but not to provide an operational service that was sustainable, since more resources would have been necessary. Nevertheless, the design approach used in MED-GOLD should a high potential how to successfully develop and implement a high-quality climate service)

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
MED-GOLD									

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.1.2 “FOCUS-Africa”

### *Brief description of the service*

FOCUS-Africa (Full-value chain Optimised Climate User-centric Services for Southern Africa, <https://focus-africaproject.eu/>) is an EU H2020 funded project (2021-2024), with 16 consortium partners, that aims to develop tailored climate services in the SADC (Southern African Community Development) region. In addition, the four NMHSs of Tanzania (TMA), Mauritius (MMS), South Africa (SAWS) and Mozambique (INAM) were not formally part of the consortium but worked closely with the FOCUS Africa consortium partners in the development of the climate services.

The full value chain of climate services is being demonstrated by piloting eight case studies in five countries (Tanzania, Mozambique, South Africa, Malawi, and Mauritius), involving a wide range of stakeholders and following a co-production approach. The case studies illustrate how the use of climate science, forecasts and projections can maximise socio-economic benefits in the targeted countries and potentially in the whole of Africa. To provide a range of examples where climate service delivery can be successfully implemented, four key sectors are targeted: agriculture and food security, water, energy and infrastructure. The project develops and/or improves the following climate services for each respective case study:

- Climate projections for the agriculture in South Africa
- Tailored climate forecasting information for the agriculture and food security sector of Tanzania
- Climate projections for the infrastructure sector in Tanzania
- Seasonal forecasts for the hydropower, solar and wind energy sectors in Tanzania
- Seasonal forecasts for the agriculture and food security sector of Malawi
- Climate projections for the hydropower sector in Malawi
- Tailored climate forecasting information for the agricultural sector of Mozambique
- Seasonal forecasts for water management in Mauritius

### *Knowledge-holders*

Knowledge holders differ depending on each case study. Climate information and background are provided by several research and industrial partners: CSIR (Council of Scientific & Industrial Research), WMO (World Meteorological Organisation), BSC (Barcelona Supercomputing Center), WEMC (World Energy & Meteorology Council), TARI (Tanzania Agricultural Research Institute), TMA (Tanzania Meteorological Authority), UK Meteorological Office, DCCMS (Department of Climate Change and Meteorological Services Malawi), INAM (Mozambique National Meteorology Institute), MMS (Mauritius Meteorological Services).

End users are involved in the co-production process from the beginning and include: South African Land Bank, Small-holder farmers using the climate services, TANESCO (Tanzania Electric Supply Company), EDF (Electricité de France), WRU (Mauritius Water Resources Unit), FAREI (Mauritius Food and Agricultural Research and Extension Institute), NASFAM (local farmers association in Malawi),

#### Quality assessment

- *Science based:* The different services developed within FOCUS Africa are governed by re-known research institutions
- *Transparent:* The co-design process within each case study team guarantees that the process, data, and methodology are transparent to the climate service (CS) user, with user feedback being essential. The socio-economic impact assessment evaluates whether the co-produced climate service led to improvements compared to the original process employed by the CS user.
- *User focused:* Adoption of a co-production approach, ensured close involvement of end users throughout the climate services value chain. Integrating scientific research, service providers, and end-user feedback to co-develop tailored climate products ensures the activities are ensuring active engagement and feedback from end users and played a critical role in shaping the services, making it both user-centric and science-driven.
- *Collaborative:* A collaborative co-production approach ensures end users are engaged from the early stages of the process. This ensures that the climate services being developed are tailored to meet their specific needs. End users work alongside scientific research partners and service providers throughout the climate services value chain, contributing to the design, development, and evaluation of products and services.
- *Timely and accessible:* As the project is still ongoing, it is too early to fully assess the long-term impact on timeliness and accessibility. However, the climate services are designed with mechanisms to ensure that climate services are accessible and timely, involving continuous feedback from end users to refine and improve service delivery
- *Sustainable:* Sustainability of climate services developed in FOCUS Africa is guaranteed through co-production with end users, tailored to sectoral needs, and based on sound scientific research. The services are designed to be relevant to decision-making processes, effective in addressing climate risks, and robust enough to be scaled across regions. The focus on continuous user feedback and the use of operational WMO infrastructure supports the aim for long-lasting, credible services.
- *Equitable:* Each case study team includes a representative from the Impact Assessment Team, responsible for guiding the socio-economic impact study throughout the service development

process. The socio-economic impact methodology ensures that the services are developed equitably, meaning they are designed to be inclusive, with equal representation and fair access to knowledge and resources. The following indicators are evaluated for each case study:

- Accessibility of the climate service (or its output) to low-income population (in the CS scope area)
  - Number and quality of measures taken by the CS team & project to be inclusive in the design and implementation of the climate service - to empower and promote the social, economic and political inclusion of all, irrespective of gender, age, disability, race, ethnicity, origin, religion or economic or other status (derived from SDG#10.2)
  - Participation rate of men and women in formal and non-formal trainings (derived from SDG #4.3)
  - Steps taken to support local communities in responsive, inclusive participatory mechanisms and access to climate service information
- *Usability of the service (Fit-for-purpose):* While the project is actively developing and testing climate services through a co-production process with end users, a final judgement cannot be made yet as it is still in progress. However, efforts are being made to ensure the services are relevant and tailored to user needs through continuous feedback during the development process.
  - *Impact:* As the project is still ongoing (ending 2024), a final judgement cannot be made yet. An impact assessment team is evaluating the expected and actual impacts of the services on the beneficiaries.

**Summary/conclusions:**

FOCUS-Africa is an EU H2020 funded project, with 16 partners, that aims to develop tailored climate services for different sectors in eight case studies in five countries (Tanzania, Mozambique, South Africa, Malawi, and Mauritius). It focuses on CS, involving a wide range of stakeholders and following a co-production approach.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
Focus Africa									

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.1.3 Sub-seasonal to Seasonal Climate Predictions for Energy (S2S4E)

#### Overview

S2S4E (Sub-seasonal to Seasonal Climate Predictions for Energy) is an EU H2020 funded project, (2017-2020, 12 partners, <https://s2s4e.eu/>) that aimed to provide more reliable and usable climate forecasts for weather-dependent solar, wind and hydropower production, with the long-term goal to make the European energy sector more resilient to climate variability and extreme events. The S2S4E Decision Support Tool (DST, <https://s2s4e-dst.bsc.es/>) is an operational climate service that integrates sub-seasonal to seasonal climate predictions with renewable energy production and electricity demand with the aim to provide more reliable and usable climate forecasts for weather-dependent solar, wind and hydropower production.

#### Knowledge-holders

Stakeholders from the energy sector, scientists within climate physics and psychology (user interactions with the tool) and commercial CS providers (Capgemini, Nnergix and TCDF) were involved in the project.

#### Quality assessment:

- *Science based:* The project is using state-of-the-art model simulations and real-time climate-predictions. The work is carried out by renowned research institutions and scientists and the results are well-documented in the scientific literature.
- *Transparent:* Statement from LGI: “Traders rely a great deal on their personal relationship with weather forecasters, and in practice social bonds of trust have more influence on how decisions are taken than technical metrics of forecast performance.”
- *User focused:* The project was initiated through a public funded project from the climate research community but involving selected companies (3 energy producers, 4 industrial partners) as partners in the project. Thus, the user community contributed to the design of the DST and the related climate services.
- *Collaborative:* Development of the service with users from the beginning. *:(Input from LGI) “Users were not yet ready to make real time decisions based on the service. Organisation of feedback sessions with the end users were key for improvement of the DST.”* From CORDIS project info (<https://cordis.europa.eu/article/id/422471-forecasting-climate-conditions-for-cleaner-energy-production>): “The S2S4E team took a transdisciplinary approach. Scientists and the energy industry came together to match the most advanced climate science with the needs, risk management practices and decision-making procedures of the perspective users of the DST.”

- *Timely and accessible*: The DST was created and applied. Access is limited to partners within the project as this is designed as a prototype service available to the project partners only. In second phase, the DST was opened to a broader audience and still available online (<https://s2s4e-dst.bsc.es/>) but without updates of actual predictions.
- *Sustainable*: The service was terminated with the end of the project. A planned commercialisation was not implemented.
- *Equitable*: n/a
- *Usability of the service (Fit-for-purpose)*: (Input from LGI): "Climate is only one of the numerous variables affecting energy decisions and it has different weights in each of them. Users were not yet ready to make real time decisions based on the service".
- *Impact of the service*: As the forecast skill was still not sufficient for the users, the project was only able to demonstrate qualitatively what could be possible. In this sense, the project had an impact for both users as well as providers. Providers understand better user needs for decision making and users obtained a much better knowledge about abilities and limitations of seasonal forecast products.

#### Summary/conclusions:

The climate service product developed within the S2S4E project based on re-knowned scientific expertise, state-of-the-art and innovative methods and reliable data. Although the product was developed in close cooperation with the user communities, the usage and impact of the services was limited mainly due to the insufficient perceived values of the forecast products vs. the needs of the users. The envisaged commercialization of the service did not happen, although the idea for the service indicated financial value

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
S2S4E	Dark Green	Light Green	Dark Green	Light Green	Light Green	Light Green	Grey	Light Green	Light Green

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.1.4 SMHI Climate Change Scenario Service

### *Brief description of the service*

The Swedish Meteorological and Hydrological Institute (SMHI) has developed an interactive scenario-based climate service (<https://www.smhi.se/en/climate/future-climate/future-climate>) that allows users to view the effects of the IPCC's Representative Concentration Pathway scenarios (RCPs) on the entire country of Sweden. The service is split into Basic and Advanced functionalities. The “Basic Service” shows the effects of the RCP scenarios (RCP 2.6, RCP 4.5, and RCP 8.5) on temperature and precipitation in Sweden. The model outputs are shown in an interactive map format and the user can select the time frame the model should run on (2011-2040, 2041-2070, or 2071-2100). The “Advanced Service” considers extreme climate events as well as gradual climate change. The user can select the same parameters as for the “Basic Service” but can further specify the season they are interested in as well as choose between model outputs for meteorology, hydrology, or oceanography. The model results are presented in a map, graph, and table format. All the presented data is downloadable. The SMHI also offers tailored climate services using their climatic models for industry and professional users as well as for national and international projects.

