D5.1 Exploitation Requirements and Innovation Design v1

WP5 - Exploitation and Business

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Figure 1: CLARITY Disclamer

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CLARITY Project Overview

Urban areas and traffic infrastructures that are linking such areas are highly vulnerable to climate change. Smart use of existing climate intelligence can increase urban resilience and generate benefits for businesses and society at large. Based on the results of FP7 climate change, future internet and crisis preparedness projects (SUDPLAN, ENVIROFI, CRISMA) with an average TRL of 4-5 and following an agile and user-centred design process, end-users, purveyors and providers of climate intelligence will co-create an integrated Climate Services Information System (CSIS) to integrate resilience into urban infrastructure.

As a result, CLARITY will provide an operational eco-system of cloud-based climate services to calculate and present the expected effects of CC-induced and -amplified hazards at the level of risk, vulnerability and impact functions. CLARITY will offer what-if decision support functions to investigate the effects of adaptation measures and risk reduction options in the specific project context and allow the comparison of alternative strategies. Four demonstration cases will showcase CLARITY climate services in different climatic, regional, infrastructure and hazard contexts in Italy, Sweden, Austria and Spain; focusing on the planning and implementation of urban infrastructure development projects.

CLARITY will provide the practical means to include the effects of CC hazards and possible adaptation and risk management strategies into planning and implementation of such projects, focusing on increasing CC resilience. Decision makers involved in these projects will be empowered to perform climate proof and adaptive planning of adaptation and risk reduction options.

Abbreviations and Glossary

A common glossary of terms for all CLARITY deliverables, as well as a list of abbreviations, can be found in the public document “CLARITY Glossary” available at CLARITY-H2020.eu.

Executive Summary

This report is the first deliverable of Task 5.1 “Exploitation Requirements” of the CLARITY project, funded by the EU’s Horizon 2020 Programme under Grant Agreement number 730355. Task 5.1 intends to make sure that the project partners can recognize realistic exploitation and innovation aspects during the co-design and implementation of CLARITY Climate Service right from the start of the project, when no detailed and focused market study and business model are available yet.

The work foreseen in this task is performed in two stages. The first stage concentrates on the technical perspective and the impact of potential Exploitation Requirements identified on basis of a general and broad assessment of Climate Service market conditions, needs and gaps. Thereby, especially the early results of the EU-MACS (Project ID: 730500. Funded under: H2020-EU.3.5.1.), reported in EU-MACS deliverables D1.1 “Review and Analysis of CS Market Condition”, D1.2 “Existing Resourcing and Quality Assurance of Current Climate Services” and D1.3 “Analysis of existing Data Infrastructures for Climate Services” are taken into account. In a second stage, the results of CLARITY’s market analysis and business model (D5.3 “Exploitation and business plan v1”) are used to re-evaluate and/or validate the findings of the initial Exploitation Requirements assessment and to concretize innovative aspects of CLARITY products and service.

This document defines CLARITY’s general approach towards Exploitation Requirements and Innovation Design and presents the results of the first stage of Task 5.1, that is, Exploitation Requirements elicitation and assessment. It describes the consolidated Exploitation Requirements, discusses the potential impact and implications of Exploitation Requirements on the Climate Services co-design process, product and service implementation and the CSIS architecture and formulates concrete technical recommendations for WP1 “Co-Creation” and WP4 “Technology Support”.

1 Introduction

1.1 Scope

As Innovation Action Project, CLARITY has to deliver innovations that create high impact during and after the lifetime of the project. Innovation in the context of H2020 is understood as the "successful **exploitation of new or improved** technologies, **products**, designs, processes, **services** or solutions, which when used, produce tangible benefits, satisfying needs and wants" [1]. That is, the expected impact of the project is not to be measured by its scientific contributions, but by the **extent of the benefits** derived from the innovation and thus relates to the wider societal, economic or environmental cumulative changes over a certain period of time.

The project's exploitation activities involve among others determining the **demand** for products and services that do not yet exist followed by an assessment of potential innovations and **opportunities** for their direct or indirect utilisation. While utilisation of project results may take part in research and development activities other than those covered by the project, CLARITY's key exploitation objective is the **marketing of operational and sustainable products and services**.

Two main categories of innovations provided by CLARITY can be identified:

1) New and improved **Climate Services** (CS) for integrating resilience to climate change into long-term and large-scale urban infrastructure planning and development activities and
2) a **Climate Services Information System** (CSIS) that is able to exploit the added value of Climate Services by providing a climate change adaptation platform based on a coherent methodology [1] integrating a marketplace and a community for Climate Services.

From architectural perspective, Climate Services and the CSIS, respectively, can be subdivided into constituting elements (Building Blocks) which may represent separate innovations (distinct exploitable results) on their own.

The expected impact of the project covers mainly the **rapid deployment and market uptake** of climate services by demonstrating their **added value** to the end-users for the decision-making process related **but not limited to** climate change adaptation.

T5.1 - Exploitation Requirements is a dedicated task established to make sure that the project partners use their best efforts to take measures aiming at ensuring the exploitation of their results. Raising awareness on exploitation possibilities and recognizing valuable and exploitable results is a crosscutting activity that has to be considered during the whole process of climate services co-creation. The task's activities are not isolated and limited to WP5 - Exploitation and Business and are therefore carried out at different levels of the project's overall work plan. Thus, they are helping to establish a sound technological basis for the collaborative exploitation of the project results by influencing topics and decisions regarding technology selection, software architecture, system distribution aspects, user interface design, and others.

Furthermore, in support of the exploitation strategy that will be defined in T5.2 - Exploitation Strategy and Business Plan, this task's activities stimulate concrete measures to ensure that the project results meet real needs and will be taken up by potential users. For this purpose, two instruments were introduced: **Exploitation Requirements** and **Innovation Design**.

2 Concept and approach

As both terms “Exploitation Requirements” and “Innovation Design” are not clearly defined in the fields of requirements analysis or innovation management, the CLARITY team developed the following concept and approach towards Exploitation Requirements and Innovation Design.

2.1 Exploitation Requirements

2.1.1. Definition

Essentially, an Exploitation Requirement is a requirement that must be met to allow for a successful exploitation of the project's results. Put in context of traditional requirements analysis in systems and software engineering, the characteristics of Exploitation Requirements come closest to those of businesses requirements, whereby the overarching business objectives are superseded by exploitation objectives. Consequently, the project's exploitation objectives can only be met if the constraints and conditions expressed by the respective Exploitation Requirements are satisfied by the overall outcome of the project.

Putting this into the context of CLARITY's main exploitation objective, the (commercial) uptake of operational and sustainable climate services, Exploitation Requirements in CLARITY have to address besides scientific and technological also non-technological (especially business and or techno-economic) and functional aspects.

In this sense, an Exploitation Requirement cannot be considered a non-functional requirement alone, as it may impose also specific behaviour or functionality of a Climate Service that is essential to achieve an exploitation objective. However, the level of abstraction of an Exploitation Requirement imposing functionality is in general higher than that of a concrete user- or functional requirement.

The focus of an Exploitation Requirement is on the “why perspective” (why should we do this?) which leads to the aspects of the “what perspective” (what needs to be done) and "how perspective" (how can it be done?). The “what” and “how” aspects relate to the consideration of technical details, definition of core functionality and an assessment of the feasibility of the approaches for design and implementation of products and services. Thus, ensuring that for example technology selection, software architecture and user interface design are aligned with the project's exploitation strategy and objectives.

2.1.2. Objectives

As Exploitation Requirements define which conditions will need to be fulfilled to enable the successful exploitation of the project results, they provide indications on which solution design path should be taken from a business and/or exploitation point of view. They further help to identify at an early stage of the project potential technical, scientific and non-technical barriers (e.g. regulatory and financial), risks, obstacles and problems that may prevent successful exploitation or lower the expected impact of the project. Early recognition of barriers and risks for exploitation provides an opportunity to avoid potential problems and anticipate possible conflicts before they actually arise. Thus, Exploitation Requirements enable CLARITY to follow a comprehensive approach towards Climate Service co-creation whereby upcoming issues can be countered with appropriate measures right from the beginning of the project. Of course, the Exploitation Requirements should also be used as input to T5.2 and help to define the exploitation strategy and business plan.

From an early stage of the project, Exploitation Requirements will help to define indicators and to identify barriers.

2.1.3. Approach

An approach towards the basic understanding of Exploitation Requirements is to recognize them as "K.O." or "show stopper" requirements for exploitation. Such a requirement, if not fulfilled, prevents potential end user from using (or buying) a product or service no matter what other (user) requirements are fulfilled. This view on Exploitation Requirements emphasises their complementarity to the requirements that are elicited in the form of User Stories through the co-creation process in WP1.

CLARITY technology support team will have to assess the Exploitation Requirements separately from the WP1 user requirements and the CSIS design and functionality will have to reflect the K.O. criteria expressed in the exploitation requirements. This will have to be done and documented both at the level of architecture and implementation[1].

The CLARITY elicitation of Exploitation Requirements follows a two-step approach:

- For the **first part**, which is related to general Climate Services market restrictions, constraints and incentives to use the project outcomes, Exploitation Requirements are extracted from relevant documents reporting on market conditions, initiatives, projects, stakeholder consultations and targeted surveys. Special attention is paid to the findings of ongoing actions within the framework of the European research and innovation roadmap for climate services [2] that relate to the qualitative assessments of barriers and enabling conditions associated with the uptake of climate services. Thereby, CLARITY greatly benefits from the early results of the EU-MACS (EUropean MArket for Climate Services) project, that intends to “clarify how the market for climate services could abound by improving the matching of supply of and demand for climate services” [3]. The list of the relevant documents that were used in this work is given in the Annex 1 of this document.
- For the **second part**, that is related to essential functionality and features required for a successful exploitation, no separate or additional requirements elicitation activity is foreseen. Instead, the outcome of the end user requirements elicitation process in T1.2 “Climate Service Requirements” will be analysed by development teams to recognize indispensable functionalities and to understand the critical success factors for the uptake of Climate Services. This assessment is embedded in the overall co-creation process in T1.3 “Climate Services Co-creation” and the specification and prioritisation of Test Cases for the implementation of Building Blocks and ultimately Climate Services and the CSIS.

The initial Exploitation Requirements collected and an outlook of their potential impact on the development of climate services and the CSIS are summarised in chapter 4.

2.2 Innovation Design

2.1.4. Definition

Innovation means change, experimentation, and new ideas which are inherently risky. Innovation Design is an activity that is incorporated in the architectural design and product development process to support the project in the **creation of high impact novelties** (products and services) on the basis of existing background (technologies, concepts, prototypes, products and services), while anticipating and addressing the involved risks.

[1] At the level of implementation, each Test Case will explicitly explain which exploitation requirements it addresses and how, in addition to explaining which User Stories it addresses and how.

Besides capturing the actual innovative aspects, Innovation Design also captures the innovation potential and capacity of products and services. Innovation potential determines the currently unrealized but **possible impact** of the innovative product or service. That is, **"how much benefit"** [4] it can potentially deliver. Innovation Capacity determines its capability to be used in other areas beyond the objective and whether it may have the capacity to "**stimulate further innovations"** [1]. For example, being able to demonstrate that the implementation of climate change adaptation measures can lead to additional benefits beyond the scope of climate resilience improvement bears both high innovation potential and capacity. In CLARITY innovation design is intrinsically tied to high-level CSIS design and implementation strategies and thus to CSIS architecture and Climate Services co-creation.

2.1.5. Objectives

The main objective of the innovation design task is to describe how CLARITY combines and improves existing inventions to design and implement innovative products and services and thus to generate added value and achieve **progress in the state of the art**. In CLARITY, innovative aspects have to be considered both on the level of the integrated CSIS as well as on the level of Climate Services and their constituting Building Blocks. Thereby, Innovation Design also addresses how additional background identified during Exploitation Requirements assessment can be incorporated in the product development activities whilst at the same time supporting T5.2 "Exploitation Strategy and Business plan" in the creation of an inventory of exploitable results.

2.1.6. Approach

Since Innovation design activities are closely related to market analysis, architecture design and climate service co-creation, there will be a tight cooperation with the respective tasks and work packages (T1.2, T4.1, T5.2). Before being able to recognize additional innovation potential, an overview and assessment of the state of the art in climate change adaptation platforms and climate services has to be performed as part of a focused market analysis. The EEA's technical report on climate change adaptation platforms in Europe [5] and The European Landscape on Climate Services [6] serve as starting point for this analysis. A cross-check with CLARITY's main driving force, the Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient [1] and the H2020 SC5 Advisory Group's Report on future strategic research and innovation priorities [4] and the latest findings of the EU-MACS project will lead to an identification of gaps and shortcomings in current solutions that need to filled by CLARITY innovations. Further potential for innovation will emerge during the end-user driven co-design process. Last but not least, also Exploitation Requirements (once fulfilled by Climate Services and CSIS) will be directly incorporated into innovation design as they are in part a direct answer to shortcomings and weaknesses of currently available climate services and adaptation platforms. More specifically, this means that the assessment of Exploitation Requirements will lead to the identification of additional background (concepts technologies, etc.) that need be considered for the design of innovate products and services.

In an ongoing and continuous activity, innovative aspects, innovation potential and innovation capacity are captured within the description of Climate Services and Building Blocks. These descriptions are maintained in CLARITY's online collaboration platform and also serve as a source for the inventory of exploitable results and dissemination activities (e.g. by advertise CLARITY Climate Services on http://climate-adapt.eea.europa.eu/).

3 Exploitation Requirements elicitation results

This chapter reports on the results of Exploitation Requirements elicitation performed during the first period of the project and based on the methodology outlined in 2.1.3. It gives a summary of the 10 consolidated requirements, highlighting the key messages relevant for CLARITY in relation to three thematic clusters. Full definitions of the exploitation requirements are shown in the Annex 1 of this document.

Table 1 lists the 10 Exploitation Requirements that resulted from the elicitation and consolidation. These requirements can be further categorised according to the thematic clusters "Business objectives", "Communication, community building" and "Quality and novelty".

Thematic Cluster	Exploitation Requirements
Business objectives	1. Develop a viable business ecosystem, business model and secure access to funding 2. Offer free basic Climate Services based on free and open data
Communication and community building	3. Demonstrate and communicate the (co-)benefits of Climate Services 4. Establish trust in Climate Services and their providers 5. Co-design Climate Services engaging a community of users, providers, purveyors and researchers 6. Follow a multi-sectoral approach that crosses the boundary of climate sciences
Quality and novelty	7. Offer commercial fit-for-purpose tailored Climate Services targeting specific sectors and user groups 8. Consider the role of new regulatory frameworks in stimulating the emergence of Climate Services 9. Provide a user-friendly, intuitive and context-aware discovery and communication infrastructure for Climate Services 10. Use, define and promote open standards for data and services

Table 1: Exploitation Requirements and Thematic Clusters

The following sub-sections describe the 10 Exploitations Requirements according to the thematic clusters.

3.1 Business objectives

The main objective of Exploitation Requirements elicitation and assessment is to make sure that the co-design process is able to produce products and services that are actually fit for exploitation. The development of a viable business ecosystem and business model is a key factor to exploit the outcomes after the end of the project. In addition, governments, development agencies and other stakeholders have to take into account not only the direct outcomes of new Climate Services, but also the value of socioeconomic benefits that will be provided by the aforementioned services. Therefore, public institutions should seek to acquire adequate financing in order to secure access to funding. To justify the funding needed, the business model should also analyse socioeconomic benefits to demonstrate how the benefits of new services are significantly larger than the cost to produce them and thus helping public bodies to take funding decisions to invest in Climate Services.

Funding the Climate Services platform could be by public money, by revenues from private business, or by a mix thereof, e.g. through public-private partnerships. The CLARITY activities should target new customer segments, so that private funding of Climate Services could increase in relation to public funding, which is significantly higher than private funding today.

Likewise, the funding of Climate Services could be direct, by end users of a service or indirect, by some other interested party – resulting in a free of freemium service from the point of the view of the end users. In order to provide both free and commercial Climate Services it is necessary to take into account how to update and improve these products and services (in terms of funding) - i.e., the design of incentives to operate, maintain and develop products and services beyond the project runtime.

In this sense, securing the long-term maintenance of the CLARITY platform (CSIS, marketplace, community) through institutional funding, development projects or commercial exploitation of Climate Services is a matter of CLARITY's overall business objectives, which are addressed in detail in task T5.2 "Exploitation Strategy and Business plan".

It is expected that any exploitable project result will in one way or another depend on the usage of the climate data offered by Upstream Climate Services (climate data services). Thus, for the long-term success of the project it is essential to base the CLARITY Downstream Climate Services on such reliable and trustworthy Upstream Climate Services that are able to continuously combine observations of the climate system with the latest scientific findings and achievements. However, the climate data that is freely available for research or educational purposes isn't freely available for commercial use. Therefore, CLARITY should provide both free basic generic Climate Services based on free and open-access data and at the same time offer fee-based services based on commercial data and highly customized and tailored Expert Climate Service based on high-quality and local data. Thereby, the purpose (from a business perspective) of offering free Basic Climate Services is to stimulate capacity building at the level of final users, thus increasing the overall CLARITY community and stimulating the uptake of commercial Expert Climate Services.

3.2 Communication, community building

Review and analysis of Climate Service market conditions processed in the H2020 Project EU-MACS [D.1.1] reveal the perceptions of providers (supply side) and users (demand side) related to barriers relevant to Climate Service development. Thereby, valuable insights about key barriers and enablers for a European Climate Services market were provided through interviews with a variety of professionals in the Climate Services field like consultants, researchers and public administrators for governmental organizations. The analysed findings show that providers tend to rate barriers and their impact higher than users. Providers as well as users assess "limited financial resources" as the economic barrier with the highest (negative) impact on their Climate Service activities. This is considered the overall main barrier from providers' side. Users consider a technological barrier - lack of appropriate technology/technological capacity including technical equipment and infrastructure - as the most influential barrier for them (going hand in hand with their main economic barrier).

While these particular barriers mainly lead to Exploitation Requirements concerned with the actual business objectives of the project (addressed in chapter 0) and qualities of Climate Services (addressed in chapter 3.3), a real "hotspot" for providers and users with considerable high rating are "social barriers" revealing room for improvements in communication and collaboration. The following Exploitation Requirements therefore specifically address the topics of communication and community building.

A major barrier relevant to the uptake of Climate Services is that added value of Climate Services is often unclear and difficult to measure[2]. Climate Services generate economic and social value only if the society and/or economy benefit from decisions and actions taken as a result of the information provided by Climate Services. Unfortunately, climate change adaptation in general and Climate Services in particular are likely to merely be seen as an additional cost factor by the relevant stakeholders and not as an opportunity.

[2] To be addressed, among other, in T5.3 Social Innovation Assessment.

In order for CLARITY CSIS and the related Climate Services to be successful, CLARITY as a whole has to demonstrate that using Climate Service(s) brings tangible benefits, and that these benefits surpass the initial investment in those services. Communicating and demonstrating the (co-)benefits of Climate Services should therefore aim at influencing the perception of the added value of Climate Services by the potential users, especially their capacity of receiving, combining and interpreting climate and non-climate information and using them in decision-making process.

Potential Climate Service customers are first and foremost interested in products of neutral and reputable providers that deliver salient, objective, credible and defensible results, even "in light of the irreducible uncertainty about future climate change" [5]. It is therefore essential for the success of Climate Services to transparently report and inform on their characteristics and provision, both in relation the origin, quality and uncertainty of the underlying models and data as well as the methodological approach and processes which created them.

To establish trust in Climate Services and their providers, quality assurance and control as well as certification have to be addressed. However, widely accepted objective measures of the quality of Climate Services do not exists, complicating the validation or verification of the Climate Service quality. On the one hand, this highlights the need to develop standards, and on the other hand the need for transparency. The latter includes the standardization of data and methods, and the inclusion of version history and metadata so that users can track the decision for suggesting climate change adaptation measures, and trace it back to the underlying data and models. Also robust data, and providing services based on state-of-the-art science contribute to a defensible analysis and product.

As an additional measure for establishing the trust relationship between the users and providers of the climate services, CLARITY platform will support the direct user/provider interactions and consultations, rather than attempting to completely replace such interactions by technology and formalism.

For Climate Service development and establishment of a co-design approach it is necessary to engage a large community of researchers, providers, purveyors and end users. This multidisciplinary community needs to be fostered on regional and European level, encourage cooperation among scientific sectors, providers and purveyors and engage end users from public and private sectors in order to co-design and deliver fit-for-purpose services. Community consultations will help to build mutual trust of different stakeholders as well as to reveal end user challenges (e.g. tight timelines and budgets), their expectations and clarify how they will use the services in their respective projects - thus leading to "communities of practice" and trusted relations along value chains.

Commercial and societal success of Climate Services is driven by users as integral and equal partners in design and build-up of Climate Services as well as their engagement in the community. In order to reach the main relevant target groups, "good practices" need to be communicated sector-specifically and multiplicators have to be integrated.

Developing, planning, constructing and operating (urban) large-scale infrastructure projects involves multiple disciplines and expertise as well as the multiple stakeholder roles and interest. Consequently, the users that would be willing to pay for Climate Services are rather heterogeneous.

General and generic Climate Services therefore may not adequately address the needs and expectations of the relevant target groups. Furthermore, climate data alone is not sufficient for the provision of targeted Climate Services but has to be integrated with local and other relevant data to address the specific needs of the users. Therefore, pictured barriers can be tackled by establishing and fostering multidisciplinary collaboration (including sharing of technical infrastructure) and community building across the whole value chain.

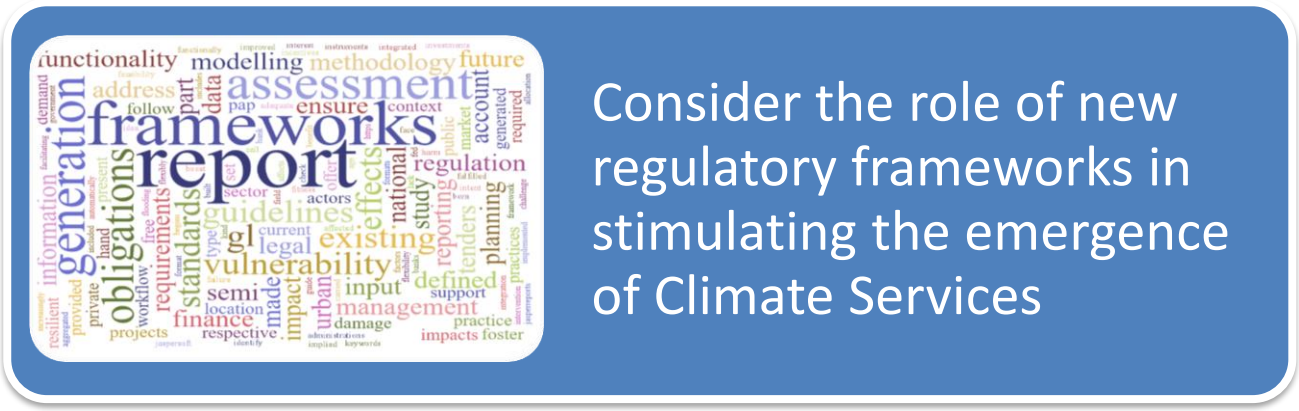
In order to be able to provide valuable Climate Services for a wide variety of end users from different sectors and disciplines, CLARITY has to follow a multidisciplinary approach that encompasses multiple sectors and domains, crosses the boundaries of climate science and facilitates the integration of both climate and non-climate information into an open knowledge infrastructure.

