3. Technical Solution Proposed

The Copernicus Climate Change Service (C3S) is a significant European investment, enhancing European capacity to adapt to climate change and reinforcing Europe's world-leading position on climate action and policy. The Sectoral Information System (SIS) will be based on a combination of world-class, authoritative science and data, and an advanced understanding of the market need. The services will stimulate the market for climate services in Europe by overcoming the recognised barriers to entry, and hence will foster economic growth as well as societal benefits.

The Evaluation and Quality Control (EQC) function has a critical role in the C3S in ensuring the service meets users' needs for high-quality data and services, and in proposing the necessary evolution of the service itself, and of the research agenda. To be successful, it is essential that C3S engages directly with a wide range of stakeholders, particularly potential users of C3S services in the priority sectors: water, energy, agriculture and forestry, health, coastal areas, insurance, tourism and infrastructure. In each of these sectors there is a clear need for consistent, authoritative climate data to contribute to decision-making, but each user is likely to have distinct and specific needs. It is therefore essential that C3S undertakes a comprehensive user requirements study led by experts in each sector, identifying where there is a need for climate data to support intelligent decision-making and filling the gaps ("user pull") rather than simply expecting users to take up products already on offer ("provider push").

To address these needs, we propose the project SECTEUR: "Sector Engagement for C3S, Translating European User Requirements". This lot provides the opportunity for this direct engagement, identifying the gaps that must be filled by C3S in future and providing both an implementation plan for the evolution of the service(s), and an articulation of the additional research needed, to meet users' requirements. For a project of this wide scope but short duration, it is essential to begin effectively and build on the existing, extensive knowledge base.

3.1 Review of existing literature

Climate impact indicators can help to inform and support decision-making (cf. *1*) by providing a deeper understanding of the risks involved as well as supporting actions to reduce those risks (*2*). The availability of indicators however, does not necessarily guarantee their use in decision-making processes (*1*, *3, 4*). Two critical factors in uptake are that scientific research (that aims to benefit societal needs) should be problem-driven and should closely engage with the end-users of those scientific outputs (*5*).

Many national and international projects have addressed climate impacts: for instance the Commission's Directorate-General for research has funded (via the Framework Programme) over 250 research projects on climate change *(6).* Numerous webpages and portals have been developed to provide access to impact indicators such as the IPCC Data Center, Climate-ADAPT, the World Bank Climate Change Knowledge Portal or the Climate Wizard. In addition, bodies such as the European Environment Agency and the Directorates-General of the European Commission have also prepared reports that address the issues around the development and use of climate impact indicators. In this section we provide an overview of those most relevant to this project that have a broad cross-sector scope. Sector-specific reports are referenced in the subsequent sections.

The CLIPC (Climate Information Portal for Copernicus) project reviewed approximately 40 projects (including ENSEMBLES, ISIMIP, IMPACT2C and PESETA I and II), 15 reports / studies and 10 web portals *(7).* The project defined three tiers of impact indicators: tier 1 (climate change indicators), tier

2 (bio-physical impacts) and tier 3 (socio-economic impacts). While tier 1 indicators were found to be well developed, good tier 2 indicators are less available (even though several exist) and the poor availability of tier 3 indicators is an obvious general weakness. CLIPC also found that not all sectors are well-served with existing indicators: many are available for the agriculture / forestry and health sectors; only very few specific ones are available for the insurance sector, for example. EUPORIAS has also compiled extensive use cases and user requirements, which we will build on in SECTEUR.

The EEA's 2012 report "Climate change, impacts and vulnerability in Europe" *(8)* provides a strong cross-sectoral knowledge base for the development and implementation of adaptation strategies and actions at both national and EU levels. The report uses a range of criteria for the selection of indicators that will be reviewed carefully in SECTEUR (WPs 1 and 2), including policy relevance, strength of causal links between climate change and observed impacts, methodological soundness, data quality, availability of observations, and information on robustness and uncertainty. Some SECTEUR partners are involved in the development of the 2016 EEA follow-up climate indicator report, and can take into account the considerably extended indicator database developed for that report. Following the EEA report, the EC published its European Adaptation Strategy in 2013 *(9),* which included further proposals for adaptation actions across the EU. Action 5 specifically references the aim to bring Climate-ADAPT and the C3S together; recommendations for this are part of SECTEUR (WP4).