### *Knowledge-holders*

The service is developed based on results from the SMHI research department at Rosby Center.

### *Quality assessment*

- *Science based:* The service is using state-of-the-art models and different AR5 climate change scenarios (RCPs). The work is carried out by the national meteorological service of Sweden (SMHI).
- *Transparent:* Comprehensive metadata and background information about the data and methods used is available via the web portal.
- *User focused:* The service was developed as a public web-based information portal by the SMHI.
- *Collaborative:* A long-lasting dialogue with local stakeholders including co-production workshops provided the basis for the service.
- *Timely and accessible:* The project developed a publicly accessible web-based information system. The information is available free of charge.
- *Sustainable:* Long-term funding is not secured. The service is extended on one-year contracts by the SMHI.
- *Equitable:* The information provided by the climate service is publicly available via the web portal.

- *Usability of the service (Fit-for-purpose):* The products provide a general overview of climate change in Sweden on a regional scale (10-20 km) for different RCP scenarios. Whereas the basic service only provides information about mean temperature and precipitation, in the advanced section many atmospheric, hydrological, and oceanographic indicators (e.g. summer, frost days, river discharge and runoff, surface salinity, ice thickness, etc.) are available. The information is comprehensive including limitations, robustness of results etc.). For the advanced service, time series data (averages for Sweden) can be downloaded in a standard (CSV) format. Regional data can be interpreted from the country maps and it is possible to select counties/catchment areas/basins.
- *Impact of the service:* According to information from the SMHI governmental agencies, county administrative boards and municipalities are using the service in their planning of climate adaptation and assessment of climate impacts. Furthermore, for example journalists are using the service for background information when reporting about climate change. “We can say that the impact of the service is significant and important as it gives society important information about climate change in Sweden - information that is not available anywhere else” (G. Strandberg SMHI).

**Summary / conclusions:**

SHMI provides a web-based service of different complexity with typical climate indicators on a regional scale for Sweden und different climate change scenarios. Governmental agencies, county administrative boards and municipalities are using the service in their planning of climate adaptation and assessment of climate impacts. Users collaborated in co-production workshops which provided the basis for the service. Although a long-term funding is not secured SHMI tried to secure the provision of the service which is freely available via a web-based portal.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
SMHI									

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.1.5 Urban Water in Valencia (case study of [INNOVA](#))

### *Brief description of the service*

Water usage in the metropolitan area of Valencia is notably high, with approximately 80% of the supply allocated to the agricultural sector. The region is particularly vulnerable to frequent droughts, a challenge exacerbated by its climate conditions. Valencia is situated within a predominantly agricultural landscape characterized by a diverse, multi-sectoral structure. Irrigated agriculture is a key player in this ecosystem, significantly contributing to the region's overall water consumption. This underscores the critical importance of sustainable water management practices in the area.

As part of the INNOVA project (<https://www.innovaclimate.org>), a climate service was developed to assess the impacts of climate change on the water quality of the available under drought conditions and distribution of potable water in the region. This service aims to identify potential adaptation strategies required to address these changes, ensuring a sustainable and healthy water supply for the future.

A chain of models was designed, validated and developed, consisting of 1) Global and regional climate models to obtain future projections of temperature and precipitation in the region; 2) Hydrological models of the system's sub-basins to obtain water inflows; 3) Water management model that simulates the operation of the water resource system to obtain the water inflows to the reservoir and its storage under climate change; 4) Reservoir model to simulate the water quality dynamics in the new climate scenarios (from Rubio-Martin et al., 2023).

The collaboration between the research team from the Universitat Politècnica de València, GERICS and the managers from the water utility company *Aguas de València* began by establishing the research goals and objectives. These were centred around understanding the potential impact of climate change on the quality of the water provided by Global Omnium. This initial step laid the foundation for aligning the research efforts with the company's needs in addressing climate-related challenges to water quality.

### *Knowledge-holders*

The service was jointly developed between the research team from the Universitat Politècnica de València and the managers from the water utility company Global Omnium.

### *Quality assessment*

- *Science based:* State-of-the-art model simulations (IMPRES e-hype (<https://energiforskmedia.blob.core.windows.net/media/23581/4-smhi-presenterar-pa-ga-ende-eu-projekt-impres.pdf>)) and other data were used as a basis for this study. Re-knowned scientists and institutions served as partners.
- *Transparent:* Due to the intensive co-design and co-production process, climate information used and methods applied were fully transparent to the users.

- *User focused:* The water utility company *Aguas de València* had a clear idea about their needs for water quality assessments and treatment methods changes in case of special drought events that might affect the water quality and probably put the delivery of water for the Valencia area at risk.
- *Collaborative:* The co-development process with the water utility company *Aguas de València* started from the beginning of the project. All relevant local experts were involved. User needs and mutual understanding were key for the development.
- *Timely and accessible:* The project delivered the needed climate service with which the water utility company could assess management plans for water deliveries in the Valencia area under different climate scenarios.
- *Sustainable:* The CS development during the project can be used to assess treatment plans changes in the future. The method is in principle applicable to other cases, nevertheless such a service is somehow individual and has to be developed and implemented according to the specific needs of the users.
- *Equitable:* n/a
- *Usability of the service (Fit-for-purpose):* The climate service developed within the project fulfilled the needs of the user.
- *Impact of the service:* The project provided science-based insights into the impacts of climate change on water quality in the Valencia area. This information was instrumental in proactively considering the future needs for water treatment under various climate scenarios, enabling more informed planning and decision-making to safeguard water resources.

**Summary / conclusions:**

The Valencia Water climate service is a case study developed in the framework of the INNOVA project. Major emphasis was on a user-focused co-development of a water management plan in the Valencia region. The project was successfully completed. It is a prototype service which was developed individually for this specific application. Thus, scalability and transferability for other applications are limited.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
Valencia water	Dark Green	Dark Green	Dark Green	Dark Green	Dark Green	Light Green	Grey	Dark Green	Dark Green

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## A2.2 CS through public funding (finished projects)

### 2.2.1 ADAPT TERrestrial systems

#### Overview

The aim of the ADAPTER (ADAPT TERrestrial systems) project (<https://adapter-projekt.org>) was to develop and provide innovative simulation-based information products for weather- and climate-resilient agriculture in Germany. This means that ADAPTER provided daily updated ("ground") weather and comprehensive long-term climate change information for agriculture and all interested parties as digital climate-data products and information free of charge.

In the area of measurements and forecasts, the focus was on the current state and development of the water balance, including groundwater. For optimized soil management, Forschungszentrum Jülich used forecast simulations with the hydrological numerical model ParFlow and the regional earth system model Terrestrial Systems Modelling Platform (TSMP) in conjunction with observation data.

For climate adaptation measures, the Climate Service Center Germany (GERICS) derived prototypical climate data products from a variety of observational data sources and for climate simulations the EURO-CORDEX database. The ADAPTER products were co-developed right from the start with key practice partners and users. The project ended in 2023.

#### Knowledge-holders

The service was jointly developed between research teams from the Forschungszentrum Jülich, Institut für Bio- und Geowissenschaften (IBG-3, Agrosphäre)) and Climate Service Center Germany (GERICS) and key practice partners from different agriculture-related agencies and organisations.

#### Quality assessment:

- *Science based:* The project was using state-of-the-art model simulations and an ensemble of climate projections. The work was carried out by well-established research institutions and scientists.
- *Transparent:* Comprehensive metadata and background about the data and methods used are available via the web portal.
- *User focused:* Agricultural actors contacted GERICS and asked for assistance in adapting to climate change. GERICS together with FZJ Jülich initiated a public funded project with involving agriculture-related agencies and organisations as praxis partners from the very start. The proposal was already co-developed.
- *Collaborative:* The products were developed in close interaction between providers and users. The co-production process encompasses interaction via multiple communication channels and

methods to ensure to meet user needs. In addition, an evaluation study including semi-structured interviews was conducted to find out by whom and for what the climate-data products are and will be used.

- *Timely and accessible:* The project developed a publicly accessible web-based information system.
- *Sustainable:* The knowledge transfer project received third party (public) funding through the Helmholtz Initiative and Network Fund. Funding was limited to the project duration, thus only prototypes could be developed and implemented. Usage of the service is free, thus, no revenue by users of the service. The project would need funding to maintain, update and improve the products. A commercialization of the product is regarded to be difficult as the market for the products is very limited. Individual farmers, even if they would be interested in the product, are reluctant to spend money as the potential economic profit is (if at all) very limited. Potential customers would be insurance and breeding companies (for agricultural plants).
- *Equitable:* The information provided by the climate service is publicly available via the web portal.
- *Usability of the service (Fit-for-purpose):* Although the co-production process was closely related to user needs, the final evaluation study showed that there were still deficiencies due to the complexity of the information. In particular, individual farmers indicated that the products are not interesting for them due to the long timescales and the lack of recommendations for actions. Agricultural agencies found the information suitable for educational purposes and to raise awareness for climate change.
- *Impact of the service:* The evaluation study including semi-structured interviews showed that the ADAPTER climate data products are now an integral part of the educational programme for farmers. The study has also contributed to raising awareness of climate change and the need to act.

