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EUPORIAS

European Provision Of Regional Impact Assessment on a Seasonal-to-decadal timescale

Deliverable 45.1

Report on methodology to assess business opportunities

Deliverable Title	**Report on methodology to assess business opportunities**	
Brief Description	*This report describes the methodology to assess business opportunities of the climate services developed. Including, as appendices, individual reports summarising the business opportunities, suitability and cost-effectiveness of climate services for each sector*	
WP number	45	
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v2	29.11.16	Cetaqua	Including WP45 partners' comments

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1. Executive Summary

The Work Package WP45 of the EUPORIAS project aims at developing a general **methodology** to **assess market for climate services** and to apply to specific key sectors to check the **economic viability** of climate services produced in this project.

The present report corresponds to the deliverable included in final Work Package WP45 entitled “Climate services as a business opportunity”. As expressed in the DOW (Description Of Work), once the research has been done for understanding users’ needs; improving models and their usability; understanding uncertainty; and finally delivering the prototypes, the new challenge is assessing whether a market for climate services in Europe exists and whether it can be effectively and efficiently used by SMEs and other relevant stakeholders. In order to do so, a general market analysis methodology has been developed within this WP and has subsequently been applied to specific key sectors to check the economic viability of the prototypes.

This final deliverable of WP45 is structured as follows: first, the **Methodology** developed is presented; then, each step of the methodology is described and illustrated with an example of the **Application to a representative sector**; and finally, some **Conclusions** are drawn both for the services developed in the project and for the methodology and its application**.** This report presents therefore the methodology elaborated to assess business opportunities of the climate services developed and the results obtained of its application to key sectors. The aim of this methodology is not only get a clear picture of the climate services market, but also be able to check the economic viability of the prototypes developed, as well as any other climate service that one wishes to check.

This methodology consists of 5 basic steps and its objective is not only assessing the business opportunities of the climate services developed, but also be useful for analysing any other climate service. The steps considered in the methodology are represented in the figure below, and are fully detailed within the deliverable, including the assumptions and procedure for the different actions to be conducted.

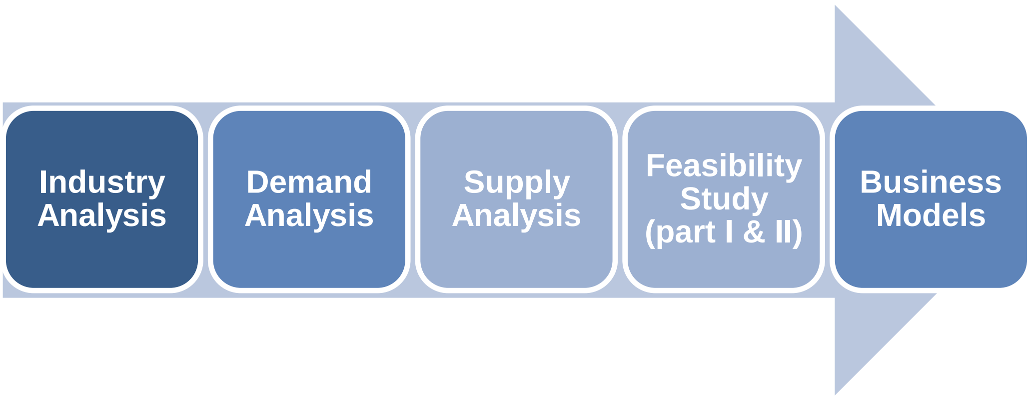


Figure 1. Main steps of the methodology

The main **conclusions regarding the services developed** in the project are as follows:

- All the sectors analysed are **sensitive to weather and climate** conditions, to a greater or lesser degree, and many actors already use seasonal forecasts. Still, the climate services market in all the sectors is considered to be **immature**. Taking into account the information about use and willingness to pay from the interviews, the wind energy sector seems to have reached a higher degree of maturity, and the electricity sector at large is willing to pay for temperature/demand and river flow/hydropower generation improvements.
- All sectors identify the same **current gaps** in climate services information, which are the lack of skill of forecasts, and the insufficient accuracy.
- Finally, all the sectors think that **Copernicus C3S** is going to have a positive influence on the development of the climate services market.

The main **conclusions regarding the methodology and its application** are as follows:

- The market analysis methodology developed **fulfils the objective of WP45** and may be of **great interest for the target readers** identified. As, on one hand, it allows getting a general overview of a market, and on the other hand, it also allows assessing a new service developed, from the point of view of its economic feasibility, as well as, giving insight of a range of current innovative business models used, and hence helping assessing which could be more suitable for the prototypes.
- Three **main difficulties** were faced when designing and implementing the methodology:
  - The lack of any previous market analysis methodology for climate services, hence the starting point was reviewing and adapting existing methodologies for other services more developed.
  - Most of the partners were not familiar with the market analysis concept and the specific tools used in these analyses, so Cetaqua sent the examples for the water sector in advance as a frame of reference.
  - The methodology has been implemented to prototypes (instead of full developed services). So, several hypotheses had to be done.
- The main result of implementing the methodology is having a **well-defined methodology** that can be **extrapolated to any climate services** that one wishes to develop. As well as the **collection of relevant information** about several markets for different sectors (needs, gaps, competition, etc.); and also information about the prototypes (features, benefits associated and value), and their economic feasibility.

2. Overall objectives of the project and Work Package 45

2.1. Project Objective

With this report, the project has contributed to the achievement of the following objectives (DOW, Section B1.1):

No.	Objective	Yes	No
1	Develop and deliver reliable and trusted impact prediction systems for a number of carefully selected case studies. These will provide working examples of end to end climate-to-impacts-decision making services operation on S2D timescales.		X
2	Assess and document key knowledge gaps and vulnerabilities of important sectors (e.g., water, energy, health, transport, agriculture, tourism), along with the needs of specific users within these sectors, through close collaboration with project stakeholders.		X
3	Develop a set of standard tools tailored to the needs of stakeholders for calibrating, downscaling, and modelling sector-specific impacts on S2D timescales.		X
4	Develop techniques to map the meteorological variables from the prediction systems provided by the WMO GPCs (two of which (Met Office and MeteoFrance) are partners in the project) into variables which are directly relevant to the needs of specific stakeholders.		X
5	Develop a knowledge-sharing protocol necessary to promote the use of these technologies. This will include making uncertain information fit into the decision support systems used by stakeholders to take decisions on the S2D horizon. This objective will place Europe at the forefront of the implementation of the GFCS, through the GFCS's ambitions to develop climate services research, a climate services information	X	

	system and a user interface platform.		
6	Assess and document the current marketability of climate services in Europe and demonstrate how climate services on S2D time horizons can be made useful to end users.	X	

2.2. Work Package 45 Objective

The main objective of WP45 is to assess whether a market for climate services in Europe exists and whether this can be effectively and efficiently used by SMEs and other relevant stakeholders. In order to achieve this objective, a general methodology has been developed and it has been implemented to assess the market potential for the services developed in the project. In particular, the methodology has successfully been applied to water sector; transport sector; energy sector; and tourism sector. In a nutshell, this deliverable focuses on the elaboration of a well-designed methodology and its application, instead of focusing on specific results.

The **target readers** of this report are summarised in the following figure:

1/ EU and EU States

- e.g. EC-DG Environment, and Spanish Ministry of Environment
- **Interest**: usefulness of funding climate services: risk reduction (including climate change), job creation (including SMEs).

1.b/ Copernicus C3S

- The Copernicus programme is coordinated and managed by the European Commission, and operated by ECMWF.
- **Interest**: Their main users are policymakers and public authorities (develop environmental legislation and policies; take critical decisions in the event of an emergency), new business opportunities; job creation, innovation and growth.

2/ Purveyors & small Providers; Start-ups and SMEs that are knowledge based, close to university

- e.g. Predictia
- **Interest**: possible existence of niche market (usefulness of data produced; market for new services.
- Start-ups and SMEs are interested in market gaps and general indications about saturated markets.

3/ Big Consultancies

- e.g. consultancy such as DHI, SUEZ WATER SPAIN
- **Interest**: promote interest; offer competitive products and services in their field integrating innovation components (reduction of costs, reduce risks, differenciation).
- Big Consultancies can incorporate climate services in their services.

Figure 2. Target readers of this report

3. Introduction

3.1. Context

According to *Road Map for climate services* (DG-Research and Innovation, EC2015), a climate service is defined as transformation of climate-related data – together with other relevant information – into customised products such as projections, forecasts, information, trends, economic analysis, assessment. As such, these services include data, information and knowledge that support adaptation and disaster risk management.

As discussed in the Road Map, the growth of the Copernicus Climate Change service (C3S) and of national climate service centres in Europe offers the conditions for realising the potential of these services. Through the provision (in a free and open access mode) of a consistent layer of data, data products, and model outputs, they can support the development of a market, in which public and private climate operators develop a variety of customised high added-value services with and for users.

The Road Map identifies **climate services market growth** as a **challenge** and proposes several **specific actions** in line with the objectives of the EUPORIAS project. Some specific actions are very relevant for this Work Package 45, such as the **assessment of climate service market**, translation of **user needs** into **reliable climate services** and **developing business models** for the provision of these services. Consistently, WP 45 aims at developing a general **methodology** to **assess market for climate services** and to apply to specific key sectors to check the **economic viability** of climate services produced in this project.

This deliverable of WP 45 presents a methodology of climate services market assessment, and it is structured in two main parts: **Methodology and Application to key sectors; and Conclusions**.

The objectives of the two parts are summarised in the figure below.

Methodology and Application to sectors

- **Objectives:**
- The main objective of this part is to **design a general methodology** in order to assess the market potential of climate services and apply it to the climate services prototypes developed in the project.
- There are many market analysis for goods and services. However, to our knowledge there is not a methodology for climate services. Therefore, the objective of this step is to adapt the existing methodologies and **develop a methodology for climate services**.
- Moreover, the methodology should be easy to understand and apply for non-economists, so it **can be applied to several sectors**, for example at European level, and should be able to consider the restrictions of all the countries where the services wants to be supplied.

Conclusions

- **Objectives:**
- The main objective of this part is to present two sets of conclusions:
- Firstly, a **summary table of the different sectors** targeted, to evaluate the economic viability of the climate services assessed. It will identify market opportunities of the climate services developed and the business models to be applied on climate services.
- Secondly, a set of **general conclusions** about the methodology developed, its implementation, and the results of its implementation.
- It will also respond to the objectives of WP45.

3.2. Methodology

A Market Analysis (also called Market Research) is the systematic gathering and interpretation of information about individuals or organizations using statistical and analytical methods and techniques of the applied social sciences **to gain insight or support decision making**.

The following figure shows the components that must be evaluated in order to assess the economic viability of a climate services prototype. All these components will be explained in detail in the successive sections of this document; however, just to give some insight into the components of the climate services market, they are going to be introduced very briefly.

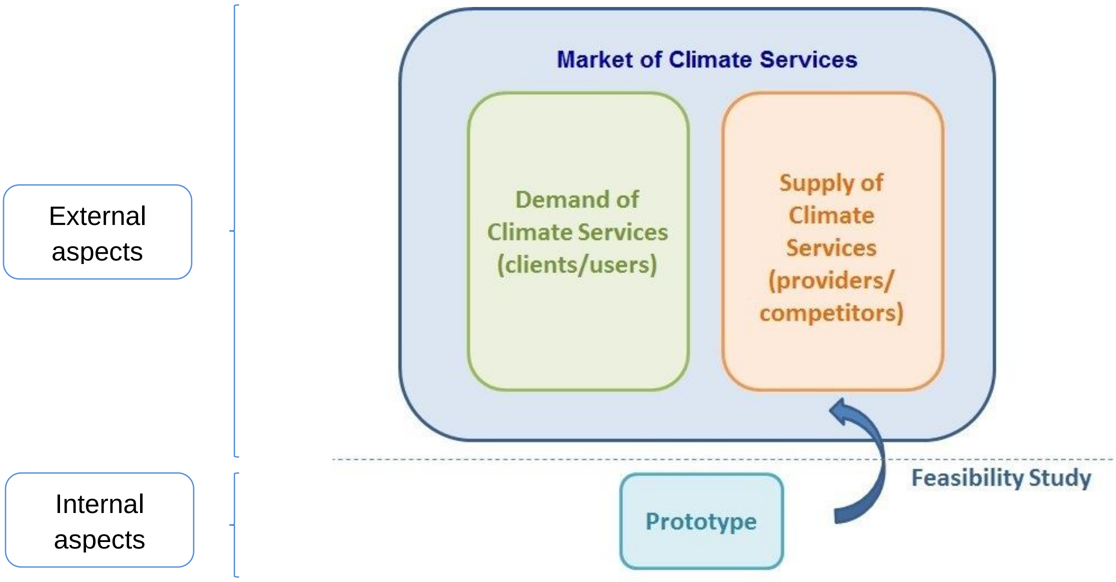


Figure 3. Approach of market analysis methodology

Once a climate service has been developed, to study its economic viability, two aspects have to be considered:

- External aspects: aspects related with the market of climate services, which are composed by the supply and demand of climate services.
- Internal aspects: related with the own prototype. In this report a tool called “feasibility analysis” will be introduced in order to assess these internal aspects.

The joint analysis of these two aspects will enable to check the economic viability of climate service prototypes produced and therefore decide if they can be effectively launched as a new service into the climate services market.

4. Methodology: Market analysis of climate services

For doing so, a general methodology has been developed and is presented in the figure below.

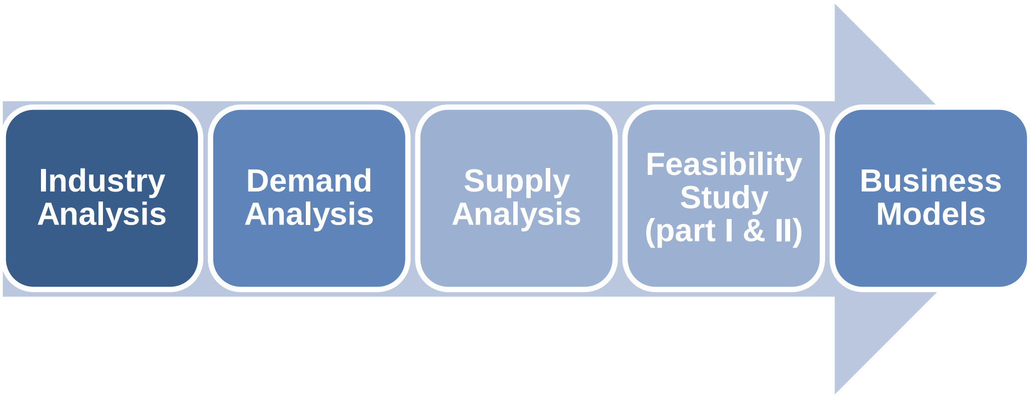


Figure 4. Main steps of the methodology

This methodology consists of 5 basic steps and its objective is not only assessing the business opportunities of the climate services developed, but also be useful for analysing any other climate service.

Several documents were reviewed on market analysis and its application to practical cases. The most relevant documents are cited in the section of references. All documents agree that an analysis of both demand and supply is necessary, as well as an analysis of the intrinsic characteristics of the service supplied. Moreover, in many documents additional information about how to develop a survey is provided, in addition to several market analysis practical examples.

4.1. Industry Analysis

4.1.1. Introduction and Purpose

In this section the concept of industry analysis is introduced; several definitions are provided, as well as its usefulness.

An Industry analysis seeks to address the following questions:

- *Which institutions provide weather and climate data?*
- *Which gaps exist in the climate services industry?*
- *Which are the structure and maturity of the industry of climate services?*
- *Which is the operation framework of climate service industry?*

An **industry** is defined as a group of companies that offer products or services which satisfy the same consumer necessity.
For example, the food industry encompasses a diversity of business, such as: agriculture, manufacturing, food processing, marketing, food technology, insurances, etc.

An **industry analysis** is an assessment market tool that aims to identify agents and relationships of the industry, to review economic, political and technological framework where it is operating, and to detect business opportunities[1].

In case of climate services, **consumer necessity** is identified as predictions (basically, temperature and rainfall) at different timescale (day, week, month, year…) that public or private companies use currently to improve their decisions making processes. Climate services are based on probabilistic climate predictions and they deliver information from one month to several years into the future (seasonal to decadal scale). Climate services use outputs of these forecasts in order to produce tailored products for decision-makers in both private and public sectors.

The **industry analysis of climate services** comprises providers and purveyors of weather, seasonal, decadal and climate predictions and characterises the operating framework of the industry (economic, political and technological environment).

The **usefulness** of an industry analysis is to provide a general picture of the current climate services providers, purveyors and the operating framework of the industry. In this sense, it provides a mapping of providers and purveyors of climate predictions at different time scale (historical, day, weeks, month, year and decadal) and allows to detect gaps on climate predictions.

[1] Definition from http://www.businessdictionary.com

4.1.2. Procedure

1. Identify the main actors (providers/purveyors) of the industry

To identify the main providers/purveyors of weather / decadal / seasonal / climate information, (either National Meteorological Agencies, Governmental Agencies (such as water or environmental agencies), private companies, consultancies, NGO, other), one's own knowledge and expertise can be useful, as well as asking to clients or research through internet.

The relevant information that could be gathered from providers /purveyors is:

- Data provided: temperature, rainfall or other variables and derived variables which are useful for your clients
- Time scale: past data, daily, weekly, seasonal or decadal predictions
- Geographical scale (if relevant)

Following, a table is provided in order to help on this task.

Table 1. Template for identifying providers/purveyors of the industry

Timescale	Providers/ purveyors of temperature and rainfall	Providers of derived variables
Historical data	*e.g. National Weather Agencies*	
0 – 24 hours		
1-7 days		*Governmental Agencies* *(Standardized Precipitation Evapotranspiration Index (SPEI))*
1-2 weeks		
1 month		
1-7 month		
1 – 10 years		
10 – 100 years		

The aim of this task is to identify data gaps of the industry using a map of providers/purveyors. A good option is to elaborate a map to classify providers and purveyors, where they are allocated by timescale. Additional information as if they are public or private organizations can be added.

Another example of mapping can be found in the Roadmap for Climate Services. The following figure shows a classification of providers and purveyors complemented with a description of their strengths, weaknesses and cultural background.

Type of climate services providers/ purveyors	Strengths	Weaknesses	Cultural background
Extension of meteorological services.	Strong infrastructure.	Main focus on physical data, limited socio-economic aspects.	Meteorology/hydrology.
Public climate services centres (not from meteorological services).	Fit for purpose.	Limited business orientations.	Multidisciplinary.
Services offered by a university or a group of universities.	Often include physical and socio-economic competences, research oriented.	Little user knowledge.	Multidisciplinary, academic.
Private business development.	Business orientation, user knowledge.	Dependence on external climate information.	Multidisciplinary, business.
Incorporation of climate information management in business consulting services.	Very good knowledge of users' needs, integration with other consulting needs, cost-orientation.	Limited climate knowledge.	Economic, business, marketing

Figure 5. European national climate services centres

2. Industry Structure

For structure, we refer to the **concentration degree** (number of agents participating in the market).

As quantifying the total number of agents participating in the market is quite a difficult task, we consider that this step is particularly relevant for the industry analysis in the cases when there is **a single provider/purveyor** of climate services (monopoly) or when the industry is dominated by a **small number of providers/purveyors** (oligopoly). In the case where there are **many providers/purveyors and users**, we can consider that industry has effective competition.

3. Identify external variables that can affect a service

The aim of this step is to analyse the operational framework of a sector (energy, water, agriculture, transport, other). It is going to focus the analysis on external variables: the economic, political, social, environmental, technological and legal variables.

It is frequently used a PESTEL analysis to conduct this study. The PESTEL analysis is a tool used to identify external forces affecting a project, product or service[2].

There are certain questions that one needs to ask while conducting this analysis, which give them an idea of what things to keep in mind. They are:

- What is the political situation of the country and how can it affect the industry?

[2] http://pestleanalysis.com

- What are the prevalent economic factors?
- What technological innovations are likely to pop up and affect the market structure?
- Are there any current legislations that regulate the sector or can there be any changes in the industry legislations?
- What are the environmental concerns for the industry?

Below, a template is provided in order to allow understanding what basics are required to conduct the analysis onto the environment.

Political factors *Trading policies* *Government changes* *Shareholder and their demands* *Funding,* *Governmental leadership* *Lobbying* *Foreign pressures* *Conflicts in the political arena*	**Economic factors** *Disposable income* *Unemployment level* *Foreign exchange rates* *Interest rates* *Trade tariffs* *Inflation rate* *Foreign economic trends* *General taxation issues* *Taxation changes specific to product/services* *Local economic situation and trends*
Social *Ethnic/religious factors* *Advertising scenarios* *Ethical issues* *Consumer buying patterns* *Major world events* *Buying access* *Shifts in population* *Demographics* *Health* *Consumer opinions and attitudes* *Views of the media* *Law changes affecting social factors* *Change in Lifestyle* *Brand preferences* *Working attitude of people* *Education* *Trends* *History*	**Technological** *Technological development* *Research and development* *Trends in global technological advancements* *Associated technologies* *Legislations in technological fields* *Patents* *Licensing* *Access into the technological field* *Consumer preferences* *Consumer buying trends* *Intellectual property and its laws* *How mature a certain technology is* *Information technology* *Communication*
Environmental *Ecological* *Environmental issues* *International* *National* *Stakeholder/ investor values* *Staff attitudes* *Management style* *Environmental regulations* *Customer values* *Market value*	**Legal/ Government** *Employment law* *Consumer protection* *Industry-specific regulations* *Competitive regulations* *Current legislation home market* *Future legislation* *Regulatory bodies and their processes* *Environmental regulations*

Figure 6. Template of PESTEL Analysis

PEST(EL) analysis has synergies with SWOT analysis[3]. In particular, the Political, Economic, Social and Technological components of the PEST(EL) analysis provide

[3] SWOT analysis is introduced in step 5 of Industry Analysis "Identify business opportunities".

relevant information about the Opportunities and Threats encompassed in the SWOT analysis, as can be seen in the following figure[4].

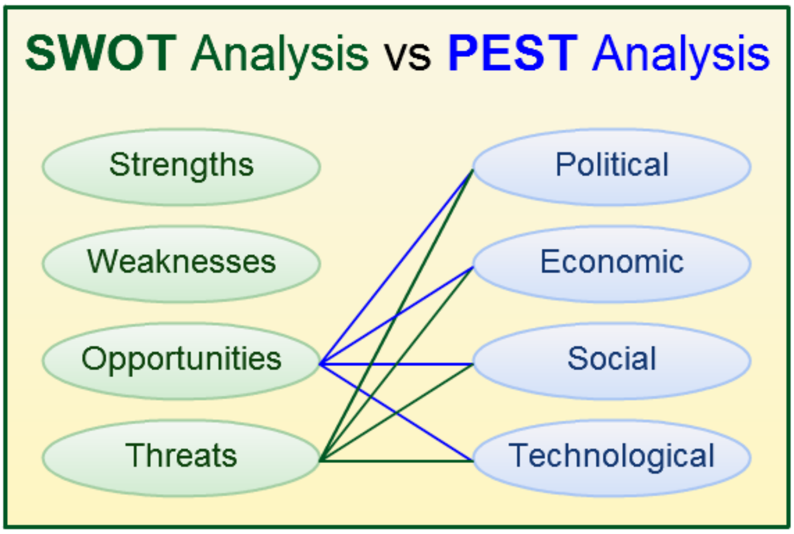


Figure 7. Link between SWOT and PEST(EL)

4. Maturity of climate service industry

The level of maturity of a service represents the market penetration of that service.

In this step two approaches of maturity are provided: the first one is the classic approach used for goods and services; and the second approach is the one used for technologies.

1. Maturity approach for goods and services

Maturity is usually represented using an S-shape graphic showing the different stages of maturity. These stages have been given different names, but following Euroconsult 2007, they are: technology phase; growth phase; maturing phase; cyclical phase; and declining phase.

The figure below shows these stages and illustrates several examples of different sectors.