3.3 Quality and novelty

The majority of Exploitation Requirements (intentionally) originate from a technical or field-based perspective and therefore relates to the quality and novelty aspects of Climate Services. This owes to the fact that the approach towards Exploitation Requirements and Innovation Design pursued in CLARITY intends to directly influence the Climate Services (co-)development process and mainly recognizes innovation in the sense of the capability to commercialise the project results. Accordingly, immediate technical impacts that are summarised in chapter 4 originate for the most part from the Exploitation Requirements belonging to this thematic cluster.

At present, potential demand for Climate Services is not fully developed because, in many cases, the services offered do not match the services requested. In order to design and develop the novel services that better match the users' needs, the users must be able to better understand and judge the features of Climate Services, assess whether or not they fit their needs, and clarify if and how they can be adopted in their planning and investment decisions.

CLARITY co-creation process and public consultations aim to eliminate or at least shorten the distance between suppliers and users and to assure the work focuses on the real demand and result in fit-for-purpose tailored services, targeting specific sectors and user groups. Besides integrated and tailored information, provided on appropriate temporal and spatial scale and sectoral assessments, such Expert Climate Service have to take the social needs, which influence business activities and public decision making, into account.



Under new EU regulatory frameworks, companies and public administrations participating in the elicitation of new (or maintenance of existing) infrastructure projects, are likely to be required to demonstrate that their project plans are climate-change resilient. These regulatory frameworks address the risks that climate change poses for such infrastructure, not just in the short to medium term, but also for the whole duration of the life of the infrastructure. Besides, they also need to address the considerable uncertainties associated with climate change, including the location, nature, timing and severity of climate change impacts or events that may occur. At present, infrastructure planners and stakeholders lack tools that can support them in assessing and assuring the compliance of their projects with such EU and national regulatory aspects.

CLARITY Climate Services should support these actors by methodological and transparent means in the assessment and documentation of the possible risks that climate change poses in their projects as well as what adaptation measures can be applied to mitigate their impacts.

Provide a user-friendly, intuitive and context-aware discovery and communication infrastructure for Climate Services

Current slow uptake of Climate Services is, at least partially, caused by deficiencies in existing Climate Services portals. In particular, the key barriers to user uptake are related to some portals not being designed with the user in mind, non-intuitive and inconsistent complex navigational schemes and search functionalities, information and service presentation that exceed the knowledge of a novice or non-expert user and unclear definitions of the actual Climate Service offers. To maximise impact and uptake the CSIS, which is CLARITY's main dissemination and exploitation platform, has to provide user-friendly, intuitive and context-aware discovery and communication mechanisms for Climate Services.

To increase user experience and usability for non-experts, the user interfaces of the CSIS platform should not presuppose any specific technical skills or deep knowledge of climate change science. Usability in this context also means hiding the complexity of the underlying scientific and technical infrastructure and finding an intuitive and easy way to present an information and service offer that is both relevant and valuable for the specific end user (while at the same time recalling that this information has to be provided within the service, see also ‘Establish trust in Climate Services and their providers’). This goes hand in hand with an improved (visual) presentation of information, products and services and context-aware discovery functions.

Use, define and promote open standards for data and services

The usage of open standards is not only a basic requirement for achieving technical interoperability of products and services and for facilitating collaboration between producers and consumers of those services but also brings considerable economic benefits. Accordingly, standards "help businesses to enhance the quality of their products and the efficiency of their processes", "play a vital and often invisible role in supporting economic growth through their role in boosting productivity and innovation" and "facilitate innovation by creating the environment for the development of new products" [6]. Therefore, the development of the CLARITY CSIS and CLARITY Climate Services, respectively, must be accompanied by the usage, definition and promotion of open standards for data, protocols and services from the very beginning of the projects. While the project does not aim to pursue the lengthy and complex process of producing a de jure standard, CLARITY aims at establishing the technical and conceptual specifications developed during the course of the project as consortium recommendations or even as de facto standard (by reusing and adapting whenever relevant already existing and well-established standards).

4 Exploitation Requirements impact assessment results

The assessment of the Exploitation Requirements identified several additional important topics that have to be considered by the CLARITY consortium through all project activities, in particular during architectural design and co-development of the CSIS and the Climate Services. This chapter intends to give a brief, nevertheless concise summary on major topics that have either not been considered explicitly or not exhaustively in the original project work plan.

A detailed assessment of all Exploitation Requirements regarding their scope and applicability in relation to the original CLARITY project setup and a more detailed elaboration on their impact and concrete technical implications on the project is given in Annex 1. This also includes an identification of concrete background (technologies, software, services …) that will be considered during Innovation Design activities when addressing the extended topics described in this chapter.

4.1 Contribution to Innovation Design

The following topics contribute to Innovation Design related activities, that is, addressing one or more exploitation requirements by adopting further concepts, technologies, etc. and incorporating them into CLARITY's overall operative work stream. These topics can also be seen as opportunities that will positively influence CLARITY's exploitation objective.

2.1.1. Free(mium) Basic ICT Climate Services

CLARITY will allow external end users ("potential customers") to draw benefits from the usage of Basic ICT Climate Services that are provided as free, simple, ready to use, generic and open-data-driven (open-source) online ICT tools (software). Among others, users will be able to perform a free high-level climate risk screening of their projects and the associated elements at risk on a rather coarse scale.

However, such a Basic Climate Service is not meant as replacement for a detailed risk assessment study. Instead, it relates to the first step in developing an overall adaptation strategy on the basis of commercial and tailored Expert Climate Services (consultancy, advisory, modelling and development), hence performing a pre-feasibility analysis as anticipated by the EU-GL methodology (high-level application of EU-GL Modules).

Thereby, free Basic ICT Climate Services can be extended by paid features (freemium model) such as (advanced) report generation or usage of high-resolution climate data. Such basic services should not depend on costly site-specific modelling, high performance computing or expensive local high-resolution climate data. Instead, they can compromise temporal and spatial resolution as suggested in EU-MACS D1.3 "Analysis of existing data infrastructures for climate services" [7] and rely on freely available data and model outputs. For example, C3S - Copernicus Climate Change Service (https://climate.copernicus.eu/) and related sectoral Climate Services like SWICCA - Service for Water Indicators in Climate Change Adaption (http://swicca.climate.copernicus.eu/) will be used as input to CLARITY ICT Climate Services. Finally yet importantly, such ICT Climate Services have to produce tangible outputs for end users, e.g. reports and data in standard formats like SHP, NetCDF, PDF, ODF, etc.

However, CSIS should also support a specific business model where high quality data is purchased by one entity and offered for use through the platform to other users free of charge or at a reduced fee. Such entity could be e.g. a local government, insurance company or a registered end-user association.

2.1.2. Commercial Expert Climate Services

In CLARITY, an Expert Climate Service is defined as an individual, professional and tailored consulting and advisory service that can be provided as joint venture activity of operational, technical and industry specialists. It may also involve project-specific analysis, custom data and model integration, site-specific numerical modelling and so on.

If disseminated via the CLARITY Marketplace, such Expert Climate Services have to be provided according to specific rules and guidelines that are set out for the one part in the CLARITY Modelling Methodology (WP3 "Science Support") and for the other part in technical specifications that allow integration with the CSIS (WP4 "Technology Support"). Such technical specifications include for example an information model for Expert Climate Services that clearly defines the service level agreements and that can be related to elements of a Climate Service providers' service portfolio or a service catalogue in the CLARITY Marketplace as well as other metadata fields (i.e., such as expertise field(s), fees rates, etc.) that enables end user to find the most appropriate professional providing the required Expert Climate Services.

Thereby, a data-driven architecture and technical facilities for integrating Expert Climate Services with the CSIS have to be provided, allowing external data- and service providers to develop their Climate Services according to CLARITY conceptual and technical standards and to join the CLARITY Community & Marketplace for offering their Climate Services. Expert Climate services will be promoted by means of case studies, e.g. the four CLARITY Demonstration Cases.

2.1.3. Advanced visualisation and user interaction concepts

The CSIS and ICT Climate Services that allow direct user interaction have to be developed according to concepts for usability and for human computer interaction with help of state-of-the art technologies for user interface design. Thereby, a good balance between accuracy and simplicity has to be found that hides (unnecessary) complexity from non-(climate change and risk management) experts but is still based on credible and defensible scientific background. In particular, this demands for modern and lightweight web applications rather than heavyweight and complex desktop applications orient towards an expert audience.

Another related aspect is how to effectively promote and demonstrate the benefits of Climate Services by means of demonstration cases. Key to communicating the potential and actual benefits that the stakeholders of the Demonstration Cases can draw from the usage of Climate Services is a modern and appealing visual presentation that exploits the possibilities of state-of-the-art data visualisation techniques (e.g. infographics, charts and diagrams of the Multi Criteria Decision Support tool, etc.). This covers not only multi-criteria (indicators) and geospatial visualisation (e.g. hazard and impact maps) but also the visualisation of the actual planning process and the workflow in relation to EU-GL modules (e.g. as graph). Additional topics for exploring advanced visualisation techniques include a graph representation of data provenance information and visualisation of (quantified) uncertainty in geographic settings, e.g. by applying different opacity levels as successfully applied by Kinkeldey et. al. [8].

2.1.4. Extended communication

Communication plays a predominant role for the uptake of Climate Service and relates not only to the communication of benefits of Climate Services but to all aspects of Climate Service co-creation and provision:

Quality assurance and uncertainty of the underlying data and models must be communicated properly throughout the whole planning process and must be easily recognizable in the Climate Service Catalogue / Marketplace. Thereby, Climate Service quality could be defined as the ability to deliver scientifically sound predictive or scenario-based information that support decision-making under uncertainty.

Reputation, neutrality and trustworthiness of a Climate Service provider must be easily recognizable and communicated, e.g. reflected in the Climate Service provider profile in the Marketplace. This could include (moderated and verified) feedback from Climate Service users ("customer ratings") and links to scientific publications, talks, etc.

Data Provenance Information including information about the quality of the data, uncertainty, etc. as well as the process (model) which created them have to be communicated to users of Climate Services.

2.1.5. Better discovery and matchmaking

Being able to present a relevant and valuable service offer requires a new information and service discovery approach that is quite different from "traditional" search- and catalogue navigation paradigms. Thereby, the challenge is to also take the user's context (sector, professional profiles, etc.) into account and should not be limited to the CSIS (Marketplace) but also provide links to partner portals like Climate-ADAPT (http://climate-adapt.eea.europa.eu/) or Upstream Climate Services like SWICCA. Consequently, the CSIS has to adopt a context-aware discovery approach that is tightly coupled to CLARITY's Modelling Methodology and the respective workflow (modules) of a Climate Change Adaptation Study. Thereby, the role of the CSIS is recognized as to bridge the gap from supply driven (Upstream) Climate Services to demand driven (Downstream) Climate Services by offering free basic and generic ICT Climate Services and to help end users to identify and discover their need for fit-for-purpose commercial Expert Climate Services.

In brief, the approach integrates discovery into a user interaction workflow. That is, for example, performing a pre-feasibility analysis with the help of Basic ICT Climate Services. At each step of this workflow, context-dependent information such as suitable and fit-for-purpose products and services (high-resolution local data, the best fitting professional(s) providing the required advanced Climate Services consultancy, etc.) will be presented. When linked with the Marketplace such a discovery approach that recommends relevant content opens new exploitation possibilities.

Furthermore, the existing Scenario Transferability tool ("Climate Twins") can be extended beyond basic climate indicators and be applied in different contexts related to "matchmaking". For example, applied to the Catalogue of Elements at Risk and Adaptation Options, infrastructure projects being assessed by end users can be matched to other projects that share the same elements at risk (covering a variety of sectors). The same could be true for adaptation options. Moreover, end users could discover other projects with the same proposed or already implemented adaptation options, in order to investigate further and learn from the experiences already made.

Moreover, a recommendation system or machine-learning practices could be used to leverage the transition from data to information (data communication) and identify implicit relationships that in turn improve the overall discovery process. It must be admitted that this discovery approach requires a rich set of meta-information (see 2.1.12) for each relevant "object of interest" and Smart Links between them.

2.1.6. Collaborative engagement and incentive design

As obtaining appropriate data that can be used free of charge for the Basic ICT Climate Services still remains a challenge (see 2.1.11), CLARITY should set incentives for collaborative engagement aiming to improve CLARITY's Catalogue of Elements at Risk and Adaptation Options, e.g. by user generated content related to infrastructure projects and their associated elements at risks and vulnerabilities.

In order to follow a multi-sectoral approach, the Catalogue of elements at risk and adaptation options needs to provide both a wide range of elements at risk which are related to many different sectors (e.g. road infrastructure, buildings, social, etc.), as well as a wide range of adaptation options. It might be that not all sectors are fully dealt with at the beginning; therefore, a community-driven mechanism by which the gaps are being filled is suggested. This challenge could be dealt with if the catalogue enables users to provide their own elements at risk and suggest their own mitigation options that then might be validated by experts. Thereby, such user provided content has to follow the same quality and transparency standards as being used for essential climate data. However, this would imply another challenge concerning the moderation and validation of the correctness of the information uploaded by "untrusted" users.

Additionally, information from previous adaptation studies performed on the CLARITY platform by other users (CSIS and related ICT Climate Services) could be contributed as (anonymized) user-generated content. This applies especially to pre-feasibility analyses performed with help of Basic ICT Climate Services. Here, the results of free studies could be made open data by default, and performing a private study would require a paid subscription.

2.1.7. Open standards for processes, data and services

To move forward in establishing standards at the European level, it is necessary to consider the existing results produced and published by the EC and by other related projects. In this respect, CLARITY intends to establish a scientifically sound and defensible standard methodology (CLARITY Modelling Methodology) based on EU-GL and combining the concepts of IPCC and the DRR community. The technical specifications and solutions, including the four Demonstration Cases, developed by CLARITY can thereby be considered as the reference implementation of the CLARITY Modelling Methodology and thus should be subject to activities that seek to establish a de facto standard.

Moreover, a lightweight data standard for climate risk adaptation studies that is based on the CLARITY Modelling Methodology, the concept of Data Packages, which "provides a simple contract for data interoperability that supports frictionless delivery, installation and management of data." (http://frictionlessdata.io/data-packages/) and the Open Geospatial Consortium's (OGC) GeoPackage standard that "is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial information." (http://www.geopackage.org/), has to be defined. CLARITY's Data Package approach could be established as a de-facto interoperability standard for climate adaptation studies that follows a (scientifically sound and defensible) methodology. To this end, Climate Services provided by external stakeholders that are both conceptually and technically compliant to CLARITY's standards can benefit from conceptual and technical interoperability with CSIS and related tools like Multi Criteria Decision Support and Report Generation as well as the CLARITY marketplace.

Additionally, the simple format for Indicators used by the Multi Criteria Decision Support tool can be incorporated into the CLARITY Data Package standard. Technically, (Impact) model output must be transformed (e.g. by an aggregation or Indicator Function) into a standardised Indicator Set so that the Indicators can easily be compared or visualised by the respective tools. This allows for presentation of data-driven insights, e.g. in the form of (standardised) indicators that can be easily visualised (chart, diagram) as part of a case study.

Furthermore, (semi-) automatic Report Generation depends on well-defined input that can be validated, aggregated and visualised. Therefore, technical standards for the respective input formats have to be adopted by CLARITY Data Packages and communicated to external stakeholders that want to use the CLARITY Report Generation functionality for their Expert Climate Services.

2.1.8. Advanced report generation

The result of a climate adaptation study is a report that could be (semi-) automatically generated. Report Generation should enable the user to easily access and download draft and final reports packages at the end of the project assessment process. Such report packages should include automatically generated documentation (with embedded supporting tables, graphs and maps of the study area) together with all the datasets (Data Package) used in the study in order to be further used in other stages of the planning project.

For example the methodology for tracking climate adaptation finance of Multilateral Development Banks [9] could be used as input to generate reports that follow a predefined document structure.

Depending on the type of the study, either pre-feasibility or expert study, the report will also contain input from Expert Climate Services. Report Generation functionality can therefore also be provided as part of an additional and possibly free ICT Climate Service (see 2.1.1) so that also "external" Climate Service providers that are not directly connected to CSIS can benefit from reporting functionally if they follow CLARITY's conceptual and technical standard. As a side effect, this opens the CSIS for additional Climate Service providers and will boost the uptake of CLARITY standards.

Due to a variety of user expectations, project types and local legislations, a single report or a small number of well configured reports cannot fully meet the needs of all the CSIS users. Therefore, the reports should be configurable by means of the reporting templates. This will allow implementing the tailor-made reports, e.g.

based on reporting templates (of regulatory frameworks as needed within the project and as a commercial service later on.

2.1.9. Collaboration and co-design infrastructure

The implications of co-designing Climate Services engaging a community of users, providers, purveyors and researchers on software architecture and implementation are twofold. They both concern the project internal co-design process that is carried out in close cooperation with stakeholders of the four CLARITY Demonstration Cases as well as an external co-design process involving external Climate Service providers and users that shall be supported by software (ICT Climate Services) and infrastructure (CSIS). Common to both variations of the co-design process are the need to provide a technical infrastructure and built environment that is shared between providers (developers) and users of Climate Services..

The CSIS must therefore provide a multidisciplinary communication framework where users and producers of Climate Services within different sectors are not only able to exchange data but also to enrich climate data with additional sector specific information. For the CLARITY demonstrators, an easy-to-use technical collaboration platform that incorporates non-it expert users in the agile software development process and allows them to receive direct feedback from software architects and developers needs to be provided also by Technology Support (WP4).

Furthermore, incentives for external stakeholders (users and producers) to participate in the co-design of Expert Climate Services have to be provided. This encompasses, among others, possibilities to easily request and exchange information needed to perform a climate adaptation study that is based on a well-defined and well-documented process (CLARITY Modelling Methodology).

4.2 Needs and gaps

The following topics relate to identified needs and gaps that, if not addressed, may negatively influence or even hinder CLARITY's exploitation objective. They cannot be addressed by architecture and implementation alone (WP1 and WP4) but also affect the data collection and modelling activities in WP3 "Science Support" and WP2 "Demonstration & Validation".

2.1.10. Data storage and processing infrastructure

Technology support has to provide Data Repositories that are not only able to store several Terabytes of climate data but also provide standardised machine-level access (OpenDAP, OGC WMS) to other ICT services and (impact) models. Thereby, data protection is an important issue as such data exchanged between providers of paid Expert Services and the users of such services will in most cases not be made public. Hence, secured access to the data repositories has to be ensured. In order to reduce the needed storage capacity, a service data-broker may be used; this service would offer access to data stored by servers external to CSIS in an easy and transparent way for the user. Additionally, not only facilities and possibilities for an automated execution of a limited number of (simple and generic) impact models for pre-feasibility analyses (see 2.1.1) have to be foreseen in the CSIS, but these the impact models have to also be provided within the expert service methodology.

2.1.11. Data Requirements

The idea of providing simple and free of charge but credible and defensible risk screening ICT Climate Service leads to stringent data requirements. Consequently data on infrastructure projects, elements at risk, climate hazards at pan-European scale, etc. so all elements that are needed to perform an out-of-the box pre-feasibility (high-level application of EU-GL) have to be collected and processed by CLARITY. As previously observed (see 2.1.10), this includes also simple (impact) models at some kind of matchmaking (Scenario Transferability) to relate elements at risk to (generic) adaptation options.

Regarding other (upstream) Climate Data Services related to climate models, issues might arise regarding the commercialisation of CLARITY Expert Climate Services. Some datasets can be used freely for research or non-commercial use, but have to be purchased for commercial use. Another issue that has not to be underestimated is the heterogeneity and lack of standardisation of climate data. While most climate data services offer NetCDF files, these files differ e.g. in terms of the encoded metadata, parameter names or array sizes.

This topic can be partly addressed by engaging users in contributing data (see 2.1.6), the imminent issues cannot be resolved by Technology Support and Innovation Design alone. Therefore, these issues have to be addressed as part of the data harmonisation and collection activities (WP2 and WP3) and the assessment of licensing schemes and business model development (WP5).

2.1.12. Metadata requirements

A rich set of metadata is required for nearly all aspects of the project. These metadata have to be collected, generated, stored, processed and made available and encompass, among others

- metadata on provenance of the underlying data and models of Climate Services, including information about the quality of the data, uncertainty, etc. as well as the process (model) from which the data originated
- metadata on the reputation, neutrality and trustworthiness of a Climate Service provider, including for example (moderated) customer rations and links to scientific publications, case studies, customers, etc.
- metadata for “Smart Links” that describe a relationship between different entities and that can be enriched with additional metadata
- metadata for case studies (CLARITY Demonstration Cases) that is connected via “Smart Links” to product portfolios of Climate Service Providers as well as to the underlying data and models and their provenance metadata
- metadata for recording the decisions that lead to the implementation of climate change adaptation measures and for tracing them back to the underlying data and models.

5 Conclusion

As Innovation Action Project, CLARITY has to deliver innovations that create high impact during and after the lifetime of the project. The activities performed in T5.2 “Exploitation Requirements” raised awareness on exploitation possibilities among all project partners and helped the technical and scientific partners that are not directly involved in business development activities to discover further opportunities for creating valuable and exploitable results.

The Exploitation Elicitation process that was based mainly on the assessment of reports on market conditions, initiatives, projects, stakeholder consultations and targeted surveys, and, most notably the first deliverables of the EU-MACS (EUropean MArket for Climate Services) Horizon 2020 project, has led to the following 10 consolidated Exploitation Requirements from 3 thematic clusters:

- Business objectives
    - Develop a viable business ecosystem, business model and secure access to funding
    - Offer free basic Climate Services based on free and open data
- Communication and community building
    - Demonstrate and communicate the (co-)benefits of Climate Services
    - Establish trust in Climate Services and their providers
    - Co-design Climate Services engaging a community of users, providers, purveyors and researchers
    - Follow a multi-sectoral approach that crosses the boundary of climate sciences
- Quality and novelty
    - Offer commercial fit-for-purpose tailored Climate Services targeting specific sectors and user groups
    - Consider the role of new regulatory frameworks in stimulating the emergence of Climate Services
    - Provide a user-friendly, intuitive and context-aware discovery and communication infrastructure for Climate Service
    - Use, define and promote open standards for data and services

The subsequent assessment of the Exploitation Requirements regarding their scope and applicability in relation to the original CLARITY project setup described concrete opportunities that will positively influence CLARITY’s exploitation objective. They are being considered by the CLARITY consortium through all project activities, in particular during architectural design and co-development of the CSIS and the Climate Services, respectively. Thereby, the following extended topics regarding technical implications and measures for adopting further concepts, technologies, etc. and incorporating them into CLARITY’s overall operative work stream have been identified:

- Free(mium) generic and basic ICT Climate Services (software and tools)
- Commercial tailored Expert Climate Services (consulting, advisory, modelling, development, …)
- Advanced visualisation and user interaction concepts
- Extended communication
- Better discovery and matchmaking
- Collaborative engagement and incentive design

- Open standards for processes, data and services
- Advanced report generation
- Collaboration and co-design infrastructure

Besides that, the Exploitation Requirements are used as input to T5.2 “Exploitation Strategy and Business plan“ and will help to recognize restrictions, constraints and barriers and, more importantly, market needs and the incentive for end users to use CLARITY exploitable results and get real benefits.