### Summary/conclusions:

The climate service products developed within the ADAPTER project based on re-known scientific expertise, state-of-the-art and innovative methods and high-quality data. The climate-data products were developed in close cooperation with the user communities through an intensive co-production process. A final study about the usage and impact of the service showed that the service is less suitable for farmers and their daily business due to the complexity of the information and missing recommendations of actions. Agricultural agencies found the information suitable for educational purposes and to raise awareness for climate change. Plant breeders also found the ADAPTER climate data products useful. They have also expressed a strong interest in the raw data. Due to the lag of long-term funding, the service could not be continued beyond the lifetime of the project.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
ADAPTER	Dark Green					Medium Green	Light Green		

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.2.2 Blue Action - Arctic Impact on Weather and Climate: Winter Tourism in Finland

#### Brief description of the service

Blue-Action: Arctic Impact on Weather and Climate (<https://blue-action.eu>) was an EU-funded Horizon 2020 research project (2016-2021) investigating the effect of a changing Arctic on weather and climate and co-designing climate service prototypes for various fields within five case studies. The winter tourism case study was one of the five case studies conducted with real-life partners in different fields. The Blue-Action project involved over 120 experts from 40 organizations in 17 countries, pooling expertise to improve how to model and predict the impact of warming in the Arctic region.

Within Blue-Action the case study “Winter Tourism in Finland” focused on developing a decision support tool (DST) providing relevant predictions on snow-making conditions for ski resorts in Northern Finland to allow the optimization of snowmaking activities and preparation for the winter season. The climate service was co-designed in close collaboration with the ski resort Ruka. Ruka is a major Northern Finnish ski resort that welcomes around 400,000 skiers annually. It is in the business strategy of Ruka ski resort to be the most snow secure resort in Europe. A consistent snow base is a key resource for Ruka that has around 200 skiing days from early October to early May, and besides plentiful natural snowfall, it relies on machine-made and stored snow to ensure the slopes can be opened early. The project ended in 2021.

#### Knowledge-holders

The scientific partners for this study are the University of Lapland and Deutscher Wetterdienst (DWD) (data). Ruka ski resort was the pilot ski resort in the co-design process.

#### Quality assessment:

- *Science based:* The project used state-of-the-art model simulations. The work is carried out by renowned research institutions and scientists.
- *Transparent:* Methodology and model information used are well documented and available via publicly available documents (via web pages and Zenodo depository) by the project.

- *User focused:* The project was initiated through a public funded project from the climate research community but involving the ski resort in Finland as a partner and pilot resort. The co-design process was conducted in close collaboration with the experts in the pilot ski resort and answers to their knowledge needs. Thus, user needs and requirements were in a central role in the project.
- *Collaborative:* The products were developed in interaction between providers and users. This included mutual learning between researchers from different scientific disciplines and winter tourism industry specialists including snowmaking personnel, resort management, environmental management, and marketing. The co-design methods included workshops, modelling and analysis, and different recasting activities. Visual methods were used at the workshops for identifying the end-user's knowledge needs, snowmaking and snow management related practices and the time spans of decision-making. The team worked mostly online from several locations already before the COVID-19 pandemic and could only meet in person annually or bi-annually at workshops at the pilot resort or at project meetings. The test round took place during the COVID-19 pandemic, which forced the team to replace the evaluation workshops with telephone/online interviews.
- *Timely and accessible:* The project developed a publicly accessible web-based information system. The website with the climate service has not been actively updated with new data after the project. The project's reports and scientific presentations are publicly available via the Zenodo depository.
- *Sustainable:* The project received third party (public) funding through an EU-project (EU Horizon 2020). As there was no sustained funding available and the data provision ended along with the project funding, the DST has remained on the prototype level after the end of the project phase. The initial willingness-to-pay value of the service was estimated as rather low at the end of the project, but it is plausible that the perceived value of the service would increase significantly as more trust is built on the accuracy and relevance. This can only be reached after several years of testing the service besides the conventional information sources. The climate service has received a lot of interest from the research community that is knowledgeable in winter tourism business and its climate related challenges, and it is plausible that a business would provide enough revenue for a successful commercialization. The Blue-Action case study team is currently preparing to start a company based on their research. As a different aspect of sustainability, the climate service can support the ecological and economical sustainability of snowmaking as a climate adaptation measure, as it can help reduce energy and water consumption and hence costs and environmental impacts from snowmaking by better prediction on the timing of snowmaking. The 4-week forecast makes the climate service a DST for ski resort management.
- *Equitable:* Winter tourism industry is globally speaking amongst the first ones to suffer from the impacts of climate change such as the increasing unpredictability and weakening of snow

conditions. The SnowApp climate service can support winter tourism industry to adapt to climate change in a more sustainable way by reducing costs and emissions from snowmaking by a 4-week reliable forecast on snowmaking conditions.

- *Usability of the service (Fit-for-purpose):* The prototype has shown that the Decision Support Tool (DST) developed has potential to provide meaningful forecast for winter tourism in Northern Finland and hence support sustainable climate adaptation. The service can potentially be utilized globally, with adjustments to geography and company specific circumstances, potentially even to other snow-dependent industries. Skilful seasonal forecasts (4-weeks in advance) provide the sound basis for optimized snow management of a ski resort. Saving can be up to 30% of energy (and GHG emissions if fossil energy is still used at other end user resorts) required for snowmaking. Savings can also be made in terms of water usage, and potentially also in personnel costs, and additional income can be gained by marketing relying on the forecast. In addition, long-term skilful forecasts would provide a better basis for optimizing the timing of snow production and extending the skiing season. The success of the project critically depends on the quality of the forecasts. As there was no sustained funding available and data acquisition from the project partner ended at the end of the project, the DST has temporarily remained on the prototype level after the project.
- *Impact of the service:* The climate service can support the ecological and economical sustainability of snowmaking as a climate adaptation measure, as it can help reduce energy and water consumption and hence costs and environmental impacts from snowmaking by better prediction on the timing of snowmaking. The 4-week forecast makes the climate service a DST for ski resort management.

Saving can be up to 30% of energy (and GHG emissions if fossil energy is still used at other end user resorts) required for snowmaking. Savings can also be made in terms of water usage, and potentially also in personnel costs, and additional income can be gained by marketing relying on the forecast. In addition, long-term skilful forecasts would provide a better basis for optimizing the timing of snow production and extending the skiing season.

Reducing the environmental and economic cost of snowmaking can make snowmaking a more sustainable climate adaptation measure in ski resorts both in terms of economy and the environment.

### **Summary/conclusions:**

The climate service product for the winter tourism developed within the Blue-Action project is based on renowned scientific and snow management expertise, state-of-the-art and innovative co-design methods and reliable data. The product was developed in close cooperation with the user (ski resort in Finland) through an intensive co-production process. Due to the lack of long-term funding, the service could not be continued directly after the project phase, but the team is in the process of starting a company.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
Blue Action	Dark Green	Light Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green	Light Green

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.2.3 ClimApp

#### Brief description of the service

ClimApp (<https://www.lth.se/climapp>, Eggeling et al. (2022) and Kingma et al. (2021)) is an EU project funded by the European Research Area for Climate Services (ERA4CS) (2017-2021) and three participating countries: Sweden, Denmark and The Netherlands. The overall aim of this project is to develop an advanced mobile phone App that integrates weather forecast data into human heat balance models. The personalized App takes individual factors into account and predicts body responses, provides health risk warning and advice for individuals, public and private sectors, to support decision-making to cope with heat and cold stress when facing extreme weather events such as heat waves and cold spells.

#### Knowledge-holders

The service was developed by a consortium of Lund University, Sweden, University of Copenhagen, Denmark, Technical University of Denmark, Denmark and Vrije Universiteit Amsterdam, The Netherlands.

#### Quality assessment:

- *Science based:* The ClimApp was developed as part of an EU-funded project by an international consortium involving renowned scientists. The results of the studies were published in peer-reviewed journals. The integrated human heat balance models and thermal indices are based on international standards.
- *Transparent:* Methodology and Data used were published in scientific journals. The App code was available on GitHub. Comprehensive background information can also be accessed through the App.
- *User focused:* Users took part in the development and improvement of the app from the beginning. Feedback was used to continuously improve the product. The usability test and evaluation were published in a peer-reviewed journal.

- *Collaborative*: “By introducing the concept of ClimApp to stakeholders at the very beginning and receiving their feedback, the outline of what ClimApp could be took form. Throughout the development phase, the stakeholders were consulted and engaged to develop the climate service tool so that it was relevant and useful to their practices.” (Eggeling et al., 2022).
- *Timely and accessible*: The app development was finalised throughout the runtime of the project.
- *Sustainable*: The App is maintained partly by a continuation EU project (HIGH-Horizons) which builds upon ClimApp beyond the end of the project. User feedback was taken into account to improve the App.
- *Equitable*: The product is available free of charge for smartphones. The app works globally and is available in different 10 languages. However, some translations are incomplete or require improvements.
- *Usability of the service (Fit-for-purpose)*: The app provides useable and valuable information on heat and cold stress and advice on how to adapt to the weather conditions. By applying personalized data, additional individual recommendations to adapt can be provided. However, expert knowledge is required for some information on the customized level (e.g. WBGT, etc).
- *Impact of the service*: “Climapp has pushed research further in the direction of personalized thermal stress warning systems. The App has proved that the concept is relevant, and it also identified the issues of applying the concept. User engagement is critical and success of similar products like ClimApp relies on the feasibility to be seamlessly integrated into individual lifestyles and/or available weather services”. (Statement by J. Eggeling)

**Summary/conclusions:**

The ClimApp works globally and provides freely available and useable information about heat and cold impact. Due to additional parameters, even individual body responses and recommendations can be provided.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
Clim App	Dark Green	Light Green	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Light Green	Light Green

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.2.4 INDECIS

### *Brief description of the service*

INDECIS, “Integrated Approach for the Development across Europe of user-oriented climate indicators for GFCS ([Global Framework for Climate Services](http://www.indecis.eu/))” (<http://www.indecis.eu/>) high-priority sectors: agriculture, disaster risk reduction, energy, health, water and tourism”, constitutes a pan-European effort focused on the development and production of climate indices, specifically targeting the priority sectors of the GFCS plus tourism and their conversion into climate services by engaging stakeholders in their definition and communication. The main objective of the project is to develop historical high quality and dense climate networks across Europe based on long-perspective time series of different stations-based meteorological variables from which accurate and robust climate indices can be calculated to create user-oriented climate products and services.