In 2015 the EC also published the Climate Services Roadmap *(10),* to "facilitate the development of a market for climate services that provides benefits to society". The roadmap highlights a variety of roles for Copernicus; SECTEUR will make important contributions to the following in particular:

- Exploring the public and private domains of the market (WP1 baseline market assessment, WP3 assessments of potential uptake)
- Recommendations for the computing, data and IT infrastructure required to develop, deliver and support access/use of climate services (WP4)
- Demonstrating credibility and assuring quality of climate services (requirements from WP3, recommendations in WP4)
- Assessment of barriers and enablers supporting open and free access to data, data products and information, and the implications for provision of, and demand for, climate services,
- Assessment of existing climate service capacity, demand and supply (WP1)
- Integration of physical and socioeconomic data and information into indicators (WP3 requirements and use cases)
- Innovations in service products and presentation, identifying and prioritising based on assessment of users' and providers'/purveyors' needs and capabilities, consideration of where innovations could lead to demonstrable benefits (WP3 requirements gathering and use cases)

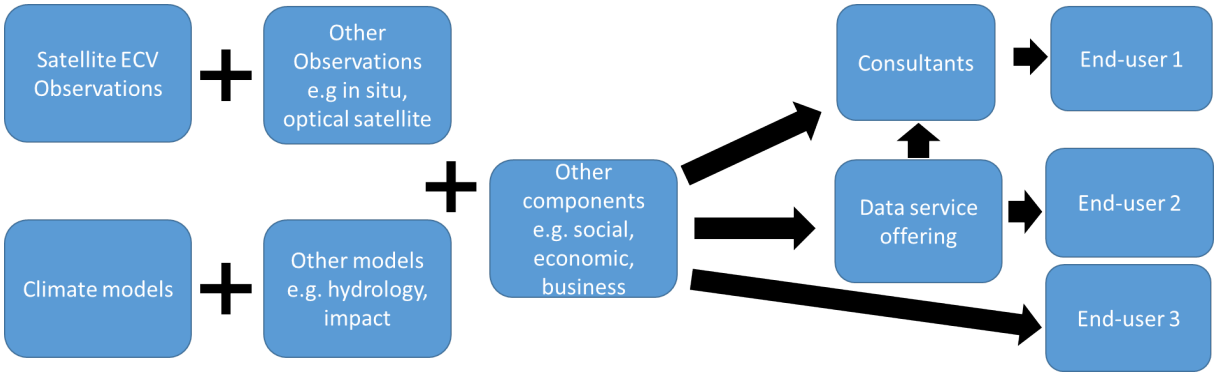
Also in 2015, DG JRC published a theoretical framework for climate risk assessment indices *(11)*. The report proposes that a fit-for-purpose index "should address a specific policy request with a clear objective". It also follows the criteria specified in the 2014 IPCC report *(12)* for selecting appropriate indicators. Furthermore it recommends that "indicator-based evaluation needs to be supported by monitoring climatic and other trends (such as environmental and economic conditions) so that adaptation action can be attributed correctly. This requires the normalisation of evaluation metrics with respect to changing climatic and environmental baselines." These criteria, the JRC framework, and the recommendations for good practice in evaluation, will be considered in SECTEUR (WPs 1, 2 and 4 respectively).

A comprehensive analysis of available projects, reports, surveys and web portals including all types of indicators, methodology, shortcomings etc. will be compiled in the first month of the project (WP 1). However, the following major gaps have already been identified:

- For many indicators of past climate change and climate change impacts in Europe improvements in the accessibility and extent of relevant data are needed (e.g. to extend the length of time series and the geographical coverage and to improve their public availability).
- Enhanced monitoring is needed of Essential Climate Variables (ECVs) relevant for adaptation, both from in situ stations and using satellites and there is also a need for further reanalysis of European climate data;
- Enhanced monitoring is also needed of climate change impacts in Europe on environmental systems, socio-economic systems and health, and of costs of damages of extreme weather;
- Further inclusion of climate change variability into the various biophysical impact analyses;
- Development of new tier 2 and 3 indicators based on regular monitoring that can explore novel data sources such as those based on earth observation, and improved attribution of changes in these indicators to climate change.;
- Harmonization of the evaluation criteria across indicators;
- Comparability of climate change impact indicators may be achieved if consistent and comparable methods and data would be implemented across EEA member countries ;
- Climate change impacts indicators are only to a very limited extent included within existing and emerging European thematic and sectoral indicator sets;
- Improved understanding of socio-economic and institutional aspects of vulnerability and adaptation is required;
- For specific indicators there was also missing or incomplete information on some criteria.

3.2 Value chain from EO and models to decision making

The wide range of climate services to different sectors will require a combination of the use of earth observation, in situ observations and climate and other (e.g. hydrology) models. Depending on the type of organisation and decision-making being supported, from short term management decisions to longer term planning decisions, different combinations of observations, models and other data/information will be required (see schematic below).