[4] http://creately.com/blog/diagrams/swot-analysis-vs-pest-analysis/

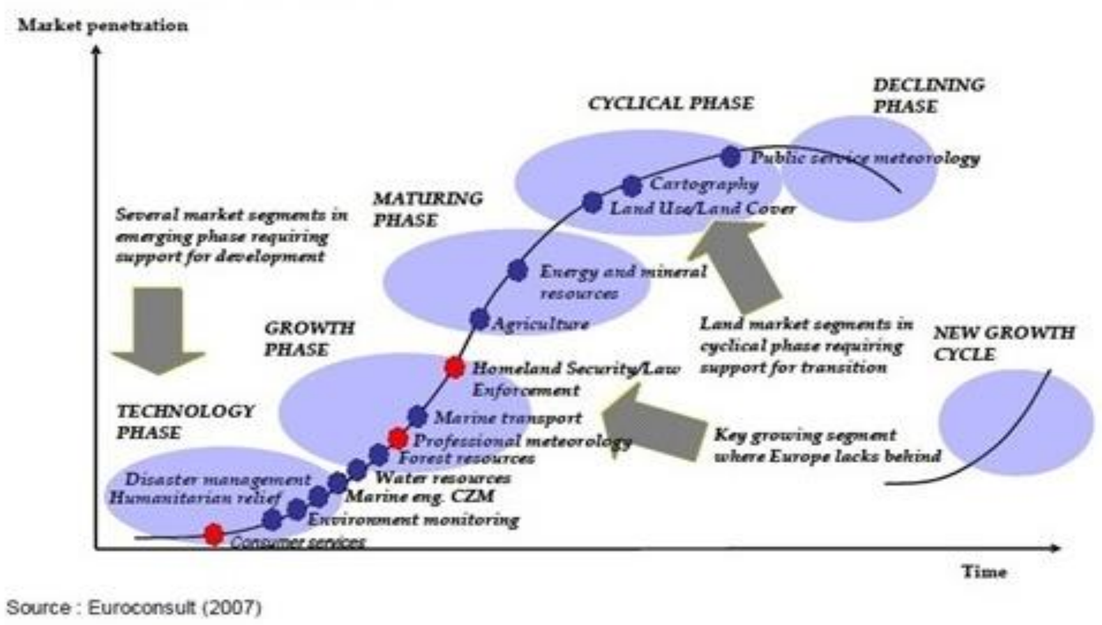


Figure 8. Maturity approach for good and services

2. <u>Maturity approach for technologies</u>

Another way of assessing the level of maturity is considering climate services as technologies. The word “technology” has many definitions; one of them is the following: “technology is the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives, such as scientific investigation[5]”. According to this definition, climate services can indeed be considered a technology, as they are a collection of skill and knowledge, able to translate climate information and data into customised tools, products and information. In this sense, it has been pointed out that climate services have the potential to become the intelligence behind the transition to a climate-resilient and low-carbon society[6].

[5] https://en.wikipedia.org/wiki/Technology
[6] https://ec.europa.eu/research/environment/index.cfm?pg=climate_services

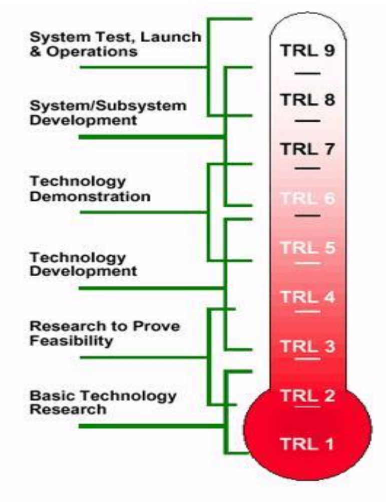


Figure 9. NASA Technology Readiness Levels.

Taking this into account, another way to represent the maturity degree of climate services would be using the Technology Readiness Levels (TRL); a method of estimating technology maturity.

Different definitions are used for TRL; the European Commission definition is the following[7]:

Table 2. Description of technology Readiness Levels

Technology Readiness Level	Description
TRL 1.	basic principles observed
TRL 2.	technology concept formulated
TRL 3.	experimental proof of concept
TRL 4.	technology validated in lab
TRL 5.	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6.	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7.	system prototype demonstration in operational environment
TRL 8.	system complete and qualified
TRL 9.	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

[7] European Commission, G. Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014)4995.

For example, according to UKCIP[8] the market of climate services is immature but evolving slowly. Moreover, they attribute this fact mainly due to a lack of demand because of the little knowledge of the range of services provided. In addition, they point out that the market in the water and transport sectors is relatively mature, whereas in other sectors, like the housing and health sectors it is rather new.

5. Identify business opportunities of climate services industry

The SWOT analysis is a business tool that aims to identify the internal and external factors of the climate service industry[9]. SWOT is an acronym which stands for; strengths, weakness, opportunities and threats.

As mentioned before, there is an obvious link between the SWOT and PEST(EL) analysis. A SWOT template is provided in the following figure.

Strengths *Strengths describe the positive factors of climate service industry.. Strengths are considered as **an internal factor** under your control, and you decide how to utilize them for the benefit of your organization.*	**Weakness** *Weaknesses are **internal factors** that are within your control. Despite being in your control, these factors somewhat detract you from performing at an optimum level. Weaknesses may include the lack of technologies, lack of capital invested in your business, unskilled labours.*
Opportunities *Opportunities are the **positive external factors**. Opportunities reflect the potential of the industry. If done right or taken advantage of them the climate service industry will have a significant boost.* *Examples: change in consumer demand or taste, weather factors, economic conditions, government subsidizing...*	**Threats** *Threats are the factors which may put climate service industry on failure. Since it is **an external factor**, you have no control over it.* *Examples: government tax, raising prices from suppliers, pressure from the activist groups, bad media coverage or even lawsuits which are likely to damage the company's reputation.*

Figure 10. SWOT Climate services industry Template

[8] UK Climate Impacts Programme. http://www.ukcip.org.uk/projects/engaging-with-climate-services-providers/#.VsxQcPnhBki

[9] http://pestleanalysis.com/

6. Influence of Copernicus on the climate services market

The Copernicus Climate Change service (C3S)[10] will combine observations of the climate system with the latest science to develop authoritative, quality-assured information about the past, current and future states of the climate in Europe and worldwide. The service will benefit from a network of observations, both from in situ and satellite sensors, and modelling capabilities. Moreover, it will provide key indicators on climate change drivers (such as carbon dioxide) and impacts (such as reducing glaciers).

The service will deliver substantial economic value to Europe by: (1) informing policy development to protect European citizens from climate-related hazards such as high-impact weather events, (2) improving planning of mitigations and adaptation practices for key human and societal activities, (3) promoting the development of new services by providing datasets and tools following and free and open data policy.

The service will be fully operational by 2018, and will be continually and independently evaluated and improved, to ensure that C3S represents the latest developments in climate science and that innovative service elements are introduced reflecting current research. Appropriate channels and interfaces with research and innovation activities in Europe will be established to ensure an efficient transfer from research to operational climate service related activities.

It is therefore expected that Copernicus C3S will have a considerable influence on the climate services market.

4.1.3. Assumptions

- The first assumption that must be done to do to apply this methodology is that **prototypes will become products** that will be exchanged in a market.
- Moreover, when talking about climate services, they are referred to similar services than the ones being developed in the EUPORIAS prototypes and case-studies, which have a seasonal to decadal timescale (S2D).
- Regarding the interpretation for the concept of climate services, this report uses the one presented in the European Roadmap “[climate services] covers transformation of climate-related data – together with other relevant information – into customised products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices, development and evaluation of solutions and any other service in relation to climate that may be of use for the society at large”.

[10] www.copernicus.eu/pages-principales/services/climate-change

- Although the demand and supply analyses are going to focus on seasonal and decadal climate predictions, for the industry analysis a broad overview in each sector is needed, considering **all timescales** (weather and climate information, or in other words, daily, weekly, monthly, seasonal, decadal and multi-decadal information), as can be seen in the following figure.

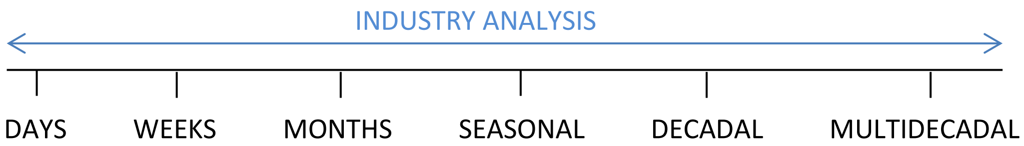


Figure 11. Timescale of industry analysis

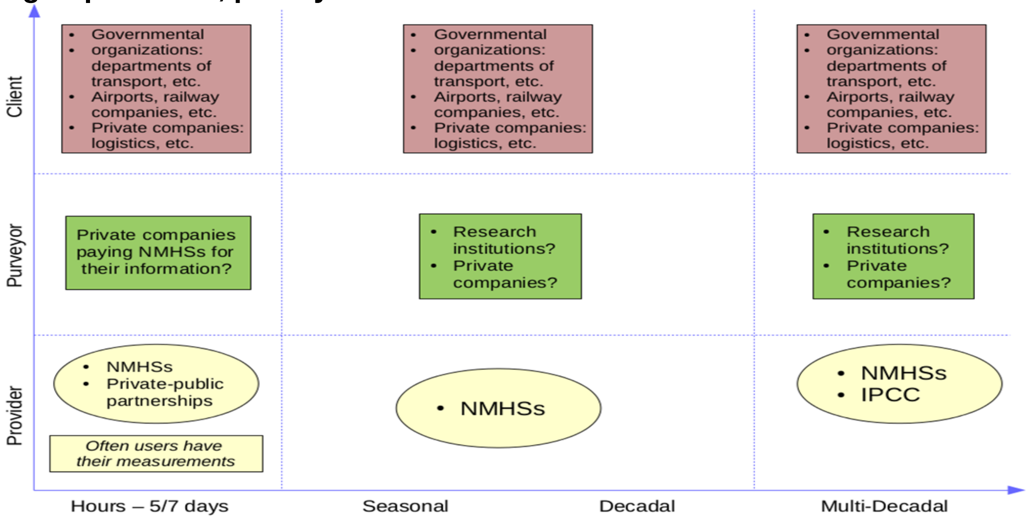
4.1.4. Example for the transport sector and particular conclusions

In this section, the main aspects of the industry analysis for the transport sector are summarised. The entire analysis can be found in Appendix 3.

Introduction In the transport sector, climate services can help to promote safe aviation and transport by road and rail. In particular, short-to-medium-term operations can be made more cost-effective through the use of weather and seasonal forecasts; whereas the rate of return on investments in infrastructure could be improved by taking into account the projected changes in future climate conditions. **Examples of climate services in the transport sector** • Transformation of historical data, monitoring data, weather forecasts, seasonal/decadal forecasts and climate change projections into transport-relevant indicators (e.g. freeze-thaw ratio, number of days when temperature is around zero...) for improving operation and planning. • Climate risk assessments and impact studies including cost-effectiveness analyses of adaptation measures, risk management plans, guidance documents and decision support systems. For instance: • Procurement of de-icing materials, snow-clearing equipment (e.g. snowploughs) and levels of stocks. • Planning and publicity of public safety campaigns. • Planning of maintenance during periods of suitable weather. • Development of extreme weather management plans (e.g. emergency timetables for public transport).
Agents Transport services are mainly offered by big (i.e. more than 1000 employees) governmental organisations pursuing activities at the national level. Most of these organisations are generally sensitive to precipitation (i.e. rainfall and snow) and floods, particularly during winter months. Some are also sensitive to cold temperatures and high winds, which can negatively affect infrastructures. Moreover, there is also potential to use transport-customized climate indices. Most (92%) of the transport-related organizations rely on weather forecasts (up to one month), whereas a 58% rely on historical data/past observations, a 50% on climate change scenarios and just a 25% on seasonal forecasts. In

particular, an important client of NMHSs is aviation, but also the UK Government Department for Transport (DfT) is using the seasonal forecasts for winter provided by the "Seasonal Prototype: Risk of Impacts from NAO on Transport (SPRINT)" developed in EUPORIAS. Moreover, in the Netherlands, the Schipol airport is using seasonal/annual forecasts of wind conditions, fog and precipitation at operational/strategic level and ProRail (the national railway company) makes a moderate use of annual forecasts of winter conditions. Finally, road maintenance (river transport) companies are aware of the potential use of monthly/sub-seasonal (seasonal) forecasts. Also, annual forecasts may have some potential for Ministerio de Fomento and ALVAC (Spain).

Mapping of providers, purveyors and clients



External variables (PESTEL analysis)

Political

ISSUES:

Transport management decisions related to planning and operation are undoubtedly linked to political decisions. E.g. (A new aviation policy, the *Single European Sky*, aims to minimize the distinct role of the many NMHSs and promote the evolution of a smaller number of aviation forecast providers).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• Policy makers are expected to promote the use of forecasts and information about current conditions. • Globalization and the consequent development of international policies may facilitate the development of CS.	• Revision/modification of current laws or agreements. • Some decisions do not depend only on technical information. That is, political vision has the last word, which is usually influenced by interest groups.

Economic

ISSUES:

Inevitably, the development of CS is constrained to the current and foreseeable shortages in public budgets as well as to the (possible) appearance of more stringent regulations in the banking system (decreased capacity lending).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• Need for innovate methodologies for risk management (promotion of cost-benefit analysis and search of cheaper solutions). • Need for alternative and cheaper transport options. • The serious capacity deficiencies found in NMHSs could be significantly remedied by relatively modest (but sustained) investments.	• Revision/modification of current laws or agreements. • Maladjusted relationship between the CS cost and their outputs in terms of higher cost-benefit ratios. • Limited budgets can lead to slow implementation of CS • NMHSs highlight that road transport agencies may not have the infrastructure or capacity to make use of the improved forecasts delivered by CS.

Social

ISSUES:

There is a need to engage the public in issues of transport and climate change using deliberative methodologies to deviate from traditional “top down” methods of information provision. New forms of research and communication need to be two-way, explore formats for learning on all sides of the issue and not necessarily strive to reach consensus.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• CS can lead to improved safety on transport and better investment policies, helping to bridge the existing gap between climate researchers and society. • CS can help in providing technical explanations to justify the decisions to be taken.	• Lack of social confidence on climate forecasts, which can prevent policy makers/stakeholders to use CS. • Risk in using climate information lacking the required lead-time, spatial resolution and skill. • Need for optimal communication of risk-based forecasts to the transport stakeholders (and society in general) and subsequent provision and evaluation of these forecasts.

Technological

ISSUES:

Responding to the climate change challenge implies taking rapid and effective steps to reduce greenhouse gas emissions, in particular through new low-carbon energy and transport technologies. This requires climate-informed decision-making at all levels in order to minimise risks and costs and to seize opportunities.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• Foreseeable availability of more skilful seasonal forecasts as well as (Copernicus C3S and others). • New electronic media (social media groups, interactive web platforms, mobile applications, etc.) may facilitate the delivery of CS to society in general.	• Strong need for upper-air sounding, specialized meteorological stations placed at key road locations, buoys and radar in coastal areas, maritime models. • Difficulty to meet the lead-time, spatial resolution and skill requirements for weather and climate information. • Difficulty to access climate and/or transport-related data. • The NMHSs of ECA highlight that road transport agencies may not have the infrastructure or capacity to make use of the improved forecasts delivered by CS. • Inadequate human resources to provide and maintain new sophisticated e-services.

Environmental

ISSUES:

The growing desire to protect the environment is having an impact on transport industries and the general move towards more environmental friendly products and processes is affecting demand patterns and creating business opportunities.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• There is need to keep enlarging and improving transport infrastructures whilst taking into account aspirations of people and businesses to reduce their impacts on the environment. • Environmental regulations can promote the development of new hybrid (non-exclusively petroleum dependent) means of	• Changes in the use of transport infrastructures as a result of more taxes being placed on traditional (petroleum dependent) means of transport.

transport.

Legal/Government

ISSUES:

Governments may be forced to promote the creation of international laws which allow to rationally and efficiently address the effects of climate change on the European economy and society, and in particular in the transport sector.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• One of the focuses of H2020 is the achievement of a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.	• Transport is a very complex system with responsibilities distributed across many different stakeholders. This situation makes integrated adaptation approaches challenging to achieve and requires appropriate governance approaches. • Rigid regulations: transport infrastructures construction is subject to several European laws. • Lack of agreement between different countries may difficult the creation of international laws.

Industry maturity

According to UKCIP, as compared with other sectors such as housing and health, the market in the transport sector is relatively mature. However, the level of maturity of CS in the transport sector highly depends on the particular application (e.g. aviation safety, road maintenance, etc.)

Business Opportunities (SWOT analysis)

Strengths	**Weaknesses**
Need for guidance on adapting transport infrastructures to the future climate, both to prevent disruption to the public and to decrease local authority maintenance costs. Creation of a new need (demand), relevant to society: CS could help improving 1) public infrastructures (increased safety) and 2) public investments. Possibility of a sustained demand of CS since they can help on both short-to-medium- and long-term decision-making processes.	Difficulty to meet the lead-time, spatial resolution and skill requirements for weather and climate information. Need for tailored decision-making processes for different applications: e.g. aviation safety, road maintenance, etc. CS development depends on public budgets to a great extent, which are subject to foreseeable shortages. Changes in regulations may be probably needed.
Opportunities	**Threats**

Could match with safety campaigns, tourism demand, etc. One of the focuses of H2020 is to achieve a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.	Difficulty to translate the outcomes (and their usefulness) from CS to society in a clear and understandable way. Lack of coordination and collaboration between the different agents/stakeholders involved. Lack of competition in the providers market.

Influence of Copernicus

One of the challenges of H2020 is to achieve a resource-efficient, climate-and-environmentally-friendly, safe and seamless European transport system for the benefit of all citizens, the economy and society. In this sense, Copernicus C3S provides information in support of adaptation and mitigation policies regarding climate change and its effects on various sectors, including transport. In particular, the essential climate variables and derived sets of indicators, the near-real-time climate monitoring, the multi-model seasonal forecasts, or the climate projections at global or regional scales are just a few of the Copernicus services that are relevant for the transport sector. Moreover, the C3S products are available to everyone so, in principle, Copernicus may be expected to positively affect the development of CS for the transport sector.

Conclusions

Transport-related companies are sensitive to determined weather and climate conditions. In particular, road, rail and maritime transport make use of information about slippery surfaces, obscured visibility and high winds. Despite this, there is a lack of meteorological data sharing by enterprises and other Government agencies so CS could help to bridge this gap.
There is a need to mitigate transport losses associated to negative weather events. CS could help to this aim by delivering tailored climate information for the aviation, maritime, road and rail transport.
Alongside its current use of weather forecast products to inform operational planning, long-range forecast information is of significant value to the transport sector and its increasing knowledge of impacts at the climate change time-scale.
As a consequence of climate change (e.g. changes in frequency and intensity of extreme weather events), transport infrastructures are expected to face growing impacts in the coming decades. Moreover, there is a need to make them more resilient to keep pace with the growing mobility needs. In this context, CS could help for better investment decisions by public authorities.
Overall, transport-related organisations seem to prefer using historical data (often their own data) and short-to-medium term weather forecasts rather than seasonal/decadal forecasts. Despite an increasing interest in integrating the latter predictions into their operational decision-making processes, the current lack of reliability seems to be the main factor which is hindering their use. Besides, it also seems that transport organizations are using climate change scenarios for strategic planning of long-term operations.

4.2. Demand Analysis

4.2.1. Introduction and Purpose

In this section a set of steps are provided in order to identify the demand of climate services in terms of **target market** and then identify users' characteristics and behaviour.

A demand analysis aims at answering the following questions:

- *Who are your potential users?*
    - *In what sector are they operating? Energy, water, transport, insurance, agriculture*
    - *What type of costumer are they? Policymakers, planners, regulators, public agencies, public services operators, private firms, citizens, other?*
- *How do they make their decisions in terms of climate predictions?*
    - *Are they using climate predictions on their decision making progress? In which type of data are based their forecasts on? (past, present, other)*
- *Which added value is going to provide your climate service compared on current forecast?*
- *Are they willing to pay for this climate service?*

Demand analysis aims to identify and quantify potential users of your climate service and their behaviour.

Market segmentation is the process of defining and subdividing a large homogenous market into clearly identifiable segments having similar needs, wants, or demand characteristics[11]. Its objective is to design a marketing mix that precisely matches the expectations of customers in the targeted segment. Usually, market is segmented by geographic, demographic and customer behaviour.

Target market is a specific group of consumers at which a company aims its products and services[12]. In case of climate services, the target market comprises all users (public or private companies) whom this climate service will give an added value in their decision making process.

The usefulness of a demand analysis is to identify potential users of a climate service and their needs. It can be useful as well to detect barriers to use climate services.

[11] Definition from http://www.businessdictionary.com/
[12] Definition from http://www.entrepreneur.com/

4.2.2. Procedure

1. Identify target market

First step of demand analysis is to identify target market. This analysis will be based on up-bottom approach. In other words, this analysis is going to identify potential users of climate services and then they are going to be segmented by geographic scope and behaviour.

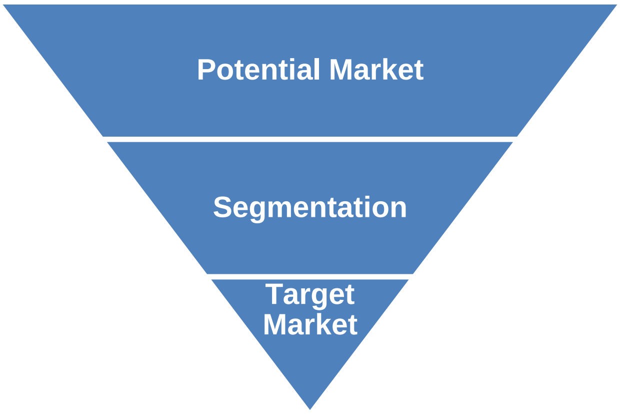


Figure 12. Identification of target market based on up-bottom approach

i. Potential market

The potential market is the aggregate of all individuals, firms, and organizations in a particular market that have some level of interest in a particular product[13]. In other words, the potential market of a climate service comprises all potential users.

In order to identify potential market, it can be useful trying to identify all potential users of a climate service, defining and describing their functions and decision they make[14]. Some examples of potential users are the following:

- State Agencies
- Regional and local governments
- Private companies
- Citizens
- Consultancies
- Other

ii. Market segmentation

Once potential users have been identified, the market can be segmented according to several scopes:

[13] Definition from http://www.businessdictionary.com/
[14] This information is available at WP12.3 (http://www.euporias.eu/system/files/D12.3_Final.pdf)

- Administration boundaries: climate service will be useful in specific countries or regions.
- Geographic and time scope: climate services will be useful in a certain geographic and time scope. For example, the “Seasonal discharge multi-model forecast system” will be used to make forecasts of seasonal discharge in the Ångerman River (geographic scope) for the spring flood period (time scope).
- Climate scope: climate service will be useful when climatic conditions are determinants. For example, in the water sector a climate service will be useful for river basins which face floods or droughts frequently, whereas in other basins not affected by floods or droughts, these services will probably have no demand.

2. Characteristics of users and behaviour

Once target market is identified, demand analysis focuses on knowing how target users behave. In terms of climate service, as “users behave” we understand:

- Sensitivity of the organization to weather events and impacts
- Users decisions making-process related to weather
- The use of weather and climate information (historical data, weather forecast, and climate change forecast).
- The sources of weather information and climate information
- The post-processing of weather information
- The use of seasonal and decadal forecasts
- The sources of seasonal and decadal forecasts
- The use of seasonal or decadal information to make decisions
- Users’ purchase determinants of using a climate service: saliency, price, quality characteristics of the service, reliability, advertising, other.
- Users’ willingness to pay for climate services.

In the EUPORIAS project context, the demand analysis proposed entails the following two tasks:

- Identification of potential market of the services developed based on WP12 interviews, which provides some information about the use for different users and different categories of services that are detailed in the following table.

Category of Services	Definition
(A) "Raw predictions of climatic variables"	"Raw predictions" of climatic variables (temperature, rainfall, wind, soil moisture, etc.) frequently used for trends and for a certain area. Raw predictions = direct output from climate model, not tailored to a specific site (large geographical scope)
(B) "Corrected predictions of climatic variables"	"Corrected predictions" of climatic variables for a specific location and for a certain use
(C) "Derivative variables"	For the water sector case, they would be hydrological derivative variables, such as river flow at the level of river basin, sub-basin, system of reservoirs, and reservoirs
(D) "Service tailored to the specific user's needs"	For the water sector case some examples could be services tailored for irrigation associations; or businesses affected by water availability (e.g. tourism sector; swimming pools, etc.)

Figure 13. Categories of services that could be offered

- Specific analysis of one product (linked to one client), which allows to analyse the clients through different criteria such as Maturity, Risk-adversity, Market Sizes, etc.
  Additional information about these criteria is provided in Appendix 2.

Criteria	Description
Maturity of the client	Approach of technology Adoption Curve (related with the type of information they use in their DMP)
Risk-adversity	Related with maturity of the client
Market size	Approach of Total Addressable Market (TAM)
Questions to get more info (WTP) Barriers, etc.	Proposal of elaborating the questions after reviewing WP12 questionnaires (e.g. it seems that in the water sector the main barrier is the low accuracy of predictions → option of asking ranges of WTP for several scenarios of accuracy improvement

Figure 14. Criteria used for demand analysis

4.2.3. Assumptions

In order to carry out this analysis, information about services with similar timescale than the ones developed in the EUPORIAS project is needed, that is to say limited to seasonal to decadal timescale (S2D).