### *Knowledge-holders*

In total 16 partners across Europe, coordinated by the Universitat Rovira i Virgili, Spain. Partner encompass National Weather Services and climate research institutes across Europe.

### *Quality assessment:*

- *Science based:* The online tool developed in INDECIS contains 125 sector-oriented climate indices applicable for different sectors based on historical data (<http://www.indecis.eu/data.php>) and future trends. The data was provided by national meteorological services and the tools were developed in an EU-funded project by an international consortium involving re-knowned scientists. The results of the study were published in peer-reviewed journals (<http://www.indecis.eu/publications.php>).
- *Transparent:* Methodology, data and application used were published in scientific journals. background information can also be accessed through the INDECIS web portal. Data can be obtained through a separate data portal (<http://www.indecis.eu/data.php>). In addition, INDECIS has created or supports different software suites for climate data quality control and homogenisation, indices calculation, datasets inter-comparison and climate indices visualization (<http://www.indecis.eu/software.php>).
- *User focused:* Within IDECIS 125 sector-oriented climate indices were developed.
- *Collaborative:* For the use case for the tourism sector (Font-Barnet et al., 2021) a comprehensive co-development process was applied.
- *Timely and accessible:* Information can be displayed through two online tools via public website: <https://indecis.csic.es> and <https://ectaci.csic.es/> (European Climatology and Trend Atlas of climate indices). Data is freely available through a separate data portal. Note, that for the climate service for tourism, the climate service was not implemented at all. The output was a code to download data and to calculate the co-created indicators.

- *Sustainable*: The tools are freely available but not maintained after the end of the project due to the limited project funding. The tourism case study has enrolled some potential applying the results to a practical example. Other projects like Impetus (<https://climate-impetus.eu/>), Life Ecodapt (<https://ecoadapt50.eu/es/>), Turlit-ods (<http://turlit.eu/>) have taken up the topic.
- *Equitable*: The products are available free of charge via web portals.
- *Usability of the service (Fit-for-purpose)*: Information about many climate indices of historical data (1950-2019) relevant for different sectors can be displayed through two online tools: <https://indecis.csic.es> and <https://ectaci.csic.es/> (European Climatology and Trend Atlas of climate indices). Data can be obtained through a separate data portal (<http://www.indecis.eu/data.php>). In addition, INDECIS has created or supports different software suites for climate data quality control and homogenisation, indices calculation, datasets inter-comparison and climate indices visualization (<http://www.indecis.eu/software.php>). The tourism case study has enrolled some potential applying the results to a practical example.
- *Impact of the service*: n/a

### Summary/conclusions:

The INDICES project developed a number of climate relevant sector-oriented climate indices applicable for different sectors based on historical data and future trends. The information is provided free of charge via web portals. The tools are freely available but not maintained after the end of the project due to the limited project funding.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
INDICES									

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.2.5 Vineyard Innovative Tools Based On the Integration of Earth Observation Services and In-Field Sensors (VitiGEOSS)

### *Brief description of the service*

ViteGEOSS (EU H2020 funded project, 2020-2024, 9 partners, <https://vitigeoss.eu/>) developed innovative vineyard management solutions, integrating and improving existing solutions coupling satellite imagery with in-field sensors to increase the resolution and reliability of satellite information applied to the viticulture sector and specific wine-business operations. The goal of VitiGEOSS was to contribute to a responsible production of wine, minimising the use of chemical fertilisers and pesticides and offering tools for a better management and optimisation of resources for greater sustainability. The project created the platform offering integrated services for sub-seasonal and seasonal predictions, crop management, disease warning, business operations and sustainability monitoring.

### *Knowledge Holders*

Multidisciplinary consortium was comprised of four research organisations (BSC, LINKS, The University of Naples Federico II, PwC), three wine producers (Familia Torres, Mastroberardino Società Agricola srl, and The Symingtons) and two technological companies (Eurecat, eLEAF) which provided the necessary range of expertise, competence and operational capacity to deliver the innovative project objectives.

### *Quality assessment*

- *Science based:* For development of the intelligent services, the project combined the Internet of Things, Earth Observation services (Basile et. al, 2023), sensors, mathematics, and Artificial Intelligence<sup>8</sup> (Otero et. al, 2022; Oldani et al., 2023, Otero et. al, 2023). The VitiGEOSS platform was deployed as a cloud-based applications portal. The results were published in the proceedings of international conferences and in peer reviewed papers<sup>9</sup>.
- *Transparent:* There was a need for balancing data sharing and privacy of sensitive information. In order to satisfy both aspects, transparency was ensured by publishing certain datasets, such as those from the in-field camera and drone services. For data that had to remain private, metadata was openly accessible and interested users were connected with data owners (VitiGEOSS D6.7, 2023b).
- *User focused:* The consortium followed user-centred design processes throughout the project duration, placing the end users at the centre of the platform design and development process.

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<sup>8</sup> <https://www.infowine.com/en/intelligent-services-for-smart-vineyard-management-released/>

<sup>9</sup> <https://vitigeoss.eu/scientific-production/>

Three wine producing companies based in different regions (Italy, Portugal and Spain) participated as partners and users. This allowed for their active and direct involvement and contribution to all the project activities and research (VitiGEOSS D6.7, 2023b).

- *Collaborative*: Throughout the VitiGEOSS project, besides co-design process with end users, partners have actively engaged and exchanged knowledge with the broader climate services and EO communities as well as other European projects. These allowed to obtain feedback to improve the services offered on the platform. Online survey for end-users and external stakeholders was conducted in order to collect their specific information requirements. Additionally, several activities, such as the local stakeholder sessions and participatory workshops, were organised to bridge the gap between science and sectoral knowledge (VitiGEOSS D6.7, 2023b).
- *Timely and accessible*: The main service product (platform) was created and applied. Access is limited to partners within the project as this is designed as a prototype service available to the project partners only.
- *Sustainable*: The platform is no longer active.
- *Equitable*: The commercialization of the VITIGEOSS Intelligent Service Platform was discussed, the commercialising players were identified, and the ownership was divided among the members of the VITIGEOSS Consortium (VitiGEOSS D5.2, 2023a). Decisions are not publicly available.

In the “General Terms and Conditions” of the platform (eLEAF, 2018), it is stated: “The price for the Products and/or Services supplied by eLEAF to Client will be the price specified by the Parties in the Agreement”

- *Usability of the service (Fit-for-purpose)*: In addition to the technical evaluations and performance assessments, end users’ feedback was incorporated into the evaluation process. While acknowledging the need for further improvements, particularly in areas like disease forecast, the overall sentiment was positive.

Evaluation was done for each service separately (VitiGEOSS D4.7, 2024):

- *Weather and climate forecasting services* - Stakeholders expressed willingness to continue using the service and gave suggestions for improvement: to be focused on enhancing prediction accuracy, providing tailored features such as frost alerts, and fostering continuous dialogue with users.
- *Phenology services* - While the data display proves beneficial, stakeholders expressed mixed sentiments regarding the presentation of results. Addressing accuracy concerns and fine-tuning the model under extreme conditions were highlighted as priority.
- *Deep drone service* - Users valued its optimal technical and scientific outcomes, demonstrating its efficacy in its ability to deliver accurate and detailed data, but the current cost constraints limit the frequency of flights per season.

- Key crop indicators tracking services - has garnered positive feedback for its usability and usefulness. Positive remarks were directed towards intuitive spatial data visualisation and efficient map layering, enhancing user experience and ease of use. However, challenges arise in validating the accuracy of visualised information, particularly regarding intra-parcel variability data.
- Disease forecast and management services – was regarded as an interesting and important tool for the management of their crops, but the performance of the service is lacking accuracy at its current state.
- Business and sustainability management - stakeholders appreciated the environmental insights provided by the service and recognize its potential to streamline operations, but continual improvement is needed, including automating data computation and simplifying usage.
- *Impact of the service:* During the project an R package<sup>10</sup> “CSIndicators” was developed (Pérez-Zanón et al, 2023). The package gathers generalised methods for the flexible computation of climate-related indicators which enables tailoring indicators to sectorial climate service applications. This package is intended for sub-seasonal, seasonal and decadal climate predictions, but its methods are also applicable to other time scales

*Summary / conclusions:*

The platform developed in the VitiGEOSS projects includes a wide set of co-developed services that can help winegrape growers in taking decisions about the most suitable vineyard management strategies (Basile et al, 2023). Consequently, this could help to mitigate the impacts of climate change on the productive and qualitative performances of the vineyard, while simultaneously optimising the use of resources and increasing the sustainability of viticultural practices. The feedback from end users underscores the optimism towards VitiGEOSS work, while acknowledging the need for further improvements (VitiGEOSS D4.7, 2024).

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
Viti-GEOSS									

*Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.*

<sup>10</sup> R packages are extensions to the R statistical programming language. R packages contain code, data, and documentation in a standardised collection format created to add specific functionality and can be installed by users of R.