The next version of this document will extend and improve these findings and present the CLARITY Innovation Design in terms of concrete innovation potential and capacity of CLARITY products and services. Thereby, D5.2 will validate the relevance of D5.1’s exploitation requirements and their potential impact against the market analysis and business model delivered in the context of T.2 “Exploitation Strategy and Business plan”.

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Annex 1: Exploitation Requirements

This annex document presents the results of the CLARITY Exploitation Requirements elicitation and assessment process in terms of ten detailed Exploitation Requirements descriptions. The elicitation addresses the following topics:

- **Description**: Pregnant and clear description of the requirement.
- **Rationale:** The reason why this requirement is considered an exploitation requirement and thus why exploitation (in a specific area) will be hindered or even made impossible if the requirement cannot be met.
- **Relevant citations:** Relevant citations from literature assessment highlighting key messages and important keywords.
- **Scope**: To which parts of the CLARITY outcome or expected results does the requirement apply
- **Applicability**: Whether and how is this requirement applicable to the current CLARITY work plan.
- **Impact**: Assessment of the implications on software architecture, technology selection, distribution aspects, difficulty of implementation, etc. and identification of additional background (concepts, technologies, products, …) that need to be considered by the project in order to deliver innovative products and services.

In absence of a detailed a focused market analysis, Exploitation Requirements have been elicited based on the following literature sources:

BK-001[3] - Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services
"The joint WMO, World Bank Group, and Climate Services Partnership book entitled "Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services" was launched at the 17th World Meteorological Congress on 28 May. The book aims to help Met Services develop a basic understanding of economic valuation methods to enable them to successfully design and commission economic studies. The book also supports the use of results from socio-economic studies to improve service delivery through optimizing business methods and improving communication with key decision makers." [10]

BK-002 - HIGH-END CLIMATE CHANGE IN EUROPE: Impacts, Vulnerability and Adaptation
"We are examining impacts and adaptation relevant to a number of areas addressed by policy: food, freshwater, forestry, coastal protection, nature conservation, urban areas and infrastructure, human health and foreign policy. We are also considering cross-cutting impacts, challenges and opportunities for transformational change as a response to multiple, interacting risks." [11]

DEL-001 - EU-MACS D1.1 Review and Analysis of CS Market Condition
"Task 1.1 – Overview of climate services markets and theoretical framework for market analysis' has the objectives to conduct a market analysis including the following elements: mapping the involved actors in terms of providers, intermediaries and users; devising a list of definitions of climate service products, sectors and sub-markets; reviewing market failures; assessing scientific progress and innovations in the value chain; current ways of climate services provision and use; Innovation dynamics; and product chains and provision modes" [12]

DEL-002 - EU-MACS D1.2 Existing Resourcing and Quality Assurance of Current Climate Services
"This deliverable concerns both providers and purveyors of climate services, currently supplying or re-using climate information and data. This Deliverable covers the output of Tasks 1.2 (collect knowledge

[3] CLARITY exploitation requirements are collected online, on the CLARITY catalogue web site. As a consequence, the literature references therein follow the "<TYPE>-<NNN>" naming convention and not the simple numbering schema that is used in this deliverable.

about and assess the financial value of the markets of climate services) and 1.3 (assesses the role and significance of quality assurance in CS), dealing with business model and resourcing, and with quality assurance respectively." [3]

DEL-003 - EU-MACS D1.3 Analysis of existing data infrastructures for climate services

"This report, Deliverable 1.3 of EU-MACS, explores how the existing climate data infrastructure inhibits or stimulates the European climate services market. The research presented herein informs the EU-MACS project with hypotheses around additional barriers and enablers to the climate services market stemming from the climate services data infrastructure. The research presented in this report comprise three individual subtasks based on literature review and the completion of a range of interviews with stakeholders involved in various aspects of the climate data infrastructure domain." [7]

PAP-001 - Conditions for a market uptake of climate services for adaptation in France

"This perspective paper reports the results of a collaborative survey of French research institutes concerned with environmental issues, which examined the potential for a market uptake of climate services for adaptation in France. Although the study does not allow to provide quantified estimations regarding the present and future size of the market, its results offer new perspectives with implications extending far beyond the sole case of France." [13]

REP-001 - Towards a European market for climate services

"This note summarises main messages arising from the workshop 'Towards a European market for climate services' (Brussels, 18 March 2014), flags possible follow-up actions and invites comments and suggestions from stakeholders for further informing the Commission's action."

REP-002 - A European research and innovation Roadmap for Climate Services

"This report will be a source of inspiration and reference for research and innovation policy and investments in the field of climate in the years to come, and will provide an essential contribution to achieving the EU objectives of an Energy Union with a forward-looking climate policy." [2]

REP-003 - Results of the stakeholder consultation for the Horizon 2020 Societal Challenge 5

"This document briefly summarises the main points raised by the participants to the public consultation, i.e. just a small proportion of all possible research and innovation (R&I) and environmental stakeholders." [14]

REP-004 - Horizon 2020 Societal Challenge 5: 'Climate Action, Environment, Resource Efficiency and Raw Materials' Advisory Group Report

"This draft report aims to identify future strategic research and innovation (R&I) priorities for the Horizon 2020 Societal Challenge 5 'Climate Action, Environment, Resource Efficiency and Raw materials' for the period until 2020. The AG recognized that the challenge is huge and, furthermore, it is linked to the other six challenges of H2020, especially: Health, Demographic Change and Wellbeing; Food, Agriculture, Marine Research and the Bio-economy; and Energy and Transport. It will be critical therefore to make sure that the design of activities across each of these challenges is not done in isolation from the others and that Societal Challenge 5 is part of the whole package of actions that, together, will make what can be described as the great transition to a low carbon sustainable future." [15]

REP-005 - Overview of climate change adaptation platforms in Europe

"This report provides an overview on the state of play of most adaptation platforms in Europe. It offers information on the scope, history, targeted users and funding models of the identified national, transnational and EU-level adaptation platforms. It also analyses existing and potential links of these platforms to climate services and disaster risk reduction (DRR) platforms. Furthermore, it identifies and explores challenges, reflections and lessons learned that are significant for platform developers and operators." [16]

REP-007 CSC Report 15 - Mapping of Climate Service Providers - Theoretical Foundations and Empirical Results: A German Case Study

"The aim of this document is to provide a guidance to support the climate service mapping activities in the JPI Climate member states and non JPI Climate members based on the experiences and lessons learned, including those learned in the initial pilot study in Germany. It provides examples, background information, supportive documents as well as results of this mapping activity and recommendations on

how to proceed. The aim of the mapping activities is to review the current capabilities for providing climate services, to lay the ground for a mid to long-term multi-disciplinary research on governance of climate services and to identify the areas, where working on European scale, that provide added value." [17]

REP-008 -CSC Report 17 - Adapting to Climate Change - Methods and Tools for Climate Risk Management

"This guidebook, Adapting to climate change: methods and tools for climate risk management, seeks to provide organisations with the information they need in order to understand the range of issues involved in adaptation, and to help them make informed decisions about how they may make progress with adaptation planning in practice." [18]

REP-009 - CSC Report 19 - Decision Support Tools as Instruments to facilitate Climate Change Adaptation

"The research objective of this thesis is thus to investigate if decision support tools can facilitate the process of developing, choosing and implementing specific measures to adapt to climate changes and what the requirements for the success of such decision support tools are." [19]

REP-010 - Monitoring & evaluation for climate change adaptation: A synthesis of tools, frameworks and approaches

"This report represents a synthesis and summary of frameworks for the monitoring and evaluation (M&E) of climate change adaptation (CCA) interventions, with a specific focus on international development projects and programs." [20]

REP-011 - Business Opportunities in a Changing Climate

"The Environment Agency encourages businesses to increase their resilience to extreme weather by preparing for the challenges of climate change and managing the risks effectively and confidently. This report is a 'call to action' to all UK businesses. You will read about UK businesses who are already responding to climate risks and identifying and taking opportunities. You will see how building climate resilience doesn't necessarily require additional expenditure. In fact, taking action makes good business sense and can have immediate benefits." [21]

REP-012 - Joint Report on Multilateral Development Banks' Climate Finance

"The MDB adaptation finance tracking methodology uses a context- and location-specific, conservative and granular approach that is intended to reflect the specific focus of adaptation activities, and reduce the scope for over-reporting of adaptation finance against projects. The approach drills down into the 'sub-project' or 'project element' level as appropriate, in line with the overall MDB climate finance tracking methodology. It also employs a clear process in order to ensure that project activities address specific climate vulnerabilities identified as being relevant to the project and its context/location." [9]

1. Develop a viable business ecosystem, business model and secure access to funding

In order to provide both free and commercial Climate Services it is needed to develop a viable business model and also to take into account how to update and improve CLARITY products and services (in terms of funding) - i.e., the design of incentives to operate, maintain and develop products and services beyond the project runtime. The starting point to develop the business model should be the description of the services in terms of value to be delivered to the customer. The results of the EC's public stakeholder consultations [14] that have been done could help to identify some of the potential customers of tailored Climate Services.

In addition, governments, development agencies and other stakeholders have to take into account not only the direct outcomes of new Climate Services, but also the value of socioeconomic benefits that will be provided by the aforementioned services. So public institutions should seek to acquire adequate financing in order to secure access to funding. To justify the funding needed, the business model should also analyse socioeconomic benefits to demonstrate how the benefits of new services are significantly larger than the cost to produce them. Besides, the use of business model will also help to take funding decisions for governments in order to invest in Climate Services.

Although overall we could consider two models to fund the Climate Services platform (by public money or by revenues from private business), there are also other mixed options such as public-private partnerships. The development of a viable business model should help to solve the problem to access to more elaborated Climate Services in terms of funding.

Finally, the development of a viable business model should show new customer segments, so private funding of Climate Services could increase in relation to public funding (which nowadays is significantly higher).

Rationale

The development of a viable business model is a key factor to exploit the outcomes after the end of the project. The initial version of this model should be updated during the project lifespan including the expected outcomes for the project partners.

The starting point should be the description of the products and services offered to meet the needs of the customers. Around a clear positioning in an attractive ecosystem, the model has to include the target customer segments and relationships, key partners and activities, and of course, the cost structure and revenue streams. The model has to consider the mutual interest (i.e., incentive) of key business partners to participate in the ecosystem.

The viability of the offered services should be analysed in this business model in order to find secure access to funding. Without a comprehensive development of the business model, including the analysis of funding sources, the exploitation of the project outcomes will not be assured once the project ends.

Scope and applicability

This requirement applies to all CLARITY outcomes in general. The development of the business model will cover all the expected results of the project including CLARITY Climate Services, data provided by the project or other products and services.

During a first stage of the project, it would be advisable to elaborate a business canvas model for each of the Climate Services. To create these canvases the recommendations of software engineers will be needed because choosing the right technology has a deep influence in the business strategy. On a second stage a detailed business plan for those Climate Services that are deemed more viable should be developed.

In terms of applicability, the requirement will take into account the expected outcomes of the project to consolidate the business model which will be needed to secure access to funding.

The requirement is covered mainly by task "T5.2 Exploitation Strategy and Business plan". This task will define the guidelines for the exploitation of the project outcomes, as a result the CLARITY exploitation strategy will include:

- The market analysis
- Exploitable results
- Potential user groups
- Suppliers
- Enabling means and tools for exploitation actions

Besides, this task will also provide an exploitation plan with business model definition and a financial plan. More technical issues regarding the provision of the implementation and hosting infrastructure are addressed in T1.4 "Industrialization and Support".

Implications

While securing the long-term maintenance of the platform through institutional funding, development projects or commercial exploitation of Climate Services is a matter of business development, the task of the co-design process is to produce products and services that are actually fit for exploitation. Therefore, this particular Exploitation Requirement can be considered a "meta-requirement" that covers all other requirements that must be met to allow for a successful exploitation of the project's results. Nevertheless, there are some implications on architecture and implementation that have to be specifically highlighted. They cover mainly the long-term **sustainability** of the CSIS, which can be achieved by the provision of a technological infrastructure that ensures **maintainability and extensibility** beyond the end of the project. This includes, for example:

- adopting state of the art **cloud and container technologies** to be able to transfer the complete CSIS to new hosting environment
- maximising the usage **open source software** for the implementation of ICT Climate Services to avoid licensing costs
- provision of a **development environment and continuous integration system** that eases common software maintenance tasks (e.g. bug fixes)
- **minimizing dependencies** to software and data that cannot be used after end of the project due to licensing, data protection issues

Related to the last topic regarding licensing issues is the need to clarify the role of (climate) data, which can only be used for non-commercial or research purposes.

Relevant citations

- The predominant vision in the public consultation focused on development of a **public-private Climate Services market**, based on free and open basic services. Building on this, small to medium-sized

enterprises (SMEs) and other businesses would provide **fee-based highly customised Climate Services** for specific needs/customers. *[REP-002, p. 14]*

- If provided fit-for-purpose, Climate Services are more attractive if they save costs or provide opportunities that can be monetarily assessed. **Businesses would pay for the entire consultancy process** and not for a Climate Service per se. *[REP-003, p15]*
- A critical determinant of what can be made available to users, and of the capability to update and further develop an adaptation platform is the **nature and amount of funding available**. There are a variety of funding models that have been used to support the development and delivery of adaptation platforms across Europe. These models — project based, policy supported and policy mandated — reflect the role and also the stage of development of the platform. Dependence on short-terms funding (e.g. typical of project based funding) can be challenging and limiting for available services. *[REP-005, p69]*
- So the challenge facing NMHSs is much more than that of mustering resources and achieving stability of funding for their infrastructure – their leadership must also foresee and plan for a wide range of social and technological changes and their implications for service provision and realization of the benefits available from effective use of the services. *[BK-001, p4]*
- National Meteorological and Hydrological Services (NMHSs), central governments and development agencies need to understand the full value of the socioeconomic benefits (SEBs) provided by hydrometeorological services, as well as the financial realities of maintaining modern operations and service delivery, so that adequate financing can be mobilized and invested strategically to ensure a significant impact of investment. *[BK-001, p9]*
- National Meteorological and Hydrological Services (NMHS) strive to maintain and improve the quality, diversity, and coverage of their services, they face challenges similar to other public institutions in **securing adequate and sustained funding**. To compete for and optimize the use of scarce public investment resources, NMHSs may be required to demonstrate that the **benefits of their services are significantly larger than the costs to produce and deliver them**. *[BK-001, p15]*
- Even within government, many investment-funding decisions are now taken on the basis of competitive business cases. Frequently, it will not be sufficient to demonstrate a positive return on investment in an NMHS; the return may need to be demonstrably higher than other potential investments seeking funding from the same source of public funds. *[BK-001, p28)]*
- Agencies and companies that pay for met/hydro services will most likely be interested in SEB analysis to inform their relationship with NMHSs, for example to gauge the fairness of the fees they are paying. International donors and financiers will of course be interested in understanding and determining the expected socioeconomic returns of their investments, and may require an SEB analysis as a condition of funding. *[BK-001, p28)]*
- When we look at how infrastructure depends on funding policy, most organisations that could achieve data curation with broad impact are usually funded for an end- product. However, funding would be better placed at the 'invisible infrastructure' level, where it might become useful only in a couple of years, but this would build the critical capacity of getting to a functional system for data and information exchange. Instead, (EU and global) project funding, and thus financed collaborations, are merely used as a way to keep up with developments. There are broadly two models for how Climate Services data infrastructure organisations are funded: by public money or by revenues from private businesses; mixed forms are not unusual (in terms of public-private partnerships on organisational level or in terms of using publically financed climate data for private business products). The question is unsolved as to how, under the prevailing market conditions, those who can't

afford to pay for more sophisticated services are able to do so. *[DEL-003, p 53]*

- Providers rated **business model development** the highest among the economic barriers related to advisory services, while overall this barriers is rated the least important economic barrier. *[DEL-001, p. 39]*
- Public funding of Climate Service activities has been hitherto clearly more significant than **private funding**, but this can change significantly, as more Climate Service **become operational** and **more user segments** get activated. *[DEL-001, p. 56]*

2. Offer free basic Climate Services based on free and open data

CLARITY intends to provide customized Downstream Climate Services to various stakeholders and customers by combining existing global and regional climate change related data (essential climate variables, economic/societal indicators, etc.) with other customer specific local and site-specific data, in line with CLARITY Objective 2 (“Maximize the re-use and tailoring of existing data, technologies and services”). To reach this goal, reliable, credible and quality assured Climate Data Services (Upstream Climate Services), like the C3S (Copernicus Climate Change Services) and CMIP (Coupled Model Intercomparison Project) data services, have to be integrated into CSIS. Therefore, it has to be ensured that these data services are both technically and legally usable for scientific as well as commercial exploitation.

Next to the integration of free and open-access data from Upstream Climate Services, from a business perspective CLARITY should focus on providing free and open basic services for capacity building at the level of final users for the purpose of scaling the overall CLARITY solution. On top of that, fee-based highly customized and added-value services with and for targeted users have to be provided in order to satisfy the users’ need for tailored information.

Rationale

It is expected that any exploitable project result will in one way or another depend on the usage of the climate data offered by Upstream Climate Services. Thus, for the long-term success of the project it is essential to base the CLARITY Downstream Climate Services on a reliable and trustful Climate Services that will continuously combine observations of the climate system with the latest scientific findings and achievements. However, often climate data freely available for research or educational purposes are not free for commercial use. This restricts the use of these data for commercial exploitation, unless potential customers of Climate Services are willing to pay for these data. Moreover, the uptake of Climate Services depends also on the provision of free Climate Services as observed for example in [22].

On the other hand, using fee-based climate information as input for (free) Downstream Climate Services potentially results in prohibitive costs for the service providers. A suitable approach to this dilemma, as suggested in [7], is to compromise temporal and spatial resolution for rather basic and general but free services and use expensive higher-resolution data and custom modelling to offer fit-for-purpose commercial services, only. Furthermore, we expect that "businesses would pay for the entire consultancy process and not for a Climate Service per se" [22], underlining the need for free, basic utilities (tools) in form of generic ICT Climate Services and additional tailored fee-based Expert Climate Services (e.g. consulting).

Scope and applicability

Upstream Climate Services provide essential climate intelligence that drives the whole project so it does apply to any part of the CSIS. The services need to be free to ensure their broad acceptance and to foster replicability of results within the realm of climate research and risk assessment.

The following main types of free basic Climate Services based on free and open data that fit within the scope, objectives and work plan of the CLARITY project can be identified:

- ICT Climate Services for basic and strategic assessment of infrastructure projects that offer basic risk analysis, screening and pre-feasibility studies and a proposal for common adaptation options. This relates to the high-level application of the CLARITY Modelling Methodology and thus the high-level version of the EU-GL modules. While the conceptual foundations, input climate data and (impact) models for such Climate Services are covered in WP2 “Demonstration & Validation” (Tasks T2.1 “Data requirements definition, data collection concept, demonstration and result validation concept”, T2.2 “Demonstrator-specific data collection”, T2.3 “Demonstration”) and WP3 “Science Support” (T3.2 “Climate Intelligence”) their technical realisation in WP4 “Technology Support” is covered mainly by T4.2 “Catalogue of elements at risk and adaptation options” and T4.3 “Scenario Management“.
- ICT Climate Services for scenario management that implements the EU-GL workflow and the CLARITY standard methodology, respectively. This relates clearly to T4.3 “Scenario Management“.
- ICT Climate Services for and local and individual Multi-Criteria Decision Support Analysis supporting different decision strategies, covered by T4.5 “Scenario Analysis, Decision Support and Report Generation”

Implications

As already recognized, main precondition for providing free, open and basic ICT Climate Services is the ability to use free and open climate data as input for some simple (impact) models. Copernicus CS3, for example, provides a consistent layer of data, data products, and model outputs in free and open access mode: "Through the provision (in a free and open access mode) of a consistent layer of data, data products, and model outputs, Copernicus Climate Change service (C3S) can support the development of a market, in which public and private Climate Services operators develop a variety of customised high added-value services with and for users." [2] Although CS3 is currently under development and will be fully operational by 2018, there exist several proof of concept sectoral information system (e.g. SWICCA - Service for Water Indicators in Climate Change Adaption (http://swicca.climate.copernicus.eu/) and UrbanSIS - Climate Information for European Cities (http://urbansis.climate.copernicus.eu/)), that can be used in CLARITY for providing both free ICT and commercial Expert Climate Service. The open data licensing schema allows exploitation of CS3 data both for free and commercial purposes. Technically, the integration of CS3 SWICCA and UrbanSIS climate data into CLARITY Data Repositories does not pose any problems as the data is freely available as download (netCDF Format) and via THREDDs data servers.

Regarding other (upstream) Climate Data Services like CMIP5, there might arise issues regarding the commercialisation of CLARITY Expert Climate Services. Some datasets can be used freely for research or non-commercial use, but have to be purchased for commercial use. Another issue that has not the be underestimated is the heterogeneity and lack of standardisation of climate data. While most climate data services offer NetCDF files, the actual data model encoded in NetCDF file format differs from dataset to dataset. Those issues have to be addressed as part of the data harmonisation and collection activities (WP2 and and WP3) and the assessment of licensing schemes and business model development (WP5).

Concrete technical implications on architecture, implementation and co-design of Climate Services can be summarised as follows:

- technology support has to provide **Data Repositories** that are not only able to store several Gigabytes of climate data but also provide standardised machine-level access (OpenDAP, WMS) to other ICT services and (impact) models. In order to reduce the storage capacity, a service **data-broker** may be used; this service would offer access to data stored by servers external to CSIS in an easy and transparent way for the user
- free but rather generic ICT Climate Services have to be implemented and offered through the CSIS. In order to be able to generate measureable benefits for external stakeholders, the services have to be provided as free, simple, ready to use and open-data-driven (open-source) software tools.