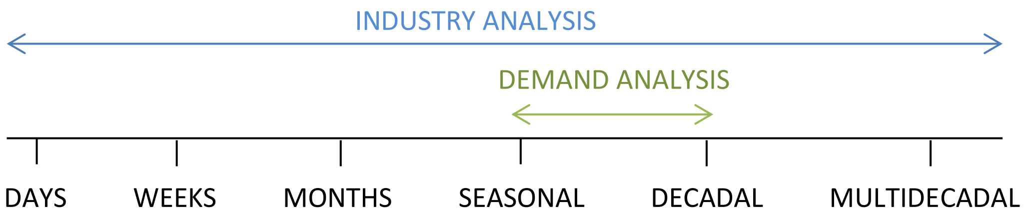


Figure 15. Timescale of demand analysis

4.2.4. Example for the water sector and particular conclusions

The demand analysis of the water sector focuses on the potential users, according to their current use of climate information and their willingness to pay.
This information is presented in a table format below, and the main conclusions extracted are summarised hereafter.

CURRENT USE			WTP	
Current use of the service considered with seasonal or decadal forecast period	NO current use of the service considered with seasonal or decadal forecast period BUT YES with weather forecast or climate change predictions		They already pay for a service based on seasonal forecast	They are interested in paying for a service based on seasonal forecast or already pay for other kind of services (weather or climate change)
NO current use of the service considered with seasonal or decadal forecast BUT some first steps done	NO current use of the service considered even for weather forecast or climate change predictions		They might be interested for a service based on seasonal forecast (and might pay for it)	They are not interested in a service based on seasonal forecast

		Potential Users							
Category of Services		A private international company (America, Asia, Europe) with around 10,000 employees	A government organisation working at the river basin level and with approximately 1,000 employees	A government organisation working at the national level with more than 250 employees	A private company working at the regional level and with approximately 2,200 employees	A government organisation working at the national level with approximately 550 employees	A government organisation working at the national level with around 400 employees	A public company working at the regional level with approximately 700 employees	A public organisation with funding coming from consultancy working at the national level.
(A) "Raw predictions of climatic variables" and (B) "Corrected predictions of climatic variables"	CURRENT USE (of seasonal forecasts)	YES (in a very qualitative way).	NOT YET. They don't use seasonal forecasting because of low confidence. They use weather forecast and climate change prediction.	YES. They use seasonal and monthly forecast to inform River Basin Agencies (RBA). RBA used it as an (informal) additional input to make decision on dam management rules and	YES. Seasonal forecasts are used as additional information.	ALMOST. They have been looking into the ECMWF 4 week forecast but are not using it operationally.	NOT YET. They use ECMWF 10 day forecast (ISS model) and are adapting their operational model to use the 14 days forecast.	NOT YET. The organisation uses weather forecasts for the next 7 days (temperature and precipitation). They have heard of seasonal forecasts but do not use	YES. They look into the 7-month forecast of ECMWF (for precipitation and temperature). They also use the European Flood Awareness System (EFAS).
	POTENTIAL WTP	They pay for some weather forecast , but most of the information they use is free. They believe that there isn't enough confidence in seasonal forecasts for having someone selling a service.	They have their own network of rainfall and temperature stations. They also use the informaton from the National Meteorological Services (NMS) and available studies from othe governemental entities about Climate Change.	They get the seasonal info for precipitation and temperature from the National Meteorological Services (NMS) website.	They have some interest in getting raw data (e.g. for ETP) and this information may be free or not depending on each case.	The organisation would be interested in seasonal information for precipitation, temperature and wind with a 5km2 grid resolution or lower (particularly for extreme events). They currently obtain weather information from their NMS, that processes and tailord it for free.	They have this information for free; and they also offer their services to their clients for free.	They get the weather forecast from the National Meteorological Services (NMS) website for free. They would consider paying for reliable climate information.	Currently they get this information for free. Any seasonal forecasts could be of interest to them even if only as qualitative information.
(C) "Derivative variables" and (D) "Service tailored to the specific user's needs"	CURRENT USE (how they currently use seasonal forecasts)	NOT YET. They check the River Basin agency prediction for the next months (based on climatology).	NOT YET	NOT YET	YES. In 2011 some maintenance works were done in advance of the predicted cold winter	ALMOST. They run simulations for the spring season but are not using ECMWF 4 week forecast operationally.	The organisation is planning to integrate the ECMWF System 4 forecasts to generate stream flow forecast.		They use all the information to prepare 3-months hydrological forecasts
	POTENTIAL WTP	They might buy them in case the meteorological conditions would influence their annual accounts to a factor of a million € (which is not believed to be the case now).	They would like to have seasonal info on rainfall and temperature transferred to floods.	Having seasonal predictions would be really useful for updating the hydrological indicators currently used by river basin agencies for decision making.	They see a market in seasonal projections use and are interested in them.	(from the answer cited above, we can assume that they might have an interest for buying as service or developing the service internally)	(from the answer cited above, we can assume that they might have an interest for buying a service or developing the service internally)		They could be interested in indices related with temperature and specially precipitation

From this analysis, the following conclusions can be given:

- The information gathered in WP12 is relatively scarce about WTP (especially for categories (C) and (D))
- It is difficult to discern between the current uses of services from category (A) and (B) from the information gathered in the interviews
- All the companies considered are already manipulating weather and climate information; some of them have developed advanced studies to adapt their activities to future weather and climate conditions.
- Five (out of 9) companies are currently consulting seasonal forecast (mainly basic information about temperature and precipitation) to adjust their decision.
- All companies see a potential benefit in new services based on seasonal prediction but only five seems to have some willingness to pay for such services.

4.3. Supply Analysis

4.3.1. Introduction and Purpose

Through a supply analysis it is intended to give answer to the following questions:

- *Who provides a climate service similar as yours?*
- *What are the characteristics of climate services delivered? (indicators, timescale, scope, frequency)*
- *Is this climate free service or is it payment service?*
- *What advantages does your climate service provide compared to other providers?*

Supply analysis describes the total amount of product or service available to customers and gathers information about them, such as price or quantity provided.

In terms of climate services, supply analysis focuses on identifying the competitors and gather relevant information about them.

In this context, competitors should be understood as providers and purveyors offering similar services as the ones developed in EUPORIAS project.

The usefulness of supply analysis is to gather information about competitors and the services they offer, and then compare the service developed with the services they

are currently offering. This will allow assessing the competitive advantage of the climate service developed.

4.3.2. Procedure

The range of the supply analysis can vary depending on the sector and data available. Below is a summary of some relevant aspects to be considered.

1. **Identify competitors**

How to identify your competitors:

- Own knowledge
- Knowledge of third party. For example, interview with customers
- Internet research

2. **Gather relevant data of competitors**

To conduct a supply analysis it is relevant gathering as much information as possible about one's competitors.

- Brief description of climate services provided by competitors
- Table with key information (see below)

Relevant data from competitors	
Current state of the service	Operational or Prototype?
Event predicted	e.g. Drought, floods, etc
Indicators delivered	e.g. Temperature, rainfall, other
Timescale	e.g. Seasonal, decadal
Frequency of information delivered	e.g. Monthly, Quarterly, yearly
Climate models	e.g. System4
Impact models	e.g. Hydrological
Maintenance	e.g. CEH
Geographical scope	e.g. River basin, region, country(ies), European Union
Source of predictions	e.g. Historical data...
Reliability	If possible, describe the degree of reliability of competitors' services
Price	Try to identify if the service is free or is payment (and its price)

Figure 16. Template for collecting competitors' information

To collect this information, one can carry out a research through internet even though the information can be limited.

3. Mapping of current best alternative options

In some cases, competitors aren't other companies providing similar services but rather current alternatives that our end-users have to make their decision processes such climate forecast based on past data.

This information can be gathered asking your customer.

Mapping of current best alternative options					
Options	Characteristics				
	A	B	C	D	E
1					
2					
3					
4					

Figure 17. Template for collecting current best alternative options

4.3.3. Assumptions

To carry out this analysis we need information about services with similar timescale than the ones developed in the EUPORIAS project, that is to say limited to seasonal to decadal timescale (S2D).

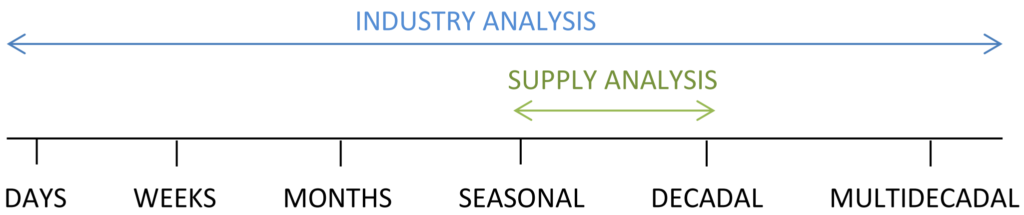


Figure 18. Timescale of supply analysis

4.3.4. Example for the tourism sector and particular conclusions

Information about competitors

There are **no direct competitors** to the PROSNOW service.
There are, however, some alternative solutions. But the quality of the information that is available today relies on the ability of the resort to collect, compare and interpret data and information from various blogs and web sites, and, for some of them, to process raw data. The presence, within the management team of the resort, of a specialist or, at least, a person that have a personal interest in weather and climate science, is a key factor.

Most resorts rely on historical climate information. It can be either collected on site or at a local level by weather professionals. Local agencies of Météo-France (for France) or other local professionals (like avalanche services, etc.) are the main providers of weather and climate services for mountain areas on a day-to-day basis for the resorts, but are generally focused on weather information and on the avalanche risk analysis. Some resorts that have a person with the related competences use all the means that are available on the internet through professional web sites, personal blogs and scientific platforms to gather and interpret information for their own use. They can then have access to tailored climate information but this cannot be considered as a general situation. Several research centres are currently working on emerging services, like climatology based snow pack provision, but there are no products on the market yet. Stakeholders seem willing to get structured in order to share information and mutualised efforts to improve knowledge on climate issues. Some initiative at local (observatory of Savoie-Mont-Blanc Tourisme, Rhône-Alpes Tourisme…) or Alpine level should allow stakeholders to cooperate and rely on existing engineering competences. Such initiatives could facilitate the structuration of a climate service at the local or Alpine scale in relation with scientific organisations.
Conclusions - Innovation potential of PROSNOW PROSNOW's objective is a direct transfer on the market of developed products after project completion, depending on the results of a demonstrator implementation and evaluation. The innovative highlights of PROSNOW not only lies in the combination of so far separated modelling tools (climate forecasts and snow models, remotely-sensed information), but also in the improved translation and visualisation of new information, and in its targeted channelling through adapted communication tools. The economic and legal conditions for a commercial service (consortium agreement, IPR, data property, business model…) still have to be detailed and tested.

4.4. Feasibility Study I

A **feasibility study** is an analysis of a certain climate service to determine if it will be profitable within the estimated cost. Nevertheless, before assessing the profitability of a service, it is mandatory to comprehend the features, benefits and value attached to the features of the service developed, as well as the weaknesses, threats and especially the opportunities of the service. Hence, feasibility study is split into two parts: the first part focuses on the description of the service, while the second part is devoted to assess the profitability of the service.

This chapter aims to provide an overall review of the prototypes developed in EUPORIAS project and the case studies; identify key advantages compared to present situation and detect market growth opportunities.

4.4.1. Introduction and Purpose

The objective of this first part of the feasibility study is to help addressing the following aspects:

- *Description of the services developed, according to its features, benefits and value.*
- *Assess strengths, weaknesses, opportunities and threats of the services developed.*
- *Identify opportunities (key advantages of the prototypes; market share; market opportunities; and alternative uses).*
- *Results obtained in the case studies.*
- *Identify entry barriers of the market.*

4.4.2. Procedure

1. Description of the climate service

Selling services by its feature can be ineffective, as customers usually can't guess how a particular feature can be significant for them. In this sense, it is very important to translate the features of the service in benefits for the customers and then link those benefits with the value attached.

In the following figure, a description of features, benefits and value is provided, as well as an example for each concept.

What are the features of your service?

- Describe main characteristics of the service:
- Which are the objectives pursued? How does it work? What kind of data provides and how often? How is information provided? (e.g. box plots, probability maps, climagrams)

What are its benefits for your customer?

- Description of a service feature but tying it to some way that it improves the customer's situation. (General benefits. e.g. protect citizens)

How can you translate these benefits into value for them?

- When "sell value," you *start* with the business goal that the customer would like to achieve–then tie that value to a specific benefit generated by a particular feature. (how much money the customer makes or saves by using the product. E.g. save in flood cost)

Figure 19. Description of climate services in terms of features, benefits and value

The agent that purchases the service will not be the only one that receives the benefits and value of this service. Indeed, many other agents can also benefit from the service even though they do not purchase it. Thus, a distinction can be done between direct and indirect benefits and value, as shown in the following figure.

Direct benefits & value = the ones that the client (who purchases the service) will perceive e.g. Increase hydropower production → increase the client revenue	**Indirect benefits & value** = the ones that the citizen, customer of the client or external companies will perceive (even if they do not directly purchase it) e.g. Reduction of flood risk → money saved for the Insurance companies

Figure 20. Direct and Indirect benefits and value

2. SWOT Analysis of climate services

SWOT analysis has already been introduced in the Industry analysis step. However, whereas in the Industry analysis SWOT is used for identifying the opportunities of climate services industry as a whole, in the context of a feasibility study, SWOT analysis can be very useful for detecting the opportunities of a certain climate service.

A SWOT template is provided in the Industry analysis step, but to be helpful, a set of questions is provided as a guideline to conduct the climate services SWOT analysis.

Strengths Compared to current forecast, what advantages does your climate service present? Based on the functional analysis, how is it helping to improve DMP of end-users? Can you list the expected impacts on end-users or society in general?	**Weakness** Is it difficult to use the climate service? It is difficult to understand data provided if the user has not a scientific profile? Is your climate service matching the needs of users? In terms of forecast data provided, frequency of data, other
Opportunities How open and free data provided by Copernicus are going to impact on your climate service? In terms of reducing cost, reliability of forecast, availability of data? Will sector demand increase? Example, it is expected that renewable energy demand will increase in coming years. Is it expected that sector is going to be boosted by public funds or regulations?	**Threats** Are forecasts reliable? Are your climate services adding value on end-users compared to forecasts available (ECMWF)? In case of your climate service, will be a payment service, does it exist similar services which can provide similar information free? Is sector regulated by the government? How can affect this to DMP of your end-user? For example, water sector is strongly regulated, so potential users of our climate service may have no incentives to improve their DMP

Figure 21. Climate Service SWOT Analysis Questions

*Most questions can be answered as positive or negative way. According to the answers' sense, sentence can be placed at Strengths / Opportunities column or Weakness /Threat column.

3. Functional Analysis of climate service

In order to identify key advantages of prototype in comparison with the present situation or with the competitors, a functional analysis is proposed.

A functional analysis aims to identify key advantages of the prototypes compared with a competitor (or present situation) though a functional scheme to share understanding on the prototypes' functionalities.

The format used is based on Functional Flow Block Diagram Format (FFBDF):

Each function stands for definite, finite, discrete action to be accomplished by system elements. Each function has a number (1, 2 or 3) and may be decomposed in sub-functions (1.1, 1.2…). The name of the function consists of an action verb followed by a noun phrase. Arrows connecting the function will show the order of execution of the functions.

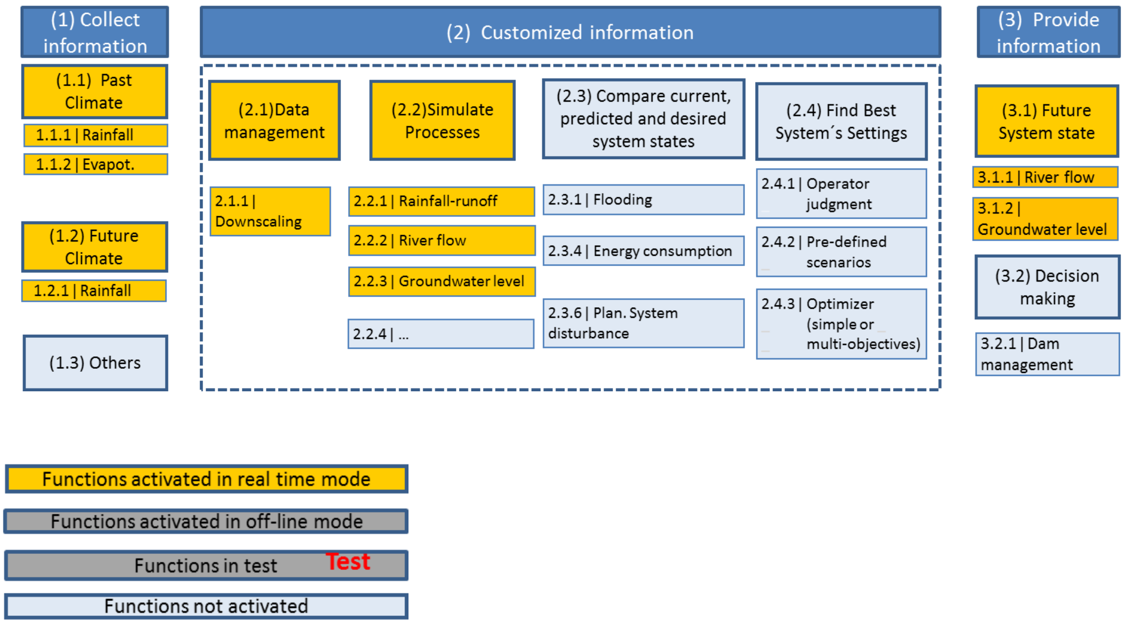


Figure 22. Operational seasonal hydrological forecasting in the UK

Source: EUPORIAS.

4. Entry Barriers

Entry barriers are economic, procedural, regulatory or technological factors that **obstruct or restrict entry of new products/services into an industry or market**. Such barriers may take the form of (1) clear product differentiation, (2) economies of scale, (3) restricted access to distribution channels, (4) collusion on pricing and other restrictive trade practices, (5) well established brands, or (6) fierce competition[15].

This definition would encompass the **entry barriers from the point of view of an organisation** which wants to launch a new service into the market.

However, another approach to take into account is the **entry barriers from the point of view of the end users**. In other words, end users might find several difficulties when trying to use a climate services. For example, if the information/data

[15] Definition from http://www.businessdictionary.com/

provided by the service is not “user-friendly”, and the end user does not have a scientific background, it may be difficult for him to include that information in his DMP.

Hence, it is important to examine the possible entry barriers that climate services (prototypes) could face in a sector, both from the approach of the provider of the service, and from the approach of the end user that is going to use that service.

5. Conclusions: climate service opportunities

Once functional analysis and SWOT have been conducted, it will be easier to identify market opportunities of climate services developed and growth opportunities. Some of the opportunities that could be identified are provided hereafter.

- **Key advantages**: Identify key advantages of a prototype compared to competitors in terms of reduce uncertainties, increase data reliability and tailoring customer needs.
- **Market share:** Differentiated aspects of the service analysed compared to the existing climate services in order to gain market share
- **Market opportunities:** Do the services developed match consumers’ needs? What are the remaining gaps? How could these gaps be bridged?
- **Alternative uses**: Other uses that prototypes could have by doing some “changes”.

6. Case studies

In case a prototype has been applied as case study, it is relevant to describe:

- Brief description of case study
- Results obtained with case studies

4.4.3. Assumptions

This chapter aims at providing an overall review of the prototypes developed in EUPORIAS project; however it is intended to help describing any climate service one wishes to develop its key advantages and detect market growth opportunities.

4.4.4. Example for the transport sector and particular conclusions

Description of the service

What is SPRINT and what does it do?

- Seasonal Prototype: Risk of Impacts of the NAO on winter Transport (SPRINT) is a seasonal prototype that provides transport stakeholders with a risk-based impact forecast at lead times of 1 – 3 months.
- Unlike many other prototypes, which have a single stakeholder or a small stakeholder group, SPRINT has a large stakeholder group coordinated by the UK Government Department for Transport (DfT).
- An in-person briefing is provided to stakeholders in November, for the DJF period. Subsequently there are also monthly teleconferences that take place between the Met Office and the DfT-led stakeholder group.
- SPRINT uses the latest Met Office seasonal forecast system (GloSea5) that has proven predictability of the winter NAO (Scaife et al., 2014) and its link to northern European winter climate, to determine the risk of transport impacts to DfT stakeholders (aviation, road and rail sectors). This impact-based forecast has been trialled in the winter of 2015/16 in the UK.
- Briefings are based on (a) the Contingency Planners' Outlook material (CPO, which predates the prototype) and (b) bespoke impact forecasts (designed during EUPORIAS).

What are the SPRINT benefits?

- These depend on the transport stakeholders (e.g. road, rail, aviation) but in the main the ultimate benefit is on optimising planning decisions. A couple of examples are provided here. These are based on Palin et al., (2016).
- **Aviation**: de-icing of planes; flight delays
- **Road**: tonnes of salt used; road accidents
- **Rail**: incidents on the railway network

How can you translate SPRINT benefits into value for the customer?

- Potential benefits:
- **Aviation, Road, Rail**: ££ saved through better planning decisions.

SWOT analysis

Strengths	Weakness
Advanced warning (up to lead times of 3 months) of potential winter impacts to transport sector (examples given above). As a consequence of the above, this should reduce costs to the relevant transport sectors.	Forecasts are currently delivered in ~October through to February covering the period ~November-April. Extending the period covered from September-April would be better. Information at 3-month lead time was considered by some stakeholders to be too uncertain to be useful. Some stakeholders would prefer 'plainer English' in communicating the forecast. Stakeholders are often reticent to make

	decisions based on the information presented in the prototype. Reasons include (a) "cost" of a wrong decision (whether financial, reputational, etc), (b) insufficient skill / too large uncertainty in the information provided.
Opportunities Potential to extend geographical coverage of prototype to other Northern European countries (but this depends upon customer data availability). As a result of the above, the market potential might be large but this needs to be determined through uptake of such impact based forecasts. Potentially increased predictability of winter NAO through enhanced super-computing power (due to procurement of new HPC) and thus potential for further predictability of sector-related impacts. Applicability of method to other sectors, depending on customer data availability and statistical link between the winter NAO and customer impact.	**Threats** Customer 'willingness' to use an impacts based forecast in the first place. The stakeholders may still prefer to use the Contingency Planners Outlook (CPO) to base their winter planning decisions on (i.e. infer what the potential impact on their operations is from the weather parameter based CPO forecast) rather than using the impact forecasts directly. Competition from other weather service providers in the road and rail sectors.

Conclusions - Opportunities

Key advantages:

- It is the first impact based risk forecast for the transport sector and therefore links a proxy for the large-scale atmospheric circulation in winter (the winter NAO) to the impacts likely to be experienced by road, rail and aviation customers.
- Monthly briefings from September through to March.

Market share:

- Based on the winter 2015/6 impacts-based seasonal forecast trial, there may be potential for future growth and thus increased market share. However, there is a need to better communicate seasonal forecast information to interested parties. As customer understanding increases, this should facilitate the incorporation of seasonal forecast information in their decision-making processes, although this will also depend on their level of risk aversion. Stakeholders that are (very) risks averse are less likely to use forecast information to alter their decision-making. Since the trial service was provided via DfT and EUPORIAS co-funding to a group consisting of multiple stakeholders across transport modes and functions, the willingness of individual stakeholders to pay for this service has not been assessed.

Market opportunities:

- As stated in 'Market share', there is significant market potential but this depends on the

factors identified (e.g. seasonal forecast communication and level of risk-aversion). Remaining gaps/improvements:

- The service should span a larger part of the year, even if the skill of the forecast is lower for some of this period
- The stakeholders would like different types of briefing material depending on their desired level of detail – hence this would further enhance customer needs.

Alternative uses:

- The alternative use and also biggest opportunity would be to apply this method to other sectors (see 'Opportunities' in SWOT analysis).

4.5. Feasibility study II

4.5.1. Introduction and Purpose

In this section a set of clear guidelines is provided in order to carry out a feasibility analysis in order to evaluate the prototypes developed and determine if they (1) are technically feasible, (2) are feasible within the estimated cost, and (3) will be profitable[16].

A feasibility study usually envisages:

- Set a potential price of the prototype
- Identify social, economic and environmental benefits

Definition

When conducting a feasibility study it is important to take into account social, environmental and economic benefits (positive externalities) of climate services. In economics, an externality is the benefit (positive externality) or cost (negative externality) that affects a party who did not choose to incur that benefit or cost[17]. Examples of externalities of climate services: increasing crop productivity, water savings or reducing delays at the airports.

However, these externalities will not be quantified due to its complexity, so they will be just listed.

Usefulness

[16] Definition from businessdictionary.com

[17] An example of external costs is pollution. In this case, the producer may choose to produce more of the product than would be produced if the producer were required to pay all associated environmental costs.

The aim of the feasibly study is to assess the profitability of a climate service prototype (which will allow to set a potential price), and to identify externalities such social, economic and environmental benefits, in a qualitative way.

In order to carry out this analysis, one has to list and quantify all the costs incurred. However, this information is frequently confidential, and hence a viable alternative is to list the main costs associated with the prototype and order them according to their relevance, or provide monetary ranges for each typology of costs.

4.5.2. Procedure

1. **Main costs**

The main costs associated with the development and operations of a climate service prototype are summarised hereafter:

i. **Investment costs:** costs associated with the development of the prototype (e.g. staff costs, supercomputing cost, data storage costs, etc.)
ii. **Maintenance and operation costs (M&O):** costs involved in running the prototype (e.g. staff costs)
iii. **Depreciation:** decline in value of a fixed asset resulting for example from its use over time or from technological evolution.
iv. **Total annual cost:** the sum of maintenance and operation costs plus depreciation.