## A2.3 Climate Services through public funding (Ongoing projects)

### 2.3.1 AGORA

#### Overview:

The EU-funded Adaptation AGORA (A Gathering place to co-design and co-create Adaptation, (<https://adaptationagora.eu>)) project aims to enhance collective resilience against climate change by establishing community-based adaptation practices in various social, economic and political contexts. To achieve this, it operates in selected pilot communities, promoting collaboration among citizens, social organizations, scholars, field experts, policymakers and entrepreneurs who are involved in co-design, co-development and implementation of solutions tailored to local needs. Outcomes include a set of digital tools and co-established frameworks, novel climate adaptation solutions, and prototypes for efficient cooperative and policymaking practices.

The Project has a budget of 3.7 Mio. €, runs from 2023-2025, and is coordinated by CMCC.

#### Knowledge-holders

The AGORA consortium, consisting of 11 partners, has a strong experience and competency in the fields of climate science, climate change, climate adaptation, co-creation and engagement, citizen science, communication, digital design and digital development.

#### Quality assessment

- *Science based:* The AGORA consortium comprises a number of re-knowned climate research institutions such as CMCC and BSC, jointly with experts from other disciplines.
- *Transparent:* Communication is a key asset in AGORA, all the activities involving local communities are designed and carried out together with local partners, being them institutions, associations, civil society organizations, academics, and are open to all potential interested participants. All project activities are well advertised before they take place and publicly reported through news on the AGORA website and/or case studies on the AGORA Community Hub, and/or posts on the project social media channels.
- *User-focused:* AGORA has 4 pilot regions which are the arena for the co-designing and the co-development and co-implementation of climate adaptation solutions. All activities are functional to support the needs of the local communities involved and local citizens, who are the main „users“ of the project.
- *Collaborative:* Citizens, civil society organizations, academics, experts, policymakers, entrepreneurs, and other relevant actors will be engaged in the co-design and co-creation of innovative and problem-oriented climate adaptation solutions that could be extensively adopted in Europe. The AGORA project takes into consideration the ongoing social changes the awareness that there is no “one size fits all” solution.

The Agora Community Hub is the living digital environment that enables stakeholders, scientists, experts, media and citizens to network and communicate, facilitating them to find peers and other communities from other geographical or societal contexts to share challenges and needs. By featuring individual and organization profiles that facilitate the identification of relevant peers and potential collaborators, the Agora Community Hub provides accessible information and knowledge for local government, municipal services, and communities.

- *Timely and accessible:* As the project is still ongoing (ending 2025), a final judgement cannot be made yet.
- *Sustainable:* A set of pilot regions constitute the co-production arena to co-design, co-develop and co-implement climate adaptation solutions. AGORA is also developing a roadmap for transformational change and upscale of citizen engagement, for transferability of effective policy instruments and for ensuring long term legacy. All digital tools developed under the project (2 digital academies, the AGORA community Hub, the mobile app, the handbook) are designed to last beyond the project duration, either being integrated in platforms owned and managed by project partners, either ensuring 5 years of maintenance of the tool.
- *Equitable:* Within the activities of citizen engagement, the project has been targeting many and different target audiences. For example, during the focus groups organized in each of the pilot areas, at least three categories of people were always involved: young/students, working population, migrants. This approach aims to include many different kind of citizens in the project, incorporating their point of view on climate change challenges and impacts and on the possible adaptation solutions, ensuring an inclusive perspective and effective solutions which are shared by large and different stakeholder groups. Given the great interest raised by the project, especially in some of the pilot areas, other target audiences were identified and involved with engaging activities, including youngsters, elderly people, and even prisoners.
- *Usability of the service (Fit-for-purpose):* The 4 pilot regions are the arena for the co-design and co-development of climate adaptation solutions, as such, all the activities organized within the pilot areas are fit for the purposed of those specific local communities but could also be of inspiration for other communities. This is the concept of “followers” within the project. Followers are other regions as well as associations, organizations and institutions that are involved in the process of adaptation to climate change can join AGORA as followers. This opportunity enlarges the AGORA community beyond the 4 pilot areas, involving a greater number of people and supporting the whole adaptation process in Europe. The followers can share with AGORA their specific needs and requests and benefit from the results of the project coming from the pilot areas. Moreover, the digital tools developed by the project are built leveraging on the experience of the pilot regions and at the same time constitute an output that the same local communities involved in the pilot areas and followers can use to improve their knowledge, to enhance networking opportunities and to define and implement local adaptation solutions.

- *Impact of the service:* The project is still under development and not all the products have been released yet. The first feedback on the products which are even partially available is very positive.

### Summary/Conclusions:

The AGORA project aims to enhance collective resilience against climate change by establishing community-based adaptation practices in various social, economic and political contexts. It focuses on the co-development of solution to adapt to climate change. A number of digital tools (digital academies, the AGORA community Hub, the mobile app, the handbook) will be developed and should be available for further application beyond the end of the project.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
AGORA									

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.3.2 City Packs

#### Brief description of the service

The City Packs (<https://www.metoffice.gov.uk/research/approach/collaboration/spf/ukcrp-outputs>) were a key output from the [UK Climate Resilience programme](#). Climate variability and change is becoming increasingly evident throughout society. The risks – including extreme heat, drought and flooding – are expected to increase over time as the planet continues to warm. People need to adapt their ways of life to become more resilient. As part of the Climate Services Pilots project, the Met Office have been working with stakeholders and end-users to develop and evaluate a number of pilot services to ensure their research is useful and useable.

The City Packs use the latest UK Climate Projections (UKCP) data to provide high-level, non-technical local summaries of a city’s future climate. They use graphics and tables to communicate scientific research in an accessible way, providing robust climate information to help city decision makers plan for the future, enabling cities to become more resilient to climate change.

#### Knowledge-holders

This service was developed by the Met Office as part of the UK Climate Resilience programme, a four-year Strategic Priorities Fund (SPF) interdisciplinary research programme led jointly by UK Research and Innovation (UKRI) and the Met Office, and under the direction of Co-Champions from the University of Leeds, the Met Office.

## Quality assessment

- *Science based:* The City Packs use the latest UK Climate Projections (UKCP) data to provide high-level, non-technical local summaries of a city's future climate. They use graphics and tables to communicate scientific research in an accessible way, providing robust climate information to help city decision makers plan for the future, enabling cities to become more resilient to climate change. The Met Office is a globally recognized leader in climate science, with decades of experience in weather and climate forecasting. The expertise behind the City Packs is well-established, giving users confidence in the scientific foundation of the data.
- *Transparent:* The City Packs include metadata that details the sources of the data, the methodologies used, and the assumptions made in generating the projections. They also communicate uncertainties and limitations clearly, which is crucial for informed decision-making. Users are made aware of the range of possible outcomes, helping them understand the confidence levels associated with different scenarios.
- *User focused:* The City Packs are specifically designed to meet the needs of urban planners, policymakers, and local authorities. By focusing on localized data, the packs ensure that the information is relevant and actionable for those tasked with managing urban environments.
- *Collaborative:* The Met Office engaged in continuous dialogue with users from the various cities to refine the city packs. Feedback mechanisms are in place to ensure that the City Packs evolve in response to user needs.
- *Timely and accessible:* The city packs are accessible through the Met Office's website and through the project website.
- *Sustainable:* While the City Packs are tailored to specific cities, the methodologies and approaches used can potentially be transferred to other regions, both within the UK and internationally, enhancing the scalability of the resource (adaptable and scalable).
- *Equitable:* The data products used (UKCP) are free of charge, as well as the City Packs themselves, and are available to all relevant stakeholders without financial barriers, promoting equitable access to crucial climate information.
- *Usability of the service (Fit-for-purpose):* The Met Office City Packs are designed with a strong focus on usability, ensuring that they are fit-for-purpose for urban planners, policymakers, and other stakeholders. The data provided is highly localised, meaning it is directly relevant to the specific climate risks faced by individual cities. Additionally, the City Packs are accompanied by guidance and support from the Met Office, further enhancing their usability and ensuring that the data can be integrated seamlessly into existing planning frameworks.
- *Impact of the service:* The City Packs provide high level, non-technical summaries of climate change projections for an individual city or town. It uses scientific research to provide robust

climate information to help decision makers plan for the future, enabling cities and towns to become more resilient to climate change.

### Summary/conclusions:

The City Packs provide high-level, non-technical local summaries of a city's future climate. They use graphics and tables to communicate scientific research in an accessible way, providing robust climate information to help city decision makers plan for the future, enabling cities to become more resilient to climate change. The data products used are free of charge, as well as the City Packs themselves. The methodologies and approaches used can potentially be transferred to other regions.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
City Packs									

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.3.3 CLIMAAX

#### Brief description of the service

CLIMAAX (CLIMAtE risk and vulnerability Assessment framework and toolbox, (<https://www.climaax.eu/>)) is a 4-year Horizon Europe project (2023-2026) that will provide financial, analytical, and practical support to improve regional climate and emergency risk management plans. CLIMAAX is designed to contribute to the harmonization and consolidation of the practice of climate risk assessment, leaving a legacy for upcoming European initiatives.

#### Knowledge Holders:

The CLIMAAX consortium has 19 partners, coordinated by Deltares and budget of about 20 Mio. €.

#### Quality assessment

- *Science based:* The project involves renowned scientific partners (e.g. Deltares, ECMWF, CMCC and others) using state-of-the-art data and methodologies. A toolbox with data, models and utilities to provide access to European and global open data archives integrated with local data and procedures and a standardized climate risk assessment (CRA) framework which builds on current community experience and best practices will be developed.