- generic ICT Services have to cover all-hazards, multi-risk and all relevant spatial and organisational scales to reach a wide basis of potential end users
- data-driven ICT Services that shall be offered for free should not depend on costly site-specific modelling, individual model execution, high performance computing or expensive local climate data
- ICT Services should be user friendly and simple, so that no or just little knowledge of climate change science or specific technical skills are needed to use them
- The role of the CSIS is recognized as to bridge the gap from supply driven (Upstream) Climate Services to demand driven (Downstream) Climate Services by offering free basic and generic ICT Climate Services and to help end users to identify and discover their need for fit-for-purpose commercial Expert Climate Services.
- heterogeneity of climate data and models is an issue that has not to be underestimated

The idea of simple and free of charge but credible and defensible risk screening ICT Climate Service leads to strong data requirements. Consequently data on infrastructure projects, elements at risk, climate hazards at pan-European scope, etc. so all elements that are needed to perform an out-of-the box pre-feasibility (high-level application of EU-GL) have to be collected processed by CLARITY. This includes also simple (impact) models at some kind of matchmaking (Scenario Transferability) to relate elements at risk to (generic) adaptation options.

On the software side, data storage and matchmaking can be partially addressed in the **Scenario Transferability** and **Catalogue of Adaptation Options and Elements at Risk**. However. there is the need to store and process additional types of data (climate hazards, project types, etc.) and of course also the user-specific pre-feasibility workflow. While the workflow part up to the **Scenario Management** which should support both the basic (high-level) and the expert (detailed) workflow, additional data storage facilities and possibilities for an automated execution of a limited number of (simple) impact models has to be foreseen in the CSIS architecture. This is currently not reflected in the original work plan.

The main challenge, though, is in obtaining the appropriate data that can be used free of charge for the basic services. For climate hazard information this might be rather unproblematic but for other types of data where no authoritative providers like CMIP5, C3S, etc. are available, it could pose a real risk. A suboptimal but still valid solution would be to collect this information from the user of the service at the cost of reduced convenience and simplicity.

Relevant citations

- In the Workshop, there was consensus among the participants that a market of Climate Services should contain a public together with a private dimension. **Free and open access** to observational data, in line with the GEO and the Copernicus data policies, should be ensured. However, **other socio-economic data sources** – like for instance market data – may **not be freely available**. The Copernicus services and part of those provided by national public sources will be free. This data and "first layer service" regime will trigger the growth of a business sector which, by adding proprietary data and intelligence, may provide **customised services** to a variety of specific users. The boundary between the "public good" dimension and the "private" one cannot be easily drawn up-front. It will be based on the natural evolution of technologies and of the skills and capacities of the various public and private service providers. *[REP-001, p. 5]*
- The operational '**Copernicus Climate Change Service**' is going to be launched during 2014, but will produce first products only in the next years. A close partnership between Horizon 2020 (Societal Challenge 5 and the Space programme) and Copernicus is being built, in order to ensure a constant flow of research results supporting the growth of the operational service. *[REP-001, p. 3]*

- A key element of a viable European Climate Services market rests in the delivering — by Copernicus and by national Climate Services centres — of a broad and **consistent layer** of publicly available (**free and open access**) data, data products, model results, indices and other climate-relevant information that other Climate Service purveyors (public or private) can use for **co-developing** a variety of **customised high added-value services** and service products with and for **targeted users**. *[REP-002, p. 20]*
- Providing **commercial Climate Services** may imply the need of elaborating **tailored information** on the basis of climate projections. In order to provide statistically credible data, the soundest scientific approach is using ensembles of model runs. However, still some of the model runs are **only available for research purposes**, and **not for commercial use**, or are granted free and open access only after an embargo period. This may constitute a **major barrier** to the use of state-of-the-art climate information in the provision of Climate Services. A fully **free and open access** to model products — or a short embargo period — would generate relevant added value. *[REP-002, p. 21]*
- Often data freely available for research is **not free for commercial use**. So, from a business point of view, in-built restrictions in public data business models negatively affect marketability. *[DEL-003, p. 58]*
- The service should be based on **free and open basic services**. *[REP-003, p. 7]*
- The predominant vision in the public consultation focused on development of a **public-private Climate Services market**, based on free and open basic services. Building on this, small to medium-sized enterprises (SMEs) and other businesses would provide **fee-based highly customised Climate Services** for specific needs/customers. *[REP-002, p. 14]*
- If provided fit-for-purpose, Climate Services are more attractive if they save costs or provide opportunities that can be monetarily assessed. **Businesses would pay for the entire consultancy process** and not for a Climate Service per se. *[REP-003, p. 15]*
- It is clear that if met/hydro products are not being used, they have no value. The value chain used in this publication indicates that value is only realized once information is collected, processed, delivered and a decision or action is taken based on the information. It follows that the more met/hydro products are used, the more value they will deliver. Efforts to increase use should therefore be pursued. To better enable provision of services to help protect life, property and well-being, certain meteorological data should be freely exchanged at the international level. As consumption under open-data policies is non-rival, the marginal cost of supplying information to additional users is close or equal to zero, and the costs of exclusion from use (that is, controlling proliferation of charged data) are too high, if not impracticable. Experience shows that an open-data policy, meaning information is both technically accessible and legally licensed to permit commercial and non-commercial use and reuse without restrictions (World Bank, 2014), tends to lead to a dramatic increase in the use of the data. *[BK-001, p. 128]*
- **Openness to exchange results of work within a community** is only one aspect of this task. Depositing or making them available through suitable channels within the community of climate data-related organisations is another task that needs strategy, contacts, efforts to document the data and virtual places to share. *[DEL-003, p. 48]*
- Basic data providers and Intermediaries (user, who process data further in order to provide Climate Services) cannot offer certain services, because **clients/users would not pay the price**. On the other hand, the provision of specific (qualities) services would require intermediaries to buy meteorological data where **costs are prohibitive**. Consequently, the spatial or temporal resolution can be compromised e.g., if data resolved on a daily basis are too expensive, then monthly data are used; the same

goes for spatial data resolution *[DEL-003, p. 57]*

- Often data freely available for research is **not free for commercial use**. So, from a business point of view, in-built restrictions in public data business models negatively affect marketability. *[DEL-003, p. 58]*

3. Demonstrate and communicate the (co-)benefits of Climate Services

In order to provide both free and commercial Climate Services it is needed to develop a viable business model and also to take into account how to update and improve these products and services (in terms of funding) - i.e., the design of incentives to operate, maintain and develop products and services beyond the project runtime. The starting point to develop the business model should be the description of the services in terms of value to be delivered to the customer. The results of public stakeholder consultations [ref] that have been done could help to identify some of the potential customers of tailored Climate Services.

In addition, governments, development agencies and other stakeholders have to take into account not only the direct outcomes of new Climate Services, but also the value of socioeconomic benefits that will be provided by the aforementioned services. So public institutions should seek to acquire adequate financing in order to secure access to funding. To justify the funding needed, the business model should also analyse socioeconomic benefits to demonstrate how the benefits of new services are significantly larger than the cost to produce them. Besides, the use of business model will also help to take funding decisions for governments in order to invest in Climate Services.

Although overall we could consider two models to fund the Climate Services platform (by public money or by revenues from private business), there are also other mixed options such as public-private partnerships. The development of a viable business model should help to solve the problem to access to more elaborated Climate Services in terms of funding.

Finally, the development of a viable business model should show new customer segments, so private funding of Climate Services could increase in relation to public funding (which nowadays is significantly higher).

Rationale

Especially in the private sector, the need to reduce risks and saving costs in the long term by using Climate Services is related to the lack of understanding on how these services can sustain productivity and reduce losses. Thus, businesses are currently geared to the free use of such services but would be willing to pay for them in the presence of demonstrable benefits, in particular the economic benefits (i.e. avoided future costs).

In the exploitation process, the demonstration and communication actions allow:

- *to prove the real value of Climate Services*.
  This involves tailoring services to more specialized applications and decisions or expanding the reach of an information product to ever-greater audiences (more people, decision makers, clients). The added value processes must also consider the ability of such services to operate as stand-alone services or as part of a sector-based support service;
- *to make known the Climate Services and their effective role,* taking into account not only weather factors, but also social, cultural, political and economic factors.
  How well the service is communicated to the user is one of the determinants of the rate of adoption of the Climate Services: better presenting the indirect impacts of climate change and the multiple

benefits of climate wise solutions can overcome the obstacles to the adoption of these services.

These actions, improving the interactions between potential users and providers of Climate Services, can:

- stimulating a deep reflection on climate change and their impact on organizations in order to identify a strategy that will guarantee the resilience of future activities to climate change;
- pointing out that the benefits of Climate Services are greater than the costs to produce them;
- showing that it is more convenient to prevent an event than to solve the problem caused by it. The cost of the action after the event is no doubt higher than the one to prevent it.

Scope and Applicability

A major barrier relevant to the uptake of Climate Services is, that added-value of Climate Services is often unclear and difficult to measure. Climate Services do generate economic and social value only, if the society and/or economy benefits from decisions and actions taken as a result of the information provided by Climate Services. Unfortunately, climate change adaptation in general and the Climate Services in particular are likely to be seen as merely additional cost factor by the relevant stakeholders and not as an opportunity. In order for CLARITY CSIS and the related Climate Services to be really successful, CLARITY as a whole has to demonstrate that using Climate Service(s) brings tangible benefits and that these benefits surpass the initial investment in those services.

This Exploitation Requirement applies therefore to CLARITY results in general. It is however particularly important for:

- The design of the CSIS in general and in particular the three demonstration cases as they need to be living demonstrators of the benefits of the CLARITY services (WP1 and 2)
- Activities validating the benefit demonstrators from socioeconomic perspectives. (WP4, 5 and 6)
- Activities for communicating project results to new stakeholders (WP6).

The requirement will be guiding the work in the following work tasks

- The co-design work in WP1, in particular T1.2 and T1.3, where all partners, technical as well as end-users, are involved in requirements specification and co-design of the CLARITY services.
- The design of the four demonstrators in WP2 (T2.1-2.2). These demonstrators will show the benefit of the system on four selected locations. These demonstrators will be made accessible and visible in the CSIS Portal / Marketplace, e.g. by linking, data, tools and ultimately Climate Services to case studies (CLARITY Demonstrators and possible others)
- Workshops with new stakeholder to advertise the benefit of CLARITY services. (T2.3)
- Task T3.5 "Economic and Societal Impact", will address this requirement. In this task, adaptation scenarios illustrating the economic and societal consequences of the implementation of different adaptation measures compared to reference scenarios are developed. This task will produce, on one hand, a comparison between adaptation costs and consequences of the expected impact and, on the other hand, the associated costs (including damages and other impacts) in the case of applying or not applying adaptation measures in each moment.
- Furthermore, a decision support component that is able to identify and quantify the associated socio-economic cost of each adaptation measure applying multi-criteria analysis will be developed in the context of T4.5 "Scenario Analysis, Decision Support and Report Generation".
- Finally, T5.3 "Social Innovation Assessment" will provide an assessment of the current and potential socio-economic impact of CLARITY and a related public report (D5.6).

In addition, Task T3.5 "Economic and Societal Impact" will address this requirement. In this task, adaptation scenarios illustrating the economic and societal consequences of the implementation of different adaptation measures compared to reference scenarios are developed. This task will produce, on one hand, a comparison between adaptation costs and consequences of the expected impact and, on the other hand, the associated

costs (including damages and other impacts) in the case of applying or not applying adaptation measures in each moment.

Implications

Two different aspects of realistic demonstration of the benefits of CLARITY Climate Service have to be considered:

- Demonstration on local / institutional / sectoral level by internal stakeholders (WP2) that present the results of the project-internal co-design process (WP1, 2, 3 and 4); and
- "hands-on" demonstration on aggregate/general level by offering ready-to-use tools (ICT Climate Service) to external stakeholders.

This translates in the main to the project internal and external usage of basic generic **ICT Climate Services** and the project internal usage of tailored **Expert Climate Services**.

The main implications on the **Demonstration Cases** are therefore, to

- design the Demonstration Cases so that they give a good impression of the benefits;
- add information on socio-economic benefits in the information used for the Demonstration Cases; and
- initiate workshops and stakeholder activities to reach the desired set of stakeholders and give a good demonstration of benefits.

The design process with stakeholders involved in the direct design of the CSIS, as well as, in workshops with external stakeholders will ensure that the design is beneficial for the end user. Additionally, the implementation of the Demonstration Cases must follow a common methodology that is supported by tools (ICT Climate Services) that are able to generate data-driven insights, e.g. in the form of (standardised) indicators that can be easily visualised (chart, diagram) on the CLARITY **Dissemination and Communication Platform** of the CSIS.

Besides workshop with external stakeholders, the main dissemination channel for communicating the benefits to a wider audience is the **CLARITY Community** on http://myclimateservice.eu/. Therefore**,** key to communicating the potential and actual benefits that the CLARITY Demonstration Cases can draw from the usage of CLARITY Climate Services is a modern and appealing visual presentation that exploits the possibilities of state-of-the art data visualisation techniques. Examples can be found at the Partnership for Resilience and Preparedness (https://beta.prepdata.org/) or weADAPT (https://www.weadapt.org/), a collaborative platform on climate adaptation issues.

Regarding the external "hands on" demonstration, the CSIS must allow external end users ("potential customers") to draw benefits from the usage of certain (free) ICT Climate Service. Those benefits have to be identified and clearly advertised in the CSIS. For example, ICT Climate Service have to demonstrate support a proactive stance towards risk management have to produce tangible results that manifest as reports, data, etc.

The main implication on architecture, implementation and co-design are:

- the Communication and Dissemination Platform must clearly advertise benefits for end users and dissemination experts should formulate and communicate these benefits, e.g. in form of online presentations and infographics (http://www.visualisingdata.com/resources), e.g. https://www.slideshare.net/ECFoundation/presentations. Thereby, relevant technologies for information visualisation (e.g. http://selection.datavisualization.ch/) have to be selected and integrated.
- the architecture has to distinguish between (internal) custom Expert Climate Service that are tailored to the CLARITY Demonstration Cases and (external/public) generic ICT Climate Service that are also directly usable by external stakeholders. Accordingly, the CSIS has to offer some free (basic) and easy-to-use generic ICT Climate Service with at least European coverage for a free to use high-level risk

screening as anticipated in the EU-GL.

- such ICT Climate Services have to produce tangible outputs for end users, e.g. reports and data in standard formats like SHP, NetCDF, PDF, ODF, etc.
- IT infrastructure and technology support as well as a **Marketplace** for Expert Climate Services is needed in the CSIS so that it is also beneficial for external Climate Service Providers to offer/provide their tailored Climate Service on the CLARITY CSIS.
- Expert Climate Services by external stakeholders should be easily integrated with generic ICT Services of the CSIS through a "data-driven" architecture. Thereby, data standards are important. This relates to the definition of standardised "**Data Packages**" which include the results of a complete climate adaptation study in standardised format.
- consequently, there is a strong need for an (meta-) information model for case studies (CLARITY Demonstration Cases) that is linked with the information models for Climate Services (marketplace offer) and their providers (**Service Portfolio**) and through indirection also with climate data and models, tools (provenance). This allows also for demonstrating the benefits of Upstream Climate Services (e.g. Copernicus C3S) by means of **Case Studies** (e.g. CLARITY Demonstration Cases).

Relevant citations

- Private sector expressed the need for Climate Services supporting them in the process of **saving costs and reducing risks** in the long term. In practice, some users have created their own capacities and most potential users have first of all expressed an **interest in free of charge services**. This indicates that businesses have not yet identified how Climate Services can help them to gain in productivity or avoid losses, and that more **interactions between users and providers** are needed. *[PAP-001, p. 4]*
- Value-adding processes involve **tailoring services to more specialized applications and decisions** (that is, **making the information more relevant and trustworthy**) or expanding the reach of an information product to ever-greater audiences (more people, decision makers, clients). The efficacy of the information is highly dependent on **communication processes** that influence the ability of users to **perceive, interpret and apply knowledge** as intended by the service or information provider(s). Such processes operate throughout the production, delivery and use of met/hydro information and are significantly affected by psychological, social, cultural, political, economic, institutional and other non-weather factors. *[BK-001, p. 22]*
- National Meteorological and Hydrological Services (NMHS) strive to maintain and improve the quality, diversity, and coverage of their services, they face challenges similar to other public institutions in **securing adequate and sustained funding**. To compete for and optimize the use of scarce public investment resources, NMHSs may be required to demonstrate that the **benefits of their services are significantly larger than the costs to produce and deliver them**. *[BK-001, p. 15]*
- In the context of growing the Climate Services market, improvements in data and information, modelling and decision-support resources should be those required to realise **meaningful and demonstrable benefits** for the intended users and their decision-making processes and decisions. *[REP-002, p. 22]*
- Users partly attribute the current slow uptake of Climate Services to the **lack of visibility of the current offer of Climate Services and their potential benefits**. Mediators of knowledge will be needed to meet this **communication challenge** and make connections among the different scientific and technological professional communities involved in Climate Services and specific sectorial activities. *[PAP-001, p. 4]*
- Ultimately, the value of met/hydro services is determined based on how (and whether) potential users **receive and interpret met/hydro information**, and how that information impacts or changes

their decisions and actions. The outcomes associated with these decisions/actions are then compared to the outcomes that would have occurred in the absence of the service. Thus, when assessing benefits, it is essential that the analyst understand the relevant components of the value chain within the context of the service being evaluated. Factors that may impact the behaviour of potential users and the rate of adoption of the met/hydro service being valued include: – How well the **service is communicated to the user**; – **Characteristics of the service** (for example, accuracy or lead time); – Decisionmaker characteristics (for example, risk aversion, or prior knowledge of information); – Decisionmaker environment (for example, government programmes and policies that might affect adoption of services, community norms); – Availability of resources and management options for changing behaviour in response to information. *[BK-001, p. 56-57]*

- From the purveyors' point of view, better assessing and **presenting the indirect impacts of climate change** and the **multiple benefits** of climate-wise solutions can overcome some of the identified barriers, and better market the services to clients. *[REP-002 p. 15]*
- A bulk of core, publicly funded data are expected to be accessible free of charge, but most stakeholders would be willing to pay for customised, integrated services, provided that they **bring demonstrable benefits**. Indeed businesses do already pay for Climate Services if this translates into **cost savings** *[REP-002, p. 17]*
- To this end, assessments are needed to **identify data and information sources of interest** (including data and information from in-situ and remote sources, from business and industrial sources, and qualitative information and traditional knowledge) where **integration will deliver demonstrable benefits to users**. Initially focusing on those sectors or decisions where early benefits could be realised, these assessments should lead to the development of **coherent sets of data and information** and identification of the means of integrating them into decision-making processes. *[REP-002, p. 22]*
- A critical aspect of growing the Climate Services market is demonstrating in a meaningful way the **added value of Climate Services** and their use in terms of **implications for decision-making processes** and the resulting decisions. Delivering such a valuation capability will require frameworks and guidance that clearly reflect the value from the users' perspectives in **different sectors and at different levels**. It will also need to include consideration of Climate Services operating as a **stand-alone service** and as part of a **sector-based support service**, as well as consideration of the means and criteria by which providers/purveyors value their services. Fundamental to delivery this capacity is the **engagement of the Climate Service community**, including in testing through pilot studies and validating and **communicating this capacity** through demonstration projects at different levels and across public and private domains. *[REP-002, p. 20]*
- This also includes investments in research and innovation needed to translate these improvements into relevant, usable, trustworthy and credible Climate Services (including their presentation and accessibility). Critical to addressing this challenge are the means to **link and demonstrate the added value of proposed and realised improvements** in science from the intended users' perspectives. *[REP-002, p. 22]*
- **Co-benefits** with existing business objectives. Adaptation may sometimes be seen as thinking about climate change that may happen a long time in the future, and as such, can often be deemed to be low priority, compared to other factors in the business environment, and thus not acted upon. However, starting a process of thinking about how an organisation may be impacted by a changing climate, and considering future risks, may lead to the **identification of strategies** or ideas which can have **immediate benefits to an organisation today**, as well as ensuring that future activities are more resilient in the face of change. *[REP-007 p. 14-15]*

- **Reputation and image**. Being seen to be in tune with, and responding to the issues of the day can be good for your image, especially if you operate in an environment where such issues are important, in terms of stakeholder relations, and consumer and public perception. Moreover, it can also improve your perception as being a good employer, helping to attract and retain good staff. *[REP-007 p. 14-15]*
- Cost effective. It is often more **cost effective** to deal with any business threats as they arise, rather than allowing them to **develop into bigger problems**. The cost of action after the event, or when changes become clearly evident is typically achieved at much greater cost, than **acting ahead of time**. *[REP-007 p. 14-15]*
- As the general awareness of climate change within society increases, investors are becoming more demanding of organisations, and increasingly want to see **climate risks disclosed and reported** in an organisation's risk profile. *[REP-007 p. 14-15]*
- **Monitoring and evaluation of processes and products**. Monitoring and evaluation procedures should allow – users as well as providers – to understand the extent to which a product is **delivering intended benefits**. The procedures will thus support adjustments to certain products. *[DEL-001, p. 31]*
- The three most important **reasons for not using Climate Services** are: Users do not know **where to get the service** or it is not available. The service is available but **provided inappropriately**. The services are **not understandable (too scientific)**. *[DEL-001, p. 41]*
- There are numerous items that may enhance cooperation across the boundary of climate sciences into other domains (e.g. the boundary between the practices of climate science and law), for example use cases that **show the value of Climate Services (i.e. the business value) to users operating in other, non-Climate Services, sectors** (e.g. aviation or road engineering). *[DEL-003, p. 7]*

4. Establish trust in Climate Services and their providers

Climate Service users search for reputable, trustworthy Climate Service providers, where their neutrality as well as the link to science is considered to be important. Furthermore, to establish trust in Climate Services and their providers, quality assurance and control as well as certification have to be addressed. However, widely accepted objective measures of the quality of Climate Services do not exists, complicating the validation or verification of the Climate Service quality. On the one hand, this highlights the need to develop standards, and on the other hand the need for transparency. The latter includes the standardization of data and methods, and the inclusion of version history and metadata so that users can track the decision for suggesting climate change adaptation measures and trace it back to the underlying data and models. Also robust data, and providing services based on state-of-the-art science contribute to a defensible analysis and product. Fundamental for the development of risk-based decision making is to phrase the Climate Service output in probabilistic terms. However, the more a Climate Service involves tailoring, non-climate data, advice or training, or the more the Climate Service users lack expertise in climate science and/or risk analysis the more the quality assurance should go beyond the statistical properties and climate data. Furthermore, clear quantification and communication of the uncertainties connected to different sources such as climate model output (related to natural variability, uncertainty in the climate response to a change in radiative forcing as included in the climate models, as well as uncertainty related to future emission levels) as well as socio-economic data and impacts, and hence the Climate Service, is needed.