Some end-users (box 1; for example energy generation and supply, water utilities) generally outsource their service provision to consultants who combine climate and other data into their systems either drawing directly on data or making use of data service providers. Other end-users (box 2; for example in CSR-related activities such as footprinting) draw directly upon data service providers who integrate data from a number of sources. Thirdly, there are end-users (box 3; for example re-insurance brokers) who ingest data from different sources directly into their operations. The value-add of each stage of development is dependent upon the sector of the end-user.

One reason that a climate services market is developing only slowly as yet is that many vulnerable actors (companies, cities, sectoral institutions) do not consider climate change to be a priority issue. SECTEUR will therefore enhance the “user pull” by framing its survey from the perspective of sector priorities other than climate change and only then consider to what extent these priorities are at risk of climate change.

3.3 Sector scoping and key contacts

In this section we introduce each of the sectors that will be studied in detail in the project, proving an initial scoping and key contacts. The "sector champions" will be supporting the engagement in each sector (see section 3.4 for more detail on this role). Further identified contacts in each sector are available as an annex, and at http://tinyurl.com/secteur-contacts.

Agriculture/Forestry (led by Alterra)

Agriculture is directly affected by climate change, as farming activities depend on climatic conditions. Extreme climatic events (incl. droughts and heat waves) have negatively affected crop productivity during the first decade of the 21st century in Europe and this is expected to further increase yield variability under climate change. Impacts to agricultural crop yields differ for the European regions. Crop productivity increases in Northern Europe by lengthened growing season and decreasing cold effects on growth, while productivity decreases in Southern Europe by a shortening of the growing period (*13*). Agricultural activities in the Mediterranean basin are particularly vulnerable to climate change impacts. Forest productivity is expected to decrease, and temperate forests can turn from sink to carbon sources in case of heat waves (*14, 15*). Climate change can also significantly undermine the services that forest can provide. Different categories of stakeholders exist in the sector, for example:

- Key users (knowledge purveyors /intermediary organisations, advisory), e.g. DLV Plant, a leading international organization providing advice to agricultural entrepreneurs , and Bodegas Torres and Sogrape Vinhos in the Iberian Peninsula, providing advice to the wine industry in the Mediterranean region/Southern Europe.
- European-level actors, e.g. European Innovation partnership (EIP) on Agricultural Productivity & Sustainability
- (Climate) Impact researchers, e.g. UKCIP, and the EU network organisation WIRE - Water & Irrigated agriculture Resilient Europe;
- Societal end users such as NGOs and policy makers.

The need for more and better climate information is growing in the sector. For agriculture, information from short term weather forecasts are available, however little information is available for decisions related to longer term seasonal to annual climate trends that could be derived from climate forecasts to prepare for unexpected conditions. An example would be the wine industry (e.g. Bodegas Torres and Sogrape Vinhos), using climate projections to explore viability of viticulture, and prediction of climate change on inter-annual time scales for crop management. For forestry, the main problem around the issue of climate change information is that the scientific community still cannot offer practical recommendations (*16*). Forest managers have innate knowledge about the small but crucial differences climate change can make to their forests. The co-generation of knowledge can contribute substantially to bridging the gap between scientists and practitioners. Possible risk indicators for the sector are yield loss, land use changes, and fire risk.

The EU strategy on adaptation to climate change (*9*) includes an implementation action to facilitate the climate-proofing of the Common Agricultural Policy (CAP). The current CAP contributes to adaptation by providing a basic level of income security to farmers, by shifting to decoupled support, which enables adaptation to market and agronomic conditions, as well as to climatic conditions. The EU Soil Thematic Strategy (*17*) recognizes that soil degradation caused by human activities contributes to climate change. The strategy encompasses various activities (awareness-raising, research, integration with others sectors) addressing climate change (adaptation). The Water Framework Directive (*18*) acknowledges that climate change will pose a major challenge for water management across the EU; lower rainfall and higher summer temperatures in the south of Europe

are putting stress on scarce water resources and negatively impact agriculture. Further, in 2013 the Commission adopted a new EU Forest Strategy (*19*) which responds to new challenges facing forests and the forest sector. It emphasizes the importance of actions to maintain and enhance forest's resilience and adaptive capacity. The Green Paper on Forest Protection and information in Europe: Preparing forests for climate change (*20*) aims to facilitate the debate on options for a European Union approach to forest protection and information in the framework of the EU Forest Action Plan.