Detailed information about each of the mentioned costs can be found in Appendix 2, along with an example of the Excel tool developed by Cetaqua to ease the cost accounting task for allowing setting a price.

2. **Profits**

Profit is a measure of profitability, which is the owner's major interest in income formation process of market production.

In order to estimate climate services profits, it can be approached by gross operating surplus. Gross operating surplus is the surplus generated by operating activities after the labour factor input has been recompensed.[18] It can be calculated from the value-added at factor cost less the annual personnel costs and depreciations.

EUROSTAT provides gross operating surplus (in percentage) by country and economic sector and it has been used on the toolkit.

According to your expectations, expected profits can be defined 0%. It will mean that selling the climate service will cover the minimum annual depreciation cost and annual operating costs.

[18] Definition from EUROSTAT

3. Set a potential price

The potential price of a service can be obtained adding total annual costs (€) and profits. Potential price is the approach of minimum annual price of the service to obtain economic benefits.

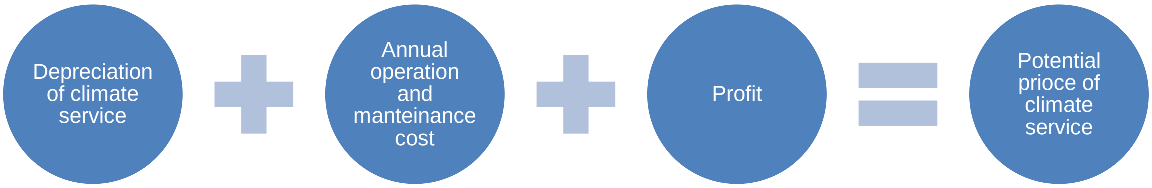


Figure 23. Potential price of climate service

In a nutshell, if the users of the service are **willing to pay** at least the **potential price**, the climate service developed will be **feasible** and **profitable**.

Other aspects to take into account when setting a potential price (current use of climate forecasts; risk appetite of target users; market price; and service degree of differentiation) are detailed in Appendix 2.

4. Potential benefits

Climate services will generate other benefits (positive externalities) apart from profits to developers. The table below shows some examples of climate services potential benefits for certain sectors, identified in the literature review:

- United States Agency for International Development (USAID). *The Value of the climate services across economic and public sectors: a review of relevant literature*. International Resources Group, 2013.
- World Methodological Organization. *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*, 2015.

Sector	Benefits
Agriculture	Increasing crop productivity due to select crops better adapted to seasonal climate forecasts. Increasing farm production and sales. Avoiding losses from drought, hail or frost due to anticipate timing of planting or / and harvest. Improving water quality due to reduce runoff from fertilizer application. Reducing insurance costs due to increase capacity to avoid losses.
Wine industry	Making strategic decisions such as buying croplands in areas not arable at present moment, potential arable in 10 – 20 years from now due to

	climate change.
Energy	Increasing revenues due to anticipated energy demand and energy supply and improved decision making process. Planning for maintenance works. More efficient planning of energy production and delivery at mid-term.
Water resources management	Water savings due to anticipated water demand and water supply. Better allocated water resources between river basin users (agriculture, industry, hydropower, domestic). Avoided agricultural production losses. Prevented flooding. Property damages avoided (crops, households, infrastructures). Avoidance of loss of life and/or injuries/illnesses from natural disasters. Reducing insurance costs due to increase capacity to avoid losses.
Transport	Reducing delays at airports. Improving scheduling of flight arrivals and departures. Planning maintenance periods of transport infrastructures (roads, rails, airports). Improve DMP linked to procurement of de-icing materials and locations of equipment, focused on transport road. Efficient scheduling of ship loading facilities. Prevent accidents.
Tourism	Increasing welfare associated with improved recreational fishing experiences or other tourism experiences linked to improve water bodies.
Retail and manufacturing	Increase revenues due to differentiation with competitors: at the end of summer, a supermarket, based on climate forecast, decided to keep on selling ice creams instead of other competitors. Weather was warmer than usual and this supermarket took a competitive advantage, because it was the only one that was selling ice creams, and it increased its revenues.
All sectors	Improve decision making processes due to increase availability of key information in advance. Improve reputation of the organizations due to include climate change on their DMP.

Figure 24. Examples of climate services potential benefits

Qualitative methods for assessing socio-economic benefits (SEB) of met/hydro services

SEB method	Description	Examples of applications
Decision theory	The decision theory approach generally involves a single agent or entity who needs to make decisions to maximize (or minimize) a given objective. This is usually represented by an economic model such as a cost-loss model, utility function or production function. It is assumed that the agent possesses a certain level of prior knowledge that informs decision-making. The value of a climatic forecast is represented by the difference between the payoffs when the forecast are used and the payoffs when only prior knowledge is applied (Rubas et al., 2006).	Met Office → SEB of increased forecast accuracy for aviation sector. Met Office → SEB of seasonal forecasts to the UK food supply chain. In the energy sector, (Hamlet et al., 2002) assessed the application of forecasts in the management of hydroelectric dams on

		the Columbia River.
Avoided costs	This type of method evaluates the SEBs based on avoided costs of weather and climate events due to improved meteorological/hydrological information. SEBs are usually expressed as avoided asset losses, lives saved, and avoided morbidity impacts. These studies are often based on decision theory as optimization occurs in the use of the climate service being valued.	Met Office → SEB associated with improved flood forecasting in terms of reductions in flood damage costs. Met Office → SEB of improved forecasts for winter planning for the road sector. Considine et al., (2004) → estimated the incremental value of hurricane forecast information to oil and gas producers in the Gulf of Mexico.
Equilibrium models	Equilibrium models tend to be applied in the context of trade and production. Unlike decision theory, general equilibrium models recognise that the choices of different decision makers are interlinked (Rubas et al., 2006). If one producer uses climate forecasts, prices will not change because the production of a single producer is very small relative to total production. However, as the number of producers using climate forecasts increases, the change in aggregate production will lead to price changes. If producers fail to anticipate this change, they may not make optimal choices (ibid).	Several related studies have examined the effect of ENSO-based climate forecasts on agricultural producers using a previously developed model of U.S. agricultural production, for example, Chen & McCarl (2000) and Chen et al. (2001). Hill et al. (2004) combined supply and demand relationships with estimated production changes caused by climate forecast use.
Game theory	Game theory is a study of strategic decision making. It is 'concerned with the actions of individuals who are conscious that their actions affect each other (Rasmusen, 1992: 21). Payoffs in game theory tend to be determined through the use of decision theory and/or equilibrium modelling. Mainly due to the extensive information and knowledge required to develop and solve games, this approach has not been widely used to evaluate climate services (Rubas et al., 2006).	Rubas et al. (2008) used an updated version of Hill et al.'s (2004) international wheat trade model to develop a three-player game between the United States, Canada and Australia.
Contingent valuation	Contingent valuation (CV) is a 'stated preference' method that is used to estimate values for non-market goods and services, such as weather and climate	Some studies have examined the willingness to pay (WTP) of households or

	services that are not typically paid for by the public. It is based on a survey that seeks to elicit the maximum amount (in monetary terms) that an individual or entity would be prepared to pay for a non-market good or service of a specified quality.	businesses using CV methods. A survey in the Sydney metropolitan area, for example, was used to estimate the economic value that householders ascribe to basic public weather forecasts and warnings. (Anaman and Lellyett, 1996a)
Benefits transfer	Due to the time and financial resources that need to be invested in original studies to estimate the value of climate services, the benefit transfer approach can be used to estimate values in one setting based on the findings of research in another setting. It can be defined as follows: 'Benefits transfer […] [is] the transfer of existing economic values estimated in one context to estimate economic values in a different context. […] [It] involves transferring value estimates from a "study site" to a "policy site" where sites can vary across geographic space and or time' (Bergstrom and De Civita 1999: 79).	Hallegatte (2012) estimated the potential benefits of establishing early warning systems in developing countries based on a study of benefits for similar services in Europe. Weiand (2008) and Costello et al., (1998) used benefits transfer to estimate values in the fishing sector.
Econometric models	These models are used to determine statistical relationships between different variables that relate to a particular economic phenomenon. This approach is generally used to model the effect of independent variables (such as price, age or income of individual) on a dependent variable (such as the value of a climate service). The most common form of econometric modelling is regression analysis.	Anaman & Lellyett's (1997) study the effect of aviation weather forecasts on operating costs of Qantas Airways Ltd for its international operations.
Value chain analysis	Unlike the traditional approach of using a cost-loss model, where the higher weather/climate forecast accuracy usually results in a more informed and therefore economically optimal decision, value chain analysis is concerned with how the initial forecast is communicated to and interpreted by the end-user. Thus, it is able to quantify, as far as practicably possible, the overall benefit of a weather/climate forecast to the end-user after accounting for information decay. This type of analysis is most useful to end-users who do not have perfect prior knowledge of weather/climate information and are not perfectly informed.	For example, this type of SEB method was used by Nurmi et al., (2013) to estimate the value of weather forecasts to vehicle users. Another example of a (qualitative) approach to value chain analysis is illustrated by a Met Office case study that investigated the SEB of seasonal to decadal climate predictions associated with the wind

		energy.
Integrated Assessment modelling	In addition to the aforementioned SEB methods, there is another modelling approach that can be used to inform SEB studies with a particular focus on the climate change timescale. The set of models that are used for this purpose are known as Integrated Assessment Models (IAMs). These global IAMs combine the scientific and economic aspects of climate change in a single iterative, analytical framework[19]. They typically contain a combination of either economic, energy or emissions modules and a climate module in addition to an impact/valuation module. The models have an additional element where climate impacts feed back onto the socio-economic module thereby linking the economy, emissions, climate impacts and climate modelling[20]. These models use simplified equations derived from relationships between climate change and economic damage to value the socio-economic impacts of climate change.	Met Office developed the Policy Analysis of greenhouse Effect 2009 integrated assessment model. The model calculates the impacts of climate change and the costs of policies to abate and adapt to it. The SEB in this case therefore arises from the contribution of increased supercomputer power to reducing uncertainty in climate change forecasts. This uncertainty reduction is translated into more optimal policy decisions on appropriate adaptation and mitigation responses.

Figure 25. Qualitative methods for assessing SEB

Additional information about advantages and disadvantages of the different SEB methods can be found in Appendix 2.

4.5.3. Assumptions

The climate services of the project EUPORIAS are in an early stage of development. In case they become a service developed to be sold in a market, a potential price will have to be set. In section 3 some guidelines are provided for fixing a price.

Additionally, to carry out the feasibility study, a toolkit based on Excel is provided. The toolkit aims to be useful either if costs structure of a climate service are known or not. A capture of the toolkit can be found in Appendix 2.

[19] http://www.unep.org/climatechange/adaptation/EconomicsandFinance/AdaptCost/tabid/29587/Default.aspx

[20] http://www.unep.org/climatechange/adaptation/EconomicsandFinance/AdaptCost/tabid/29587/Default.aspx

4.5.4. Example for the transport sector and particular conclusions

Introduction

A description of this prototype is provided in Feasibility Study I, and in this section a value for money is determined.

Important aspects: 1) The value for money calculations reported in this document are highly uncertain (due to very limited data availability for calculating both costs and benefits of the prototype). 2) There are no impacts data with witch to verify the prototype against. Hence, in order to accurately depict the value for money associated with this prototype, a targeted study needs to be undertaken, based on much more comprehensive cost and benefits data. However, within its limitations, this example highlights a possible methodology that could be used to capture the value for money of a particular climate service.

Rationale for the choice of socio-economic benefit method used

In Feasibility Study I, a wide range of SEB methods available was presented. For estimating the value for money of this prototype, the value chain analysis approach has been followed. Value chain analysis starts with forecast accuracy, and then is usually followed by dissemination of weather/climate information through various communication channels. This method can also incorporate the risk aversion characteristics of the end-user. Further details on this method can be found in GFDRR, (2015)[21]. Given that the DfT prototype significantly relies on briefing material and that a significant fraction of the end-users are risk averse, we have chosen this method to attempt to quantify the SEB.

DfT seasonal transport prototype costs

An estimation of the costs associated with the development of the prototype is detailed hereunder.

Staff time (development)	Staff time (maintenance and on-going delivery)	Computer use (data storage)	TOTAL
£145,000	£ Up to 70,000/year	£5,000	~£220,000

DfT seasonal transport prototype socio-economic benefits

Value Chain step	*Percentage of useful information*
Forecast accuracy	70% (based on the 3-month outlook)
Communication of information (through DfT briefing materials)	Based on the outcomes of a DfT workshop which trialled the DfT seasonal prototoype in winter 2015/6, the following proportion of attendees thought that the October briefing for NDJ was useful (55%), the November briefing for DJF was useful (75%), the December briefing for JFM was useful (60%) and the January briefing for FMA was useful (100%). Therefore through the whole winter season the usefulness of the briefings was ~72.5% (55% + 75% + 60% +100%/4).
Access to weather	Briefings are undertaken largely by teleconferences, and hence

[21] https://www.gfdrr.org/valuing-weather-and-climate-economic-assessment-meteorological-and-hydrological-services

information (in this case the briefings)	should be accessible to all. It is reasonable to assume that unforeseen circumstances could prevent some people from attending; we therefore set this parameter to 90%. We assume the same proportion of stakeholders to be able to attend these briefings in the future, though this may be affected by any changes in delivery mechanism for the briefings (e.g. switching to web conference).
Comprehension of information	The survey results of the winter 2015/6 trial revealed that 70% of respondents found the briefing material for DJF issued in November 'easy to understand'. In the absence of information for the other briefings (e.g. October, December and January for NDJ, JFM and FMA respectively) we assume the same level of comprehension of briefing information.
Effectiveness of response (i.e. the ability with which the end-user can or is willing to act upon the forecast)	After an initial workshop held at the Met Office in July 2015, it was apparent that there was a wide range of risk aversion attitudes. This ranged from highly risk averse (i.e. where the end-user would always plan for a cold winter irrespective of the seasonal forecast) to significantly less risk averse (i.e. where the stakeholder was in principle willing to incorporate the seasonal forecast information into their decision making). In the absence of information on the proportion of individuals that were either risk averse or not, we propose to set this value chain component at 50%.
Total estimated cost savings (per year)	Annual average winter transport costs: £950 million. We take this figure and run it through the value chain to estimate the potential cost savings (per year) that could be attributed to the DfT seasonal prototype. First we establish the percentage of value left at the end of the value chain. This follows the approach taken in Nurmi et al., (2013): 0.70 (forecast accuracy) *0.90 (access to weather information) *0.70 (comprehension of information) *0.50 (effectiveness of response) = ~0.22 or ~22%. Thus, the cost saving per year to the transport sector of using the DfT seasonal prototype based on the 3-month temperature forecasts is estimated to be: £950 million *(0.22/0.78) = **~£266 million/yr.** For the 1-month temperature forecasts, the cost savings are slightly higher due to the slightly higher forecast accuracy component of 75%. The value remaining at the end of the value chain in this case is: 0.75 (forecast accuracy) *0.90 (access to weather information) *0.70 (comprehension of information) *0.50 (effectiveness of response) = ~0.24 or ~24%.

	As such, the cost savings per year from the DfT seasonal prototype using the 1-month temperature forecasts is: £950 million *(0.24/0.76) = **~£304 million/yr.**

Conclusions
The value for money estimate of the DfT seasonal prototype obtained in this work is based on the Winter Resilience Review 2010 estimate of £950 million cost associated with severe winter weather disruption across the transport sector, and represents a cost savings of approx. **~£304 million/yr.**

4.6. Business Models

4.6.1. Introduction and Purpose

A Business Model describes how an organisation produces, distributes and captures the value[22]. It also answers the fundamental questions every manager must ask:

- How do we make money in this business?
- What is the underlying logic that explains how we can deliver value to customers and at an appropriate cost?

Definition

A Business Model has many definitions, but a possible approach is that a Business Model is a description of means and methods a firm employs to earn the revenue projected in its plans[23].

Usefulness

The aim of a Business Model is to give answer to the questions raised in the introduction step of this section. In other words, the aim is to choose the most suitable way for producing, distributing and capturing the value of a climate service.

4.6.2. Procedure

The aim of this point is to gather information about the current business models that are being used for climate services, and hence be able to select the most suitable business models for the prototypes developed in EUPORIAS project.

How to identify the current business models:

[22] https://hbr.org/2015/01/what-is-a-business-model
[23] http://www.businessdictionary.com/

- Own knowledge. For example, the business models used in your organisation.
- Knowledge of third party. For example, interview another organisation.
- Internet research.

List of Innovative Business Models

The figures below show some examples of the so-called Innovative Business Models. Additional information of these business models, as well as some examples and comments/ideas of how they could be used for climate services can be found in Appendix 2. **Additional details on the methodology**

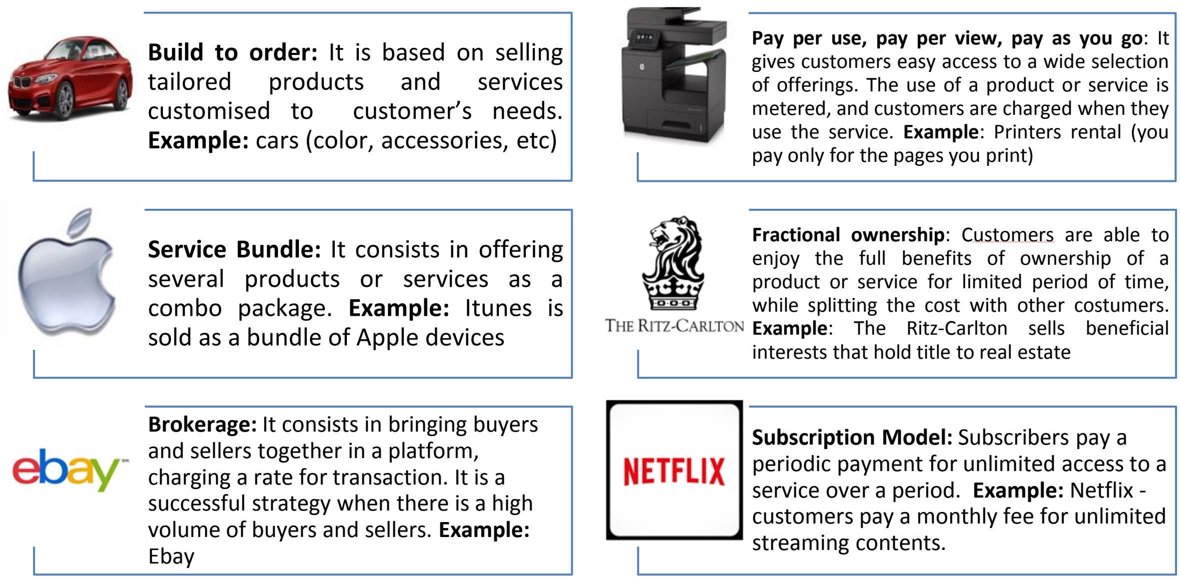


Figure 26. Some examples of innovative business models I

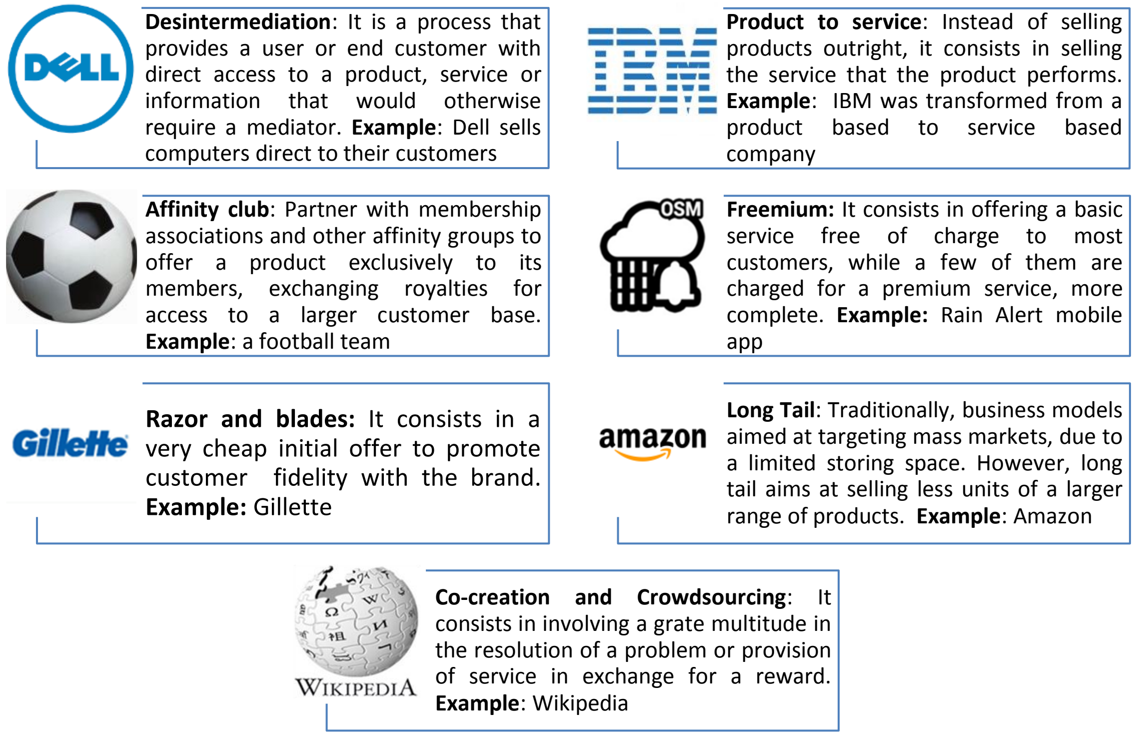


Figure 27. Some examples of innovative business models II

After introducing the concept of innovative business models, two useful tools linked with business models, Business Model Canvas and Lean Startup methodology are introduced hereafter.

Business Model Canvas

The business model canvas helps organizations conduct structured, tangible, and strategic conversations around new businesses or existing ones. The canvas's main objective is to help companies move beyond product-centric thinking and towards business model thinking[24].

The usefulness of Canvas is mapping an entire business model in a single image[25].

[24] https://hbr.org/2013/05/a-better-way-to-think-about-yo

[25] businessModelGeneration.com

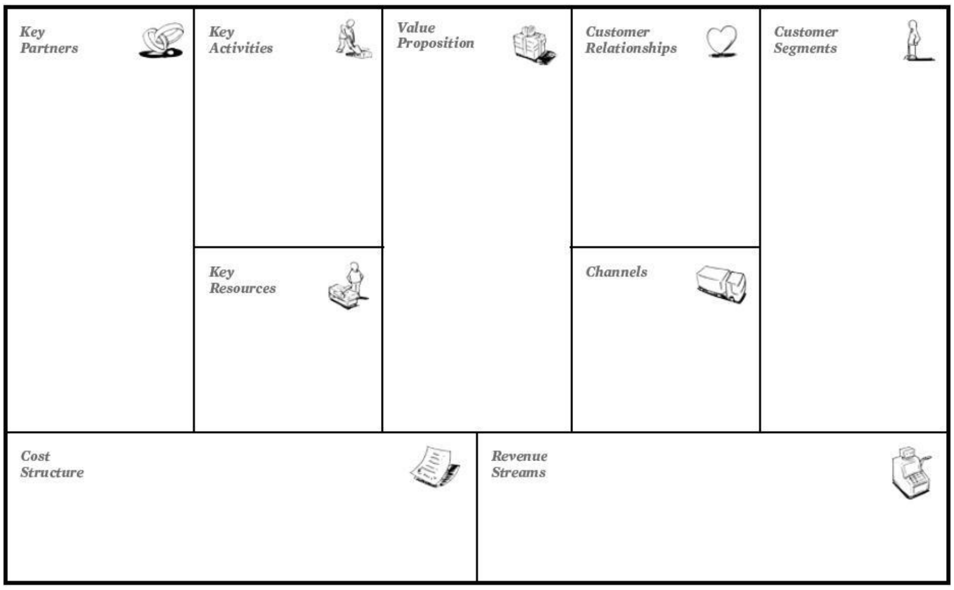


Figure 28. Canvas Business model template

A template with additional information necessary for testing Canvas business model can be found in Appendix 2.

Lean Startup Method

The Lean Startup provides a scientific approach to creating and managing startups and get a desired product to customers' hands faster[26]. It teaches you how to drive a startup, how to steer, when to turn, and when to persevere and grow a business with maximum acceleration. It is a principled approach to new product development.