Rationale

Potential Climate Service customers are first and foremost interested in products of neutral and reputable providers that deliver salient, objective, credible and defensible results, even "in light of the irreducible uncertainty about future climate change" [EU-GL]. It is therefore essential for the success of Climate Services to transparently report and inform on their characteristics and provision, both in relation the origin, quality and uncertainty of the underlying models and data and the methodological approach and processes which made them

Scope and applicability

This Exploitation Requirements is relevant for the project as a whole as it covers both the process as well as the actual outcome of the project. For example, quality assurance and control as well as certification have to be addressed during Climate Service co-creation already in order to establish trust in Climate Services among the users community. To enable users to assess the added value that Climate Services offer to their business, clear information needs to be easily available regarding the data sources, generation methods, version history and metadata. User perception is also influenced by the quality achieved by the service delivery. A useful approach to ensure user confidence in the products is the use of standards both for the components of the Climate Service and for the interfaces to access the information.

Furthermore, the project needs to be very visible and transparent throughout all project stages, discussing with other climate experts and getting in contact with the huge climate community in order to make them understand about CLARITY's aim and proceedings. It will be most important that the knowledge and trust of the community will grow during the lifetime of the project and also be fed into CLARITY's services and data

in order to foster trust through incorporation of external knowledge. Along with these issues, uncertainty, level of confidence, and likelihood should be considered when designing a trustworthy service.

CLARITY users will be able to objectively rank the adaptation scenarios according to explicitly stated decision objectives of the different stakeholders, taking into account key performance indicators including those related to uncertainties. This will allow the groups of stakeholders to understand everyone's concerns and agree on a compromise scenario which will -in the end- foster the confidence in CLARITY's services.

To move forward in establishing standards at European level, it is necessary to consider the existing results produced and published by the EC and by other related projects. In this respect, CLARITY WP2/3 intends to establish a scientifically sound and defensible standard methodology based on EU-GL so Climate Service providers following this methodology can be considered trustworthy.

WP1 task T1.2 (Climate Service Requirements) will formulate the first consolidated set of CLARITY User Stories based on EU-GL specifications and stakeholder's feedback. A key factor is that suppliers, purveyors, and users must be engaged in the co-creation of the service requirements.

T1.3 "Climate Service Co-creation" will be in charge of creating a system that fulfils the requirements defined in the previous task.

T1.4 "Industrialization and support" must comply with the platform requirements resulting from the development of tasks T1.2 and T1.3.

T2.1 "Data Requirements Definition" and T2.2 "Demonstrator-specific Data Collection" will define data requirements and will support data collection activities in the different demonstration cases. This will require collecting and storing all metadata since the first stages of the project, but also the use of the widely accepted standards.

T2.3 demonstration feedback obtained during the pilot cases will be essential to ensure that confidence is established between service providers and end users.

T2.4 (Validation) will be in charge of quantifying the satisfaction level expressed by service users.

Implications

This Exploitation Requirement can be translated into the following technical and functional requirements of the CSIS and its constituting elements, respectively:

- Users must be able to record the decisions that lead to the implementation of climate change adaptation measures and to trace them back to the underlying data and models. This relates mainly to **Scenario Management**.
- Quality assurance and uncertainty of the underlying data and models must communicated properly throughout the whole planning process. This relates mainly to Scenario Management and a potential **Catalogue of Data and Models** that has to include appropriate meta-information on quality and uncertainties. The data collection and harmonisation activities have to take this into account also.
- Climate Service providers have to disclose information on which data or methods they used to develop their Climate Service and how they dealt with uncertainties. This relates mainly to the Climate Service **Provider Portfolios** in the **Service Catalogue** / **Marketplace**.
- Quality assurance must be easily recognizable in the Climate Service Catalogue / Marketplace. Thereby, Climate Service quality could be defined as ability to deliver scientifically sound predictive information that support decision-making under uncertainty.
- Reputation, neutrality and trustworthiness of a Climate Service provider must be somehow reflected in the Climate Service **Provider Profile** in the Marketplace. This could include (moderated and verified) feedback from Climate Service users ("customer ratings") and links to scientific publications, talks, etc. Moreover, Climate Service Provider Profiles should also be linked to **Case Studies** that are

available in the CSIS (e.g. CLARITY demonstrators) as it for example done in Australia Governmental Marketplace (https://marketplace.service.gov.au/search/sellers/).

- Active participation of Climate Service providers in the Climate Service **Community** will help to establish a relationship of trust both in providers and Climate Services. Thus, Marketplace and Climate Service Community have to be connected so that a Climate Service Provider Profile in the Marketplace reflect Climate Service community activities.
- Data **Provenance Information** including information about the quality of the data, uncertainty, etc. as well as the process (model) which created them have to be attached to each dataset. Such Provenance information has to be considered in the information model of each element of the overall climate adaptation study workflow. This includes for example also the information model of elements at risk, adaptation options, etc. Therefore, the original information source of the contents **Catalogue of Elements at Risk and Adaptation Options**, other CSIS catalogues, and data stores must be disclosed transparently.
- As previously recognized, a (lightweight) Catalogue of Models and Data Sources (e.g. based on **CKAN**) is needed in the CSIS in order to be able to link to this Provenance Information. The information model for such a catalogue could be based on CKAN's standard meta-information model.
- The information model of the planning process that is implemented in the Scenario Management has to be based on the **World State Concept** originally introduced in the CRISMA project and adapted to the overall **CLARITY Modelling Methodology**, which integrates the EU-GL [2] with the IPPCC-AR5 [23] perception of disaster risk assessment and reduction.
- The complete planning process should be visualised, e.g. in a graph representation of data provenance information thus allowing users to easily trace back a decision for implementing a climate change adaptation to the underlying data. The technical implementation of a fully automated online visualisation graph could be based on one of the solution presented at http://www.visualisingdata.com/resources/. If it turns out, that the implementation of such a visualisation is too costly (in terms of effort) for the project, a simplified "offline" visualisation of the **Provenance Graph,** which based on the Scenario Management's **World State Graph,** could be part of a report.
- An information model for **Smart Links** (relations between entities that can be enriched with additional information) and in particular for **Provenance Links** is needed. This information model can for example also hold references to external information sources (documentation, papers, websites, etc.).
- Uncertainty should be quantifiable, e.g. derived from statistical properties. Then, uncertainty could be considered as an indicator that can be transformed (normalised) to criteria. This way, uncertainty could be incorporated into **Multi Criteria Analysis**.

If uncertainty can be quantified, it can also be visualised. The ukko project (https://truth-and-beauty.net/projects/ukko) presents an interesting approach for visualising uncertainty in geographic settings. Put simply, the approach uses different opacity level to provide an indicator for uncertainty. This could be adapted and implemented for example in the **Map Component** and Multi Criteria Analysis, e.g. by adapting the opacity of layers or graphs according to the attached (quantified) uncertainty.

Relevant citations

- Establishing **confidence** in and the role of uncertainty in Climate Services and decision-support systems. Assessment of the roles of uncertainties within decision-making (adaptation, mitigation and DRM), and means of increasing the effectiveness of uncertain information under different decision framings. Develop methods and guidance for interpreting and integrating uncertainties from **different sources** (e.g. those associated with climate, socioeconomic and impacts) as a basis for better

informing decision-making processes and decisions. Assess existing and develop appropriate methods and processes of including and **presenting uncertainties** that enhance the **effectiveness** and **robustness** of decision-making processes and the resulting decisions. *[REP-002, p. 28]*

- Uncertainty related to Climate Services is a major factor that needs to be specified. Framing of outputs in probabilistic terms is fundamental for development of **risk-based decision making** on mitigation and adaptation. European decision makers and businesses are currently lacking access to a consistent, authoritative set of high-resolution climate projections linked to impacts, and socioeconomic information for Europe. There is therefore a need to develop science to underpin a Climate Service prediction system for the European region. *[REP-002, p. 17]*
- An approach for handling risks and **uncertainties** related to Climate Services needs to be elaborated. This should address: a. How can the uncertainty be **communicated** b. Approaches for decision making given uncertainty, different decision rules c. Considerations of consumer and the private sector preferences given uncertainty and ambiguity *[REP-002, p. 48]*
- The risk analysis stage of risk management provides an estimate of the **likelihood** of a given event and its consequences. It is however also necessary to provide a statement on the **level of confidence** that may be had in the evidence, upon which the assessment of the likelihood and consequences is based. *[REP-008, p. 65]*
- The development of future climate information based on climate model outputs is confronted by **three sources of uncertainty**, related to: natural variability, uncertainty in the climate response to radiative forcing as represented by the models and greenhouse gas scenario or emissions uncertainty. The relative importance of these different sources of uncertainty varies with the time and space scale considered. The most common way in which we may try and quantify uncertainty is through the use of **probability**. This can mean specifying a percentile range or possible variation to be expected, through to generating full probability density functions. The way in which we **quantify uncertainty**, is important for the meaning we may attach to the results of any model or statistical analysis, and thus how this may be used and interpreted in informing the adaptation decision making process. This issue of quantifying uncertainty is relevant to the way in which we may generate information about possible future climates, and has implications for how we may go about developing adaptation strategies.*[REP-008, p. 76-77]*
- Climate service products should include **detailed descriptions of uncertainty**. Describe different kinds of uncertainties related to Climate Services (which includes structural uncertainties, condition uncertainties and parameter uncertainties) and how they 'limit' the usage of Climate Services. *[DEL-001, p. 31]*
- The development of Climate Services should be accompanied since the early phase by the **standardisation of data and protocols**, the development of a certification system and of **Quality Assurance methodologies**. Only this may allow to appropriately addressing potential legal issues in relation to the **liability of the operators** providing Climate Services. *[REP-001, p. 4]*
- Currently, no framework for the **evaluation of Climate Services** exists, which makes it difficult for users to identify high quality Climate Services; especially, when providers do not provide information on databases, methods used, etc. As mentioned in section 3.3, one goal is to **improve the quality of Climate Services**. This seems to be a very important question. The questions to be addressed might be the following: What are **indicators for the quality of Climate Services**? What will mechanisms such as e.g. **certification** of services achieve? How will these mechanisms be used? By whom and for what purpose? *[REP-007, p. 24-25]*
- Robustness of the data used is very important. In the cases in which there are no **robust data**, a

proper explanation on this is very important. The services have to be based in the "state of the art" science. **Meta-data** is important criteria. *[REP-007, p. 27]*

- Since users usually are not climate experts, it is difficult for them to **judge the quality of a certain Climate Service** . This becomes even more challenging as most providers (the majority being private providers) do not provide information on which data or methods they used to develop their Climate Service or how to deal with **uncertainties**. *[REP-007, p. 28]*
- A comprehensive evaluation of met/hydro services would cover **verification of service quality**, characteristics of service uptake by user communities and the **economic value** of services to user communities. These evaluations might involve ex-ante or ex-post analysis of forecasts with actual weather data to generate routine verification scores and/or customer satisfaction surveys to assess perceptions of service reliability and access. Together, these analyses can be used to support service improvements and **demonstrate reliability to funding authorities and user communities**. In addition to their utility in assessing service quality, **customer satisfaction surveys** are a tool used by NMHSs to understand who is accessing information, how that information is being used, and the experience of users in matching that information to their specific needs. *[BK-001, p. 24]*
- Quality assurance (QA) is not only a matter of control, but **just as much of communication**. The more a Climate Service involves **tailoring**, **non-climate data**, advice and training, or the more the user lacks expertise in climate and/or risk analysis the **more QA should go beyond the statistical properties and origins of the climate data**, and consider also **linking feasibility with non-climate data** as well as the service delivery process. **Broad scoped QA** (beyond climate data properties) greatly benefits from or even requires interactive approaches such as **co-design** of the Climate Service with the user – the so-called **open model** *[DEL-002, p. 60]*
- Quality assurance for predictive climate scenarios and broader analyses derived based on them is fundamentally different in nature when compared to other Climate Services. This is because the **impossibility of meaningful validation**. The long time scale of predictions makes direct validation by observations impractical and the unprecedented nature of current climate change compared to earlier climatic shifts makes it and out-of-sample event in terms of verification (also, only proxy data is available for most of climate history). Model performance can still be evaluated according to their ability to reproduce historical climates, but this validation approach seldom is independent as models are also calibrated according to most of them. Widely **accepted objective measures of quality of quality hence do not exist** and the issue of quality becomes more dependent on its definition and also the use context. For climate scenarios, **quality could be defined as ability to deliver scientifically sound predictive information that support decision-making under uncertainty**. Accordingly the following three pillars can be identified as the basis for the broad quality evaluation and assurance of climate scenarios: - **Scientific and technical rigor**: Climate scenarios should be produced using scientifically sound and technically reliable models that are based on up-to-date understanding and modelling of the Earth system. - **Diversity**: Instead of relying on one model or scenario, uncertainty can be addressed and to some extent quantified by using multiple models and runs. - **Transparency**: Assessing rigor and utilizing diversity requires transparency in climate model and scenario construction and communication. *[DEL-002, p. 86-87]*
- Climate service products should be **credible and defensible**. Provide information, **which data sources, methods, tools etc.** have been used or applied to develop a certain service. This information should be **well documented** and made available to users.*[DEL-001, p. 31]*
- Climate service products should be documented. **Metadata and version history** of certain products should be available to users.*[DEL-001, p. 31]*

- **Monitoring and evaluation of processes and products**. Monitoring and evaluation procedures should allow – users as well as providers – to understand the extent to which a product is **delivering intended benefits**. The procedures will thus support adjustments to certain products. *[DEL-001, p. 31]*
- The various shortfalls with respect to quality assurance have somehow all to do with the **access, comprehensibility, trustworthiness and accuracy of information**. From the professional and academic literature can be inferred a collection of measures that can help to improve these features: Awareness raising (by user group), Certification and standardization, Profiling users in terms of (initial) capacities and Mechanisms to promote learning. *[DEL-001, p. 40-41]*
- **Quality control, certification and standards** have to be addressed to reinforce the **relationships of trust between** offer and demand, which is crucial for a healthy market *[REP-002, p. 17]*
- Part of the framework needed to support growing Climate Services relates to **building trust** among users, provider/ purveyors and researchers, and providing a supportive environment that promotes and enables the development, delivery and use of Climate Services. One aspect of building trust requires being able to **evaluate and demonstrate credibility** and assure the quality of Climate Services and of those providing such services. Delivering these will include working with the Climate Service community to develop appropriate and meaningful **standards** and **quality assurance** and control mechanisms that are based on a needs assessment and testing of options. These standards and schemes will also require supportive governance and other structures and measures (e.g. training and capacity building, demonstration projects, and case studies) to promote and sustain their use and continued development *[REP-002, p. 21]*
- This applies to both providers and services. **Reputable, trustworthy sources** are sought by users, whereas the definition of what a reliable provider is varies significantly. However reputation, size of organisation, public character, independence, and closeness to the raw data generation process are recurring elements in the definition. **Reliability of services/information** is often assessed by direct experience (comparison with in-house information, historical data, past performances, etc.). *[REP-002, p. 16)]*
- The user should have available information related to providers' track record such as information on the **credibility and saliency of the service provided** and whether those services (and the provider) meet **recognised standards**. The user has to **trust in the expertise** and services of the provider. This is easiest for him/her if there is access to any kind of **verification** of the provider. *[REP-007, p11]*
- The reputation of the services providers and their **link to science** is very important. **Neutrality** of the service provider. There has been research to suggest that there are three essential elements to ensuring "actionable" climate knowledge. These essential elements are: saliency (the perceived **relevance of the information**), credibility (the perceived **technical quality of the information**), and legitimacy (the perceived **objectivity of the process by which the information has been produced**). *[REP-007, p27]*
- Each climate data set and the derived information has strengths and weaknesses due to underlying assumptions. To **communicate these characteristics transparently and saliently** providers should have an understanding of the specific sensitivities and capacities of individual users and supply advice about the applicability of the respective climate information *(Steiniger et al. 2012, JPI Climate 2011).*
- how to make information about the services providers more **transparent and accessible** and how to facilitate the contact between services providers and user: It is important to clarify to the users which institution is offering which service. Data provision should be linked to data communication. **Transparency of the data origin** is important. Therefore the **documentation of the individual steps taken**

up until the provision of the Climate Service should be visible *[REP-007, p. 27]*

- **Credibility** in the development of climate information and products, demands that efforts are made to report and inform on the **reliability** of different products, both in relation to the methodological approach, and the subsequent model results. The **legitimacy of the process** by which climate information and products are developed is related to the way in which the **needs of different users** have been considered and realised in the final product. *[REP-008, p. 87]*

5. Co-design Climate Services engaging a community of users, providers, purveyors and researchers

Developing, planning, constructing and operating (urban) large-scale infrastructure projects involves multiple disciplines and expertise as well as stakeholder with different roles and interest. User and beneficiaries of Climate Services are not a homogenous group or from a single discipline. Therefore, for Climate Service development and establishment a co-design approach engaging an enlarged community of researchers, providers, purveyors and end users suggests itself. The multidisciplinary community needs to be fostered on regional and European level and encourage cooperation among scientific sector, providers and purveyors and engage end users from public and private sectors in order to co-design and deliver fit-for-purpose services. Mutual understanding reveal end user challenges (e.g. tight timelines and budgets), their expectations and how they will use the services in their respective projects thus leading to "communities of practices" and trusted relations along value chains.

In order to reach the main relevant target groups and for service replication "good practices" need to be communicated sector specific and multiplicators have to be integrated. Commercial and societal success of Climate Services is driven by users as integral and equal partners in design and build-up of Climate Services as well as their engagement in the community. In order to create value (in terms of close connection between needs and offered services) it is crucial to understand the audience beyond purchase of parameters and data sets. An established multidisciplinary "community of practices" fosters trustful relations between researchers, providers, purveyors and end users from different public and private sectors and industries.

Rationale

Review and analysis of Climate Service market conditions processed in H2020 Project EU-MACS [12] reveal the perceptions of providers (supply side) and users (demand side) related with barriers relevant to Climate Service development (PESTEL Analysis; **P**olitical, **E**conomic, **S**ocial, **T**echnological, **E**thical, **L**egal Barriers). The analysed findings show that providers tend to rate barriers and their impact higher than users. Providers as well as users assess "limited financial resources" as the economic barrier with the highest (negative) impact on their Climate Service activities. This is considered the overall main barrier from providers' side. Users consider a technological barrier - lack of appropriate technology/technological capacity - as the most influential barrier for them (going hand in hand with their main economic barrier).

"Hotspot" for providers and users with considerable high rating are "social barriers" revealing room for improvements in communication: difficulties to involve different stakeholders, infrequent interaction between provider and user. In this context, it is interesting that users state that "different cultural settings in science and applications" have only low impact on their Climate Service activities.

Valuable insights about key barriers and enablers for a European Climate Services market were provided through interviews with a variety of professionals in the Climate Services field like consultants, researchers and public administrators for governmental organizations. Primary barrier specified across all questioned sectors is stated as general lack of awareness about the importance of Climate Service data on the customer/user side and the (potential) value of climate information related to commercial applications.

Recommendations for counteraction are improved communication methods (including sales skills for Climate Service providers) when interfacing with customer/users and "determining ways to convert climate information into an easily understandable format free of difficult-to-understand scientific jargon".

Pictured barriers can be tackled by establishing and fostering multidisciplinary collaboration (including sharing of technical infrastructure) and community building across the whole value chain and may pave the way for a pan-European ecosphere for Climate Services.

Scope and applicability

The scope of this requirement will mainly be considered in the co-design process for the general system (WP1) and the demonstrators (WP2) which aims to involve as many stakeholders as possible. In addition, it is captured by many of the objectives in the DOW:

- "Climate Service development will be facilitated by a bottom up approach with integral stakeholder and end user involvement (user-centred design). CLARITY Climate Services will be co-developed by city planners, consultants and providers of the climate intelligence and end-users from urban and regional planning as well as infrastructure providers." (DOW, Objectives, O3, 5)
- "to scale up the results of the project we will create and manage a CLARITY community encompassing the different stakeholder categories (see O3). The community will grow throughout the project to prepare the uptake and become a core of future sustainability. Communication will aim at creating awareness and interest for CLARITY results and activities and interest to join the CLARITY Community;" (DOW, Objectives, O5)
- "CLARITY aims to assure that the project results are turned into an operational and sustainable Climate Services deep-seated in the existing CC adaptation data and tools landscape." (DOW, Objectives, O6)
- "CLARITY Climate Services based on concrete user needs will be designed for the emerging market of “resilience by design” of (urban) infrastructure in direct support of a EC Guideline (EU-GL) that is likely to be taken up as the de-facto standard for planning climate-proof infrastructure in Europe. Dedicated community building and marketing activities will further push the market uptake of CLARITY and Climate Services in general." (DOW, 2.2.1. Expected Impacts mentioned in the work program)
- "New value chains will be established providing business opportunities also for SME in multiple sectors from planning and engineering services to auditing and finance industry. In particular, the purveyor type businesses involved in the project expect to significantly enlarge their capacity for serving the customers and generate new business opportunities." (DOW, 2.1.2.2 Job creation, strengthening competitiveness and growth)
- "CLARITY addresses broad and heterogeneous target groups; the classification in categories is a guideline for all participants to browse their respective networks for access to different groups and to contribute to the spread by providing contacts, visit and host events in their region and act as "ambassadors" for CLARITY as a whole and in their specific field of expertise." (DOW, 2.2 measures to maximise impact)
- One instrument for low-threshold involvement of practitioners and prospective follower communities will be an online Climate Services platform (working title "myClimateService.eu" (T5.4). Prospective end-users can fathom the benefits for their specific project and test the tools on their own, get in contact with the growing community and register for workshop attendance and consulting services.

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- Co-creation implemented in the work plan, own work package: "The objective of WP1 is to involve practitioners, suppliers, purveyors and technology providers, scientists and potential end users (customers) in the Climate Service co-creation and deliver the CLARITY CSIS software and workflows in support of the climate-resilience planning."

In the CLARITY work plan, the requirement will mainly be addressed in the co-design process described for in WP1 and WP2:

- The co-design work in WP1, in particular T1.2 and T1.3, where it is important that partners, technical as well as end-users, are involved in requirements specification and co-design of the CLARITY services.
- The design of the four demonstration cases in WP2 (T2.1 & T2.2). Here stakeholders and end-user will drive the development with input on their needs, and the work will be jointly carried out by end-users as well as researchers and technicians.
- Workshops with a larger group of stakeholders during the project that ensures that requirements and design of the system wider set of end-users. (T2.3)

Implications

Implications on software architecture and implementation are twofold as they both concern the project internal co-design process that is carried in close cooperation with stakeholders of the four CLARITY Demonstration Cases as well as an external co-design process involving external Climate Service providers and users that shall be supported by software (ICT Climate Services) and infrastructure (CSIS). Common to both variations of the co-design process are the need to provide a technical infrastructure and built environment that is shared between providers (developers) and users of Climate Services and to empower the users with the methods and tools that the providers use.