Key contacts	Organisation	Name	Contact details
Sector champion (confirmed)	DLV Plant	Jacob Dogterom	j.dogterom@dlvplant.nl
	DLV Plant is a leading, independent advisory and research partner for the horticultural and agricultural sectors		
	Sogrape Vinhos	Antonio Graça	Antonio.Graca@sogrape.pt
	Bodegas Torres	Xavier Sort	xsort@torres.es

Coastal areas (led by CMCC)

Coastal areas are of strategic importance for Europe's economic, environmental and societal development. Coasts consist of multi-sectoral and multi-user environments often with users' interests and strategies in conflict with each other. The stakeholder communities are extremely broad and include: 1) Large industry (e.g. tourism, aquaculture, energy, harbours, coastal infrastructures, multi-modal transport); 2) Small and medium-sized enterprise (e.g. consultancy, service providers); 3) European agencies, policymakers and regulators (e.g. European Environment Agency, European Maritime Safety Agency, DG Environment); 4) International bodies (e.g. Regional Conventions, UNESCO International Oceanographic Commission); 5) National public authorities (e.g. National environment protection agencies, Civil protections, Ministries of environment) 6) sub-national and local authorities (e.g. Local and regional administrations, municipalities); 7) Non-governmental organisations (e.g. WWF, Nature Conservancy).

Specific indicators and tools are needed for the stakeholders to take relevant decisions and plan adaptation strategies, with the main objective of increasing European citizens' resilience to climate change and to facilitate the safe growing of coastal economy and industry in a balanced equilibrium with respect to the natural environment and sustainable exploitation of resources. Some of the users (e.g. international bodies, EU agencies) need large-coverage indicators that include the European domain if not the entire globe; other users are more locally focussed and need high spatial resolution indicators that should allow extremely specific analysis. Several climate indicators (e.g. temperature increase, sea level rise, warming of the ocean) and climate indices (e.g. based on records of temperature, precipitation, drought events) will be of relevance for the coastal areas sector. Climate indicators including scenarios based on C3S data will represent a crucial element in the definition of adaptation strategies, with the potential to combine them with spatially explicit socio-economic indicators to analyse future impacts of climate change in coastal areas (*21, 22*).

Coastal zones and marine waters have already been greatly affected by rapid urban development, draining of coastal marshes, changes in river and sediment flow, expansion of irrigation for agriculture and unsustainable fishing practices. Large cities have been growing in coastal zones and this trend is increasing thus concentrating, in relatively small areas, a significant number of societal and human values to be protected. Warmer climate projections show a further increase of the risk of coastal floods in many areas worldwide *(24)* and also in particular for cities along north-western European, northern Italian and Romanian coasts due to sea level rise in combination with storm surges *(25)*. The scientific knowledge on sea level rise, other climatic and human drivers of coastal change, related impacts and vulnerabilities of natural and human systems, and adaptation has been recently summarised in the IPCC working group 2 report *(12).* The PESETA Coastal Systems study *(26)* reports the results of the physical impacts and adaptation cost assessment of sea-level rise for the

European Union. Several EU projects (e.g. ClimateCost, PEGASO, Perseus, CIRCE) have developed datasets and indicators for the assessment of climate change impacts in EU coastal areas and have shown the importance of interacting with users to properly address their requirements.

The European Commission's EU strategy on adaptation to climate change includes a Staff Working Document that addresses adaptation, coastal and marine issues *(26)*. The current policy framework at EU level includes the Water Framework and Floods Directives and the Marine Strategy Framework Directive. EU policies and instruments relevant for coastal areas include Integrated Coastal Zone Management and Maritime Spatial Planning. The coastal sector represents an important occasion for C3S to interact with the other relevant Copernicus elements such as the Marine and Land services. The integration with the other services will offer the occasion to better serve some user communities and increase the focus and fitness-for-purpose of C3S datasets and indicators.

Key contacts	Organisation	Name	Contact details
Sector champion (proposed)	European Environment Agency	Trine Christiansen	<Trine.Christiansen@eea.europa.eu>
	The European Environment Agency (EEA) is an agency of the European Union and a major information source for those involved in developing, adopting, implementing and evaluating environmental policy.		
	DHI S.r.l.	Birnur Ayse Yavuz	yavuz@dhi-italia.it
	UNESCO-IOC	J. Barbiere	j.barbiere@unesco.org

Health (led by IC3)

Climate change endangers human health, affecting all sectors of society, from the local to the global level, and is becoming a central issue in public health and global political agendas. The environmental consequences of climate change, both those already observed and those that are anticipated, such as sea-level rise, changes in precipitation resulting in flooding and drought, heat waves, more intense hurricanes and storms, and degraded air quality, will substantially affect human health in the next decades, both directly and indirectly.