- *Transparent:* In the CLIMAAX CRA Handbook (<https://handbook.climaax.eu/intro.html>) which is currently established comprehensive information about the approach, data, etc. is provided. D2.2 ([https://www.climaax.eu/wp-content/uploads/2024/07/CLIMAAX\\_D2.2.pdf](https://www.climaax.eu/wp-content/uploads/2024/07/CLIMAAX_D2.2.pdf)) provides detailed information about the datasets used for risk assessments in CLIMAAX. CRA risk workflow scripts can be downloaded from the CLIMAAX github: <https://github.com/CLIMAAX>
- *User-focused:* The Framework and handbook (CRA workflows) have been designed with the 5 pilot regions in the project. In the coming years about ~60 regions are funded to test the service and run a CRA<sup>11</sup>. Their feedback will be collected through questionnaires, live meetings and the helpdesk. This will be used for further improvement of the CS.
- *Collaborative:* CLIMAAX project will provide financial, analytical and practical support to regional authorities, communities and civil protection agencies in at least 50 regions. Up to 300,000 Euros funding per project are available for participating regions.
- *Timely and accessible:* As the project is still ongoing (ending 2026), a final judgement cannot be made yet.
- *Sustainable:* CRA guidance material and online helpdesk for other European regions. A proposal to upscale results into the future operationalization of the regional CRA support function will be delivered.
- *Equitable:* In the CLIMAAX handbook documentation, principles for a comprehensive approach to climate risk assessment that is fair, robust and prudent are established ([https://handbook.climaax.eu/CRA\\_steps/beforeyoustart/principles.html](https://handbook.climaax.eu/CRA_steps/beforeyoustart/principles.html))
- *Usability of the service (Fit-for-purpose):* As the project is still ongoing (ending 2026), a final judgement cannot be made yet.
- *Impact of the service:* As the project is still ongoing (ending 2026), a final judgement cannot be made yet.

### Summary/Conclusions:

CLIMAAX will provide financial, analytical, and practical support to improve regional climate and emergency risk management plans. A toolbox with data, models and utilities to provide access to European and global open data archives integrated with local data and procedures and a standardized climate risk assessment (CRA) framework which builds on current community experience and best practices will be developed. CLIMAAX project will provide financial, analytical and practical support to regional authorities, communities and civil protection agencies in at least 50 regions to apply CRA workflows.

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<sup>11</sup> In the first round of funding, 32 European regions from 13 countries, have been selected to perform a regional Climate Risk Assessment (<https://www.climaax.eu/results-of-the-first-open-call/>).

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
CLI-MAAX	Dark Green				Grey	Medium Green	Grey		

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.3.4 PROVIDE

Overview:

Overshooting temperature threshold targets included in the Paris Agreement is a hot issue. The impacts of such overshoot scenarios would be particularly consequential for vulnerable regions and systems where thresholds of abrupt and possibly irreversible shifts or adaptation limits may be exceeded. The EU-funded PROVIDE (Paris Agreement Overshooting – Reversibility, Climate Impacts and Adaptation Needs, (<https://www.provide-h2020.eu>)) project will develop innovative, integrative climate services that incorporate information on impacts of overshoot pathways from the global to the regional and urban level, directly feeding into adaptation action. Bringing together a consortium of leading climate scientists, as well as climate services purveyors, urban planners and adaptation experts, the project will identify overshoot adaptation needs and develop a generalisation methodology for adaptation strategies to respond to overshoot risks. The project runs over a 3-year period from 2021-2024

*Knowledge-holders*

The project, coordinated by the Humboldt Universität Berlin, has 17 partners, comprising renowned scientific institutions such as ETH, CICERO, FU Berlin, UEA, etc. (<https://www.provide-h2020.eu/about/>).

*Quality assessment*

- *Science-based:* The research consortium of the project ensures state-of-the-art data and research methods applied in the development of this climate service. The idea is to develop the adaptation plans for 4 regions: Bodø (Arctic), Lisbon Metropolitan Area (Iberian / Mediterranean), Islamabad (Indus Basin) and Nassau (Caribbean small islands).
- *Transparent:* Datasets and tools used are fully documented and available via the PROVIDE website (<https://www.provide-h2020.eu/tools-data/>)
- *User-focused:* PROVIDE has engaged with a set of regional and high-level EU stakeholders in multiple meetings throughout project duration, allowing for feedback on its development

throughout its life cycle. Wider events like EU policy workshops, COP29 side events, and Climate risk dashboard update launches have allowed further opportunities for comments and feedback. Additionally, informal interviews and conversations with climate services experts before the Climate risk dashboard's proof-of-concept and semi-structured interviews with adaptation experts before the final concept of the Climate risk dashboard's "Avoid impacts" mode informed decisions. Regional partners repeatedly gave feedback on conceptualisations where the timeframe for a decision was too short to organise external stakeholder feedback but select priority stakeholders were invited to give feedback before the beta launch.

- *Collaborative*: The PROVIDE Climate Services Dashboard (<https://climate-risk-dashboard.climateanalytics.org>) is being co-developed jointly with practitioners, scientists, litigation experts, business, civil society and other potential users. The collaboration between potential users of climate impact information, researchers and providers of climate services should be advanced to develop stakeholder-oriented climate science and a community around overshoot issues in adaptation planning. In the four regions (see above) adaptation needs were identified and prioritised.
- *Timely and accessible*: The draft dashboard (<https://climate-risk-dashboard.climateanalytics.org>) is already available prior to the end of the project. As the project is still ongoing, a final judgement cannot be made yet.
- *Sustainable*: The Climate risk dashboard will remain available after the end of the PROVIDE research project. This will be supported by joint ownership between Climate Analytics GmbH, the developer of the tool, and International Institute for Applied Systems Analysis (IIASA). Climate Analytics has given support to similar tools in the form of inquiry responses and offering API queries. IIASA's involvement increases support of the tool, as it is custom for such tools to receive support for several years after completion. The consortium separately seeks opportunities for horizontal (toward new users and new uses) as well as vertical (toward new functionalities) upscaling in the final months of PROVIDE, with the help of its end dissemination and capacity building.
- *Equitable*: PROVIDE includes case studies in four diverse global regions, the Bahamas, Norway, Portugal, and Pakistan. The PROVIDE Climate risk dashboard offers global coverage, including high-resolution urban data across all continents (except Antarctica). The Climate risk dashboard is open source, while also offering applicable guidance as to its use. The project has had multiple online webinars in order to promote the tool to an international audience.
- *Usability of the service (Fit-for-purpose)*: The Climate risk dashboard has already been used as a data source in further academic studies which can inform local adaptation efforts and prioritisation. The tool has therefore proven use for potential partnerships between academia and local government. PROVIDE offers clear visualisations and guidance to inform policy makers. The service may need further translation for its services to be taken up by non-academic ad-

aptation professionals directly. Specific stakeholder groups have noted the Climate risk dashboard's usability as a demonstration of evidence for the impact of early mitigation in terms of climate overshoot, and as an easy-to-use indication of scientific progress on the topic of climate overshoot.

- *Impact of the service:* Application of PROVIDE results has informed plans for end of project dissemination and identification of where added support could be useful, to promote uptake of project results. Applications also have made clear the value of local studies to particular peak temperatures.

### Summary/Conclusions

The Climate risk dashboard offers projections into the impacts of overshoot and non-overshoot scenarios, with global coverage. In addition to national aggregation, it includes higher-resolution projections for 140 global urban areas. Case study storylines offer example uses of the dashboard's information for adaptation consideration. Key concept definitions, clear definitions of indicators, and guidance for selection of scenarios aim to offer intuitive guidance for a range of users.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
PROVIDE	Dark Green				Grey	Medium Green		Grey	

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.3.5 REACHOUT

*Brief description of the service*

[REACHOUT](#) is an EU-funded research and innovation project under Horizon 2020 working to advance user-oriented climate services to support the implementation of the Green Deal. Therefore, research partners, climate service providers and city stakeholders are co-developing a coherent set of services for seven city hubs across the EU. These services support cities to **Analyze** hazard, exposure and vulnerability to climate change, formulate **Ambitions** for Climate Resilient Urban Development and define respective adaptation measures to reach these ambitions, and to decide on short, medium, and long-term **Actions** to initiate the implementation, as well as the monitoring and evaluation. This so-called "Triple-A toolkit" builds upon and utilizes existing tools and services. Already from the start of the project co-operations with existing climate service platforms and development business models for implementation of the services were initiated to ensure sustainability beyond the lifetime of the project (ending mid-2025).

## Knowledge-holders

The consortium of REACHOUT is co-led by Deltares and CAS (Climate Adaptation Services) and comprises 10 partners. On the user side, stakeholders in the seven city hubs (Amsterdam, Athens, Cork, Gdynia, Lillestrøm, Logroño, Milano) are involved.

## Quality assessment

- *Science-based*: The research consortium comprises 10 partners including renowned scientific institutions. The co-created tools and climate services are rooted in scientific research. Results are published in peer-reviewed scientific journals.
- *Transparent*: The tools used in this project are well-documented and training modules are being developed. A large share of the tools are open access.
- *User-focused*: The tools and climate services are co-created together with the stakeholders of the 7 city Hubs, tailored to their specific needs. City staff, full partners in the project, contribute local insights on climate service requirements, initiatives, and networks. Each city has a liaison, a project partner that is located in the same region, who serves as a crucial link, overseeing the execution of co-creation activities and supporting coordination with tool & service developers. More information: [https://reachout-cities.eu/wp-content/uploads/2024/07/bo\\_policybrief-nr2-Reachout-v5.pdf](https://reachout-cities.eu/wp-content/uploads/2024/07/bo_policybrief-nr2-Reachout-v5.pdf)
- *Collaborative*: Climate service providers and city stakeholders are co-developing a coherent set of services for seven city hubs across the EU. Tools (<https://reachout-cities.eu/tools/>) and training modules are developed collaboratively between scientists and practitioners of the partner cities. There are specific sessions, so-called city lounges, organized to facilitate exchange between the different cities, sharing knowledge, challenges and best practices about adaptation planning in the cities throughout Europe.
- *Timely and accessible*: Up to now the project has delivered in a timely fashion. As the project is still ongoing (until 2025), a final judgement cannot be made yet.
- *Sustainable*: Contextualized city hubs narratives, so-called Climate Stories, that highlight the benefits of using climate services in the different cities are developed for the city hubs (<https://reachout-cities.eu/climate-stories/>). Demonstrators are underway which showcase the tools, their applicability and their outcomes, to inspire other EU cities to also use the climate services and tools of the REACHOUT project.
- *Equitable*: The REACHOUT project aims to bridge the gap between scientists and society with climate stories. The scientific outcomes of the REACHOUT project are translated into stories using the innovative communication method of storytelling (<https://reachout-cities.eu/climate-stories/>). Climate stories combine a narrative structure with visualizations to communicate scientific knowledge to an audience to get a message across. Furthermore, the Social-Vulnerability-Index Tool specifically identifies areas with high social vulnerability in the city

hubs. This tool has been applied in multiple cities, to incorporate vulnerability and equity aspects into adaptation planning.