Regarding the internal co-design process, the practical implications are:

- follow an iterative rapid prototyping approach that delivers early results with limited functionality as basis for validation and further refinement. This is can for example easily achievable by providing mock-ups to end users at an early stage of the co-design process before the actual implementation starts. Popular tools for creating such mock-ups are “Balsamiq Mockups” (https://www.balsamiq.com) and Pencil (https://pencil.evolus.vn/).
- provide an easy-to-use technical collaboration platform that incorporates non-it expert users in the agile software development process and allows them to receive direct feedback from software architects and developers. Such a popular platform is for example GitHub (https://github.com/) which provides a simple yet powerful ticket system (GitHub Issues) that connects users and developers and thereby supports also traceability and quality assure.

Regarding the co-design process involving external Climate Service providers, the main implications on the technical platform (CSIS) are:

- allow external stakeholders participating in co-design of Expert Climate Services to easily request and exchange information needed to perform a climate adaptation study. This includes for example secure cloud storage facilities that are suitable for exchanging confidential and private data.

- be based on a well-defined and well-documented process (CLARITY Modelling Methodology) so that both users and providers of Climate Services are aware of the steps of the process as well as the required input and the required output
- provide possibilities to disseminate (possibly anonymized and aggregated) study results as case study or as input to other Expert Climate Services.
- integrate with the CLARITY community and the marketplace be able to involve also new stakeholders (e.g. data providers) during all phases of the co-design process

Relevant citations

- The role of the actual and potential Users of Climate Services has to be put up-front. *[REP-001, p. 4]*
- Multidisciplinary approach and innovation. **Cooperation** among providers, purveyors and users, as well as among physical scientists, social scientists, economists, behavioural experts, practitioners, software and interface designers is needed for prioritising research efforts, **co-design** and delivery innovative **fit-for-purpose** services. *[REP-002, p. 17]*
- Co-design and **co-production** of services engaging users, providers/purveyors and researchers. *[REP-002, p. 19]*
- The enhancing the quality and relevance of Climate Services challenge seeks to **engage users**, providers, purveyors and researchers to identify and provide through co-design, co-development and co-evaluation the improvements and innovations in Climate Services that are needed to better inform decision-making processes and the resulting decisions. *[REP-002 p. 21]*
- To develop a climate change services market, a need emerged to 'strengthen the provider-user interface, whereas currently there is only limited consideration of the products needed by the users. It is also necessary to create appropriate '**communities of practices**' and emphasise the co-design of Climate Services products *[REP-002, p. 14]*
- Stakeholders belong to **communities** and establish **relations of trust**. Strong linkages are observed between the world of consultancy and enterprise on one hand, and between academia and the public sector on the other. Relationships exist also between consultancies and the public sector (e.g. land use planning), but the **linkage** is weaker between academia and businesses. Enterprises act in **networks** and pose climate-related questions within their community of peers. **Existing communities** appear to be the appropriate entry point for the end-users of Climate Services. *[REP-002, p. 17]*
- Building capacities and '**communities of practice**'. Strengthening existing capabilities and **building the appropriate expertise at user, purveyor and supplier levels** will support the products and market development. Purveyors, in their capacity to **link providers and users**, and multipliers, such as networks, business organisations, **existing platform and communities**, front-runners and market/opinion leaders are key targets. *[REP-002, p. 17]*
- Central to strengthening the market for Climate Services is a sustained and supportive **European Climate Service community** within which **users, providers and purveyors, and researchers are engaged** to support a viable and growing Climate Services market across Europe. *[REP-002, p. 20]*
- While networking and communication amongst providers seems to be sufficiently developed, the existing communication strategy fails in **reaching the main target groups**. How can users be addressed in a more effective way? The **communication has to be user/sector specific**. A proper strategy is needed to identify and **integrate the multiplicators** of the most important sectors. Part of such a strategy could be presentations, workshops, consultancy, etc. Lessons learned from other countries would also be helpful to move forward in this field. The communication strategy should consist of web-based platforms as well as direct face-to-face communication. Important to note here is, that

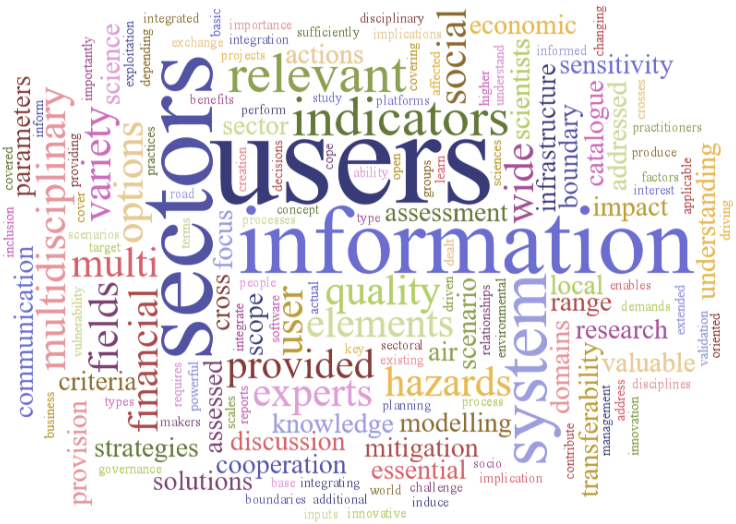
numerous platforms already exist leading to a non-transparent supply – which platform offers what for whom? It might be important for the future to either make clear, what the differences between platforms are, or to **merge different platforms and initiatives** to reduce their number. *[REP-007, p. 28]*

- **Understanding the audience** (users, clientele, market, customers, stakeholders), its problems, needs and perceptions, and use of existing products and services, is an essential activity for modern NMHSs and one in which **social science methods** play an important role. This inward-looking exercise should go beyond a simple shopping list of variables or elements (for example, temperature forecasts) and include reflective commentary on the following aspects of particular products and services: information/message content, attributes related to precision and quality, frequency, duration, format, means of distribution/dissemination, production and dissemination process, support services assisting with interpretation, competing/complementing products from other sources target audience, intended/expected use and historical evolution of the product/service. Differences in perceptions between those ;developing a product/service and those of the intended user audience may point to significant sources of untapped or poorly developed value (that is, disconnections between services and needs) *[BK-001 p. 186-187]*
- Overall, appropriate **involvement of stakeholders** was highlighted as a key element to identify users' needs, develop users' capacity and improve the exploitation of existing capabilities. *[REP-002, p. 14]*
- Broad scoped QA (beyond climate data properties) greatly benefits from or even requires interactive approaches such as **co-design of the Climate Service with the user** – the so-called **open model** *[DEL-002, p. 60]*
- Precisely here, we argue, **success or failure of Climate Services** will be determined: in our ability to view and practically **embed users as integral and equal partners in the co-construction of Climate Services** - be it direct collaboration in the development of services or indirectly connected to service just on the basis of "good contacts" and mutual willingness to interact. *[DEL-003, p. 43]*
- Engagement with users and co- exploration. In order to develop services that are fit for purpose providers should engage with their users to **understand and continuously update** their knowledge of methodologies and **context** the users is framed by. *[DEL-001, p. 31]*
- Providers, in contrast, rated 'methodologies for **stakeholder interaction**' the most important innovation. This is also reflected by the fact that '**cooperation between providers and users**' is among the least interfering barriers; users also rate this barrier as least influential. *[DEL-001, p. 31]*
- It is important that organisations responsible for the platform effectively **engage users in all phases of the platform development**, from design and implementation to maintenance. *[REP-06, p. 69]*
- A key element of a viable European Climate Services market rests in the delivering — by Copernicus and by national Climate Services centres — of a broad and **consistent layer** of publicly available (**free and open access**) data, data products, model results, indices and other climate-relevant information that other Climate Service purveyors (public or private) can use for **co-developing** a variety of **customised high added-value services** and service products with and for **targeted users**. *[REP-002, p. 20]*
- The **legitimacy of the process** by which climate information and products are developed is related to the way in which the **needs of different users** have been considered and realised in the final product. This involves having a sustained, mature, constructive, **two-way dialogue** between users and providers, where users can make their needs clear, and providers can **explain the status of the science** to meet these needs, and the implications for possible product development. *[REP-008, p. 87]*

6. Follow a multi-sectoral approach that crosses the boundary of climate sciences

In order to be able to provide valuable Climate Services for a wide variety of end users from different sectors and disciplines, CLARITY has to follow a multidisciplinary approach that

- encompasses multiple sectors and domains;
- crosses the boundaries of climate science;
- and facilitates the integration of both climate and non-climate information into an open knowledge infrastructure.



During the co-development process of Climate Services, it is therefore very important to consider merging essential climate data obtained from Upstream Climate Services with other sources of non-climate data and being able to integrate these data with various kinds of modelling and assessment tools to provide tailored adaption strategies and induce actions, that explore also cross-benefits beyond the need to adapt to a changing climate.

Rationale

The users that would be willing to pay for Climate Services are rather heterogeneous in terms of sectors, disciplines as well as actual needs. Providing Climate Services only that are general and generic may therefore not reach the relevant target groups. Furthermore, climate data alone is not sufficient for the provision of targeted Climate Services but has to be integrated with local data to address the specific needs of the users.

Scope and applicability

This exploitation requirement especially concerns the architecture of CSIS as a whole, starting from the co-creation process of the CSIS itself until the ongoing operation of the CSIS and the services it provides for end users as multiple experts from different sectors have to work together to provide the best and valuable results for end users which again might work in a variety of sectors and therefore have to base their decisions on a wide range of factors from a multiple of fields of study. This has already been anticipated in the setup of the project.

Implications

The general implication regarding co-design, architecture and implementation are:

- the CSIS must provide a multidisciplinary communication framework where users and producers of Climate Services within different sectors are not only able to exchange data but also to enrich climate with additional sector specific information.
- In order to follow such a multi-sectoral approach, the **Catalogue of elements at risk and adaptation options** needs to provide both a wide range of elements at risk which are related to many different sectors (e.g. road infrastructure, buildings, social, etc.), as well as a wide range of mitigation options. It might be that not all sectors are fully dealt with at the beginning; therefore, a community-driven mechanism by which the gaps are being filled is suggested. This challenge could be dealt with if the

catalogue enables users to provide their own elements at risk and suggest their own mitigation options, which then might be assessed by experts. Thereby, such user provided content have to follow the same quality and transparency standards as being used for essential climate data.

- As different user perspectives (depending on the sectors in which they work in) will lead to different solutions being assessed by the use of CSIS, the **Scenario Management** is required to be flexible enough to cope with this variety of possible solutions. This is heterogeneity challenge can only be addressed by enforcing standardised processes (CLARITY Modelling Methodology) and data formats (Data Packages)
- The scope of the **Scenario Transferability** concept could be extended beyond basic climate indicators so that end users could also discover "twin" regions within other sectors e.g. where the probability of certain hazards is similar to their actual project region. Furthermore, the Scenario Transferability concept could also be applied to the Catalogue of elements at risk and adaptation options so that the end users project being assessed can be matched to other projects that share the same elements at risk (covering a variety of sectors). The same could be true for adaptation options. By the use of Scenario Transferability, end users can search for and find other projects with the same proposed or already implemented adaptation options, in order to investigate further and learn from the experiences already made.
- Depending on the type of project as well as the sector and fields of interest of end users, the importance of different parameters will vary. E.g. For most project managers, financial parameters/indicators and information will be of higher interest, than climatic indicators and information by itself, while end users with a focus on risk assessment in order to keep people save will value indicators about the occurrence and intensity of climate related hazards higher, than financial parameters. In order to provide pinpointed information for all relevant parties, it must be ensured that the results and provided information suits their respective needs. If there is the need to rank different scenarios, this could e.g. done by implementing a weighing system for indicators (automatic per type of end user or end users set the weighting factors according to their preferences) for the **Multi Criteria Analysis**. With indicators, being part of the results provided to end users, those indicators must address all possible questions related to Climate Services end users might have. Therefore, indicators need to cover a wide variety of topics (climate, air quality, financial, social, etc.).
- Besides the possibility to produce a general/summarized report which contains the most important information, the ability of **Reporting Generation** to produce additional "extended focus reports" which addresses certain sectors (climate, adaptation, financial, people, etc.) in more detail, could contribute to always providing the most valuable information to end users without overloading them with information.

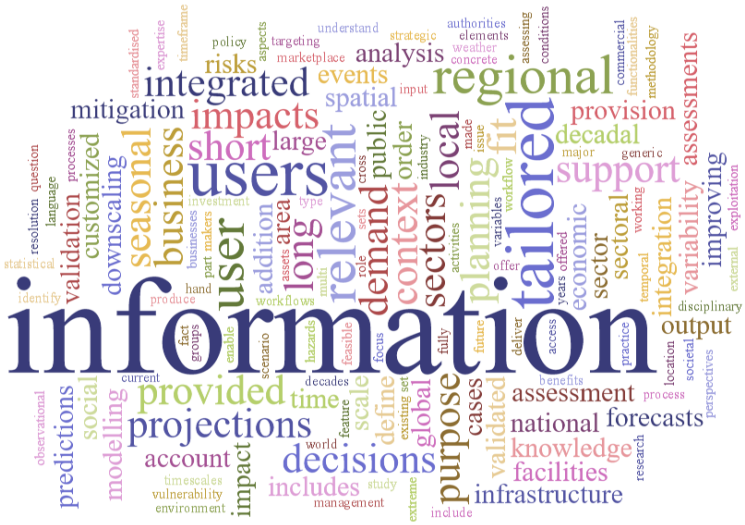
Relevant citations

- **Multidisciplinary approach** and innovation: **Cooperation among providers, purveyors** and users, as well as among physical scientists, social scientists, economists, behavioural experts, practitioners, software and interface designers is needed for prioritising research efforts, co-design and delivery of innovative fit-for-purpose services. *[REP-002, p. 17]*
- **crossing climate intelligence** with multiple data sources: Integrating climate information with **multiple data sources** and with user organisation logics, practices, existing processes and tools, and the other **socioeconomic criteria** determining decision-making. *[REP-002, p. 17]*
- Integrating climate data, information and knowledge with **multiple data sources and competencies** that are needed for informed decisions. *[REP-002, p. 19]*

- Bringing **users' needs and demands upfront** oriented the discussion more towards the 'service' dimension of Climate Services, which should not only provide a regular flow of data on the 'essential climate variables', but **merge those data with other sources of data** – most of which of **socio-economic** nature – and, most importantly, with various kind of **modelling and assessment tools**, **impact and vulnerability data** and **adaptation or mitigation solutions**, in order to be translated into useful and usable services. *[REP-002, p. 42]*
- While networking and communication amongst providers seems to be sufficiently developed, the existing communication strategy fails in **reaching the main target groups**. How can users be addressed in a more effective way? The **communication has to be user/sector specific**. *[REP-007, p. 28]*
- While the use of climate data may be of use to develop a broad understanding of possible ways in which a system may be affected under a changing climate, the question that really needs to be answered is: how will my system be affected by these changes in climate, and thus the ability to meet business objectives? In other words, we need to understand our system sensitivity to changes in the key driving variables, **both climate and non-climate**. If we have an accurate understanding of our system sensitivity then this provides powerful information which we can use to inform the development of adaptation strategies and actions. To obtain this system understanding we need a causal model, which describes either quantitatively, or qualitatively, the relationships and inter-relationships between the driving variables that are relevant to the functioning of a given system. A powerful way of obtaining more detailed information on the way in which a given climate sensitive system may respond to changes in climate is through the use of environmental modelling tools, which are sometimes also referred to as **climate impact models**. Impact models will typically be driven by climate variables, and other system relevant variables, and may offer some scope for the inclusion of socio-economic variables. These models may be used to perform sensitivity analyses to try and understand better the way in which a given system responds to climate, and should ideally be able to simulate or integrate the action of adaptation actions or strategies on the system function. *[REP-008, p. 83]*
- Recognized as crucial products in 2009 (World Climate Conference-3), Climate Services were originally developed using a top-down approach, mainly focused on weather forecasting and risk assessment (Brasseur & Gallardo, 2016). Given the interests and inputs provided by universities and research centres, Climate Services have only recently employed a **bottom-up approach**, covering a wider spectrum of **multidisciplinary** fields (social vulnerability, resilience and impacts). *[DEL-002, p15]*
- The ultimate task of a good data infrastructure governance is to emancipate it (from technical-technocratic restrictions of specialists' mono-disciplinary 'boundary working') into a '**knowledge infrastructure**' with **greater usability and real-world application by other sectors** (e.g. use of data by the mining sector). There are numerous items that may enhance **cooperation across the boundary of climate sciences** into other domains (e.g. the boundary between the practices of climate science and law), for example use cases that show the value of Climate Services (i.e. the business value) to users operating in other, non-Climate Services, sectors (e.g. aviation or road engineering).*[DEl-003, p. 7]*
- Establishing **links across sectors, scales and platforms** is significant for the provision of relevant and high-quality information. Furthermore, promoting **two-way sharing** and **exchange of knowledge between users**, platform developers, researchers, other adaptation platforms, policy fields like DRR and governance levels from local to international is recognised as a factor for a successful way of collaborating. *[REP-005, p.69]*

- To ensure salient climate information is developed demands that the climate related problems faced by **different economic sectors** are well known and explained before product development is embarked upon. This requires the gathering of key stakeholders and decision-makers from different economic sectors, together with scientists and other experts, to engage in a discussion, and to learn about their adaptation challenges. This engagement requires a proper discussion of the issues and possibilities for development of climate products, where the needs and requirements of users can be reconciled with what the science is currently able to deliver. *[REP-008, p. 87]*

7. Offer commercial fit-for-purpose tailored services targeting specific sectors and user groups



The success of the CLARITY exploitation process is strongly influenced by the type of Climate Services offered. CLARITY must offer commercial fit-for-purpose tailored services, targeting specific business sectors and user groups, in order to provide (or take into account):

- integrated and tailored information: Climate Services must produce integrated and tailored information in order to produce benefits for the users. Information has to be provided in the user's own language and logics and integrated into their priorities, business culture and working practice;
- short term (seasonal) projections: they can be relevant for decision making and a strategic use of Climate Services;
- information at regional level: for decisions of businesses, industry and local authorities, it is very important to take the regional perspectives of climate changes into account;
- sectoral assessment: the Climate Services targeted to specific economic sectors can contribute to identify the relations between the climate variations and sectoral economic impacts, as well as to define the relevant workflows, improving the risks reduction and a tailored usage of the adaptation measures;

In addition to the above, fit-for-purpose tailored services must take into account the social needs, which influence business activities and public decision-making.

Rationale

At present, potential demand for Climate Services is not fully developed because, in many cases, the services offered do not match with the services requested. The CLARITY exploitation process, offering fit-for-purpose tailored services, targeting specific sectors and user groups, can allow eliminating the actual distance between suppliers and users, focusing on the real demand. Users must be able to better understand and judge the features of Climate Services and whether or not they fit their needs and if they can be adopted in their planning and investment decisions. To be feasible for the users and support them in making better decisions, information provided by Climate Services must be coherent with the environment in which they operate.

In other words, in order to be completely satisfied, demand must be analysed with respect of the several user needs in terms of:

- specific context;
- temporal scale;
- spatial scale;

- business sector;
- level of integration; and
- social needs.

Scope and applicability

The this requirement is clearly related the overall Climate Service co-creation process that results in the provision of tailored Expert Climate Services, which are dealing with the detailed versions of the EU-GL modules and the CLARITY Modelling Methodology, respectively.

These Expert Climate Services would enable the interaction with the end users, as well as the context assessment and the provisioning of customized Climate Services. In addition to the above, short-term and long-term projections have to be taken into account. In fact, the CLARITY project is mainly oriented towards the infrastructure sector, dealing with adaptation planning for long-term assets, in line with the lifecycle of new infrastructure facilities. However, also climate variability, short-term weather forecasts and the impact of extreme events are important aspects that have to be considered in CLARITY CSIS.

CLARITY Climate Services will follow the "staircase" principle that is central to EU-GL to quickly and cost-efficiently determine how the project is sensitive to climate change in the first place and what types of adaptation options (if any) need to be considered before investing in fully fledged studies. CLARITY CSIS will feature support for:

- assessing the sensitivity of elements at risk (humans, buildings, infrastructure, etc.) in relation to a range of climate variables and secondary effects/climate-related hazards, addressed in the **T3.2** "Climate Intelligence";
- assessing the exposure of the project(s) and assets to climate hazards in the location(s) where the project will/could be implemented" in the **T3.2** "Climate Intelligence" to provide climate and environmental data for reference and adaptation scenarios, existing "historic" data sets, local context;
- assessing the vulnerability of the project(s) to current and expected climate conditions at the project site, addressed in the **T3.3** "Vulnerability and Risk Assessment";
- mapping of this new knowledge to concrete project(s) as well as incorporating the concrete calculations and expert opinions in order to estimate the concrete CC-related risks for the project at hand, addressed in the **T3.4 "**Adaptation Strategies and Decision Support";
- assessing the costs and impacts of different adaptation options for the concrete projects / elements at risk, addressed in the **T3.5** Economic and Societal Impact;
- provide requirement for the CLARITY marketplace addressed in **T5.4** Climate Service Marketplace.

Furthermore, **T2.1** "Data requirements definition, data collection concept, demonstration and result validation concept" will define data requirements to provide the Climate Services and preparatory work. It will provide a harmonized approach for data collection to support the transferability, scalability and replicability of CLARITY Climate Services in different EU contexts. This approach will be oriented towards the integrated management of multi-scale information in a GIS environment. It will define spatial units of analysis (model grid spacing, street blocks, etc.) with territorial level data (census data, land use, regional & urban climate model results, microclimate modelling results).

Implications

This exploitation requirement clearly identified the need for the provision of tailored and fit-for purpose **Expert Climate Services** that users are willing to pay for. An Expert Climate Service is an individual and professional consulting and advisory service that can be provided as joint venture activity of operational, technical and industry specialists. It may also involve project-specific analysis, custom data and model integration, site-specific numerical modelling and so on. If disseminated via the CSIS, such Expert Climate Services have to be provided according to specific rules and guidelines that are set out for the one part in the

CLARITY Modelling Methodology and for the other part in technical specifications that allow integration with the CSIS. Such technical specifications include for example an **Information Model for Expert Climate Services** that clearly defines the service level agreements and that can be related to elements of a Climate Service Providers **Service Portfolio** or a **Service Catalogue** in the CLARITY **Marketplace**. But technology support provided by WP4 cannot be limited to just managing information about Expert Climate Services disseminated (and sold) via the CSIS but also has to provide the (technical) means to actually provide such a Climate Service that fits into the CLARITY Modelling Methodology and the workflow induced by it, respectively. So **Scenario Management** whose primary objective is to guide the user through the standardised workflow of an Climate Change Adaptation Study has to provide also convenient functionalities for Climate Service Providers that deliver major input to the study workflow in form local data and models. This includes for example functionalities for supporting Climate Service Providers to deliver the (computational) results of their services as standardised **Data Packages** which neatly fit into the CLARITY Modelling Methodology (conceptually) and the CSIS (technical).