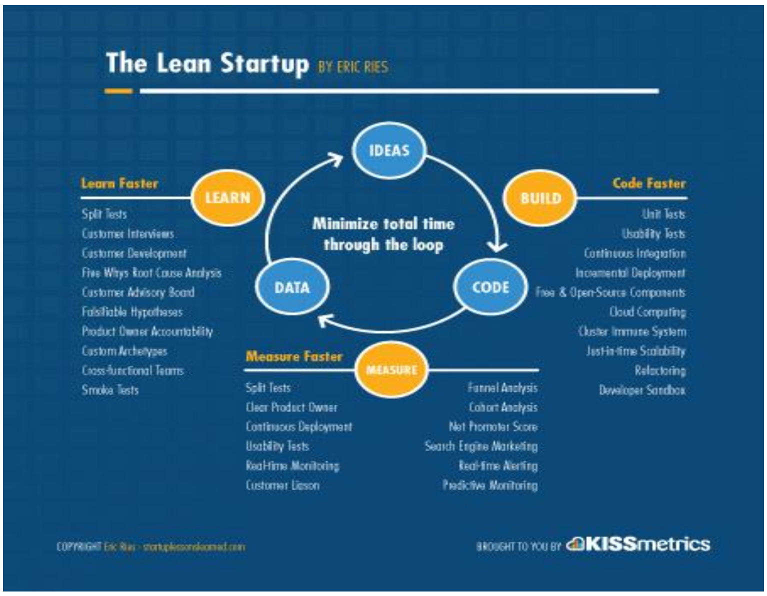


Figure 29. Lean startup business model

26 http://theleanstartup.com/principles

List of Current Business Models

The following figures exemplify the business models of several climate services providers.

METEO FRANCE
Toujours un temps d'avance

Meteo France applies different business models according to customer needs and products offered:

- ✓ Weather forecast is available free of charge
- ✓ Weather services are available based on **pay per use or pay as you go** business model.
- ✓ User can be **subscribed** to observational data service by number of stations and subscription period (1 year, 2 year…).
- ✓ Products derived from weather services are available based on **subscription** business model.

Figure 30. Météo France business model

GERICS
Climate Service Center
Germany
An institution of Helmholtz-Zentrum Geesthacht

The Climate Service Center Germany also combines different business models:

- ✓ **Freely** available products and services
- ✓ CSC develops methodologies, instruments and skills, for (1) conceptual development for climate services, (2) generation of new products and services and (3) improvement of knowledge transfer and communication
- ✓ **Order-related**, target group addressed products and services, subject to a charge

Figure 31. GERICS business model

METEO CONSULT

Meteo Consult, marine weather forecast for shipping, provides the following tailored services:

- ✓ **Free access shipping services**: this service is a free account that provides weekly the following information: 14 day forecasts for inshore areas, spots, bodies of water and ports for free, satellite animations and precipitation radars, etc.
- ✓ **Flagship subscription** offers the following services: 14 day offshore forecasts, personalised briefings included, all shipping forecasts by telephone also accessible from abroad, unlimited shipping weather e-mails & personal alerts, etc.

Figure 32. Meteo Consult business model

Some Business Models used in mobile applications and several examples can be found in Appendix 2.

4.6.3. Assumptions

In this section some examples of innovative business models have been introduced, as well as several practical examples of firms using these business models. All the information provided can be useful when choosing a suitable business model for a certain climate services, of for example the prototypes developed in EUPORIAS project.

4.6.4. Example for the energy sector and particular conclusions

Business Model for **RESILIENCE climate service** (wind energy prototype of EUPORIAS project) is presented using the Business Model Canvas[27].

<table>
<tr>
<td rowspan="2">Key partners

- Global Producing Centres of seasonal predictions
- Scientific institutions with interest in climate services – this could help levering the production and/or promotion of the service
- Large wind-energy companies – can help further tailoring of the service for users' needs and gaining new customers</td>
<td>Key activities

- Forecasting seasonal wind speed based on raw seasonal prediction data
- Developing and maintaining the user-friendly interface
- Providing additional information about seasonal predictions
- Promoting and commercialising the service
- Maintaining relationships with customers</td>
<td rowspan="2">Value Proposition

- Prediction of seasonal variability of (or better seasonal mean) wind speed
- Probabilistic predictions able to simulate the physical processes governing the whole climate system
- User-friendly interface for assisting the use of this service
- The service improves current practice based on a retrospective climatology
- The service can decrease uncertainty related to the future wind speed conditions that hinder well informed decisions about production, use and maintenance of wind energy and its facilities</td>
<td>Customer Relationships

- There is already a community of interested stakeholders that were engaged in collaboration during the development phase of the project
- Direct engagement with prospective customers, e.g. through workshops, may gain their interest
- Reaching potential customers by participating in wind-energy related events
- Maintaining relationships with customers, e.g. through the support activities, or annual meetings
- Online support</td>
<td rowspan="2">Customer Segments

Wind energy sector, in particular:
- Turbine manufactures
- Energy consultants
- Wind farm operators
- Energy producers
- Energy traders

and:
- Insurance companies</td>
</tr>
<tr>
<td>Key resources

- Seasonal prediction data
- Computational and designing skills
- Resources for sustaining customer relationships, promotion and popularisation of the service</td>
<td>Channels

- Online – the service is available as an online platform
- Direct engagement with potential clients, through invitation to take part in events, workshops, interviews</td>
</tr>
<tr>
<td colspan="2">Cost structure

- Costs of high quality raw seasonal forecast data
- Data processing and tailoring costs
- Costs related to maintaining the online service
- Customer relations costs – participating in wind-energy related events, organising events</td>
<td colspan="3">Revenue Streams

- Potential for charging the used of the service – processed and tailored seasonal wind speed predictions
- The service could be commercialised by introducing subscription pricing model
- Potential additionally tailored services to answer users' demands
- Customers will presumably be willing to pay for improved knowledge on seasonal predictions
- Currently, most of the potential customers pay for some types of raw or tailored weather and climate related data</td>
</tr>
</table>

Conclusions: the Value Proposition block, which represents what problems or needs the service responds, illustrates that the service improves the current practice based on retrospective climatology, with a user-friendly interface for end-users, and the service also can decrease uncertainty related to the future wind speed conditions, and hinder better decisions.

[27] *Note:*
We would recommend reading the table in the following order: 1. Value proposition; 2. Customer segments; 3. Channels; 4. Customer relationships; 5. Key resources; 6. Key activities; 7. Cost structure; 8. Revenue stream; 9. Key partners

5. Overview of application of the methodology for EUPORIAS prototypes

In this section, the main results found from applying the methodology to the EUPORIAS prototypes are summarised.

<table>
<tr><th colspan="2">Water Sector</th></tr>
<tr><td>Industry Analysis</td><td>Providers, purveyors and users
National Weather Agencies are the main providers of historic climate data and forecast for all the period considered. Historic data are also provided by River Basin Agencies that have their own monitoring network.
While end-users interact with both providers and purveyors of weather services and climate change predictions, the interaction are scarcer at seasonal to decadal scale (no purveyor has been initially identified in the water sector by the project´s stakeholders).
PESTEL analysis
In general, the main driver of climate services would be their low cost compared to structural solutions to face current challenges of water management and new challenges driven by climate change. The main barriers of climate services are the use of pre-defined and rigid rules to manage the resources, and the risk of trying something new that could have some negative consequences in a tense context (social reluctance, political involvement, sharing of scarce resources, etc.)..</td></tr>
<tr><td>Demand Analysis</td><td>Conclusions from interviews:
The information gathered in WP12 is relatively scarce about WTP (especially for categories (C) and (D))
It is difficult to discern between the current uses of services from category (A) and (B) from the information gathered in the interviews
All the companies considered are already manipulating weather and climate information, some of them have developed advanced studies to adapt their activities to future weather and climate conditions.
Five (out of 9) companies are currently consulting seasonal forecast (mainly basic information about temperature and precipitation) to adjust their decision.
All companies see a potential benefit in new services based on seasonal prediction but only five seems to have some willingness to pay for such services.</td></tr>
<tr><td>Supply Analysis</td><td>From the information gathered regarding current competitors, the following preliminary conclusions can be made:
Platforms currently exist that provide to multi-purpose dam</td></tr>
</table>

	managers **seasonal inflow forecasting** based on seasonal climate forecast. These platforms exist for Australia and USA. • Water operators use the information provided by national platform to improve their decision making. Still, no detailed information has been gathered on the processes of integrating this information. • **Prototypes** currently exist to provide advices to multi-purpose dam manager to use **seasonal inflow forecasting in decision making**. Examples are the Arzal reservoir in France and Angat reservoir in Philippines. • No operational software and platforms have been found that could provide tailored information to dam manager and provide them recommendation for decision making.
Feasibility Study	• It was distinguished between direct and indirect benefits in the water sector. • It was detailled the characteristic of the S-Climaware service. • A first SWOT analysis of the S-Climaware was done TABLE. • The avoided cost methodology was selected to study the S-Climaware but due several limitations, the estimation of the potential benefits cannot be completed. • It was not posible to calculate the benefits for the RIFF prototype either.
Business Models	In the Business Models section, several recommendations on the most adapted Business Models, based on the interview with experts. For more details, see the full report in Appendix 3. **Full examples for all sectors**

Transport Sector	
Industry Analysis	**Business opportunities identified** • Transport-related companies are sensitive to weather and climate conditions. But there is a **lack of meteorological data sharing** by enterprises and other Government agencies. CS could help to bridge this gap. • There is a need to **mitigate transport losses** associated to weather events. CS could help to this aim by delivering tailored climate information for the aviation, maritime, road and rail transport. • As a consequence of climate change, transport infrastructures are expected to face growing impacts in the coming decades. Moreover, there is a need to make them more resilient to keep pace with the growing mobility needs. CS could help for **better investment decisions in transport infrastructures** by public authorities. **Providers, purveyors and users** • Most (92%) of the transport-related organizations included in WP12 interviews rely on weather forecasts (up to one month), whereas a 58% rely on historical data/past observations, a 50% on climate change scenarios and **just a 25% on seasonal forecasts.**

	• Overall, transport-related organisations seem to prefer using historical data (often their own data) and short-to-medium term weather forecasts rather than seasonal/decadal forecasts. Despite an increasing interest in integrating the latter predictions into their operational decision-making processes, the current **lack of reliability** seems to be the main factor which is hindering their use. **Influence of Copernicus C3S** • Essential climate variables and derived sets of indicators, the near-real-time climate monitoring, the multi-model seasonal forecasts, or the climate projections at global or regional scales are just a few of the Copernicus services that are relevant for the transport sector. So, Copernicus may be expected to **positively affect the development of CS** for the transport sector.
Demand Analysis	**Conclusions from interviews** • For doing this analysis, 7 organisations' interviews were used, and most of these companies just use own measurements and weather forecasts for short-term operations and climate change projections for long-term planning. • However, some interviewees state that there is still some potential for the use of seasonal forecasts, especially with the aim of reducing the costs when hiring external contractors **(which are needed sometimes for the implementation of certain maintenance operations).** • Despite this, the use of seasonal forecasts in the transport sector is very limited nowadays**.** The main reason for this is the **lack of skill** of forecasts at this particular time-scale (users would explore their use if they were more reliable). Other limiting factors are the **insufficient lead-time** and the **lack of spatial resolution**. • Therefore, and despite seasonal forecasts are usually freely distributed by national met services, there might be an **opportunity for business in providing tailored seasonal forecasts**. In particular, besides downscaled forecasts, climate-derived impact indices (instead of meteorological variables themselves) might be relevant for some companies. • In all these cases, it is **not very clear if companies might be paying** for these services, at least until they do not prove to be more reliable to what they are nowadays. • Finally, another opportunity for business may be related to the immaturity of the potential users of seasonal forecasts. Very often, they do not have any experience with this kind of prediction so they cannot figure out how they may help them for better investment and planning decisions. Therefore, there might be also some room for **consultancy services** (e.g., help the user

	understand the uncertainties that are involved in these predictions).
Supply Analysis	**Competitors from the Met Office point of view** • In terms of climate services, and particularly at the 3-month timescale, the Met Office's DfT/EUPORIAS seasonal transport prototype is the only climate service in the market currently (**lack of direct competition**). • However, given that **customers are very much interested in the 1-month timescale**, and our competitors offer services at this timescale, there may be a need to assess whether the MO can provide potential customer impact information on a monthly timescale.

Feasibility Study	**Conclusions from the prototype**
	
	• **Key advantage**: It is the first impact based risk forecast for the transport sector and therefore links a proxy for the large-scale atmospheric circulation in winter (the winter NAO) to the impacts likely to be experienced by road, rail and aviation customers.
	
	• **Market share**: There may be potential for future growth and thus increased market share. However, there is a **need to better communicate seasonal forecast information** to interested parties. As customer understanding increases, this should facilitate the incorporation of seasonal forecast information in their decision-making processes, although this will also depend on their **level of risk aversion**. Stakeholders that are (very) risk averse are less likely to use forecast information to alter their decision-making. Since the trial service was provided via DfT and EUPORIAS co-funding to a group consisting of multiple stakeholders across transport modes and functions, the willingness of individual stakeholders to pay for this service has not been assessed.
	
	• **Market opportunities**: Remaining gaps/improvements
	  ○ The service should **span a larger part of the year**, even if the skill of the forecast is lower for some of this period.
	  ○ The stakeholders would like **different types of briefing material** depending on their desired level of detail – hence this would further enhance customer needs.
	
	Feasibility conclusions
	• Value chain analysis approach was used for assessing the preliminary feasibility of the prototype, obtaining cost savings per year from the DfT seasonal prototype using the 1-month temperature forecasts of **~£304 million/yr**

	• Given that the DfT stakeholders do not represent the total fraction of all UK transport stakeholders, the SEB calculated is likely to be an over-estimate of the value for money for this prototype. • It would be advisable a more thorough analysis of each of the value chain components listed, once the DfT seasonal prototype has been in operation for several years, at the earliest.

Energy Sector	

Industry Analysis	**Business opportunities identified**
	
	• The energy sector (in general) can benefit from climate services for:
	• Improving planning;
	• Providing evidence required to support new investments and increase profits;
	• Security reasons;
	• Strategic planning and support of decision-making (e.g. forecast energy prices);
	• Anticipating supply and demand.
	
	• **Anomalous years**, like 2015 for wind power production in the USA, **foster the interest** of the industry in climate predictions.
	
	• European Commission pushes Climate services development and **Copernicus initiative** might give more sectoral visibility to climate services for the energy industry.
	
	• However, the following threats were identified:
	
	  o Each company might want to use its own confidential method to have climate predictions included in their decisions to have a competitive advantage.
	
	  o **Users might not understand the need for a climate service** if they already can have direct access to official predictions form ECMWF or other providers and highly technical departments to make their own estimations.
	
	  o Limited collaboration on the validation of predictions of climate services if that requires firms to release confidential information about their processes (power generated in a particular wind farm, real observed data of wind, etc.).
	
	Providers, purveyors and users
	
	• Unlike the other sectors analysed, in the wind energy sector, several providers, purveyors and users can be identified in the seasonal – decadal timescale.

Demand Analysis	**Conclusions from interviews**
	
	• 14 organisations were interviewed, encompassed in 3 groups: Electricity generation companies; Transmission system operators; and Research and Consultancy.
	
	• Some of them might be interested in using and paying for derivative variables and services tailored, probably this sector has a higher propensity to use and pay in comparison with the others analysed. This fact can give us clues about a possible higher degree of maturity in comparison with the others.
	
	Characteristics of demand
	
	• The total addressable market (TAM) would be the whole energy sector, whereas the served available market (SAM) would include:
	  o Wind farm developers
	  o Wind farm owners
	  o Operation and maintenance teams
	  o Wind resource assessment consultancies
	  o Energy traders.
	
	• The **target market** (TM) would include those users that at the moment do not have suitable alternative data. This includes **energy traders** and **large wind energy providers** (those owning multiple wind farms in diverse geographic locations).
	
	• **Main barrier**: The main reason for not using seasonal wind predictions so far, as perceived by the clients, is their **lack of reliability**[28].

Supply Analysis	**Competitors** • At present, a few providers of seasonal weather predictions provide maps on temperature and precipitation (e.g. Meteo France, NOAA NCEP, IRI, CCCma), we thus **could not detect a real "competitor" to EUPORIAS RESILIENCE service**, i.e. a provider who processes seasonal weather forecasts for wind. Met Office Seasonal Prediction prototype provides storm prediction, among other data, and we used this service as an example of a potential competitor to RESILIENCE.
Feasibility Study	**Conclusions from the prototype** • The RESILIENCE prototype needs to reach a large enough number of users in order for the innovation to be more broadly accepted. Rather than through simple knowledge transfer, innovations are more effectively adopted through stakeholders'

[28] The term Reliability is used here as a synonym of trustworthiness and, as a result, it can be mapped onto a number of other technical concepts such as skill, reliability, and sharpness.

	interactions, i.e., through knowledge exchange. More **active communication and collaboration with these early users** could thus make them aware of the service and motivate them to use it. • Most importantly, we should **address** those aspects that are at the moment perceived as the **main obstacles to using seasonal to decadal predictions: low predictability and reliability**. Promotion and popularisation, as well as better communication could result in improved understanding and more accurate perception of what is the added value of this service. **Feasibility conclusions** • **Decision theory approach** was used for obtaining a preliminary study of avoided loss for a hypothetical use of the RESILIENCE prototype for an offshore wind farm maintenance. The hypothetical loss due to scheduling the maintenance in the period of good wind was estimated in **13 500eur for five days**. This loss could be avoided if the information from the service was used. • A **qualitative socio-economic benefit analysis** for RESILIENCE climate service was also conducted, assessing the full suite of financial, social and environmental benefits and considering whether the climate service will result in downstream impacts. • Finally, the feasibility of the prototype was also assessed from the **Value Chain Analysis** perspective, evaluating the three phases in which the value added in the supply chain for climate services occurs.
Business Models	• Business Model for RESILIENCE climate service is presented using the **Business Model Canvas**. • A remarkable finding is the **Value Proposition block**, which represents what problems or needs the service responds, and illustrates that the service improves the current practice based on retrospective climatology, with a user-friendly interface for end-users, and the service also can decrease uncertainty related to the future wind speed conditions, and hinder better decisions.

Tourism Sector	
Industry Analysis	**Providers, purveyors and users** • The mapping of providers/ purveyors of the tourism sector was focused in the French industry. And it shows that there is a gap of providers and purveyors for 1 month up to 10 years' timescale (especially in the case of providers of derived variables).

Demand Analysis	**Business opportunities identified**
	
	• Climate services could help improve product design and communication for destinations and tourism companies as well as facilities management and investment.
	
	• Three main threats have been identified:
	  o Depending on the type of tourism, weather/climate is not considered as a major factor.
	  o Tourism in a very heterogeneous sector in terms of stakeholders, decision-makers.
	  o There is a need for very local climate information.

Supply Analysis	**Current use of climate information in tourism sector**
	
	• If the tourism sector shows on one hand, a growing perception of the issue of climate change as a key issue affecting on-going and future development, on the other hand, there is a **very low level of awareness and use of climate services**.
	
	• The ways in which actors currently access climate information vary greatly from one person to the next. This is in terms of the approach used, and the kinds of information sought (political, technical, etc.). There is no real homogeneity or clear structure in the approaches adopted, which are mostly dominated by in-house or personal monitoring of the general situation, despite the use of traditional information circuits in the tourism sector.
	
	• There is a **very low level of awareness and use of climate services** in the world of tourism:
	  o Lack of knowledge about the existing climate products.
	  o Complexity and level of uncertainty of the products.
	
	• **Very few organisations use S2D predictions**. Reasons given are mainly related to the **lack of reliability**[29] of the information provided (uncertainty, low skill) and also the **accuracy** of the products provided (too large scale, not enough parameters).
	
	• The main **purchase determinants** for seasonal prediction services in the mountain tourism sector seem be related to:
	  o Reliability of climate information
	  o Detailed and tailored interpretation of the data
	  o Quality of the graphical interface
	  o Geographical scale (ski resort to slope scale)
	
	• There is a **need to develop intermediaries**, since most ski resorts do not have high level skills in climate data interpretation, and therefore seasonal forecasts might not be beneficially used if

[29] The term Reliability is used here as a synonym of trustworthiness and, as a result, it can be mapped onto a number of other technical concepts such as skill, reliability, and sharpness.

	not provided in a proper way.

Feasibility Study	**Conclusions from the prototype**
	
	• Main **opportunities** identified:
	  o Strong dependence on climate of the ski activities.
	  o Better management of human and technical resources for the ski resort.
	  o Possibility to develop new products (early opening for local customers).
	
	• Main threat: Low technical skills of decision makers, need for training.
	
	Feasibility conclusions
	
	• A Feasibility Study was conducted, making assumptions of potential costs and profits, and hence a proposal of different potential prices is provided, associated with different business models that could be used.

Extrapolation from specific findings

- All the sectors analysed are sensitive to weather and climate conditions, to a greater or lesser degree.
- All the sectors think that Copernicus C3S is going to have a positive influence on the development of the climate services industry.
- The climate services industry in all the sectors is considered to be immature. However, taking into account the information about use and willingness to pay from the interviews, the wind energy sector seems to have reached a bit higher degree of maturity. This general low degree of maturity, especially regarding the S2D timescale, opens doors to take advantage of a possible market niche in all sectors. However, the information used for conducting the demand analyses (based on WP12 interviews) is not representative enough, and additional interviews should be done to collect relevant information about potential use and WTP.
- Finally, all sectors identify the same current gaps in climate services information, which are the lack of skill of forecasts, the insufficient accuracy.

6. General conclusions

General conclusions on the methodology

The main objective of WP45 is to develop a general market analysis methodology to assess business opportunities of the climate services developed.

In this sense, a methodology has been developed that, on one side, allows getting a general overview of a market (both the variables that affect an industry; and analysing the most relevant aspects of current and potential demand and supply). And on the other hand, the methodology also allows assessing a new service developed, from the point of view of its economic feasibility, as well as, giving insight of a range of current innovative business models used, and hence helping assessing which could be more suitable for the prototypes.

Regarding the target readers identified, for EU and EU Sates this report can be useful for identifying the main risks in the sectors analysed and hence prioritise the funding of climate services projects in the sectors more vulnerable to weather/climate conditions, as well as promoting new business opportunities and job creation. Copernicus C3S can also take advantage of this report, as policymakers and public authorities can use the information collected for developing legislations and policies. In the case of purveyors, start-ups and SMs, this report can help them identifying market gaps and niche markets in the sectors analysed. Finally, big consultancies can also be interested in this report for getting information about what kind of climate services they could incorporate in their services.

In conclusion, the methodology developed fulfils the objective of WP45 and may be of great interest for the target readers identified.

Conclusions on the implementation of the methodology

The main difficulty entailed regarding the elaboration of the methodology is that to our knowledge there is no particular market analysis methodology for climate services. Therefore, the starting points were reviewing the existing methodologies for other typologies of services (more developed) and then adapt them to climate services characteristics thanks to the collaboration of the partners that applied it gradually to their sectors.

Another difficulty encountered is that most of the partners were not familiar with the market analysis concept and the specific tools used in these analyses (e.g. SWOT, PESTEL, etc.). This difficulty was successfully overcome by sending in advance the different examples for the water sector, so it served as a frame of reference. Additionally, it was really useful scheduling periodic follow-up meetings with the partners to present the tasks to do stepwise and to solve doubts.

The last difficulty is that the methodology has been implemented to prototypes (instead of full developed services). So, in some cases several hypotheses had to be done, particularly about the costs and benefits associated with the prototypes. Indeed, the first hypothesis to do was assuming that prototypes will become services that will be exchanged in a market.

Finally, it is worth pointing out that in the demand analysis, conclusions have been extracted from WP12 interviews. These results should be taken with caution, as they necessarily do not represent all the sectors.

Results of implementing the methodology

The main added value of implementing the methodology developed is having a well-defined methodology that can be extrapolated to any climate services that one wishes to develop.

Moreover, relevant information about several markets has been collected for different sectors (needs, gaps, competition, etc.); as well as information about the prototypes (features, benefits associated and value), and their economic feasibility. One of the objectives of project EUPORIAS task 43.6 is developing a mobile phone application associated to one of the prototypes developed in WP42 to bring the information generated directly to the Smartphone. Hence, the information gathered about business models for mobile applications can be very useful for this task.

Finally, remark that a feasibility study has been done for several sectors and using various methods. The results obtained are interesting, but what is more relevant is seeing the steps followed for doing these studies.

7. References

Alberici, S., Boeve, S., van Breevoort, P., Deng, Y., Förster, S., Gardiner, A., van Gastel, V., Grave, K., Groenenberg, H., de Jager, D., Klaassen, E., Pouwels, W., Smith, M., de Visser, E., Winkel, T., Wouters, K. (2014). “Subsidies and costs of EU energy”. Final report. European Commission.

Anable, Jillian, Ben Lane, and Tanika Kelay. (2006). “An Evidence Base Review of Public Attitudes to Climate Change and Transport Behaviour”. Department for Transport, London. http://www.pdfwww.china-up.com:8080/international/case/case/1457.pdf.

Anaman, K.A. and S.C. Lellyett. (1996a). “Contingent valuation study of the public weather services in the Sydney metropolitan area”. Economic Papers 15(3):64–77.