Europe emerges as an especially responsive area to temperature increases under climate change, particularly during the warm season (*27*). The extended heat of the European summer of 2003 caused a rise in death rates that was 4 to 5 times expected levels at the peak of the event in some cities (*28*), eventually causing over 70 000 additional deaths across twelve countries (*29*). This event revealed the lack of reactivity of the society, the health system and even the media to such an extreme event. Certain adverse health effects could easily be avoided if informed decisions were made prior to heat waves, to protect vulnerable populations, such as children and the elderly and ensure access to preventive measures well in advance. Collaboration between health and climate services is critical to implement these actions. As an example, the EU-FP7 EUPORIAS project is developing climate impact indicators for the health sector. Probabilistic mortality forecasts for both heat and cold wave events, derived from temperature reanalysis data have been produced, using pre-defined emergency and probability decision thresholds based mortality data across 54 European regions (*30, 31*).

The health sector, whose primary purpose is to promote, restore and maintain health, would highly benefit from tailored-made climate impact indicators based on CS3 climate forecasts and projections, to support decision making from the local, regional, national and European level. Health stakeholders include government ministries and departments, hospitals and other health services. These agencies could use climate impact indicators to optimize the resources in the health system, and to enforce preventive measures that could improve quality of life, particularly for the most vulnerable sectors of society. However, many other complex factors that also determine vulnerability, including biological

susceptibility, socioeconomic status, cultural competence, and the built environment, should be considered, along with climate impact indicators, in the decision-making process, to mitigate and adapt to the effects of climate change in the healthiest and most efficient ways possible.

Key contacts	Organisation	Name	Contact details
Sector champion (proposed)	Public Health England	Bernd Eggen	Bernd.Eggen@phe.gov.uk
	Public Health England (PHE) is an executive agency of the UK Department of Health (DH) and coordinator of the Healthy-Polis consortium (International Consortium for Urban Environmental Health & Sustainability).		
	Public Health Agency of Barcelona (ASPB)	Carme Borrel i Thió	cborrell@aspb.cat
	Health Department, Generalitat of Calalunya	Andreu Segura	andreu.segurab@gencat.cat
	Ministry of Health, Spain	María C. Vázquez	mvazquezt@msssi.es

Infrastructure (led by Tecnalia)

This sector includes all physical and organizational structures and facilities needed for the operation of a society or enterprise. This sector includes assets that would be also be analysed in other sectors of C3S (energy, tourism, health, water, transport etc.). Main threats to infrastructure assets include damage or destruction caused by extreme weather events, which climate change may exacerbate; coastal flooding and inundation from sea level rise; changes in patterns of water availability; and effects of higher temperature on operating costs, including effects in temperate and/or permafrost (*9*). The three officially recognized European Standardization Organisations are the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI). With energy being addressed by another C3S (SIS) project, the focus of SECTEUR will be on transport and buildings, sectors also included in the recently started CEN/CENELEC project on including climate change in European standards (*32*). The following activities are considered especially relevant to C3S:

Spatial planning: Spatial planning has been identified as a critical tool to facilitate climate change adaptation and mitigation. Due to its multi-level governance (European, national, regional, local), it includes different disciplines and levels of decision-making that range from the definition of a territorial agenda for Europe (*33*) to the detailed urban planning of all European municipalities. Consideration of the wrong climate-related variables can lead to situations that are difficult to correct in later stages of decision-making such as engineering, maintenance, etc. Therefore, spatial planners should be considered as potential "preferred consumers" of C3S.

Civil engineering: Engineering is a discipline that is used to managing uncertainty. However, climate change is a new source of uncertainty and is still not being integrated in most projects. Prevailing practice considers "past climate" as immutable, and future climate projections are not being incorporated into infrastructure design. The gap between climate data provided by C3S and engineering practice must be bridged by developing clear climate services tailored to practice needs. The document "Adapting Infrastructure and Civil Engineering Practice to a Changing Climate" (*34*) identifies the technical requirements and civil engineering challenges raised by adaptation to a changing climate. Climate change may result in a more frequent exceedance of design thresholds currently considered as exceptional. So, in this particular field, information related to extreme events (floods, heat waves, tornados, etc.) is especially interesting.

Green and Blue Infrastructure: Complementary to the grey infrastructures (buildings, roads, and other hard infrastructures), increasing attention is being paid to green (plants) and blue (water) ones, see for instance "Green Infrastructure — Enhancing Europe's Natural Capital" (*3535*). Being both a solution to climate change and a particularly vulnerable sector, as it is living infrastructure, the design and exploitation of green and blue infrastructures are activities with a high potential for climate services from the C3S.