Additional implications on architecture and implementation include:

- easy technical facilities for external data and service providers to join the CLARITY **Community & Marketplace** and to offer their Climate Services have to be provided. This includes for example functionalities for creating Service Provider Profiles and Service Portfolios and to link them with other relevant information available in the CSIS. Thereby, rich meta-information is important to describe providers and services and to put into regional and sectoral context.
- easy technical facilities for external service providers to develop their Climate Services according to CLARITY conceptual and technical standards have to be offered. This includes for example convenient data (e.g. study results and model outputs) upload facilities that enable Climate Service providers that deliver their result in the standardised data formats recognized by CLARITY, to benefit from CSIS functionality for workflow integration, data visualisation, decision support, report generation, etc..
- data repositories (Thredds, GeoServer, etc.) for secured and controlled access have to be provided and technically integrated into the CSIS Infrastructure. Thereby, data protection is an important issue as such data exchanged between providers of paid Expert Services and the users of such services will in most cases not be made public, so secured access to the data repositories as to be ensured.

Relevant citations

- Integration and **framing of data** and information to support decision-making is fundamental to **enhancing the quality and relevance of Climate Services**. Effective decision-making must draw on a variety of physical data, **socioeconomic**, and other non-physical data and information. Their integration and framing to support decision-making processes, including impacts, vulnerability and risk assessments, are critical to improving the quality and robustness of decisions. To this end, assessments are needed to identify data and information sources of interest (including data and information from in-situ and remote sources, from business and industrial sources, and qualitative information and traditional knowledge) where **integration will deliver demonstrable benefits to users**. Initially focusing on those sectors or decisions where early benefits could be realised, these assessments should lead to the development of **coherent sets of data and information** and identification of the means of integrating them into decision-making processes. *[REP-002, p. 22].*
- At present there is a **dis-connect between supply and demand** for Climate Services so that what is supplied does not match what is demanded and potential demand for services is not fully developed. *[REP-002, p. 46].*
- Providing **commercial Climate Services** may imply the need of elaborating **tailored information** on the basis of climate projections. *[REP-002, p. 21]*
- A link to new and already existing data beyond the traditional scope of climate information could be

made. **Socioeconomic information** and planning data are very important here, and Eurostat and other statistical offices are key partners. *[REP-002, p. 47]*.

- The gap between large data sets and users need to be bridged (**cross-disciplinary expertise** in the data as well as user needs), and the service demand side should get a strong role ('the services have to reflect societal needs both related to business activities and to public decision making'. *[REP-004, p. 6]*.
- The service should be based on **free and open basic services**. Based on this, SME's and other businesses can provide 'fee-based, **highly customized Climate Services** for specific needs/customers'. *[REP-003, p. 7]*
- **Fit-for-purpose**. This is linked to the need for users to be guided in the scattered market of available resources, have information translated into their own language and logics, and integrated into their priorities, business culture, working practice and tools. Related to this is the demand for climate information that can be treated in economic/monetary term and thus play a role in planning and investment decisions. *[REP-002, p. 16]*
- In addition, there is a need for **tailoring Climate Services** to specific users or economic sectors. Users of climatic services for a **specific sector** consider that these services should not only provide the relevant climate variables and impacts, but also identify where the climate information can help them in their decisions, in order to ultimately build the relevant workflows improving the risk prevention and adaptation. *[PAP-001, p. 4]*
- focus on both the demand and the supply of the Climate Services market *[REP-002, page 19]*
- End users have access to large databases (such as CMIP5) but lack expert knowledge in using that raw data. Users are much more than just business and local governments – national and international level **policy makers** (i.e. mitigation as well as adaptation) are also users. There is a requirement, and emerging activity, to bridge this gap – shown here as **"consultancy services"** which might be through large data providers, but should also include many smaller services (e.g. SMEs) with **local or sector-specific expertise**. These consultancies will draw on information including, but not limited to, downscaled regional output and output from impacts models. There is a R&I requirement here for **cross-disciplinary expertise in both the data and the user needs**. "Climate Services" is much more than just this consultancy area – it has to encompass the whole spectrum and includes the components of science which provide the information to start with. It is also vital to ensure that the service demand side gets a strong role. The services have to reflect **societal needs both related to business activities and to public decision making**. *[REP-002, p. 45-46]*
- The nature of the service often relates to the conditions under which it is offered: to what extent are services provided **without charge to the user**, when are they **commercially available** and who is offering the service. Another question to be addressed is why as well as to what degree services are **generic or tailored to specific users' needs**. A service can either be provided in anticipation (**supplier driven**) or respond to a specific request of a certain user or user group (**demand driven**). As the demand of specific user groups, e.g. financial institutions, for climate information is growing, the amount of tailored services is likely to increase too. *[REP-007, p.9-10]*
- **Customised products based on generic ones**. Meteorological data on its own is not a Climate Service: the analysis, interpretation and formulation of this data for adaptation are very important. Results from climate models are not products but the interpretation and analysis of these models for particular processes. *[REP-007, p 27]*
- Typically there are very **few mass products in Climate Service** – mainly generic information on public www-pages. The real benefit of Climate Services realize in **tailored Climate Services**. There can be

some concepts of tailored services, but typically, services need to be tailored for specific location and time frame to be feasible for the user. *[DEL-002, p87]*

- Depending on the characteristics of the observational data set (e.g. spatial and temporal resolution), and the use or question to which they are applied, they may be more or less useful for their intended purpose. For example, if the task is to generate a climate baseline for a given region or country, an issue to consider will be the density of observational sampling in relation to the heterogeneity of the landscape within a region. If a given observational data set is sparsely sampled over an area of homogeneous relief then the data may be more suitable than if they are sampled sparsely over a more heterogeneous area e.g. with mountain ranges, major lakes, and/or major changes in land cover. To assist in answering such questions about fitness for purpose, it may well be necessary to consult relevant experts. *[REP-008, p. 74]*
- Demand needs to be seen in **context**: "Analysts need **climate-change data tailored to their location and context**" (NASA, NOAA, and OSTP 2016, 4). Climate Service products should be **fit for purpose**. Provide **tailored (to geographical and / or temporal) information** to the specific decision-makers needs. This also includes an appropriate and understandable language. *[DEL-001, p. 31]*
- Communication of value judgments and principles of practice Provide information that all allow users to better understand and judge the product they receive and whether or not it fits their needs. *[DEL-001, p. 31]*
- Scientific progress and Climate Service innovations should, in the end, lead to improved, **easier to understand**, **fit-for-purpose** Climate Services that support decision-makers making **better-informed decision**. *[DEL-001, p. 31]*
- Improving climate information/projections at regional level and the capacity to provide '**regional perspectives**' of changes, risks and impacts at timescales (seasonal to inter-annual to decadal) that were relevant for decisions to businesses, industry and local authorities. *[REP-002, p. 14]*
- **Short-term** weather forecasts and the impact of extreme events are in most cases considered very relevant for decision-making. **Long-term** climate change is either considered less relevant (with the main exception of sectors linked to mitigation policies and bound to GHG reductions) or, even if considered relevant, it proves difficult to integrate it into the decision-making/investment cycle. This asynchrony between the planning and investment time (or better, the time of return on investments) and the timeframe for climate change impact is among the main constraints to the strategic use of Climate Services. *[REP-002, p. 16]*
- Improving regional modelling capabilities, and the capacity to provide **regional** and **sectoral assessments** of changes, risks and impacts at timescales (seasonal to inter-annual to decadal) relevant for decisions to businesses, industry and local authorities. *[REP-002, p. 17]*
- While the timeframe for climate change impact goes from decades to centuries, the planning cycle is usually 20 years, and the **timeframe** for return on investments is often 3-5 years. This does not necessarily apply to the infrastructure sectors and other long-term assets, and is likely to change in the near future, when the **lifecycle** of new facilities will start spanning beyond 2050, when the impacts of climate change are expected to become more evident and important. This constraint is particularly relevant for the majority of SMEs, which in the current European economic scenario have to struggle for their short-term sustainability. In addition, the short turnover time for decision-makers (both chief executive officers (CEOs) and governments) reinforces this asynchrony between climate and decision-making cycles. *[REP-002, p. 17]*
- There will be demand for initialised near-term predictions as well as scenario-based long term predictions. R&I is required to make improvements in both, and also to combine both in a seamless

manner at intermediate timescales. Climate Services output will be both deterministic and probabilistic in nature, depending on the type of service considered and the question addressed. R&I is required into how to extract useful forecasts from model output, how to evaluate such output and how to communicate and use it. **Regional downscaling** of climate, mechanisms of climate variability and its impacts and risks of extreme events will become increasingly important to end users. [REP-002, p46]

- **Cross-border**, **regional** data should be generated in a consistent way *[REP-004, p14]*.
- The issue of adaptation to climate change is addressed internally by large companies (e.g., energy and transportation sector). Respondents justify this autonomous development by the fact that specific types of data are needed for each type of sector, whereas the existing portals and services delivered by public organizations remain **too generic**. In addition, there is a need for **tailoring Climate Services** to specific users or economic sectors. Users of climatic services for a specific sector consider that these services should not only provide the relevant climate variables and impacts, but also identify where the climate information can help them in their decisions, in order to ultimately build the relevant workflows improving the risk prevention and adaptation. *[PAP-001, p. 4].*
- Existing providers focus on different spatial scales for which climate information is provided: the local level that is a distinct area within a nation, the national scale, the regional scale, being determined as an entity that stretches across national borders and the global level What are we adapting to? Over the short term it is the impacts from weather events, whereas over the longer term it is adapting to both climate variability and change. These changes may be made manifest through changes in the incidence and magnitude of extreme weather events, or changes in the mean climatology in a given area. *[REP-008 p. 14-15]*
- Global climate models can be used to generate information for a few months ahead and these are known as seasonal forecasts; for the next decade - these are known as decadal predictions; or for many decades ahead i.e. 20-100 or more years - these simulations are known as multi-decadal or centennial projections. To date, most focus in adaptation planning has tended to use multi-decadal projections, which is a function of the relative maturity of this field, and data availability, compared to the seasonal and decadal projections. Seasonal forecasts have been shown to provide useful information in some parts of the world and are used to help people adapt particularly in developing nations. Decadal predictions on the other hand also have some skill in predicting certain climate variables and phenomena in Adaptation to Climate Change: Methods and Tools for Climate Risk Management certain parts of the world and/or at the global scale, however, these predictions are very much an experimental research area. As such, despite their appeal in terms of the time horizon for planning, a major amount of progress is needed in this area before they may be suitable for assisting with typical adaptation planning problems. *[REP-008, p. 74-75]*
- Global climate model outputs are not particularly well suited to the kinds of questions related to adaptation planning, owing to their coarse spatial resolution. In order to bring the results of global climate models closer into line with the needs of users, the global climate data may be downscaled. There are two main approaches to downscaling climate information to the regional level: dynamical and statistical downscaling. Dynamical downscaling uses regional climate models, whereas statistical downscaling can proceed via a range of methods, for example regression analysis. A precondition for all downscaling however, is the realistic representation of large scale circulation patterns from the driving GCMs. *[REP-008, p76]*
- In the form of long term projections and supporting information, Climate Services are conceived as

facilitating adaptation and mitigation, by timely producing, translating and delivering meaningful climate data and knowledge for decision-making purposes (Board on Atmospheric Sciences and Climate, 2001). In addition so-called seasonal projections represent another branch of Climate Services aimed operational and tactical planning in private and public sectors, for which seasonal variation in meteorological conditions has consequences for costs and/or sales (which can be understood as adaptation to climate variability). In summary, Climate Services can be input for coping with climate change (through adaptation – including adaptation aspects in mitigation), as well as input for coping with climate variability (in current and future climate). *[DEL-002, p17]*

- While mitigation practices found a relatively successful window of opportunities so far, on the other hand, due to the hitherto large challenges to infer meaningful signals above ~40 0 latitude in Europe, seasonal climate projections are a quite new product forcoping with climate variability. *[DEL-002, p19]*
- The latest development of climate model simulations have encouraged national activities to investigate into **national climate scenarios**. National climate projections are a set of **government approved descriptions of future climates** in a specific geographical area covering one whole nation. *[DEL-001, p. 42]*

8. Consider the role of new regulatory frameworks in stimulating the emergence of Climate Services

The vulnerability of urban and transport infrastructure to climate change and its effects depend upon a variety of factors, including the type of infrastructure in question, its location, design, age, relative usage and the particular climate change risks to which the infrastructure might be subject. Furthermore, resilience of infrastructure to the effects of climate change depends, at least in part, upon the applicable existing EU and national regulatory frameworks and the extent to which those frameworks foster adaptation to climate change by reducing or eliminating the risk of harm or damage now or in the future.

These regulatory frameworks need to address the risks that climate change poses for such infrastructure, not just in the short to medium term, but also for the duration of the whole life of the infrastructure. Besides, they also need to address the considerable uncertainties associated with climate change, including the location, nature, timing and severity of climate change impacts or events that may occur.

The regulatory frameworks offer a range of instruments that could be particularly useful in facilitating adaptation of the infrastructure to climate change, including:

- **Performance-based standards**, which provide flexibility to respond to the uncertain effects of climate change.
- **Technical standards or guidelines** for new and existing infrastructure to ensure that such infrastructure is designed, constructed and operated in a way that is resilient to climate change risks.
- **Codes of practice**, which could be used to ensure that climate change risks are accounted for as part of ongoing management and operation of existing infrastructure.
- **Licences, approvals and accreditation**, which can be made conditional on adequate assessment and management of climate change risks.
- **In-built risk assessment processes**, which provide an opportunity for climate change risks to be included in existing regimes for risk assessment.
- **Computer-based modelling tools** to assist targets of regulation with assessment of climate change risks and, therefore, compliance with adaptive management regulation.
- **Fitness for purpose obligations** that could be used to ensure that infrastructure has been designed to cope with current and future climate change risks.
- **Market mechanisms**, which can flexibly and dynamically account for climate change risks in determining the most efficient allocation of resources affected by climate change with limited government intervention.
- **Incentives to drive changes** in practices to better account for climate change risks.
- **Stakeholder engagement** in the design and implementation to foster support for climate change action.

Rationale

At present, there is a lack of tools that can support infrastructure planners and stakeholders to check and meet compliance of their projects with EU and national regulatory aspects. Under these new regulatory frameworks, companies and public administrations participating in the elicitation of new (or maintenance of existing) infrastructure projects, are likely to be required to demonstrate that their project plans are climate-change resilient. CLARITY Climate Services enables for these actors, supporting them in the assessment and documentation, in an methodological (by means of the EU-GL guidelines application) and transparent manner, the possible vulnerabilities and risks of climate change in the project as well as what adaptation measures are to be applied to mitigate its impacts.

Scope and applicability

This requirement applies mainly to the CLARITY CSIS in general and the Report Generation in particular. Although this exploitation requirement affects the whole CSIS, it should not have a major impact on it in the sense that CSIS concept is already based on the idea of providing to infrastructure project managers various semi-automated tools that follow the EU-GL guide modules.

Implications

This Exploitation Requirement has mainly (technical) implications on **Report Generation** functionality as the overall architecture and implementation follows the **CLARITY Modelling Methodology** that is based on guidelines [2] and thus EU regulatory frameworks. The final result of a climate adaptation study is a report that should be (semi-) automatically generated. Report Generation can be fed by a Data Package, a **Reporting Template** and should then be able to output a report following a specific structure. Content validation is, however, on-trivial. Therefore Report Generation functionality will be limited to structural aspects of reports.

Depending on the type of the study, either pre-feasibility or expert study, the report will also contain input from **Expert Climate Services**. Report Generation functionality can therefore also be provided as part of an additional and possibly free **ICT Climate Service** so that also “external” Climate Service providers that are not directly connected to CSIS can benefit from reporting functionally if they follow CLARITY’s conceptual and technical standard. As side effect, this opens the CSIS for additional Climate Service providers and will boost the uptake of CLARITY standards.

The implications on architecture and implementation can be summarised as follows:

- template-based Report Generation has to be implemented based on free and open source software like JasperReports (https://community.jaspersoft.com)
- simple templates for reports have to be defined. This requires an assessment of regulatory frameworks and their requirements. Besides the omnipresent EU-GL [2], this includes for example also the methodology for tracking climate adaptation finance of Multilateral Development Banks [9].
- (semi-) automatic Report Generation depends on well-defined input that can validated, aggregated and visualised. Therefore, technical standards for the respective input formats (Data Packages) have to be defined and communicated to external stakeholders that want to use CLARITY Report Generation functionality for their Expert Climate Services.
- All datasets included in the Data Package that are provided together with the accompanying report document must enclose the corresponding metadata records so that external parties are aware of who, when, how (including information about the uncertainty) and for what purpose the data was produced.

Relevant citations

- Climate adaptation is undertaken to lower the current and expected risks or vulnerabilities posed by

climate change. For a project to be counted towards Multilateral Development Bank (MDB) adaptation finance, it must:

  - a. Set out the climate vulnerability context of the project;
  - b. Make an explicit statement of intent to address climate vulnerability as part of the project; and
  - c. Articulate a clear and direct link between the climate vulnerability context and the specific project activities. *[REP-012, p. 8]*

- Continuing the **integration of adaptation in the regulation** and in public and private tenders so that private actors can take ownership of the challenge of climate adaptation, and translate their investments in this field by an improved offer and competitiveness when responding to such tenders. *[PAP-001, p. 4]*.
- In the first case, users face difficulties in applying the regulation and writing call for tenders, because no **guidelines** are provided to identify the needs to be fulfilled in priority and the methods to be applied to assess vulnerability to climate change. Conversely, **methodological documents** were made available by the state to evaluate present and future coastal flooding risks, so that the difficulties are essentially related to the availability of data and the choice of appropriate modelling frameworks, which coastal managers are used to deal with *[PAP-001, p. 6]*.
- The order of Climate Service demand: it all begins and ends with what the user needs, questions and concerns are. Demand for Climate Services is also born out of **legal obligations**, e.g. to account for climate change effects in urban and infrastructure planning; Legal obligations might increasingly explicitly specify that information on climate risks should be integrated in decision making or practices (such as in urban planning and permitting). Implied motivations owing to market led or **legislative accountability for damage and/or malfunctioning** (such as failure minimisation in networks). *[DEL-003, p. 44-45]*
- Many EU Member States have legislation in place, especially in relation to land use, urban planning, water, and physical infrastructure, that obliges or at least strongly recommends to **account for effects of climate change**. Yet, the legislation or guidelines leave often a lot of leeway to the sector or regional decision makers how rigorous and with what kind of information the climate change impact and adaptation assessment is carried out, and consequently there is **no strict obligation** to use Climate Services or assure a certain **quality level** of these services – hence **standards are set by how the practice develops**. In the finance sector emerges interest in defining **national and international reporting obligations** with respect to exposure to climate risks, which encompasses both asset value risks of climate (mitigation) policy and various value loss risks related to climate change impact. *[DEL-002, p. 62]*

9. Provide a user-friendly, intuitive and context-aware discovery and communication infrastructure for Climate Service

For maximising impact and uptake, the CSIS, which is CLARITY's main dissemination and exploitation platform, has to provide user-friendly, intuitive and context-aware discovery and communication mechanisms for Climate Services. To increase user experience and usability for non-experts, the user interfaces of the platform should not presuppose any specific technical skills or deep knowledge of climate change science. Usability in this context also means to hide the complexity of the underlying scientific and technical infrastructure and to find an intuitive and easy way to present an information and service offer that is both relevant and valuable for the specific end user. This goes hand in hand with an improved (visual) presentation of information, products and services and context-aware discovery functions. Thereby, CLARITY should not develop yet another general climate portal, but seek to integrate the CSIS with existing climate (data) portals to initiate a transition from mere climate data to relevant information and services.

Rationale

The analysis of the different reports revealed many deficiencies of existing Climate Services portals that can be attributed to the current slow uptake of Climate Services. In particular, the key barriers to user uptake are related to some portals being not designed with the user in mind, non-intuitive and inconsistent complex navigational schemes and search functionalities, information and service presentation that exceeds the knowledge of a novice or non-expert user and a rather unclear definition of the actual Climate Service offer. EU-MACS D1.3 [7] states for example that, "most websites do not provide navigational schemes or search functions that support data discovery. If a user is generally searching for a climate variable and does have a specific data set in mind, the process of data retrieval is likely to be cumbersome or even prohibitively complex.". The lack of usability and the lack of the end user's ability to discover relevant Climate Services and to assess their value pose real risks for exploitation of the CSIS and the associated Climate Services, and therefore have to be addressed by this Exploitation Requirement.

Scope and applicability

In CLARITY, this requirement is addressed by the following tasks:

- User requirements in terms of discovery, visualization and reporting needs: Tasks T1.2 Climate Services Requirements, T5.4 Climate Service Marketplace
- Implementation and integration of the different building blocks involved that cover this requirement: T1.3 Climate Services Co-creation and T1.4 Climate Services Industrialization and Support (integration of WP3 and WP4 results), and all WP4 tasks.

Implications

Being able to present a relevant and valuable service offer demands for a new information and service discovery approach that is quite different from a "traditional" search- and catalogue navigation paradigms. Thereby, the challenge is to take user context (sector, professional profiles, etc.) into account. The **CLARITY**

Community encourages users to register and create user profiles that contain sector information, professional background, etc. However, this also has to work in the absence of detailed user profiles, that is, when little or no information about the user is available. Thus, the information gathering process needed to drive the discovery engine must be embedded into a workflow that fits the user's needs. Consequently, the CSIS has to establish a goal-driven contextual discovery approach that is tightly coupled to CLARITY's Modelling Methodology and the respective workflow of a Climate Change Adaptation Study. At each step "module" in EU-GL terminology) the **Scenario Management** that actually implements the basic or expert workflow, has to present information on additional suitable context-dependent and fit-for-purpose local and sectoral data or providers that are able to generate such data. This includes of course also potential Expert Climate Services and their providers, respectively. When linked to the **Marketplace** such a discovery approach that recommends relevant content opens new exploitation possibilities.