Anaman, K.A., S.C. Lellyett, L. Drake, R.J. Leigh, A. Henderson-Sellers, P.F. Noar, P.J. Sullivan, and D.J Thampapillai. (1997). “Benefits of meteorological services: Evidence from recent research in Australia”. Meteorological Applications 5:103–115.

Bergstrom, J.C. and P. De Civita. (1999). “Status of benefit transfer in the United States and Canada: Review”. Canadian Journal of Agricultural Economics 47(1):79-87.

Bhat, A., & Blomquist, W. (2004). “Policy, politics, and water management in the Guadalquivir River Basin, Spain”, 40, 1–12. http://doi.org/10.1029/2003WR002726

Boulahya, M. S. (2010). “Climate services for development in Africa with a potential focus on energy”. In: TROCCOLI, A. (ed.) Management of Weather and Climate Risk in the Energy Industry. Springer Science.

CarbonTrust (2013). “Socioeconomic value of Met Office High Performance Computing to the renewable energy industry”. The report was prepared by The Carbon Trust and Orion Innovations. The research was commissioned under tender number DNWD-8WYJSP: Research of the Value of Met Office Climate Projections to the Energy Industry.

C.E.E.I GALICIA, S.A. (BIC GALICIA). (2010). “Como realizar un estudio de mercado. Manuales prácticos de la PYME”.

Chen, C.C. and B.A. McCarl. (2000). “The value of ENSO information on agriculture: Consideration of event strength and trade”. Journal of Agricultural and Resource Economics 25(2):368–385.

Chen, C.C., B.A. McCarl, and R.M. Adams. (2001). “Economic implications of potential ENSO frequency and strength shifts”. Climatic Change 49:147–159.

Considine, T.J., C. Jablonowski, B. Posner, and C.H. Bishop. (2004). "The value of hurricane forecasts to oil and gas producers in the Gulf of Mexico". Journal of Applied Meteorology 43:1270–1281.

Costello, C.J., R.M. Adams, and S. Polasky. (1998). "The value of El Niño forecasts in the management of salmon: A stochastic dynamic assessment". American Journal of Agricultural Economics 80:765–777.

Dessai, S. and Bruno Soares, M. (2015). "Report summarising users' needs for S2D predictions". European Provision Of Regional Impact Assessment on a Seasonal-to-decadal timescale, Deliverable D12.3.

Downey, J., & Technical Information Service (2007). "Strategic Analysis Tools". Topic Gateway Series No. 34. CIMA.

Dubus, L. (2010). "Practices, needs and impediments in the use of weather/climate information in the electricity sector" In: TROCCOLI, A. (ed.) Management of Weather and Climate Risk in the Energy Industry. Springer.

Dubus, L., (2014). "Weather and Climate and the Power Sector: Needs, Recent Developments and Challenges. In Weather matters for energy", A. Troccoli, L. Dubus & S.E Haupt (Eds), Springer, 2014, 528p. Doi 10.1007/978-1-4614-9221-4.

European Comission (2014) "Communication from the commission to the European Parliament, the council, the European economic and social committee and the committee of the regions: A policy framework for climate and energy in the period from 2020 to 2030". European Commission, Brussels.

EDUMARKETING. (2005). "Guía para realizar una investigación de mercados" Área de Comercialización e Investigación de Mercados. Área de Organización de Empresas. Universidad de Extremadura.

EUPORIAS Deliverable D12.3. (2015). "Report summarising users' needs for S2D predictions".

European Environment Agency. (2014). "Adaptation of Transport to Climate Change in Europe Challenges and Options across Transport Modes and Stakeholders". Luxembourg: Publications Office. http://bookshop.europa.eu/uri?target=EUB:NOTICE:THAL14008:EN:HTML.

Fazey, I., Bunse, L., Msika, J., Pinke, M., Preedy, K., Evely, A.C., Lambert, E., Hastings, E., Morris, S. and Reed, M.S. (2014). "Evaluating knowledge exchange in interdisciplinary and multi-stakeholder research", Global Environmental Change, 25:204–220

Gary Graham, Dr, David Bonilla, Hartmut Keller, and Juergen Schmiele. (2015). “Climate Policy and Solutions for Green Supply Chains: Europe’s Predicament”. Supply Chain Management: An International Journal 20, no. 3: 249–63.

GFDRR (2015). “Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services”.

Great Britain, Department for Transport, Richard Brown, and Stationery Office (Great Britain). (2014). “Transport Resilience Review: A Review of the Resilience of the Transport Network to Extreme Weather Events”. [London]: [Stationery Office].

Hallegatte, S. (2012). “A Cost Effective Solution to Reduce Disaster Losses in Developing Countries: Hydro-meteorological Services, Early Warning, and Evacuation”. Policy Research Working Paper Series 6058. The World Bank, Washington, DC.

Hamlet, A.F., D. Huppert, and D.P. Lettenmaier. (2002). “Economic value of long-lead streamflow forecasts for Columbia River hydropower”. Journal of Water Resources Planning and Management 128:91–101.

Hill, H.S.J., J.W. Mjelde, H.A. Love, D.J. Rubas, S.W. Fuller, W. Rosenthal, and G. Hammer. (2004). “Implications of seasonal climate forecasts on world wheat trade: A stochastic, dynamic analysis”. Canadian Journal of Agricultural Economics 52(3):289–312. DOI:10.1111/j.1744-7976.2004.tb00371.x.

IEA (2016) Internation Energy Agency website, available at https://www.iea.org/ (Accessed 06/09/2016).

Jonkman, J., Butterfield, S., Musial, W., Scott, G. (2009). “Definition of a 5-MW reference wind turbine for offshore system development”, Technical Report NREL/TP-500-38060, National Renewable Energy Laboratory, Golden, Colorado, USA.

Koeppe, O and Schulze, K. (2010). “Offshore-Windparks in Europa”, KPMG, Berlin, Germany.

Kotler, P., & Armstrong, G. (2010). Principles of marketing. Pearson education.

Krijnen, J. (2016). “Socio-economic benefit studies of weather and climate services: an overview of different methodologies”. Met Office.

Liljas, E. (2007). “The economic value of snowstorm forecasts in winter road maintenance decisions”. Elements for Life. Geneva: Tudor Rose on behalf of the WMO.

Lirio, A. (2012). “Investigación de Mercados”. Universidad Nacional de Ancash Santiago Antúnez de Mayolo.

Makri, S. (2015). “EUPORIAS seasonal wind prediction prototype: User evaluation”. City Univeristy London.

Martin-ortega, J., & Markandya, A. (2009). “The costs of drought : the exceptional 2007-2008 case of Barcelona”, (November).

Mills, B. (2007). “Applications of weather and climate information in road transportation examples from Canada”. Elements for Life. Geneva: Tudor Rose on behalf of the WMO.

Nurmi, P., Perrels, A. and Nurmi. V., (2013). “Expected impacts and value of improvements in weather forecasting on the road transport sector”, Meteorol. Appl. 20: 217-223.

Osterwalder, A. (2013). “A Better Way to Think About Your Business Model”. Harvard business review, available at: https://hbr.org/2013/05/a-better-way-to-think-about-yo (accessed: 22/09/2016).

Perrels, A., Th. Frei, F. Espejo, L. Jamin, and A. Thomalla. (2013). “Socio-Economic Benefits of Weather and Climate Services in Europe”. Advances in Science and Research 10: 65–70. doi:10.5194/asr-10-65-2013.

Rasmusen, E. (1992). “Game and information: an introduction to game theory, reprint with corrections”. Blackwell Publishers, Oxford.

Rothstein, B. and Halbig, G. (2010). “Weather sensitivity of electricity supply and data services of the German Met Office”. In: TROCCOLI, A. (ed.) Management of Weather and Climate Risk in the Energy Industry. Springer Science.

Rubas, D.J., H.S.J. Hill, and J.W. Mjelde. (2006). “Economics and climate applications: Exploring the frontier”. Climate Research 33:43–54.

Rubas, D.J., J.W. Mjelde, H.A. Love, and W. Rosenthal. (2008). “How adoption rates, timing, and ceilings affect the value of ENSO-based climate forecasts”. Climatic Change 86:235–256.

Sauri, D. (2013). “Water conservation campaigns and citizen perceptions : the drought of 2007 – 2008 in the Metropolitan Area of Barcelona”, 1951–1966. http://doi.org/10.1007/s11069-012-0456-2

Scaife A.A., A. Arribas, E. Blockley, A. Brookshaw, R.T. Clark, N. Dunstone, R. Eade, D. Fereday, C.K. Folland, M. Gordon, L. Hermanson, J.R. Knight, D.J. Lea, C. MacLachlan, A. Maidens, M. Martin, A.K. Peterson, D. Smith, M. Vellinga, E. Wallace, J. Waters and A. Williams, (2014). “Skilful Long Range Prediction of European and North American Winters”. Geophysical Research Letters, Vol. 41, Issue 7, 2514-2519.

Scheu, M., Matha, D., Hofmann, M., Muskulus, M. (2012). "Maintenance strategies for large offshore wind farms", Energy Procedia 24: 281-288.

Sireli, Y., Ozan, E., & Kauffmann, P. (2001). "A market research study for future weather information systems in general aviation". In American Society for Engineering Management (ASEM) National Conference.

Street, Roger, Martin Parry, Jesse Scott, Daniela Jacob, Tania Runge, European Commission, and Directorate-General for Research and Innovation. (2015). "A European Research and Innovation Roadmap for Climate Services". Luxembourg: Publications Office.

Thornes, J. (2007). "Climate and Transport Systems". Contribution to WMO Working Group Meeting on Socio-Economic Benefits of Climatological Services.

USAID (2013). "The value of climate services across economic and public sectors. A review of relevant literature".

Wieand, K. (2008). "A Bayesian methodology for estimating the impacts of improved coastal ocean information on the marine recreational fishing industry". Coastal Management 36(2):208–223.

Willway, T, S Reeves, L Baldachin, Great Britain, and Department of Transport. (2008). "Maintaining Pavements in a Changing Climate". London: TSO.

Windeurope (2016) The European Wind Energy Association website, available at https://windeurope.org/

World Bank. (2008). "Weather and Climate Services in Europe and Central Asia: A Regional Review". World Bank Working Papers. The World Bank. http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-7585-3.

World Bank Working Paper. (2016). 'Weather and Climate Services in Europe and Central Asia'. http://elibrary.worldbank.org/doi/abs/10.1596/978-0-8213-7585-3.

World Meteorological Organisation (2011). "Organization Climate Knowledge for Action: A Global Framework for Climate Services — Empowering the Most Vulnerable". Report No. 1065.

World Meteorological Organisation (2015). "Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services". Report No. 1153.

World Food Programme and Food Security Analysis Service (ODXF) (2011). "Market Analysis Framework". Tools and Applications for Food Security Analysis and Decision-Making.

8. Appendices

8.1. Appendix 1. “Methodology express”

In this section the main slides (used in teleconferences with EUPORIAS WP45 partners) summarising the market analysis methodology are presented, with the objective of providing an overview of the methodology (in other words, “a methodology express”) and easy the implementation of the methodology to anyone interested in applying it to a certain climate service.

Two typologies of tasks are proposed: “Basic tasks” (in green colour) and “Optional tasks” (in orange colour).

Task typology	Description
Basic tasks	“A must”
Optional tasks	“Depending on the resources availability”

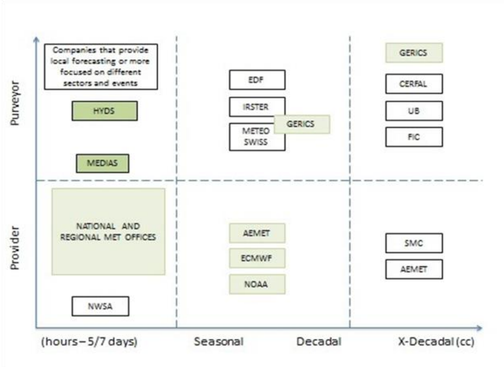
Industry Analysis

Task	Description	Comments
Agents	Identify and map the main actors of the industry for this sector (Providers/Purveyors/End-users)	Template (fill the table) → Map of providers/ purveyors
External variables	PESTEL analysis (considering Opportunities / Threats – this is related with SWOT)	Fill the template (1page) + 1-3 pages of explanation
Industry Maturity	Two approaches to assess maturity are provided	
Industry Structure	Concentration degree	Only relevant in case of few providers
Business opportunities	Consequence of SWOT for the CS in general in this sector	Fill the template
Influence of Copernicus	How can C3S influence the climate services market?	If relevant add information (should be in the PESTEL)

Agents

Identification of providers/purveyors

Timescale	Providers/ purveyors of temperature and rainfall	Providers of derived variables
Historical data	*e.g. National Weather Agencies*	
0 – 24 hours		
1-7 days		*Governmental Agencies* *(Standardized Precipitation Evapotranspiration Index (SPEI))*
1-2 weeks		
1 month		
1-7 month		
1 – 10 years		
10 – 100 years		



External variables

Political		Economic	
Opportunities	Threats	Opportunities	Threats
Social		**Technological**	
Opportunities	Threats	Opportunities	Threats
Environmental		**Legal/Government**	
Opportunities	Threats	Opportunities	Threats

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Example for the water sector

External variables

Political

ISSUES:

Water management decisions related to planning and operation are strongly link to politics´ visions, especially for the following topics: sharing of resources (e.g. water transfer in Spain, restriction of agricultural uses for ecological flow, desalination), risk management actions (e.g. priority in financing actions for limiting impacts of drought or flooding, consideration of climate change), costs and management of water services (cost-recuperation, private/public management).

IMPACTS ON CS BUSINESS:

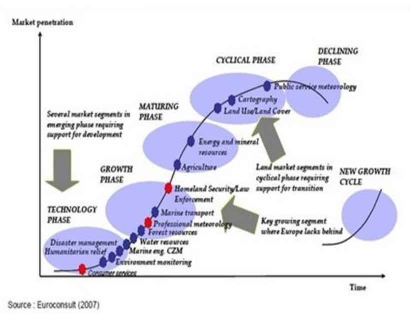
Opportunities	Threats
Need for low-cost (non- structural) measures in risk management	Some decisions do not depend (yet) on technical information

Industry Structure

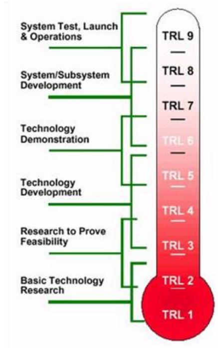
Concentration degree (specially relevant in cases when there is a single/small number of providers/purveyors or users.

Industry Maturity

Maturity approach for goods and services



Maturity approach for technologies



Business opportunities

Influence of Copernicus

Strengths	Weaknesses
• Could help improving flood policies and drought policies. • Possibility of a long term demand of climate services. • Creation of a new need (demand). • Water sector depends on climate change.	• Need of training. • Probably will require changes in regulation. • Dependent on public finance. • Decision-making processes tailored to each basin and based on fixed rules.
Opportunities	**Threats**
• WFD defines river basin as a unit of management. • Could match with hydro-electric, tourism demand, etc. • EC support for applying in water sector the related climate services.	• Risk-adverse end-users (dam management) • Lack of understanding the benefits of their application. • Lack of coordination and collaboration between involved agents/stakeholders. • Difficulty to understand the role of climate services. • Lack/need of standardisation of climate forecasts systems. • Lack of competition in providers market.

How can C3S influence the climate services market?

Demand Analysis

Task	Description	Comments
Task 1 **Identify potential market (general analysis of the sector in a Table format)**	▪ Based on EUPORIAS WP12 questionnaires. Filling the table with **information on their use** (YES/NO/IT DEPENDS) **and willingness to pay** (YES/NO/IT DEPENDS) for different type of services that could be offered. ▪ List the advanced services that could be developed.	Fill template for your sector
Task 2 **Specific analysis of one product linked to one client (sub-sector)**	▪ Could be for the **Prototype/Case study** in development in EUPORIAS or other. ▪ Will analyse the clients through **different criteria** such as Maturity, Risk-adversity, Market Sizes…. ▪ Will propose some questions to be asked to the clients to get more information (**willingness to pay**)	

Task 1. Identify potential market

Types of Services

Category	Definition
(A) "Climate model outputs"	"Raw Forecast" of Climate Variables (temperature, rainfall, wind, soil moisture, etc.) frequently used for trends and for a certain area
(B) "Customized information"	"Corrected predictions" or "Indices" of climatic variables for a specific location and for a certain use
(C) "Derivative variables"	For the water sector case, they would be hydrological derivative variables, such as river flow at the level of river basin, sub-basin, system of reservoirs, and reservoirs (need the use of "impacts model")
(D) "Service tailored to the specific user's needs"	For the water sector case some examples could be services tailored for irrigation associations; or businesses affected by water availability (e.g. tourism sector; swimming pools, etc.)

Task 2: Specific analysis for one product linked to one client (sub-sector)

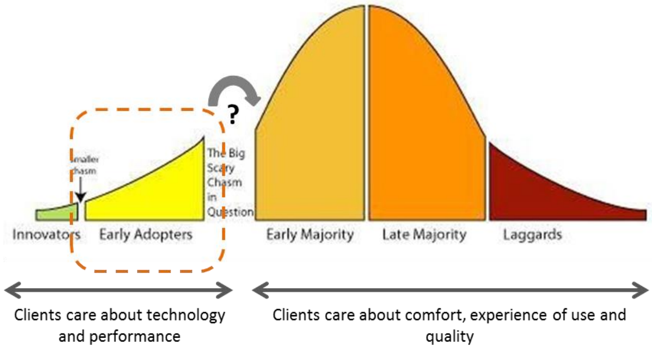
e.g. case study on dam management in Spain with Water Agencies as clients

Criteria	Description
Maturity of the client	Approach of technology Adoption Curve (related with the type of information they use in their DMP)
Risk-adversity	Related with maturity of the client
Market size	Approach of Total Addressable Market (TAM)
Questions to get more info (WTP) Barriers, etc.	Proposal of elaborating the questions after reviewing WP12 questionnaires (e.g. it seems that in the water sector the main barrier is the low accuracy of predictions → option of asking ranges of WTP for several scenarios of accuracy improvement

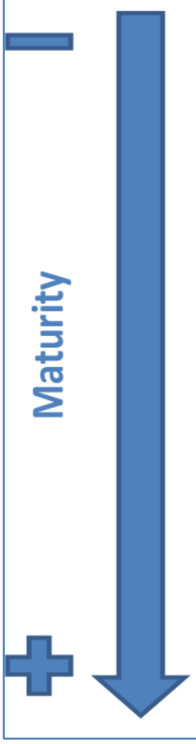
Key clients: Early Adopters

- They have a **greater need for a solution** → they are willing to **take a major risk** for buying an immature service (e.g. more vulnerable to climate)
- They are **willing to try** a new service
- The **have influence** on other clients and can help spreading the results (e.g. Do small pilots → "Bank of Experience /Results) → Reach the majority)
- They can **help us improving** the service

Maturity of the client



Maturity of the client & risk-adversity

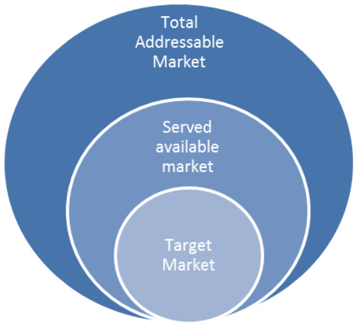


Proposed Stages of Maturity Degree	Typology of information used by the client
Stage 1	Historical information
Stage 2	Stage 1 + weather information
Stage 3	Stage 2 + climate information (service A)
Stage 4	Stage 3 + climate information (service B)
Stage 5	Stage 4 + climate information (service C)
Stage 6	Stage 5 + climate information (service D)

Market size

At least try to quantify the TAM for your country. Possibility of making assumptions for SAM & TAM

- **Total Addressable Market (TAM)**: all potential consumers of a service. Should be treated as a "bounded theoretical maximum
- **Served available market (SAM):** it is the part of TAM that can truly be reached
- **Target Market:** part of the SAM which a company aims its services.



Questions

Questions to get more info (WTP)	Proposal of elaborating the questions after reviewing WP12 questionnaires (e.g. it seems that in the water sector the **main barrier is the low accuracy** of predictions → option of **asking ranges of WTP for several scenarios of accuracy improvement**

Supply Analysis

Task	Description	Comments
Task 1.a List of competitors	Competitor = a climate services with similar characteristics as EUPORIAS´s one	Try to identify at least 3 competitors
Task 1.b Gather relevant data of competitors		• Brief description of the CS provided by competitors • Fill the template provided
Task 2 Mapping of current best alternative options	Alternative = NO Climate services	

Task 1

Relevant data from competitors	
Current state of the service	Operational or Prototype?
Event predicted	e.g. Drought, floods, etc
Indicators delivered	e.g. Temperature, rainfall, other
Timescale	e.g. Seasonal, decadal
Frequency of information delivered	e.g. Monthly, Quarterly, yearly
Climate models	e.g. System4
Impact models	e.g. Hydrological
Maintenance	e.g. CEH
Geographical scope	e.g. River basin, region, country(ies), European Union
Source of predictions	e.g. Historical data…
Reliability	If possible, describe the degree of reliability of competitors' services
Price	Try to identify if the service is free or is payment (and its price)

Task 2

Mapping of current best alternative options

Options	Characteristics				
	A	B	C	D	E
1					
2					
3					
4					

Feasibility Study I

Task	Description	Comments
Brief description of the climate service	Brief description according to: features, benefits, and value	Info available from: WP42 (D42.1) Microsites WP11 (D11.2) WP22(D22.1)
SWOT Analysis		Fill the template provided
Conclusions – Opportunities		Related with SWOT
Case studies	Brief description of case study and results	Expected vs obtained results (benefits and value)
Functional Analysis		
Entry barriers		Related with SWOT

Brief description of the climate service

Brief description of your climate service (prototype), trying to identify:

What are the features of your service?

- Describe main characteristics of the service:
- Which are the objectives pursued? How does it work? What kind of data provides and how often? How is information provided? (e.g. box plots, probability maps, climagrams)

What are its benefits for your customer?

- Description of a service feature but tying it to some way that it improves the customer's situation. (General benefits. e.g. protect citizens)

How can you translate these benefits into value for them?

- When "sell value," you *start* with the business goal that the customer would like to achieve–then tie that value to a specific benefit generated by a particular feature. (how much money the customer makes or saves by using the product. E.g. save in flood cost)

What are its benefits for your customer?

How can you translate these benefits into value for them?

Direct benefits & value = the ones that the client (who purchases the service) will perceive
e.g. Increase hydropower production → increase the client revenue

Indirect benefits & value = the ones that the citizen, customer of the client or external companies will perceive (even if they do not directly purchase it)
e.g. Reduction of flood risk → money saved for the Insurance companies

Brief description of the climate service: Example for RIFF prototype

What is RIFF and what does it do?	What are RIFF benefits?	How to translate RIFF benefits into value?
• RIFF is the new climate service experimented in France to manage water resources at a seasonal scale over Seine Catchment and Garonne Valley • By feeding a river-routing model by seasonal forecasts, RIFF provides river-flow forecasts at key period to anticipate the evolution of water-stocks	• Risks assessed and DMP: • Anticipate drought and maintain minimum rivers flows in Summer • Ensure refilling of reservoirs at the end of the Winter • Adapt the management in Winter to possible flooding events at Spring while ensuring efficient low flow support in Summer and Autumn	• Monetary valuation of the benefits identified in the previous step

Note: this example is not yet completed

SWOT Analysis

Strengths	Weaknesses
• Better management water resources. • Should help reducing risks of flooding • Should help reducing supply risk in case of drought.	• Difficult to be applied in general. • Not clear how to be incorporated into DMP. • Although the prototype has been tested, it seems that the results have not been shared enough.
Opportunities	**Threats**
• New market opened to new developments. • Added value to water-non-directly-related sectors. • New jobs creation.	• In some cases regulation acts as a barrier. • Lack of innovation in water management. • Uncertainty about climate models. • Uncertainty about the results of the water prototype.

Note: this example is not yet completed and needs to be validated

Conclusions – Opportunities

Key advantages: Identify key advantages of your prototype compared to competitors (e.g. in terms of reduce uncertainties, increase data reliability and tailoring customer needs).

Market share: Differentiated aspects of the service analysed compared to the existing climate services in order to gain market share

Market opportunities: Do the services developed match consumers' needs? What are the remaining gaps? How could these gaps be bridged?