Industrial engineering and technical standards: Important components of infrastructure designs are defined using techniques, norms, standards and protocols. Aspects such as safety design, comfort, insulation, air removal, cooling, structural resilience, etc. have clear design procedures where climate variables (e.g. temperature and rain projections) could directly be integrated. In 2014 CEN and CENELEC established the Adaptation to Climate Change Coordination Group to foster collaboration in standardization work in the field of adaptation to climate change. For these reasons, European and national normalization organizations will be engaged in the project.

Networks and interdependencies: energy, transport, information technology and water infrastructure are clear examples of networks integrated by multiple elements: failure in one of them can quickly lead to cascade effects. Thus, planners and operators of these infrastructure systems are specific stakeholders for this project, especially those considered as "critical infrastructures" (*36*). The scientific community are also paying attention to this area of study, requiring specific data and developing new methods for generating processed information for improved decision making (*37*).

Key contacts	Organisation	Name	Contact details
Sector champion (proposed)	Tecnalia	Efrén Feliu	efren.feliu@tecnalia.com
	Tecnalia are an intermediary organisation with many contacts and projects themselves in the climate change adaptation area.		
	European Construction Industry Foundation	Helen Visser	h.visser@bouwendnederland.nl
	CEN/CENELEC	Ab de Buck	Ab.deBuck@nen.nl

Insurance (led by University of Reading)

The insurance sector is defined by all entities which accept the transfer of risk of a loss from another entity in exchange for money. This includes insurers as such, but also re-insurers (insurer's insurer), public bodies acting as insurer of last resort and insurance sector regulators. We also include in this group the catastrophe modelling firms, whose provide information on potential losses to the insurance industry. The structure of the market is that the sector is distributed in several hubs in Europe (especially London, Zurich and Munich). The primary users to date for climate-related information have been re-insurers as they operate at a global scale and are most interested in catastrophe risk. There are likely to be emerging opportunities with insurance companies, including those that specialise on business interruption, life insurance, agriculture and other areas where risk is changing. While insurance can be considered as a separate sector to others, it is, in effect, cross-cutting as it works with all sectors of the economy. It can therefore be an enabler of resilience across sectors.

Because insurance is under-written on an annual basis, insurers have traditionally used historical records of past events to inform current risks, however they are beginning to change their viewpoint as climate change is likely to significantly affect the regularity and intensity of extreme events. It is now widely recognized that climate change will have a wide range of impacts (more severe storms, rising sea levels, increased frequency of drought and floods…) which are expected to have serious consequences on many different societal aspects (food scarcity, clean water shortage, devaluation of

assets, flooding,…). The changing risks between the recent past and the not-so-distant future are of great interest to the insurance industry because even slight changes in climate characteristics can translate into large impacts on risk distribution/management and expected losses.

In an insurable context, extreme events impact property and people the most. These extreme events can take several forms: tropical cyclones, extratropical windstorms, heavy rainfall and flooding, heat waves and drought, each associated with a specific set of challenges. Sea level rise is also expected to contribute to change in risk exposure, especially in coastal cities exposed to storm activity (e.g. Miami, New York). In Europe, hydro-meteorological events (windstorms, floods, and landslides) account for 64 % of the reported damages due to natural disasters since 1980; climatological events (extreme temperatures; droughts and forest fires) account for another 20% (*8*). Overall damages from extreme weather events have increased from EUR 9 billion in the 1980s to more than EUR 13 billion in the 2000s (inflation-corrected) (ibid.). And although there are large geographical differences, projections suggest large increases in costs from coastal and river flooding and heat waves due to the combined effects of climate change and socio-economic developments in Europe.

The insurance industry has always been interested in the impacts of climate change on risk; however, insurers are also driven by regulation. The Solvency II regulation in Europe is leading to an increased reliance on open-source information such that regulators can understand the way in which pricing has been determined by companies. Regulators have also begun to ask the insurance industry questions concerning their capacity to adapt to climate change (for example, the Bank of England's Prudential Regulation Authority current Climate Change Adaptation Report (*38*)). Members of the project team have already provided guidance to reinsurance companies on changes in European Windstorm risk for the PRA report. One of the key questions facing insurance industry is that climate model projections are uncertain: how can the insurance industry use uncertain climate model information to respond to regulatory reviews of changing climate risks?