- *Usability of the service (Fit-for-purpose):* The extensive REACHOUT co-creation process is ensuring that tools and services are fit-for-purpose. Outcomes of the tools have been used by the municipalities in multiple ways, e.g. identifying suitable measures and drafting adaptation plans. As an example, the heatmaps of the Thermal Assessment Tool, as well as the Social Vulnerability Index (SVI) Maps of the SVI-Tool are featured in the latest Urban Heat Plan of the city of Logrono (Spain) and serve as the backbone for planning adaptation measures in the city.
- *Impact of the service:* The project is still on-going, so longer-term impacts are challenging to assess at this stage. Nevertheless, as mentioned previously the outcomes of tools and services are directly used for adaptation planning and plans. Several tools are currently being considered for longer-term adoption by the municipalities. Through the final stage of the project, partners are also collating learnings and recommendations for urban climate adaptation with the hope of supporting further work in this sphere. Reflections are geared towards both service producers and users, including topics such as service development, usability & implementation; CS markets and business models; co-creation processes; communication via *storytelling*; and *further knowledge and implementation gaps in urban climate services*.

### Summary/Conclusions:

REACHOUT aims to advance user-oriented climate services to support the implementation of the Green Deal. These services will support cities to *Analyze* hazard, exposure and vulnerability to climate change, formulate *Ambitions* for Climate Resilient Urban Development, and identify, evaluate and select adaptation *Actions* or implementations. This so-called Triple-A toolkit builds upon and utilizes existing tools and services. The tools and climate services are co-created together with the stakeholders of the 7 city Hubs, tailored to their specific needs.

CS	Science based	Transparent	User focused	Collaborative	Timely & accessible	Sustainable	Equitable	Usability	Impact
REACHOUT	Dark Green	Dark Green	Dark Green	Dark Green	Grey	Light Green	Dark Green	Dark Green	Grey

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## A2.4 Private CS

### 2.4.1 CLIMANOMICS®

#### *Brief description of the service*

S&P Global Climanomics® (<https://www.spglobal.com/esg/solutions/climanomics>) puts a price on the impact of physical climate risk using standardised so-called “one-click scenario analysis”. The commercial climate scenario analysis from S&P Global provides actionable insights about potential future outcomes and is recommended by the TCFD for reporting purposes. A set of scenarios, Shared Socioeconomic Pathways (SSPs), focuses on projecting socioeconomic changes and when used alongside the RCPs capture both physical and socioeconomic factors. The company uses mainly publicly available data e.g., from NASA, NOAA, and IPCC in their scenarios. Customers can pick out of about 300 different asset types to estimate financial risks due to climate change based on different RCP scenarios and decadal projection periods until the 2090s.

#### *Knowledge-holders*

S&P Global is a globally operating company developing (amongst other branches) solutions on climate risk assessment for the financial sector.

#### *Quality assessment*

- *Science-based:* S&P Global Climanomics® uses a standardized software tool based on Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathway (RCPs) for financial risk assessment for the financial sector. The product is based on about 300 different asset types, the user can select and adopt and interpret for their purposes.
- *Transparent:* Full details of the data and methodology applied are available under [https://portal.s1.spglobal.com/survey/documents/SPG\\_S1\\_Climanomics\\_Methodology.pdf](https://portal.s1.spglobal.com/survey/documents/SPG_S1_Climanomics_Methodology.pdf)
- *User focused:* As the demand for e.g. actionable financial impact analysis, sustainable reporting or energy transition is increasing, S&P Global Climanomics® develops solutions that fulfil user needs. In this sense, the development of CS products of S&P is user focused.
- *Collaborative:* S&P Global Climanomics® is trying to provide their customers solutions which are efficient and easily applicable to climate risk assessment of their assets.
- *Timely and accessible:* As customers have to pay for the service a timely delivery of the products is indispensable. Customers have access to the products they pay for.
- *Sustainable:* The increasing demand for climate risks assessments and the TCFD framework provides potential to sustain and expand the S&P Global Climanomics® service. The number of assets of the standardized product is continuously increasing.

- *Equitable*: Applying climate risk assessments can contribute towards an equitable transition to a low-carbon economy.
- *Usability of the service* (Fit-for-purpose): The provider mentioned three case studies to document the usability & impact of the Climanomics® products:
  1. A Pension Fund Enhances Its Analysis of Climate-related Physical Risks (<https://www.spglobal.com/esg/case-studies/a-pension-fund-enhances-its-analysis-of-climate-related-physical-risks>)
  2. A Global Cement Producer Takes Steps to Better Understand and Mitigate Climate-related Risks (<https://www.spglobal.com/esg/case-studies/a-global-cement-producer-takes-steps-to-better-understand-and-mitigate-climate-related-risks>)
  3. A Global Conglomerate Focuses on Sustainable Procurement (<https://www.spglobal.com/esg/case-studies/a-global-conglomerate-focuses-on-sustainable-procurement>)
- *Impact of the service*: see also examples referred in the previous section

### Summary/conclusions:

The Climanomics® product provide decision support for climate risk of financial related assets. S&P Global Climanomics® offers a growing library of proprietary impact functions that model the vulnerability of about 300 different asset types to climate-related hazards, based on a wide range of factors specific to each one. Assessments of hazards and of vulnerabilities can be considered for each asset to estimate the average annual loss associated with climate risk to provide an informative evaluation of exposure. This can be disaggregated by type of hazard and, within each hazard, by type of expense. The loss data is provided for each decade out to 2090 under the four standard IPCC/RCP scenarios. S&P Global Climanomics® is trying to provide their customers solutions which are efficient and easily applicable to climate risk assessment of their assets.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
Clima-nomics	Dark Green	Dark Green	Dark Green	Light Green	Light Green	Dark Green	Light Green	Grey	Grey

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.4.2 FATHOM - Climate risk / flood management

### *Brief description of the service*

Fathom (<https://www.fathom.global>) is an SME founded in 2013 as a start-up of scientists from the University of Bristol. The aim of the company was to create a data-driven, research-led enterprise, providing transparent world-leading methods of understanding water risk. Today, the company works with a variety of users from small organizations to government agencies to multinational corporations, across industries including humanitarian aid, insurance, international development, engineering, conservation, and financial markets. As of December 2023, Fathom is a subsidiary of Swiss Re. Fathom's products are designed to support customers to understand flood risks both now and in the future. Products encompass global flood maps, catastrophe modelling and terrain data.

### *Knowledge-holders*

Scientific expertise at Fathom encompasses climate scientists, coastal, hydrological and catastrophe modellers and software engineers. In addition, Fathom has several scientific partners such as University of Bristol, NASA, MetOffice, GfZ, NCAR etc.

### *Quality assessment:*

- *Science-based:* Fathom uses state of the art hydrological models and global flood hazard data, incorporating the latest scientific advancements to predict flood risks accurately. Quality assurance is ensured as the methods and data are validated through peer-reviewed publications, ensuring credibility and reliability. Fathom's science has been critically tested and refined through academic peer-review over the past 15 years and published in world-leading scientific journals. Fathom's team comprises experts from leading institutions, such as Bristol University, and the University of California, and work with a wide range of world leading research institutes and organisations, demonstrating extensive knowledge and experience in flood risk modelling.
- *Transparent:* Detailed metadata is provided for all datasets, ensuring users understand the origins and context of the data. Fathom openly communicates the uncertainties and limitations of their models, helping users make informed decisions. The information is presented in a clear and accessible manner, making it easy for non-experts to understand. Additionally, Fathom provides examples and case studies of how their data has been used in various sectors and regions, demonstrating the value and impact of their services.
- *User-focused:* Fathom engages with users to understand their specific requirements, tailoring their services to meet these needs. The services are designed to be practical and applicable to real-world flood risk management scenarios, ensuring relevance and utility. Fathom also provides evidence and guidance through insights and case studies on how to use their services effectively, demonstrating fit for purpose and value for money.

- *Collaborative*: Through close collaboration with partners and users e.g. Nature Conservancy, and The World Bank, Fathom fosters a mutual understanding between users and providers. This cooperative approach helps for example in generating immediate reports that support disaster relief efforts for extreme flooding incidents around the world.
- *Timely and accessible*: Fathom ensures that their data and models are updated regularly to deliver the latest information to users. Although select premium services require payment, Fathom extends a variety of resources that are available at no cost, assuring widespread access.
- *Sustainable*: Fathom secures funding through a mix of public and private sources, ensuring the long-term viability of their services. The models are designed to be adaptable and scalable, allowing for continuous usage and updates. Fathom's methods and data can be applied globally, demonstrating their scalability and transferability to different contexts.
- *Equitable*: Fathom offers essential flood risk data openly, ensuring fair access to important information. The data and information are delivered in a clear format and in a variety of ways e.g. interactive platform (portal), high-resolution data sets, podcasts, videos etc, making it easily comprehensible for diverse user groups and enhancing its practical applicability.
- *Usability of the service (Fit-for-purpose)*: The outputs can be precisely tailored, enabling users to create flood maps for any combination of future year and climate scenario. This adaptability makes them useful across various geographic scales and sectors, enhancing their relevance for decision-making, risk assessment, and policy planning in flood risk management.
- *Impact of the service*: Fathom works with NGOs, governments, and organizations worldwide to boost flood risk awareness, management, and mitigation efforts in response to both current and future climate change. By revolutionizing decision-making processes, Fathom helps protect crucial infrastructure valued at over \$1 trillion across the globe. It has been nominated and has made it as a finalist in the NERC 2023 Impact Awards (<https://www.ukri.org/news/announcing-the-nerc-impact-awards-2023-winners/>).