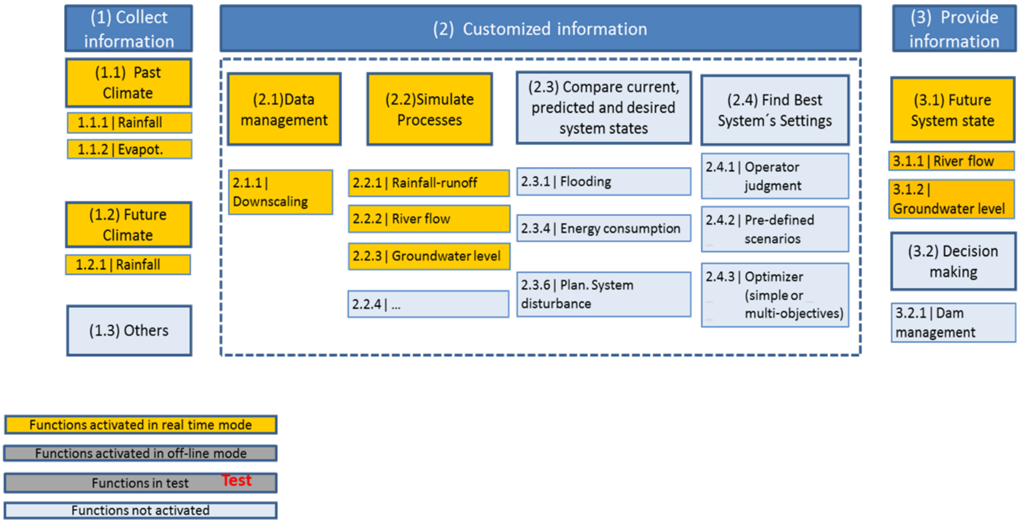
Alternative uses: Other uses that prototypes could have by doing some "changes".

Case studies

In case your prototype has been applied as case study, describe:

- Brief description of case study
- Results obtained with case studies in comparison with the results expected

Functional Analysis



Operational seasonal hydrological forecasting in the UK

Entry barriers

List of entry barriers from 2 points of view:

- From the point of view of an **organisation which wants to launch a new service** into the market. E.g. advertising expenses; scale economies; product differentiation; large initial investments; legal barriers.

- From the point of view of the **end users** (difficulties end users may face when trying to use the service). E.g. (if information provided is not “user-friendly”, it may be difficult for them to include it in their DMP).

Feasibility Study II

Industry Analysis → Demand Analysis → Supply Analysis → **Feasibility Study I & II** → Business Models

Feasibility Study II Tasks

Task	Description	Comments
Potential benefits	**Review** the different methods of SEB valuation and **choose one** for your prototype/case study	SEB info in WMO, USAID, **Doc WP45 Justin Krijnen**
Costs	**List** the main costs associated wit the development of the prototype - **provide overall value** → **Complete the template excel**	If not possible to give specific value, try to provide ranges
Set a potential price	**Mentioned in the DOW**	However Carlo mentioned there is no need to give a price; **focus on the overall study!**

Some Socio-economic benefit methodologies

Decision theory

Difference between payoffs when forecast is used and payoffs when only prior knowledge is applied

Pros	Cons
Useful to examine decisions and expected outcomes at household or firm level. Can be relatively simple to perform depending on model employed	Can be time and data intensive, depending on model employed. Requires sector expertise. Often assumes perfect information as a simplifying measure

Avoided costs

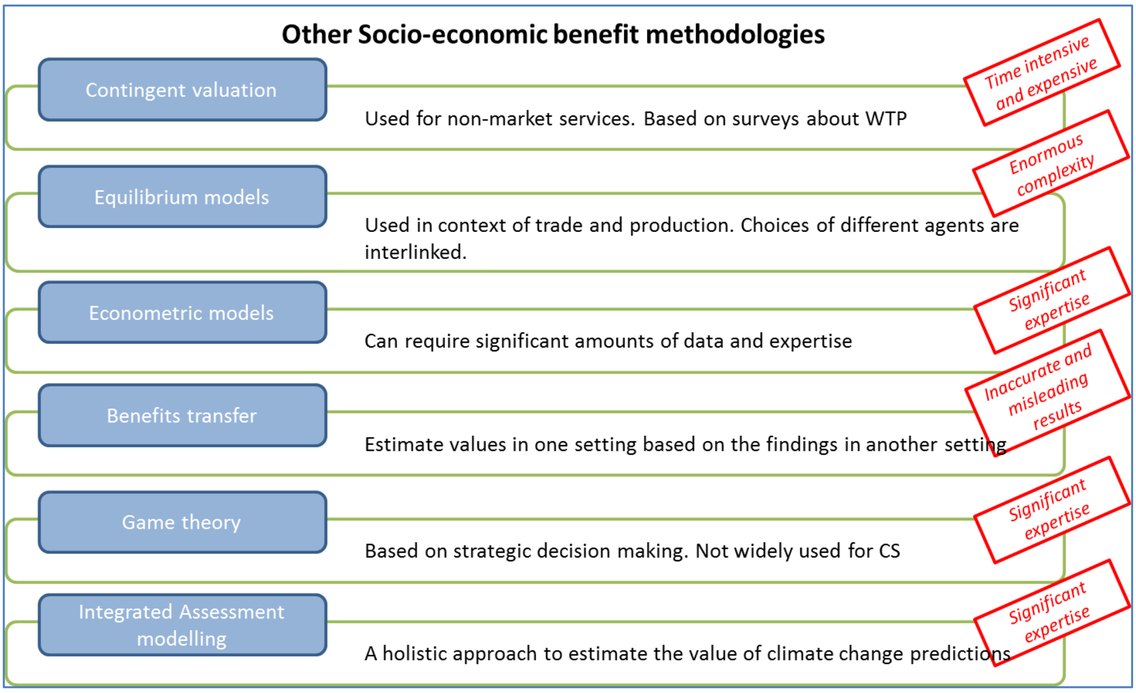
Evaluates the SEBs based on avoided costs of climate events due to improved meteorological/hydrological information

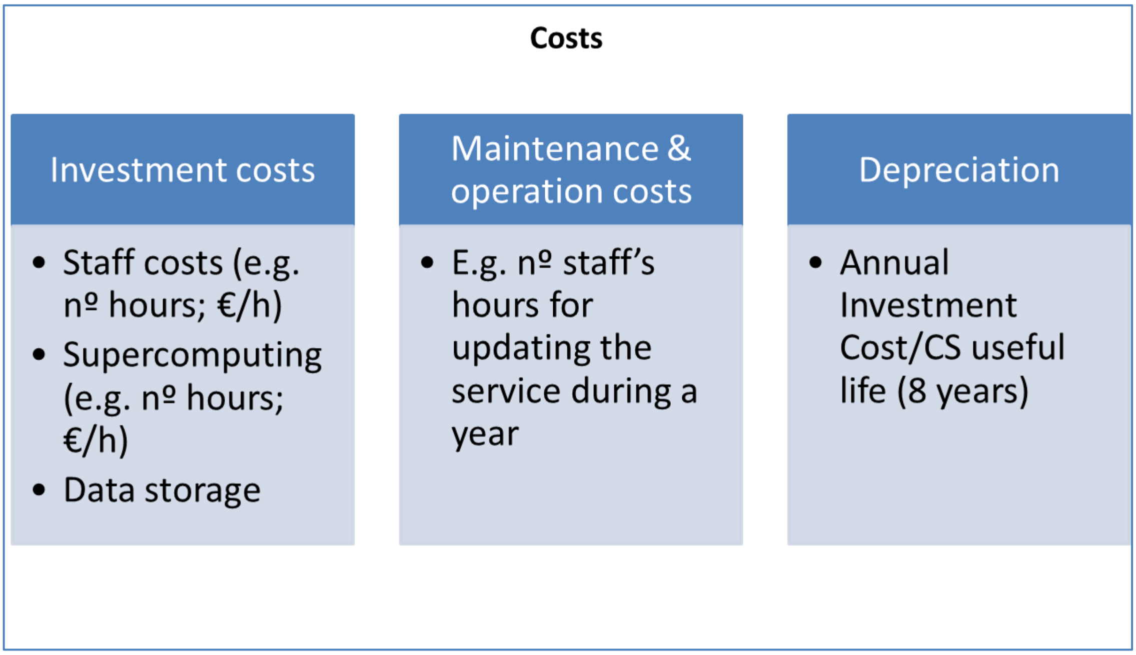
Pros	Cons
Can be applied in ex-post and ex-ante analyses. Relatively easy to implement.	Only represents partial value (for example, it does not take into account benefits o met/hydro services associated with increased productivity and enjoyment)

Value chain analysis

Concerned with how the initial forecast is communicated to and interpreted by end-users. (Accounting for information decay)

Pros	Cons
Accurate/realistic assessment of forecast value. Useful for decision-makers that are not experienced with using weather/climate forecasts.	Can require significant amounts of data gathering to estimate the value chain components.


Other Socio-economic benefit methodologies
Contingent valuation
Used for non-market services. Based on surveys about WTP
Time intensive and expensive
Equilibrium models
Used in context of trade and production. Choices of different agents are interlinked.
Enormous complexity
Econometric models
Can require significant amounts of data and expertise
Significant expertise
Benefits transfer
Estimate values in one setting based on the findings in another setting
Inaccurate and misleading results
Game theory
Based on strategic decision making. Not widely used for CS
Significant expertise
Integrated Assessment modelling
A holistic approach to estimate the value of climate change predictions
Significant expertise


Costs
Investment costs
Staff costs (e.g. nº hours; €/h)
Supercomputing (e.g. nº hours; €/h)
Data storage
Maintenance & operation costs
E.g. nº staff's hours for updating the service during a year
Depreciation
Annual Investment Cost/CS useful life (8 years)

Example for water sector

S-ClimWaRe

La Cuerda del Pozo Reservoir

Direct Uses

- **Douro River Regulation**
- **Water Supply** (to Soria and partially to Valladolid)
- **Irrigation** (provides water to 26,000 Ha
- **Hydropower production** (installed capacity of 6,080 Kw and average annual energy production 8.5 GWh)

Indirect Uses

- **Water sports** (windsurf, sailing, etc)
- **Camping**
- **Fishing**

Water sector — Avoided costs methodology

Direct costs	
Drought costs	**Flood costs**
❑ In 2004/05 Douro River Basin: • In the area irrigated by canal San José, **600 hectares of corn** were lost. • The Governing Council of Castile-Leon and the Council of Zamora planned to invest **300,000 €** during 2005-2006 for granting the urban water supply. • the drought caused the **hydropower production** to be **halved** in comparison with the previous year etc	❑ 117,000€ in February 2016 due to Douro river overflow (due to release in La Cuerda del Pozo).

Indirect costs	
Drought costs	**Flood costs**

Water sector — Avoided costs methodology

Issues encountered:

- the decision making processes in Cuerda del Pozo are complex and involve many actors beyond the dam commission (who is the target user of the S-Climaware)

→ in its current state the S-Climaware could have a limited impact

Decision	Potential integration of seasonal forecast
Minimum discharge from October to April	Necessary to extent forecast to the drought indicators used (precipitation and river discharge) and already pre-defined in the legal document (drought management plan). Need to get approval of Ministry.
Maximum discharge from October to April	Not a priority
Minimum safeguards in December, January, February, March and April	Some small changes could be done. Decision depends on the Dam Commission
Allocation of reserve in the next months	Might need forecast at an early stage for the seeding plan (September/October) then other organisms should be involved to predict irrigation water demand (such as the National irrigation association and corresponding administration)
Minimum volume in dam by the end of September	Not identified as priority – not discussed further
Irrigation period beyond September	Not identified as priority – not discussed further

Water sector | **Avoided costs methodology**

Issues encountered:

- the dam of Cuerda del Pozo is only one of the dam in the basin, while the information on the costs are aggregated for all the basin)

→ Extrapolate S-Climaware results to all the basin? Use a fixed % to determine the cost related to Cuerda del Pozo (e.g. dam of 246hm3 = 3% of the total basin reserve of 7.500 hm^3)

- no big issues reported in the years simulated (1973-2013…. 2015/2016 year with floods is not considered)

→ No much information on costs

The stakeholders of the S-Climaware have decided to implement the methodology in another sub-basin.

Costs

Investment costs

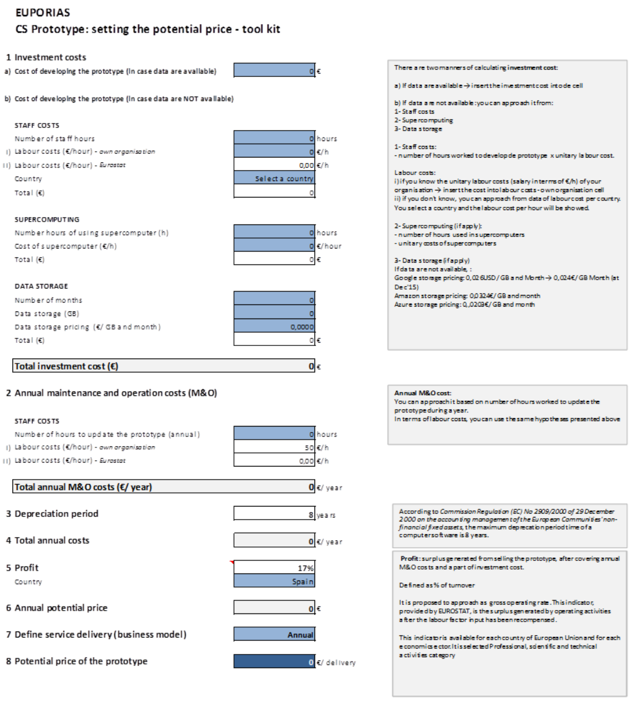
- Staff costs (e.g. nº hours; €/h)
- Supercomputing (e.g. nº hours; €/h)
- Data storage

Maintenance & operation costs

- E.g. nº staff's hours for updating the service during a year

Depreciation

- Annual Investment Cost/CS useful life (8 years)



EUPORIAS
CS Prototype: setting the potential price - tool kit

1 Investment costs		
a) Cost of developing the prototype (In case data are available)	0	€
b) Cost of developing the prototype (In case data are NOT available)		
STAFF COSTS		
Number of staff hours	0	hours
i) Labour costs (€/hour) - *own organisation*	0	€/h
ii) Labour costs (€/hour) - *Eurostat*	0,00	€/h
Country	Select a country	
Total (€)	0	
SUPERCOMPUTING		
Number hours of using supercomputer (h)	0	hours
Cost of supercomputer (€/h)	0	€/hour
Total (€)	0	€
DATA STORAGE		
Number of months	0	
Data storage (GB)	0	
Data storage pricing (€/ GB and month)	0,0000	
Total (€)	0	€
Total investment cost (€)	0	€
2 Annual maintenance and operation costs (M&O)		
STAFF COSTS		
Number of hours to update the prototype (annual)	0	hours
i) Labour costs (€/hour) - *own organisation*	50	€/h
ii) Labour costs (€/hour) - *Eurostat*	0,00	€/h
Total annual M&O costs (€/ year)	0	€/ year
3 Depreciation period	8	years
4 Total annual costs	0	€/ year
5 Profit	17%	
Country	Spain	
6 Annual potential price	0	€
7 Define service delivery (business model)	Annual	
8 Potential price of the prototype	0	€/ delivery

There are two manners of calculating investment cost:

a) If data are available → insert the investment cost into de cell

b) If data are not available: you can approach it from:
1- Staff costs
2- Supercomputing
3- Data storage

1- Staff costs:
- number of hours worked to develop de prototype x unitary labour cost.

Labour costs:
i) if you know the unitary labour costs (salary in terms of €/h) of your organisation → insert the cost into labour costs - own organisation cell
ii) if you don't know, you can approach from data of labour cost per country. You select a country and the labour cost per hour will be showed.

2- Supercomputing (if apply):
- number of hours used in supercomputers
- unitary costs of supercomputers

3- Data storage (if apply)
If data are not available, :
Google storage pricing: 0,026USD / GB and Month → 0,024€/ GB Month (at Dec'15)
Amazon storage pricing: 0,0324€/ GB and month
Azure storage pricing: 0,,0203€/ GB and month

Annual M&O cost:
You can approach it based on number of hours worked to update the prototype during a year.
In terms of labour costs, you can use the same hypotheses presented above

According to *Commission Regulation (EC) No 2909/2000 of 29 December 2000 on the accounting management of the European Communities' non-financial fixed assets*, the maximum deprecation period time of a computer software is 8 years.

Profit: surplus generated from selling the prototype, after covering annual M&O costs and a part of investment cost.

Defined as % of turnover

It is proposed to approach as gross operating rate. This indicator, provided by EUROSTAT, is the surplus generated by operating activities after the labour factor input has been recompensed.

This indicator is available for each country of European Union and for each economic sector. It is selected Professional, scientific and technical activities category

Business Models

Industry Analysis → Demand Analysis → Supply Analysis → Feasibility Study I & II → **Business Models**

Business Models (BM)

Task	Description	Comments (TO DO:)
List of Innovative Business Models	A summary of some innovative BM is provided in the following slides. Additional information (plus examples of BM for apps) can be found in the draft methodology document	**Review the list**
List of Business Models used in Climate Services context	Some examples are provided in the following slides	**Review the examples and do some research about BM used by companies that provide climate services**
Suggest suitable Business Models for the prototypes developed	Taking into account all the examples, list which business models could be applied to the prototypes developed in EUPORIAS	**List which BM could be used for the prototypes developed and justify why**

Innovative Business Models

Build to order: It is based on selling tailored products and services customised to customer's needs. **Example:** cars (color, accessories, etc)

Pay per use, pay per view, pay as you go: It gives customers easy access to a wide selection of offerings. The use of a product or service is metered, and customers are charged when they use the service. **Example**: Printers rental (you pay only for the pages you print)

Service Bundle: It consists in offering several products or services as a combo package. **Example:** Itunes is sold as a bundle of Apple devices

THE RITZ-CARLTON

Fractional ownership: Customers are able to enjoy the full benefits of ownership of a product or service for limited period of time, while splitting the cost with other costumers. **Example**: The Ritz-Carlton sells beneficial interests that hold title to real estate

Brokerage: It consists in bringing buyers and sellers together in a platform, charging a rate for transaction. It is a successful strategy when there is a high volume of buyers and sellers. **Example:** Ebay

Subscription Model: Subscribers pay a periodic payment for unlimited access to a service over a period. **Example:** Netflix - customers pay a monthly fee for unlimited streaming contents.

Innovative Business Models

Desintermediation: It is a process that provides a user or end customer with direct access to a product, service or information that would otherwise require a mediator. **Example**: Dell sells computers direct to their customers

Product to service: Instead of selling products outright, it consists in selling the service that the product performs. **Example**: IBM was transformed from a product based to service based company

Affinity club: Partner with membership associations and other affinity groups to offer a product exclusively to its members, exchanging royalties for access to a larger customer base. **Example**: a football team

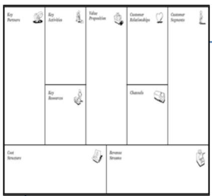
Freemium: It consists in offering a basic service free of charge to most customers, while a few of them are charged for a premium service, more complete. **Example:** Rain Alert mobile app

Razor and blades: It consists in a very cheap initial offer to promote customer fidelity with the brand. **Example:** Gillette

Long Tail: Traditionally, business models aimed at targeting mass markets, due to a limited storing space. However, long tail aims at selling less units of a larger range of products. **Example**: Amazon

Co-creation and Crowdsourcing: It consists in involving a grate multitude in the resolution of a problem or provision of service in exchange for a reward. **Example**: Wikipedia

Useful tools:



The Business Model Canvas: It allows to show and shape your business model in a single page. The usefulness of Canvas is mapping your entire business model in a single image

Lean Startup Method: The Lean Startup method teaches you how to drive a startup-how to steer, when to turn, and when to persevere-and grow a business with maximum acceleration.

Some examples of current Business Models

METEO FRANCE
Toujours un temps d'avance

Meteo France applies different business models according to customer needs and products offered:

- ✓ Weather forecast is available free of charge
- ✓ Weather services are available based on **pay per use or pay as you go** business model.
- ✓ User can be **subscribed** to observational data service by number of stations and subscription period (1 year, 2 year…).
- ✓ Products derived from weather services are available based on **subscription** business model.

Some examples of current Business Models

GERICS
Climate Service Center Germany
An institution of Helmholtz-Zentrum Geesthacht

The Climate Service Center Germany also combines different business models:

- ✓ **Freely** available products and services
- ✓ CSC develops methodologies, instruments and skills, for (1) conceptual development for climate services, (2) generation of new products and services and (3) improvement of knowledge transfer and communication
- ✓ **Order-related**, target group addressed products and services, subject to a charge

Some examples of current Business Models

METEO CONSULT

Meteo Consult, marine weather forecast for shipping, provides the following tailored services:

- ✓ **Free access shipping services**: this service is a free account that provides weekly the following information: 14 day forecasts for inshore areas, spots, bodies of water and ports for free, satellite animations and precipitation radars, etc.
- ✓ **Flagship subscription** offers the following services: 14 day offshore forecasts, personalised briefings included, all shipping forecasts by telephone also accessible from abroad, unlimited shipping weather e-mails & personal alerts, etc.

8.2. Appendix 2. Additional details on the methodology

Feasibility Study II

Investment costs

Investment costs involve costs of developing the prototype. It includes staff costs, supercomputing running costs and data storage costs invested on developing the prototype.

If data are not available, investment costs can be approached as following:

- Staff costs:
  - Number of staff's hours invested on developing the prototype
  - Labour costs: Hourly salary (€/h) of R&D sector for each EU country (Eurostat 2013). These data are provided.
- Supercomputing:
  - Hours using supercomputer for developing the prototype
  - Costs of supercomputing: hourly cost of supercomputer (€/h)
- Data storage:
  - Cost of storage data

Maintenance and operation costs (M&O)

Maintenance and operation costs involve annual costs of running the prototype annually to provide the climate service properly.

It includes staff costs in terms of annual hours invested in updating the climate service.

If data are not available, M&O costs can be approached as following:

- Staff costs:
  - Number of staff's hours invested on updating the prototype during a year.
  - Labour costs: Hourly salary (€/h) of R&D sector for each EU country (Eurostat 2013).

Depreciation

Assets and services suffer depreciation during their cycle life. From an economic point of view, depreciation has to be included as a way of recovery climate service

investment. To calculate depreciation cost of your climate service is basically to know (i) investment cost (step 1) and (ii) depreciation period.

Depreciation[30] period: it is the period of time in which the value of the asset (prototype) is decreased (it can be defined as useful life or time life). According to *Commission Regulation (EC) No 2909/2000 of 29 December 2000 on the accounting management of the European Communities' non-financial fixed assets*, computer software useful life is **8 years**.

Figure 33. Depreciation of climate service

Depreciation is calculated as total investment cost (€) / depreciation period (years).

Total annual cost

In order to obtain the **total annual cost**, maintenance and operation costs and **depreciation** have to be added.

Figure 34. Climate service annual cost

Other aspects to take into account when setting a potential price

[30] Depreciation shall be understood as the accounting estimate of the durable and, normally, irreversible decline in value of a fixed asset resulting for example from its use over time or from technological evolution. It shall consist in spreading, over the expected useful life of the fixed asset, the value of the asset according to a pre-established schedule (Source: Commission Regulation No 2909/2000 of 29 December 2000 on the accounting management of the European Communities' non-financial fixed assets.

Once a potential price is set following the mentioned steps, additional factors should be taken into account to adjust that price.

These additional factors should be already collected in the information gathered from the supply and demand analysis. Some of these relevant factors are summarised in the following table.

Factor	Influence on the price
Whether target users actually use climate /whether forecasts or if they only rely on their own climate knowledge	If users actually use climate forecasts, it will probably be easier to commercialise the service developed. On the contrary, if users rely on their own climate knowledge, this could represent a handicap for commercialising the service.
Risk appetite of target users	If users are risk-averse, they will probably make no use of the service, even with reliable and skilful predictions.
Price of the market (price of competitors)	If the price of the service developed is higher than the market price (the price of competitors), it could be difficult to sell the service (unless the degree of differentiation is high enough).
Degree of differentiation of the service	If the service developed is quite differentiated from the services offered by competitors, (in other words, the prototype provides an added value in comparison with the existing services), it will probably be easier to set a higher price. On the contrary, if the service developed is not perceived by users as an enough differentiated service, it will probably be harder to set a higher price.

Toolkit of climate service feasibility study

EUPORIAS
CS Prototype: setting the potential price - tool kit

1	**Investment costs**		
a)	**Cost of developing the prototype (in case data are available)**	0	€
b)	**Cost of developing the prototype (in case data are NOT available)**		
	STAFF COSTS		
	Number of staff hours	0	hours
i)	Labour costs (€/hour) - *own organisation*	0	€/h
ii)	Labour costs (€/hour) - *Eurostat*	0,00	€/h
	Country	Select a country	
	Total (€)	0	
	SUPERCOMPUTING		
	Number hours of using supercomputer (h)	0	hours
	Cost of supercomputer (€/h)	0	€/hour
	Total (€)	0	€
	DATA STORAGE		
	Number of months	0	
	Data storage (GB)	0	
	Data storage pricing (€/ GB and month)	0,0000	
	Total (€)	0	€
	Total investment cost (€)	**0**	€
2	**Annual maintenance and operation costs (M&O)**		
	STAFF COSTS		
	Number of hours to update the prototype (annual)	0	hours
i)	Labour costs (€/hour) - *own organisation*	50	€/h
ii)	Labour costs (€/hour) - *Eurostat*	0,00	€/h
	Total annual M&O costs (€/ year)	**0**	€/ year
3	**Depreciation period**	**8**	years
4	**Total annual costs**	**0**	€/ year
5	**Profit**	**17%**	
	Country	Spain	
6	**Annual potential price**	**0**	€
7	**Define service delivery (business model)**	**Annual**	
8	**Potential price of the prototype**	**0**	€/ delivery

There are two manners of calculating **investment cost**:

a) If data are available → insert the investment cost into de cell

b) If data are not available: you can approach it from:
1- Staff costs
2- Supercomputing
3- Data storage

1- Staff costs:
- number of hours worked to develop de prototype x unitary labour cost.