The main implications on architecture, implementation and co-design can be summarised also follows:

- ICT Climate Services that allow direct user interaction should be developed according concepts for usability and for human computer interaction with help of state-of-the art technologies for user interface design. This demands for modern and lightweight web applications rather than heavyweight and complex desktop applications.
- a good balance between scientific accuracy and simplicity has to be found that hides complexity from non-(climate change and risk management)exerts but still signals credibility to experts. For example, the (novice) user should not be forced to make a choice for a specific emission scenario or circulation model. Nevertheless, this particular information has to be given in the provenance information of the respective Climate Services.
- 'machine-learning' practices could be used to leverage the transition from data to information (data communication) and identify implicit relationships, which in turn improve the overall discovery process. Thereby, each usage of CLARITY ICT Climate Services by end users represents an interaction among (not only climate) data and will lead to information enrichment. As an example, the Database of Infrastructure Projects / Elements at Risk and Adaptation Options can be improved on basis of (pre-feasibility) studies performed by the users (user generated content). In consequence, automatic discovery (matching) based on user input, e.g. during pre-feasibility study, requires to following (user-provided information) information to be collected: sector (energy, health, infrastructure, ...), project type (road network, city planning, ...), spatial location, types of elements at risk, etc.
- this type of 'automatic discovery by **user context**' requires a rich set of meta-information for each relevant "object of interest" and **Smart Links** between them.
- the source code of the various visual modules to be implemented/integrated in the CIS web client(s) must be tested against the different browser flavours available in the market (i.e., Firefox, Chrome, Safari, Internet Explorer) in order to ensure that they run smoothly and free of incompatibilities in each them. To that end, plugins for the Jenkins(https://jenkins-ci.org/) Continuous Integration service like Selenium(http://www.seleniumhq.org/) allowing carrying out such automated tests will be used in the development phase.
- the new discovery process has to follow the EU-GL process and the CLARITY Modelling Methodology, respectively: present matching services, data, case studies, etc. at each module step.
- discovery and matchmaking (**Scenario Transferability**) should not be limited to the CSIS (Marketplace) but also provide links to partner portals like Climate-ADAPT (http://climate-adapt.eea.europa.eu/) or Upstream Climate Services like SWICCA (http://swicca.climate.copernicus.eu/). Thereby, contextual information (e.g. spatial location, climate hazard, sector, ...) should also be used (e.g. by means of HTTP GET parameters or deep links) to direct the user to relevant information (e.g. guidance documents) and data (provenance).

- the CLARITY EU-GL-based approach, should allow project planners to quickly establish (in a visual manner) the configuration parameters for the project assessment, including the possibility to select previous projects as boilerplate. Previous projects could be contributed as (anonymized) user generated content by others users of the free ICT Climate Services for pre-feasibility analysis.
- The different steps proposed by EU-GL should be presented to the user in a "story" manner, allowing him to go back and forth, assessing in a visual manner (i.e, maps, graphs, tables) the consequences of the decisions he/she makes in each step.
- **Reporting Generation** should enable the user to easily access and download draft and final reports packages at the end of the project assessment process. Such report packages should include automatically generated documentation (with embedded supporting tables, graphs and maps of the study area) together with all the datasets (**Data Package**) used in the study in order to be further used in other stages of the planning project.

Relevant citations

- Users partly attribute the current slow uptake of Climate Services to the **lack of visibility of the current offer of Climate Services and their potential benefits**. Mediators of knowledge will be needed to meet this **communication challenge** and make connections among the different scientific and technological professional communities involved in Climate Services and **specific sectoral activities**. *[PAP-001, p. 4]*
- Developing **common Climate Services portals, building on the existing ones**, so that potential users are supported in their efforts to integrate climate data in their practices. Here, research in the field of **geographic information management** is needed to ensure that the different types of databases (climate, soils, impacts. . .) can communicate and be used in distributed systems of systems. *[PAP-001, p. 6]*
- Attention should be paid on how the ownership of a service platform can be structured in a way where **data is open source**, and business creates tools and custom designed products. A mainstreaming approach should be developed, where **Climate Services are related to other planning issues and GIS based information**. *[REP-002, p. 47]*
- Climate Services philosophies sometimes seem to pin all hopes on **either a good portal or a good set of aides**; the solution, however, seems to be more of a **combination of both**, plus a good overview of available data sources, functional methods and active human (personal/personnel) engagement facilitating how users interact with both portals and aides. It makes sense that **free and open climate data is made accessible through a portal** (e.g. Copernicus C3S) when **flanked by support and tutorials** that enhances inclusivity of a broader user base. Portals need to **increase user experience to maximise impact**. Freely available data, when it is not combined with appropriate levels of support, can be problematic. *[DEL-001, p. 7]*
- The EC has recently financed several large studies around various aspects of its flagship earth observation programme, Copernicus, which highlight important findings relating to the **need for communication infrastructure development**. One study focussed on developing the Copernicus user uptake strategy indicates the data and information access is a key barrier to user uptake. The study also highlights the fragmented nature of this corner of the overall infrastructure – in highlighting the fact that Copernicus portals are not centralised and are dispersed over several websites. Furthermore, the study finds the Copernicus websites lack content which reflect the knowledge levels of the users, and provide a limited amount of information for private sector stakeholders. The study suggests several solutions: a Data Access Information Kit could be provided to potential users at conferences and

events, **open data discovery functions** on the data portals could be enabled, and portals could be **more user friendly**. *[DEL-003, p. 17]*

- **Peak-portal may have been reached**. Although there is still much to be achieved in developing data access sites for specific user segments (e.g. the mining sector who have specific data needs) we may see increasingly diminishing returns in the value of launching more 'general' climate data portals. *[DEL-003, p. 31]*
- **MORE PORTALS DOES NOT INCREASE USER UPTAKE**. The survey focused on a few observational data portals from very large and international organisations. However, more portals do exist and even more were announced or launched while work on this report was being carried out. While the provision of access to observational data is a desirable aim, **the sheer amount of options to access it becomes almost confusing**, especially when several portals carry, for example, the same observational data from the same satellite missions. Some confusion could be avoided by having **clear statements** on each portal **regarding intended user groups and explaining overlaps with other portals**." *[DEL-003, p. 41]*
- In many cases **finding data sets was a cumbersome task** that involved numerous steps that could otherwise be minimised or avoided. For example, complex registration processes that involve numerous or complex questions are roadblocks that are a deterrent for users who wish for quick and expedient data access. *[DEL-003, p. 38]*
- For what follows, the leading question is how **climate data is bound into interaction between various actors and things**. Furthermore, when data is used, actors need knowledge on how to use the data, how to read the data, how to link it to problems to create new insights – and thus, **data becomes information** (data charged with knowledge about what it means) **and it will be communicated**. *[DEL-003, p. 44]*
- The order of Climate Service demand: **it all begins and ends with what the user needs, questions and concerns are**. Demand for Climate Services is also born out of legal obligations, e.g. to account for climate change effects in urban and infrastructure planning; *[DEL-003, p. 44-45]*
- In addition, we know that **users need to link climate data to various other data** (economic, geographical, historical, medical, etc.), and thereby **create new information** in which climate data are only one aspect. This means not only scientific vs. other rationalities may clash or have to learn to link up, but also inner scientific, interdisciplinary gaps need to be overcome, as well as distinct logics of different professions. Only if there is capacity, will, and capability, the communication can take place and meaningful climate intelligence be developed. Linking to other datasets, however, does raise important challenges for **data management, conventions, and quality insurance**. *[DEL-003, p. 46]*
- Updating the platforms requires striking a balance across three aspects; to select the **information that is most relevant** for decision-making on adaptation; to present the **most up-to-date scientific knowledge** on adaptation; and to **consider the available human and IT resources**, including those of the intended users. *[REP-005, p. 69]*
- There are numerous items that may enhance cooperation across the boundary of climate sciences into other domains (e.g. the boundary between the practices of climate science and law), for example use cases that **show the value of Climate Services (i.e. the business value) to users operating in other, non-Climate Services, sectors** (e.g. aviation or road engineering). *[DEL-003, p. 7]*
- Climate Service providers are **not always easy to identify** as they do not solely advertise their services as Climate Services, and may use different terms. This is due to the broad range of Climate Services offered and their dynamic development. Thus, there is **no standard key word that could be used to**

identify Climate Service providers through an internet research. The best way to identify Climate Service providers is to look into existing initiatives, such as dedicated Climate Service providers, co-ordinators of research projects, national programs, regional activities and their partner institutions. *[REP-007, p. 9]*

- Organisation of information: In several instances in order to retrieve data, users are prompted to search by satellite mission or instruments. This assumes that the users' knowledge goes beyond the climate parameters that they are searching for. **This search prompt is likely to exceed the knowledge of a novice user** and maybe even that of many professionals. *[DEL-001, p. 39]*
- Jargon: Abbreviations and technical terms are used frequently throughout the websites. The use of **jargon alienates the layperson** (as well as perhaps experts from related fields) and suggests that the website is catered to a highly technical user group. Supporting materials, including guidance, are generally available on all the websites, however they are **written in technical terms** and assume a **high level of pre-existing knowledge**. These guides are therefore catered to an experienced audience and do not **support the non-experts** in understanding how to use the data. *[DEL-001, p. 39]*
- **Role-specific data finding aides** (e.g. effective search functions and clear navigation), offered with real **human interactive support**, are crucial for successfully establishing and maintaining data provider/ user relationships. *[DEL-003, p. 7]*
- **SITES AND PORTALS ARE NOT EASILY NAVIGATED**. Most websites do not provide navigational schemes or search functions that **support data discovery**. If a user is generally searching for a climate variable and does have a specific data set in mind, the process of data retrieval is likely to be **cumbersome or even prohibitively complex**.
    - Navigation scheme: Several websites presented **complex navigational schemes** that were **not intuitive and inconsistent**. On several websites, the site maps were confusing and did not (directly) lead to areas where data could be accessed. Further, it was easy to get lost within the pages on the website.
    - Search function: most of the websites offered search functions, however they did not always **generate relevant results**. *[DEL-003, p. 39]*
- Typically, a "search is conducted without **taking into account such context as professional profiles, work goals, data provenance**", whereas now there is an emergence of a situation where "relevant aspects of data attributes, tools/services functionality and deployability, context, provenance, researcher profile and goals, etc." are becoming increasingly common. *[DEL-003, p. 39]*
- Key to findability is the "capability to quickly and accurately identify and find data that supports … requirements" (CNR-ISTI 2012, 56): data discovery, which includes data classification, dictionary, metadata registry, inventory. The same is true for tool/service discovery (including tool/service description, registration, and mediation support along the process of using). *[DEL-003, p. 48]*
- Enhancing the **quality and relevance of Climate Services** will require the development and introduction of service and product innovations — such as **data visualisation, processing interfaces, web tools, applications (apps)**, etc. —, in the form of sets of **standard tools, products and protocols, along with knowledge sharing protocols**. Testing and validation of these innovations should lead to demonstration projects and case studies that should promote and enable their use, and support the development and promotion of further innovation. *[REP-002, p. 22]*
- Rather than better science, most interviewees advocated **practical, solution-oriented instruments**, such as **sectorial guidance** and best practices, success and business cases, **user-friendly tools** and learning materials. As an interviewee said 'sophistication of models is already beyond sophistication of users' *[REP-002, p. 16]*

- A **strong provider-user interface is necessary** *[REP-003, p. 7]*.
- There needs to be a clear translation from the 'raw' data to data that **fits the needs of the user**. Not only business and local governments should be considered as users, also national and international level policy makers (e.g. mitigation as well as adaptation) should be taken into account. *[REP-004, p. 6]*.
- **Capacity building** is important in order to bridge the gap. Several solutions are highlighted: 'providing general knowledge to the demand side on diverse climate-related information and modelling, taking account of **different time scales** for different uses', 'mapping stakeholder interest related to different planning issues and business creation and to achieve leadership by including the private sector, governments, insurance, and Public Private Partnership needs', 'identify and target the right actors […], who are knowledgeable how to deal with the Climate Service information, including dealing with uncertainties & serve as quality multipliers to the respective sectors'. *[REP-008, p. 8]*
- In general, a Climate Service user is considered an **individual or organization with responsibilities for decisions and policies in climate-sensitive settings**, to whom some form of climate information is delivered. According to Review and Analysis of Climate Service Market Conditions this definition, users can be expected to be **decision-makers in businesses and the policy area and / or public administrations on various levels from local to international**. This notion of a user is also reflected in the value chain depicted in the Roadmap. In addition, societal actors are included in the Roadmap called 'public / society'. **Societal actors**, for instance, could be media, non- governmental organizations or other non-profit-organizations such as industry bodies. *[DEL-001 p. 18]*
- present better quality scientific data and determining ways to convert climate information into an **easily understandable format** free of difficult-to-understand scientific jargon for target clients *[DEL-001, p. 36]*
- SITES AND PORTALS ASSUME A HIGH LEVEL OF EXISTING KNOWLEDGE. The level of knowledge that these websites presuppose of users is generally very high, which suggests that the **portals are not designed with a lay user in mind**. There was a strong tendency for websites to be catered to an expert user base and not to novice users or those who did **not have a clear objective of what they were looking for or how to find it**. This is shown through the organisation of information, the use of jargon and supporting materials that are catered to an expert audience. One needs to be an expert, or at least an experienced user to access data. Non-proficient data users will have a **challenging time locating specific data sets**, and understanding how they can be used. *[DEL-001, p. 39]*
- **SITES ARE NOT DESIGNED WITH THE USER IN MIND**. The websites generally follow a 'loading dock' approach rather than a customer service approach. This means they do not appear to offer features that allow users to expediently **access data sets of value and relevance**, but rather host the data and present users with the task of having to find the data sets. *[DEL-003, p. 38]*
- Climate science, which is a **highly specialised and sophisticated** array of various disciplines, produces climate data, which is far beyond everyday users' capacity to process, presupposes a high level of data processing expertise; in addition, the background of users in different disciplines and professions together create a real threshold with regards to **knowing how to use climate data**. *[DEL-003, p. 38]*
- The information presented on adaptation platforms must take into account the **different levels of adaptation knowledge and IT capabilities of users**. The **relevance and usability** of the platform is **critical to the successful uptake** of the information presented. *[REP-005, p. 69]*

10. Use, define and promote open standards for data and services

The development of the CLARITY CSIS and CLARITY Climate Services, respectively, must be accompanied by the usage, definition and promotion of open standards for data, protocols and services from the very beginning of the projects. On the one hand, this includes technical interoperability and information exchange standards which refer to the structure, content, format and semantics of data used and produced by Climate Services. Here, special attention has to be paid to the compatibility of these standards to existing infrastructure and tools of actual end users and potential providers of Climate Services. On the other hand, this includes also standards for service provision and quality assurance procedures. In particular, CLARITY has to face the challenge of integrating climate change research results, risk and impact assessment concepts and decision support tools into a well-defined standards-based service offer under the umbrella of the de-facto standard methodology for climate proofing of vulnerable investments.

Rationale

The usage of standards is a basic requirement for achieving technical interoperability of products and services and for facilitating collaboration between producers and consumers of those services. Likewise, the EU-MACS project's "Review and Analysis of CS Market Conditions" [12] recognized that "missing standardisation of information" is one of the highest technical barriers related to Climate Services and that "standardization [...] can make use and cooperation across (end)users easier". Besides those technical benefits of standards which are vital for the realisation of a complex and distributed ICT system like the CLARITY CSIS, also the economic benefits of standards and their contribution to the market uptake of climate services substantiates the importance of this Exploitation Requirement. Economic benefits of standards are discussed in depth in the report "The Economic Contribution of Standards to the UK Economy" [6]. Among others, the report highlights that standards "help businesses to enhance the quality of their products and the efficiency of their processes", "play a vital and often invisible role in supporting economic growth through their role in boosting productivity and innovation" and "facilitate innovation by creating the environment for the development of new products".

Scope and applicability

This Exploitation Requirement applies therefore to CLARITY results in general. It is however particularly important for the CLARITY Modelling Methodology ("EU-GL + IPCC AR5 + Risk Community") and thus the standardisation of the related processes and involved data.

According to the standardisation plan of the TaToo FP7-ICT project [24], a standard can be defined as a formal specification that builds the uniform vision of a process, method, practices or technical issues. Commonly, the following types of standards can be identified:

- A de facto standard is produced when a product, convention, technology or system has achieved a dominant position by public acceptance or market forces. A facto standard generally becomes the basis of a standardisation initiative that can produce a consortium recommendation or a de jure standard.

- A de jure standard is emitted by entities with legal power in a national (i.e. BSI, ANSI) or international (i.e. ISO, CEN, IEEE, W3C) scope.
- Consortium recommendations are given by groups of companies with a high level of relevance in a specific domain, suggesting a specific technological element to satisfy a particular necessity.

CLARITY will identify and if possible adopt the current standards relevant to the scientific and technical domains of project. Technical standards are mainly related to climate information and are identified in WP2 as part of the data collection and harmonisation activities and will also be reported in the next version of CLARITY's Data Management Plan [25]. Standards regarding processes and methods are represented by a standard Modelling Methodology that is developed in WP3 on basis of the EU-GL [5] and a unified disaster risk management concept recently adopted by IPCC.

Although T5.2 "Exploitation Strategy and Business plan" mentions standardisation as one example activity of an exploitation strategy, there is no dedicated task and resources regarding standardisation foreseen in the CLARITY work plan. Therefore, the project does not aim to pursue the lengthy and complex process of producing a de jure standard. However, standardisation has been identified as critical to the success of Climate Services. Therefore CLARITY aims at establishing the technical and conceptual specifications developed during the course of the project as consortium recommendations or even as de facto standard.

To move forward in establishing standards at European level, it is necessary to consider the existing results produced and published by the EC and by other related projects. In this respect, CLARITY WP2/3 intends to establish a scientifically sound and defensible standard methodology based on EU-GL so Climate Service providers following this methodology can be considered trustworthy.

Implications

This Exploitation Requirement can be translated into the following technical and functional requirements of the CSIS and its constituting elements, respectively:

- The **CLARITY Modelling Methodology** that is developed in WP3 based on EU-GL combining the concepts of IPCC AR5 and the risk assessment community has to manifest in technical specifications and concrete technical solutions (e.g. **Scenario Management** and **CSIS**) that are to be provided and co-developed in WP4 and WP5. The technical specifications and solutions can be considered as the reference implementation of the CLARITY Modelling Methodology and thus should be subject to activities that seek to establish a de facto standard.
- T2.4 "Validation" will be in charge of verifying that format, interface and report standards are met, as well as collaborating with WP3 partners in order to define and validate that the established methodologies are met in the operation of the services.
- Standardisation or adoption of the CLARITY Modelling Methodology and its reference implementation can be leveraged with help of dissemination activities that promote and advertise the benefits of **Conceptual and Technical Standards for Climate Services**.
- (non-CLARITY) Climate Services that are both conceptually and technically compliant to CLARITY's Standards for Climate Services can benefit from conceptual and technical interoperability with the CSIS, ICT Climate Services (**Multi Criteria Decision Support**, **Report Generation**, ...) and the **Marketplace**.
- Technical solutions encompass on the one hand (lightweight) data standards, the so called **Data Packages** (http://frictionlessdata.io/data-packages/), the implementation of the actual workflow (**Scenario Management**) and ultimately respective (CLARITY-) standards based **ICT Climate Services**.
- A standardised Data Package "provides a simple contract for data interoperability that supports frictionless delivery, installation and management of data." (http://frictionlessdata.io/data-packages/).

It is a general container format for climate risk adaptation studies that is based on the CLARITY Modelling Methodology, best practices, data standards and state-of-the art ICT technologies. As starting point, a simple directory layout that follows the CLARITY Modelling Methodology (adapted EU-GL modules) and defines the format and details of contained (model I/O) data as it is done for example by CMIP5 - Data Description (https://cmip.llnl.gov/cmip5/output_req.html). Then, the Data Package Standard will evolve during the course of the project (agile approach).

- Additionally, a simple (KISS principle) standardised format for Indicators that are relevant for the Multi Criteria Decision Support has to be defined. Technically, (Impact) model output must be transformed (e.g. by an aggregation or **Indicator Function**) into a standardised **Indicator Set** so that the Indicators can easily be compared or visualised by the respective tools. Of course, this Indicator Set is also part of a Data Package.
- Technically, a standardised Data Package can be realised as "distributed data object" so that not all data has to reside in the same location (database, server). Here arises also the need for **Smart Links** that are able to combine, relate and describe different information entities (in this particular case the distinct elements of data package).
- A serialisation feature for Data Packages is needed that allows to put all contents of package that into a concrete (zip) file that can be shared, e.g. with other experts. Thereby, the actual output of **Expert Climate Services** should be delivered as such a Standardised Data Package to ensure technical interoperability to the CSIS and thus the Climate Services Ecosystem.
- Consequently, a data package can either reside on the CSIS as **Virtual Data Package** (distributed among several physical data stores) if the provider of the Expert Climate Service uses the CLARITY CSIS to provide its service, or as concrete file (**Serialized Data Package**) if the provider works offline.
- The data package approach bears considerable innovation potential and capacity as it represent the de-facto interoperability standard for climate adaptation studies that follows a (scientifically sound and defensible) standard methodology.

Relevant citations

- The development of climate services should be accompanied by the **standardisation of data and protocols**, the development of a certification system and of **Quality Assurance methodologies** from the early stages of the project onwards. This will allow the project to appropriately address potential legal issues in relation to the **liability of the operators** providing climate services. *[REP-001, p. 4]*
- **Quality** control, **certification** and **standards** have to be addressed to reinforce the **relationships of trust between** offer and demand, which is crucial for a healthy market *[REP-002, p. 17]*
- Developing **standards and protocols for data** in support of vulnerability and risk assessments, and decision-support systems. Standards and protocols for facilitating incorporation of global and regional observations of physical and non-physical data and information into impacts, vulnerability and risk assessments and related decision-support systems. *[REP-002, p. 28]*
- Standards on Climate Service provision might help to **enhance communication**. *[REP-007, p27]*
- Users rate '**missing standardization of information**' (technical-scientific barrier) and 'accessibility of information, incl. **open data policie**s' (political barrier) as main barriers related to advisory services, while, at the same time, enhancements in open data policies in order to improve accessibility are considered the most important innovation. *[DEL-001, p. 39]*
- Standardization is related to certification and usually a prerequisite to it. Standardization in data handling protocols can **promote the uptake of quality control and quality assurance procedures**. Standardization can also be applied at the output side with respect to **information presentation**, which can make **use and cooperation** across (end)users easier. *[DEL-001, p. 40]*

- the use of open-source infrastructures increases the credibility and the standardisation of protocols and methods and reaches a growing number of potential stakeholders. *[DEL-002, p. 58]*
- A **common data format** and a **common convention for data records** and exchange will boost services and the popularisation of climate data use. *[DEL-003, p. 6]*
- **Non-standardisation of key aspects of the data infrastructure could hinder the uptake of the climate services market** in Europe. Data formatting is not yet completely standardised within data storage, despite concerted efforts toward this, slowing networking and innovation potential. *[DEL-003, p. 31]*
- For the CMIP5 NetCDF files, for instance, the assumption was "if I can talk to one, I can talk to all" – but the code doesn't work equally across the file format, for there are **discrepancies at different levels**. There is no "consistent tool" yet in sight for the huge data warehouse. *[DEL-003, p. 47]*.
- For CMIP5, the community went through somewhat of a revolution in terms of people talking to each other and defining standards (**structure, content, format of data files**) – if data is standardised, it is **easy to build software around** it. Significant effort went into **agreeing these standards**, but the result was far from perfect. For CMIP5, it was agreed to use NetCDF, however, there were still discrepancies, like naming conventions for versions, and overriding of versions making it difficult to comprehend the evolution of datasets *[DEL-003, p. 50]*