Key contacts	Organisation	Name	Contact details
Sector champion (confirmed)	XLCatlin	Tom Philp	Tom.Philp@xlcatlin.com
	Science analyst at XL Catlin and member of the Lighthill Risk Network, facilitating knowledge transfer into business from academic, government and commercial experts at the forefront of risk-related research.		
	Willis Re	Geoff Saville	Geoffrey.Saville@willis.com
	Risk Management Solutions	Jara Imbers	Jara.ImbersQuintana@rms.com

Tourism (led by TEC Conseil)

The tourism sector supports the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes. This concept can be applied to different forms of tourism relevant to this study, both in terms of geography (domestic tourism from residents within their country and international tourism) and motivation (holiday, business tourism, visiting friends and relatives). *"Tourism represents the third largest socioeconomic activity in the EU after the trade and distribution and construction sectors" (39)*. The EU profits from a large share of domestic and intra-European tourism by its own residents, as well as being the largest market for international arrivals. This makes it the most stable tourist region worldwide. 94% of all 1200 million tourism trips and 78% (€ 310 billion) of tourism expenditure by EU residents stays within the EU28. Tourism generates over 5% of the EU GDP and workforce, with a broader definition estimating this contribution at 10% (GDP) and 12% (workforce).

The tourism sector is particularly sensitive to weather and climate conditions; seasonal risks are most commonly considered, but information longer-term change may affect the viability of a destination. The sector faces different types of impacts, such as (*40*):

- Direct impacts on tourist safety, comfort and health (social impacts): heat waves, storms, heavy rains, forest fires, urban pollution etc.;
- Indirect impacts via environmental and landscape concerns : scarcity of resources (e.g. water resources), loss of resources (e.g. biodiversity, coral reefs, snow cover);
- Financial impact (loss of revenues, heating-cooling costs) ;
- Institutional impact (e.g. risk of reputational loss).If the tourism sector shows, on the one hand, a growing perception of the issue of climate change as a key issue affecting ongoing and future development, on the other hand, there is a very low level of awareness and use of climate services. "*The potential use of climate information within the tourism sector is tremendous given the high number and diversity of end-users" (41).*

Acting at the European scale seems particularly appropriate when one considers the diversity of policy challenges raised by the notion of sustainable development of tourism. Indeed, the European Union hosts the world's largest international tourism destinations, and the economic union has allowed the development of a single market with common rules and a single currency for the Eurozone, which facilitates tourism development. The past decades, however, reveal an asymmetry between the approaches to tourism and sustainable development within the EU. Indeed, whilst the EU has continuously reaffirmed the central goal of sustainable development in its policy and legal framework, it did not develop, until recently, the legal foundation for a sustainable European tourism policy. However, the EC has progressively developed the basis of a vision for sustainable and competitive European tourism (*42*).

The tourism system is complex, with a combination of public and private, tourism and non-tourism players at all scales. Due to this great variety of tourism stakeholders (tour operators, tourism and destination offices, professional organizations, planners, practitioners, receptive agencies, tourists etc.), tourism activities (bathing, trekking etc.), host environments and climate locations (coastal, mountain, rural etc.), the potential demand for climate information is likely to be very different from one stakeholder to another. The engagement of users will have to take into account this diversity.

Although there are very few current users of climate services, there is a growing interest in these kinds of products, as shown in the tourism case studies carried out in EU F7 CLIMRUN (www.climrun.eu) and EUPORIAS (www.euporias.eu). These projects and others, as well as relevant initiatives from the such as the annual European tourism forum organized by the EC, the NECSTOUR network of regions for sustainable tourism (www.necstour.eu) and the European Environment Agency supported Destinet portal (www.destinet.eu), provide relevant lists of stakeholders to engage in the development of the C3S.

Key contacts	Organisation	Name	Contact details
Sector champion (confirmed)	Ecotrans- Destinet	Herbert Hamele	contact@ecotrans.de
	Herbert has been involved for more than 20 years in EU debates on tourism and sustainable development and has many key contacts		
	Comité régional du tourisme of Rhône Alpes	Hugues Beesau	Hugues.Beesau@rhonealpes-tourisme.com
	Retired former Head of Savoie Mont Blanc tourism	Remy Charmetant	

3.4 Methods and approach

The brief for this project is challenging in scope and timescale, and requires efficient and effective cross-sectoral engagement, built on a sound understanding of both the state-of-the-art science and the economic potential in each sector. An overview of each workpackage is provided below, with more detail in the work package descriptions in the Management proposal. A key concept in our proposal is that of a "sector champion". This is someone who is:

- A user of climate data within the sector and understands current limitations;
- Can provide a detailed understanding of the key challenges faced by the sector;
- Would be in a position to advise which climate impact indicators would add value;
- Has a large network of contacts that can be utilised for the purposes of engagement;
- Has influence within the sector user community and could chair a sector workshop.