#### Summary/conclusions:

Fathom demonstrates how a high-quality climate service can effectively address the multifaceted challenges of flood risk management and support informed decision-making across various sectors. Fathom uses state of the art hydrological models and global flood hazard data, incorporating the latest scientific advancements to predict flood risks accurately. Fathom engages with users to understand their specific requirements, tailoring their services to meet these needs. The services are designed to be practical and applicable to real-world flood risk management scenarios, ensuring relevance and utility.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
Fathom	Dark Green			Medium Green					

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

### 2.4.3 Future Drainage

#### Brief description of the service

FUTURE-DRAINAGE is a Newcastle University led consortium involving the Met Office, JBA Consulting and Loughborough University, funded by the NERC (UKRI) UK Climate Resilience Programme. JBA consulting have provided guidance ([https://artefacts.ceda.ac.uk/badc\\_datadocs/future-drainage/FUTURE\\_DRAINAGE\\_Guidance\\_for\\_applying\\_rainfall\\_uplifts.pdf](https://artefacts.ceda.ac.uk/badc_datadocs/future-drainage/FUTURE_DRAINAGE_Guidance_for_applying_rainfall_uplifts.pdf)) for the water industry and flood risk community on how to apply rainfall intensity change estimates derived from the Met Office 2.2km UKCP18 climate model and use the information in its surface water models to assess changes in flood impact (<https://www.jbaconsulting.com/projects/climate-change-guidance-and-resilience-research/>).

#### Knowledge-holders

FUTURE-DRAINAGE is a Newcastle University led consortium involving the Met Office, JBA Consulting and Loughborough University, funded by the NERC (UKRI) UK Climate Resilience.

#### Programme Quality assessment:

- *Science based:* JBA Consulting uses the latest climate models, tools, and methodologies to provide robust climate change guidance. The use of state-of-the-art data from sources such as the UK Climate Resilience Programme and collaborations with institutions like the Met Office ensures that the project uses cutting-edge, scientifically rigorous information. The project used the most up to date UKCP high resolution 2.2km data (UKCP Local) to derive more robust rainfall uplift estimates for the high greenhouse gas emissions scenario RCP8.5 (Chan et al., 2023).
- *Transparent:* The project clearly outlines uncertainties and limitations inherent in climate modelling, making it easier for users to understand the scope and reliability of the information. JBA have even written a blog for non-technical audiences about uncertainty.
- *User focused:* The project places a strong emphasis on user needs, offering climate change guidance specifically tailored for the water sector. The goal is to provide practical, actionable insights that stakeholders can use to develop climate resilience. This approach ensures that the

tools and methodologies are designed with end-users in mind, addressing real-world issues. The guidance (Dale, 2021) is intended to be user-friendly and results from close consultation with users, such as incorporating aspects such as aligning outputs with the time horizons needed for Drainage and Wastewater Management Plans (DWMPs).

- *Collaborative*: The FUTURE-DRAINAGE team co-designed and co-developed the climate service with its users. Consultations with stakeholder groups (users and providers) throughout the project duration to make outputs as practical and useful as possible, while maximising cutting-edge science from the Met Office and other climate service and information providers.
- *Timely and accessible*: The project details and data information are contained in an open-access guidance report and peer-reviewed papers, which offers comprehensive insights into the project, the service's development, and the data utilised ([https://artefacts.ceda.ac.uk/badc\\_data-docs/future-drainage/FUTURE\\_DRAINAGE\\_Guidance\\_for\\_applying\\_rainfall\\_uplifts.pdf](https://artefacts.ceda.ac.uk/badc_data-docs/future-drainage/FUTURE_DRAINAGE_Guidance_for_applying_rainfall_uplifts.pdf)).
- *Sustainable*: The project's methods are scalable and transferrable, adaptable to other regions. Though initially for a UK audience, these approaches can apply anywhere with relevant high-resolution climate data, such as UKCP Local (Kendon et al., 2021).
- *Equitable*: While the project is designed for specific stakeholders, JBA's findings (via the guidance report) have been shared with wider industry partners and is available online, promoting open access to critical information. The language used is understandable for technical and non-technical audiences alike.
- *Service Usability (Fit-for-purpose)*: The FUTURE-DRAINAGE project is tailored to meet the needs of industries in drainage, flood management, and water utilities.
- *Impact of the service*: The FUTURE-DRAINAGE project significantly changes how authorities and planners manage drainage and flood risks. It enhances flood prediction accuracy, guiding infrastructure adaptations to handle climate change's impact on rainfall. The data informs long-term planning, helping municipalities upgrade drainage systems, lower urban flooding risks, and boost community resilience.

#### Summary/conclusions:

FUTURE-DRAINAGE is a UK Climate Resilience Programme project designed to turn the latest CPM climate change projections into specific climate services for the water industry and flood risk management. This initiative is essential for ensuring that communities benefit from the latest climate models and creating a climate-resilient society (Chan et al., 2023).

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
Future Drainage	Dark Green				Light Green				

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.

## 2.4.4 Repath - Climate risk management

### Brief description of the service

Management of climate risks will be one of the most important challenges as a consequence of climate change. As more than 60% of companies are already suffering financial losses due to climate risks which will substantially increase in the coming years and decades even if emissions decrease rapidly. Nevertheless, many forward-looking decisions still do not consider climate risks. In addition, mandatory climate risk reporting obligations are emerging globally.

The repath GmbH (<https://repath.earth/>) is a German start-up that provides B2B solutions for climate risk management in particular for energy providers. The core of the service is a software product which empowers businesses to identify, understand and effectively manage global climate risks. The company which was co-founded by former scientists from the Climate Service Center Germany (GERICS) uses publicly available high-resolution model results (max. 12x12 km) from CORDEX climate change projections (RCPs 2.6, 4.5, 8.5). Repath solutions uses 13 climate indices, categorized into temperature-related hazards, wind-related hazards, and water-related hazards.

### Knowledge-holders

Repath is a German start-up of climate scientists and software developers that provide solutions for climate risk management based on publicly available data and a customized software product.

### Quality assessment

- *Science-based*: Repath uses the latest multi-model ensemble, based on the latest Regional Climate Models (RCMs) simulations developed under the Coordinated Regional Climate Downscaling Experiment Framework (CORDEX). Repath's data comes from over 400 regional climate simulations from prestigious climate research centers worldwide. This approach assures robustness in results and a better understanding of the uncertainty coming from the simulations, contributing to the local climate information generated. The grid resolution is the highest available in the market, with 12 km x 12 km in Europe and 25 km x 25 km everywhere

else. Co-founders (Julius Pröll and Thomas Remke) are part of the Center for Earth System Research and Sustainability (CEN) at the University of Hamburg.

- *Transparent:* Repath provides detailed analysis on customers individual climate risks. The platform enables access to intelligent indicators (for heat, heavy rain etc.), ensemble statistics and dashboards for customized and interactive climate risk analysis.
- *User focused:* Repath has a customer centric approach. They work with customers in order to provide them with the context and clarity to understand the concrete changes to their locations.
- *Collaborative:* Repath cooperates with more than 15 international research institutions for the most accurate and always up-to-date regional climate models.
- *Timely and accessible:* Repath's services are designed to be both timely and accessible. The platform provides real-time data and automated adaptation recommendations, ensuring that organisations can quickly respond to emerging climate risks. As a SaaS<sup>12</sup> solution, Repath's platform is accessible from anywhere with an internet connection. This makes it easy for users to access the information they need without significant barriers.
- *Sustainable:* Repath constantly works on new climate indices to expand understanding of the changing environment with the goal to have the best solution in the market. As a startup company, they can secure funding through venture capital, grants and subsidies, partnerships and revenue from services. They received EXIST stipend<sup>13</sup> and were based for one year in the group Climate Modeling of the Institute of Oceanography.
- *Equitable:* Repath's platform is available on market and anyone interested in the product can request a demo and buy the right to use the software as a service. Due to focus on automation and user-friendly design, the services are both efficient and easy to use.
- *Usability of the service (Fit-for-purpose):* Repath provides a list of renowned customers for reference on their website.
- *Impact of the service:* n/a

### Summary/Conclusions:

The repath GmbH provides B2B solutions for climate risk management in particular for energy providers. The core of the service is a software product which empowers businesses to identify, understand

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<sup>12</sup> Software as a Service

<sup>13</sup> <https://www.exist.de/EXIST/Navigation/EN/Start-upFunding/EXIST-Business-Start-up-Grant/exist-business-start-up-grant.html>

and effectively manage global climate risks. Repath uses the latest multi-model ensemble, based on the latest Regional Climate Models (RCMs) simulations developed under the Coordinated Regional Climate Downscaling Experiment Framework (CORDEX). The web-based platform enables customers to access to intelligent indicators (for heat, heavy rain etc.), ensemble statistics and dashboards for customized and interactive climate risk analysis.

CS	Science based	Trans-parent	User focused	Collab-orative	Timely & accessible	Sustaina-ble	Equi-table	Usa-bility	Im-pact
repath	Dark Green	Light Green	Medium Green	Light Green	Medium Green	Medium Green	Light Green	Light Green	Grey

Colour coding: dark green: very good, medium green: good, light green: average, yellow: acceptable, red: poor; grey: no rating possible.