WP1 State of the art: Summarising existing knowledge (led by GERICS):

We will begin with a comprehensive cross-sector desk study, assessing the existing, known policy needs and user requirements from the many existing climate service projects and initiatives as highlighted in the literature review. In parallel, the team will compile the required baseline inventory of existing ECVs and indicators. A suitable affiliate partner *(expected to be the specialists KMatrix, see letter of support)* will carry out a "market potential" study, with international and cross-sector scope, to provide a baseline for assessing the impact of the C3S in future. A further task is to define the approach to be adopted in the feasibility and market studies, and the methodology for scoring indicators in each category. Experts in the team will define a best practice approach to be adopted by the sector leads in phase 3) and adapted where required to the needs of their sectors. This cross-project approach ensures the prioritisation exercise is fair and representative across the sectors and makes best use of the expertise in the team. The desk study phase culminates in a gap analysis.

WP2: Engagement strategy: planning efficient and effective engagement across sectors (led by the University of Leeds)

We will start by developing an online multi-lingual survey covering all sectors of interest. This survey will build from the information collected in WP1, targeting European organisations in the sectors of interest (i.e. agriculture and forestry, health, coastal areas, insurance, tourism and infrastructure). The findings of the survey will provide information regarding other users of CIIs in Europe (beyond those identified in WP1) as well as their potential (future) needs. The survey will also allow us to identify and recruit additional users to be involved in WP3. A bottom-up approach will then be applied in WP3 where a closer and more interactive engagement with the users will be pursued.

WP3 Future climate impact indicators (engaging in all sectors to ensure user needs for C3S are well known) (led by the Met Office)

This workpackage has an overall leader but the work will be carried out in each sector by a dedicated sector lead. The sector leads will implement the engagement plan which will involve a combination of workshops, interviews and surveys according to the needs of the sector. Initial workshops will be led by the sector champions in order to identify key challenges and potential use cases for indicators (including those not yet available to users). The outputs from these initial workshops will then direct the engagement with users in each of the sectors, focussing on technical feasibility, market analysis and the needs for additional research. A second round of workshops will then be realised with a wider group of users per sector. These will aim to understand: a) whether the identified use cases and indicators meet the requirements of a broader set of users; b) what modifications would be required to make them more usable/useful; and c) whether additional use-cases can be identified. Results of this study will allow the prioritization of impact indicators in each sector, highlight any that are cross-sector and produce the recommended shortlist for implementation. The team will establish the need for future research in to address the indicators list that scored lower on scientific and

technical feasibility, but with high potential for uptake. The detailed use cases will also provide the basis for the implementation studies in WP4.

WP4: Sectoral Climate Impact Indicator Implementation Plan (led by Telespazio)

A set of criteria will be developed and analysed regarding implementation in C3S. This set of criteria is expected to include: input data, output indicator data, time & space resolution, uncertainty, guidelines of use, licensing, as well as requirements on visualisation, usability, toolbox, data access, traceability and user evaluation. A central part of the activity will be the engagement with the other C3S project teams. The table below outlines the key two-way information that should take place:

C3S Project Team	**Information to be provided by EQC for SIS Lot 2 project team**	**Information extracted for use by EQC for SIS Lot 2 project team**
Software Infrastructure for the CDS	Specify methodology for integrating relevant data and tools into CDS and Climate-Adapt portals	Architecture of CDS and Climate-Adapt portals, and information on data, tools & applications
Software Development of the CDS Toolbox	Recommend software tools and applications for data analysis and visualisation.	Understand the plans for a common data model, envisaged tool sets and tool cataloguing.
EQC for SIS Lot 1	EQC Process report taking into account information received from theLot 1 team, with further info from the additional sectors	Relevant metrics, KPI's and processes required to perform EQC of the pocSIS water and energy services
EQC for SIS Lot 3	Communicate additional user needs for EQC-based applications based on the sectors studied.	Understand plans for tools to monitor KPI's as well as visualise and exploit the SIS data.
EQC for CDS Lots 1-4	Input data needed from the CDS to derive recommended indicators, including from observations, re-analysis, forecast / projections, and ancillary & socio-economic data	Plans for data to be included in the CDS relevant to deriving indicators. Understand strategies developed to assess quality and uncertainty.
pocSIS Lots 1-3	Direct interaction limited as main interface to project teams is expected to be via the EQC for SIS Lot 1 & Lot 3 project teams	Direct interaction limited as main interface to project teams is expected to be via the EQC for SIS Lot 1 & Lot 3 project teams

WP5 Project management (led by the Institute of Environmental Analytics, University of Reading)

Arrangements for project management are described in the Management proposal. The team will also deliver the final updated inputs to the User Requirements Data Base and User Requirements Analysis Document. We will also provide recommendations on how to maintain the user engagement processes into the future.

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