Labour costs:
i) if you know the unitary labour costs (salary in terms of €/h) of your organisation → insert the cost into labour costs - own organisation cell
ii) if you don't know, you can approach from data of labour cost per country. You select a country and the labour cost per hour will be showed.

2- Supercomputing (if apply):
- number of hours used in supercomputers
- unitary costs of supercomputers

3- Data storage (if apply)
If data are not available, :
Google storage pricing: 0,026USD / GB and Month → 0,024€/ GB Month (at Dec'15)
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Annual M&O cost:
You can approach it based on number of hours worked to update the prototype during a year.
In terms of labour costs, you can use the same hypotheses presented above

According to *Commission Regulation (EC) No 2909/2000 of 29 December 2000 on the accounting management of the European Communities' non-financial fixed assets*, the maximum deprecation period time of a computer software is 8 years.

Profit: surplus generated from selling the prototype, after covering annual M&O costs and a part of investment cost.

Defined as % of turnover

It is proposed to approach as gross operating rate. This indicator, provided by EUROSTAT, is the surplus generated by operating activities after the labour factor input has been recompensed .

This indicator is available for each country of European Union and for each economic sector. It is selected Professional, scientific and technical activities category

Figure 35. View of toolkit of climate service feasibility study

The following table shows the different types of quantitative SEB methods detailed in the Feasibility Study II, along with a summary of their advantages and disadvantages.

Table 3. The advantages and disadvantages of SEB methods

SEB method	Advantages	Disadvantages
Decision theory	- Useful to examine decisions and expected outcomes at household or firm level - Can be relatively simple to perform depending on model employed	- Can be time and data intensive, depending on model employed - Requires sector expertise (for example, agriculture, transport) - Often assumes perfect information as a simplifying measure
Contingent valuation	- Estimates use and non-use values - Incorporates hypothetical scenarios that closely correspond to policy case	- Time intensive and expensive to implement - Challenging to frame survey questions that elicit valid responses - Potential response biases
Avoided costs	- Can be applied in ex-post and ex-ante analyses - Relatively easy to implement	- Only represents partial value (for example, it does not take into account benefits of met/ hydro services associated with increased productivity and enjoyment)
Equilibrium models	- Partial equilibrium modelling useful to examine benefits of met/hydro services for a specific sector	- Time and data intensive - Expensive to implement - Requires significant expertise
Econometric models	- Uses observed data to conduct ex-post and ex-ante analyses	- Can require significant amounts of data and expertise
Benefits transfer	- Relatively simple and inexpensive - Accepted as a suitable method for	- Can generate potentially inaccurate and misleading results - Limited number of original

	estimating order-of-magnitude values for use and non-use benefits, in ex-post and ex-ante analyses	studies
Game theory	- Useful to understand the effect of other actors on forecast value	- Time and data intensive - Significant expertise required
Value chain analysis	-Accurate/realistic assessment of forecast value -Useful for decision-makers that are not experienced with using weather/climate forecasts	-Can require significant amounts of data gathering to estimate the value chain components
Integrated Assessment modelling	-A holistic approach to estimating the value of climate change predictions	-Significant expertise required

Business Models

Table 4. Innovative Business Models

Business Model	Description	Example	Comments/Ideas
Build to order	This business model is based on selling tailored products and services configured to the customer's specifications. This strategy increases customer satisfaction and perceived value. From the supply side, it requires high degree of specialization of products and services sold and it can create barriers to new entrants		Early stage of current climate services
Service Bundle[31]	This business model focuses on offer several products or services as	• **Microsoft Office** is sold as a bundle of	Bundling is a rather easy way of putting

[31] http://www.forbes.com/sites/hbsworkingknowledge/2013/01/18/product-bundling-is-a-smart-strategy-but-theres-a-catch/

	one combined offer. Form the demand side, this strategy can be successful when customer acquisitions cost are high for each service, consumers have heterogeneous demands or consumers appreciate the resulting simplification of the purchase decision. From the supply side, bundling can be profitable, drive rivals from the market, and open up opportunities to cross-sell or up-sell existing products.	computer software, including Word, Excel, and PowerPoint • **Itunes** is sold as a bundle of Apple devices • **Cable companies** offer their channels in bundle packages • **Fast Food** restaurants	new product offerings together to complement the product line
Pay per use, pay per view, pay as you go	This business model gives customers easy access to a wide selection of offerings and the use of a product or service is metered, and customers are charged when they use the service. Pay-per-use works well when the service can be effectively metered and delivered immediately. In terms of costs, once the initial minimum viable product is built, companies can scale revenue closer to the scale in costs required to deliver the service.	• **Pay-per-view TV** • **Online journal publications,** • **Custom research firms, who sell access to high value content on a per use or per download basis**.	
Fractional ownership (fractionalization)	This business model is based on that costumers are able to enjoy the full benefits of ownership of a product or service for limited period of time, while splitting the cost with other costumers. From the demand side, costumers can't afford all the property / asset by their own, but can afford an amount of the ownership. From the supply side, this strategy is taken for offering high quality products or services.	• **Time-share of leisure** real states properties (tourism), aircraft sector	This strategy is been applied on physical products features

Subscription model[32]	The customer pays a periodic fee for unlimited access to a service over a set period. From the customer side, its predictable cost over the term of the plan, it is a flexible service (in terms of cancelation and subscription) and low cost of entry. Form the supply side, the subscription model ensures predictable revenue stream with good potential for up-selling and cross-selling of additional products or services. Some models combine the free content with premium content.	• **Netflix:** customers pay a monthly fee for unlimited streaming contents	
Disintermediation	Disintermediation is a process that provides a user or end consumer with direct access to a product, service or information that would otherwise require a mediator. From demand side, customers pay less for a customized product or service. From the supply side, it reduces cost of servicing costumers and provides customized products to customers.	• **Dell sells computers direct to their customers.**	It's an advanced strategy of build to order
Affinity club[33]	Partner with membership associations and other affinity groups to offer a product exclusively to its members, exchanging royalties for access to a larger customer base. From a consumer's perspective, affinity credit cards allow individuals to benefit from a wide range of rewards put forward by the brands they support, ranging from discounted flights to football shirts, tickets to events and charity donations, as well	• **Airlines, football clubs, charity, MBNA**	

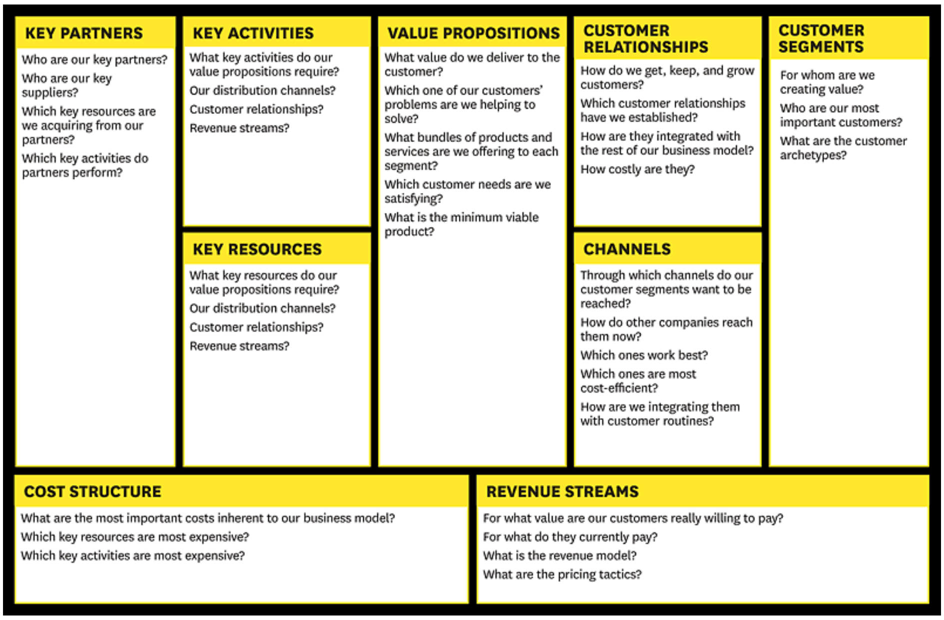
[32] https://www.zuora.com/guides/nine-keys-building-successful-subscription-business/
[33] http://raconteur.net/business/powering-loyalty-with-credit-cards

	as helping to support that particular cause financially.		
Reverse razor / blades	This business strategy is based on offer a low margin item below cost (ebook, music…) to encourage sale of the high-margin of companion product (hardware)	• **Kindle** • **iPod**	
Product to service (servitization) [34]	This strategy is based on transforming from being a product-dominant to a customer-centric organisation in order to maintain or recover competitive advantage. For manufacturers, benefits include growth through improved customer intimacy brought about by closer and stronger relationships. This often results in new market opportunities. Customers benefit principally through cost reductions that can be as high as 25 to 30 per cent, and service quality can also improve.	• **Xerox XRX** +0.00%'s Managed Print Services customers get "document solutions". Contracts are based on pay per use, over two years or more, with risks managed by the manufacturer, and a commitment to rolling process improvement and cost savings.	
Two (or several)-sided Models	There are at least two groups of customers interdependent (sides). One of the sides only gets benefited if the other is present. The objective of the firm is to ease the interaction between the two sides. Typically one of the sides is subsidised.	• "Metro newspaper" (and all derivatives) • Google • Nintendo Wii/PS3 • Manufacturers of credit cards • Safaricom	Tool to bring together providers of climate services and end users. End users subsidised, providers pay an amount to advertise their services.
Bait & Hook (also called "Razor and Blade")	It consists in an initial offer attractive and very cheap in order to foster customer loyalty with the brand.	• Gillette • Telecommunications Operators (new mobile in exchange for a long-term contract).	
Cloud and SaaS	It consists in transform a product into a service and	• Salesforce • LiteBi	Pay a monthly/yearly

[34] http://raconteur.net/business/bringing-production-and-service-together

(Software-as-a-Service)	a fixed cost into a variable one. The customer pays for a monthly (or yearly) service.		amount in order to have access to periodic reports/services
Freemium	It's a particular case of the two-sided model, where one of the sides receives a free product/service continuously. For example, offer a basic service (free) to most customers, while a few of them pay an amount for a more complete service (premium).	• Example: Radiohead give free access to their songs and obtain benefits in concerts and merchandising.	
Co-creation and Crowdsourcing	It consists in involving a grate multitude in the resolution of a problem or provision of service in exchange for a reward.	• Pure communities (Wikipedia, iStockPhoto, Threadless). • Contests/Challenges (12Designer) • "Ideágoras" (WorthIdea, Innocentive, NineSigma).	

Each of these nine components contains a series of hypotheses about your business model that you need to test[35]:



[35] https://hbr.org/2013/05/a-better-way-to-think-about-yo

Figure 36. Canvas Business model template

Business Models for Mobile Applications

One of the objectives of project EUPORIAS task 43.6 is developing a mobile phone application associated to one of the prototypes developed in WP42 to bring the information generated directly to the Smartphone.

Hence, in this section a description of the different typologies of mobile applications is included, plus several practical examples of mobile applications related with weather[36].

Table 5. Business models for mobile applications

Typology of Apps	Advantages	Disadvantages
Free Apps	• Can be attractive for potential users as it is free. • Allows the option to introduce advertising. • Allows to made known and so encourage people to pay for the next app.	• Usually associated with "simple products" with little development (idea that paid apps must be good).
Payment Apps	• Associated with "good products".	• Difficulty to measure willingness to pay.
Purchases within the App (Both for Free and Payment Apps)	• This modality works well with free apps. • Versatility: pay for a more quality service, pay to remove advertising, etc.	
Premium Services (Freemium)	• Works very well with mobile devices.	

Four examples of mobile applications and business models run are introduced in the table below.

[36] http://www.bbvaopen4u.com/es/actualidad/principales-modelos-de-negocios-en-app-moviles

Table 6. Mobile applications examples and business model used

	Rain Alarm OSM is an example of Freemium app. It warns users when reain is currently nearing. It warns using almost real-time data from governmental weather services. The paid version “Rain Alarm OSM Pro” has several improvements, like the possibility to remove advertisement, customizable settings, more widget themes, etc.
	Flood Alert is a free app that uses the live flood warning feeds provided by the Environmental Agency. Allows monitor flooding in certain areas (England and Wales). Information is updated every 15 minutes, 24 hours a day
	NOAH is a mobile app developed by Rolly Rulete in cooperation with Poject NOAH.with the objective of helping preventing and mitigating disasters.
	The Ultimate Weather App is a payment app that offers a wide range of information related with wind, precipitation, marine weather, aviation weather, satellite images and videos, temperatures, forecasts, water vapour, severe weather, river flooding and national drought, among others.

8.3. Appendix 3. Full examples for all sectors

Water Sector

Industry Analysis

According to the methodology developed, this section aims to identify agents and their relationships in the water sector, to review economic, political and technological framework where it is operating, and to detect business opportunities for climate services. This is a general analysis that will be later detailed according to the climate services considered in EUPORIAS. This specific analysis will be the purpose of the next steps of the methodology.

Scope of the water sector
There is no well-defined limits for the water sector. For the purpose of this study will be considered all the activities related to the following project types (listed in Research and Markets, 2015): water and wastewater treatment plants, water and wastewater networks, water resources, desalination plants.

Accordingly, the main activities related to water management are the following:

- River basin planning: strategic vision to share water resources, protect them and manage natural hazards in the long-term (modification of management rules, construction of new infrastructures…)
- Operational management of the infrastructures or water reserves constituting the water system: dams, aquifers, treatment plants, distribution networks…
- Water allocation: provision of water for agricultural, household (or domestic), industrial and recreational, as well as environmental uses

The different agents intervening in the activities mentioned above are the followings:

- State Agencies (e.g. Ministry)
- River Basin Organizations (water agency or confederation)
- Local administration (municipalities, federal or autonomous authorities)
- Private or public organizations offering different well-defined water services: water treatment, dam management, aquifer management
- Private or public organizations using water resources for different purposes: hydroelectricity, irrigation, industry…
- Private or public organization offering consultancy services to water stakeholders

Example of climate services in the water sector
We consider the climate services matching the broad definition of a “transformation of climate-related data into customized products”.

Accordingly, the following categories and examples of services are considered:

- Transformation of historical data, monitoring data, weather forecasts, seasonal forecasts and projections (e.g. climate change scenarios) into indicators and variables to be used in the water sector (e.g. discharge, flood hazard,..) for improving operation and planning. Some examples are presented below:
    - European Flood Awareness System (EFAS), forecasting floods across Europe
    - Site specific streamflow forecast system to provide a more accurate knowledge of the expected inflow to the reservoir a few weeks in advance

- Climate risk assessments and impact studies (e.g. impacts of climate change in water supply for a specific region) including cost-effectiveness analyses of adaptation measures, risk management plans, guidance document and decision support system.
    - Guidance document on how to consider climate change in River Basin Management Plans (e.g. Guidance document No. 24 RIVER BASIN MANAGEMENT IN A CHANGING CLIMATE)
    - Consideration of climate-related risk in a Water safety plan (plan to ensure the safety of drinking water through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer).

Preliminary mapping of providers, purveyors and users
This section identifies the main agents in the climate services market.

The following table provides information on the providers of climate data and derived variables identified for the water sector. Some examples are also inserted as references (in bracket). The information is grouped by the period (historic, forecasts with different horizons) and the type of the information provided (climate-related data, derived variables).

The table shows that National Weather Agencies are the main providers of historic climate data and forecast for all the period considered. Historic data are also provided by River Basin Agencies that have their own monitoring network.
Source: In dark blue = Stakeholders interviews (WP12) and in light blue = own research[37]

Table 7. Providers of climate data and climate-related data – Water Sector

Time scale of forecasts	Providers of weather/climate variables (temperature, precipitation, Standardized Precipitation Index (SPI), etc.)	Providers of other variables (discharge, water quality, soil wetness etc.)* including purveyor of climate services for these variables *(e.g. use of climate forecast to produce inflow forecast)*

[37] (1) "Catalogue Données publiques Météo France." [Online]. Available: https://donneespubliques.meteofrance.fr/?fond=rubrique
(2) "METEO CAT." [Online]. Available: http://www.meteo.cat/.
(3) "Sistema Automático de Información Hidrológica de la Cuenca Hidrográfica del Ebro." [Online]. Available: http://www.saihebro.com/saihebro/index.php.
(4) "ECA&D - European Climate Assessment & Dataset." [Online]. Available: http://eca.knmi.nl/.
(5) "Portail eaufrance." [Online]. Available: http://www.eaufrance.fr/.
(6) "European Drought Observatory." [Online]. Available: http://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000.
(7) "HYDS." [Online]. Available: http://www.hyds.es/.
(8) "EFAS." [Online]. Available: https://www.efas.eu/.
(9) "MeteoLogica." [Online]. Available: http://www.meteologica.com/.
(10) "Met Office - Global long-range model probability maps." [Online]. Available: http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks/glob-seas-prob. [Accessed: 22-Apr-2016].
(11) "GERICS - Climate Service Center Germany." [Online]. Available: http://www.climate-service-xcenter.de/index.html.en.
(12) "E-HYPE - Climate Change on hydrology." [Online]. Available: http://hypeweb.smhi.se/europehype/climate-change/.
(13) "FIC - Fundación para la Investigación del Clima." [Online]. Available: http://www.ficlima.org/.

Historical Information	National (or local) Weather Agencies [1][2] River Basin Organizations and Public Organizations – System of Information on Water (SAIH in Spain[3]) Other organizations with their own network (e.g. Urban Water Company owning meteorological station) European Dataset [4]	River Basin Organizations and Public Organizations - System of Information on Water (e.g. SAIH in Spain[3], SIE in France[5]) Other organizations with their own network (e.g. Urban Water Company owning monitoring stations) European information systems (e.g. European Drought Observatory [6])
0-24 hours	National (or local) Weather Agencies Private companies (e.g. management of radar data provided by national agencies) [7]	River Basin Organizations (*Water level, water discharge, flooding risk)* Private companies (e.g. alert based on radar data)[7]
1-7 days	National (or local) Weather Agencies Private companies (based on information provided by national or international agencies)	River Basin Organizations (*Water level, water discharge, flooding risk)* Private companies (based on information provided by national or international agencies)
1-2 weeks	National (or local) Weather Agencies ECMWF	River Basin Organization: *Flooding Risk* European information systems (e.g. *EFAS-flood risk at European level)*[8] Private companies (based on information provided by national or international agencies) [9]
1 month	National Weather Agencies	
1-7 months	National Weather Agencies [10] NOAA (very informal use) ECMWF	National Weather Agencies (in development) Private companies (in development)
1 – 10 years	National Weather Agencies (?)	
10-100 years	IPCC European Projects and Initiatives such ENSEMBLES, EURO-CORDEX Universities (regional studies) National Weather Agencies and National Climate Service Centers	National Climate Service Centers providing prediction of discharge [11] National Weather Agencies European Projects and Initiatives [12] University Private companies (based on information provided by national or international agencies) [13]

PESTEL Analysis for the Water Sector

As described in the general methodology, the PESTEL analysis provides a broad view on the drivers that characterize the water sector. Most of the elements of the PESTEL presented below are representative of the situation at the European scale, but it is important to remark that the analysis that has been performed is tailored to the Spanish context.
In general, the main driver of climate services would be their low cost compared to structural solutions to face current challenges of water management and new challenges driven by climate change. The main barriers of climate services are the use of pre-defined and rigid

rules to manage the resources, and the risk of trying something new that could have some negative consequences in a tense context (social reluctance, political involvement, sharing of scarce resources, etc.).

Political

ISSUES:

Water management decisions related to planning and operation are strongly linked to **politics´ visions** (for example, depending on centralized or decentralized government), especially for the following topics: (See references (1) & (2))

- **Sharing of resources** (e.g. water transfer in Spain, restriction of agricultural uses for ecological flow).
- **Risk management actions** (e.g. priority in financing actions for limiting impacts of drought or flooding, consideration of climate change, desalination).
- **Costs and management of water services** (cost-recovery, water tariffs, private/public management).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
Need for **low-cost (non-structural) measures** and services in risk management, which represents a specific chance for CS provision (for example, in drought management)	Some decisions do not depend (yet) only on **technical information**, or in other words, they are not only based on rational criteria. Because current political vision has the last word, and it is usually influenced by interest groups (e.g. lobbies). And as a consequence, there is a rejection to accept reforms, innovations, etc.

Economic

ISSUES:

Economic crisis that influence public administration such as water agencies (budget reduction, debts, cut in programmes of measures, big water infrastructures stopped, to comply with legal requirements, etc.) and private sectors (more competition for less contracts, lower prices, etc).

Strong impact of water management decisions on economy due to a **major interdependency between sectors** (e.g. energy-water-food nexus, flood & drought indirect impacts on economy).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
Need for **low-cost (non-structural) measures in risk management** (improve systems efficiency – so more need of predictions). Promote cost-benefit analysis and new solutions (such e.g. water markets) **Innovation and differentiation** is a must in the private sector **New clients** can be outside the traditional water market (e.g. swimming pool manufacturer have been tremendously affected by the 2009 drought in Barcelona´s region; touristic offer; etc)	Maladjusted **relationship between the CS cost and the output** in terms of output probability (highest cost-benefit ratio). In a context of budget constraint, CS development can be too costly; which can lead to a **slow implementation of CS** (implementation step by step).

Social

ISSUES:

Environmental protection is a major concern, sense of collective responsibility (e.g. water consumption, water footprint, climate change, preference for renewable energy such as hydropower).
Social pressure to ensure there are **no disturbances or service interruption** (e.g. water restriction, flooding). (See reference (3)).
Debate around the **ownership of water resources management** (public/private) and cost of services.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
Need to provide **technical explanations** to justify the decisions to take (e.g. rationalization of costly decision during drought). Rationality in decision making (CS could help in DMP). Increase need for **education** (e.g. climate change impacts and adaptation)	**Lack of social confidence** on climate forecast, which can prevent politics/stakeholders to use CS. **Risk of implementing** an innovation.

Technological

ISSUES:

Recent **advances in monitoring** (e.g. low cost sensors), **modelling** (e.g. 2D flood mapping, probability of water deficit, etc.), **climate predictions skills** (e.g. NAO predictions), **decision-making methodologies and tools** (collaborative vision, risk-based and cost-benefit analysis…).
Next context of **"Sensorized" society** (e.g. citizens consumption, Internet of things), WEB 2.0 (e.g. Social media groups, interactive web-platforms, discussion forums, online polls and mobile applications), big data applications. Still a remaining **gap between research/knowledge and market' needs**. (See reference (4)). Data transfer and sharing protocol (e.g. INSPIRE Directive, etc.) for water information (discharge, historical climate variables). Still **lack of common platform** for seasonal and climate change predictions (but COPERNICUS on going).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
Easy to get data in the water sector (historical information, etc.) so possible to concentrate effort on crossing it with seasonal forecast. Need to interpret this data. **Easy to launch a start-up** and test new ideas. **Future availability of seasonal forecast** (COPERNICUS C3S and others). Diversity in providing information in different countries (models; methods; ways; channels; etc).	Bad interpretation of available data by mass media. Not yet available seasonal forecasts and climate change predictions in a friendly, common and low-cost way.

Environmental

ISSUES:

Environmental regulations can promote the use of renewable energies, like hydropower energy, which are more sensitive to climate.

Climate change and environmental health is a major concern. As climate change causes an increasing dependence on weather for some sectors, it can promote the use of CS for adaptation and mitigation.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
Environmental regulations that promote the use of hydropower can **boost the use of water inflow predictions** in reservoirs.	

Legal/Government

ISSUES:

Rigid regulations in the water sector, for example the rigid ecological flow legislation in reservoirs.

Water infrastructures construction is subject to several European laws (e.g. reservoirs construction is subject to a law of evaluation of the environmental impact).

Decentralization of decisions among the Spanish river basins. The management of the Spanish basins is quite different between each basin since most of the decisions are the responsibilities of the local river basin agencies ("Demarcaciones Hidrográficas") which are independent organisms.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
Decentralization of decisions among Spanish river basins can promote the use of CS tailored to each specific basin.	Rigid regulations can slow down the use of CS (for example, water release decisions for reservoirs are generally pre-defined according to historic information)

(1) Bhat, A., & Blomquist, W. (2004). Policy , politics , and water management in the Guadalquivir River Basin , Spain, *40*, 1–12. http://doi.org/10.1029/2003WR002726

(2) Martin-ortega, J., & Markandya, A. (2009). The costs of drought : the exceptional 2007-2008 case of Barcelona, (November).

(3) Sauri, D. (2013). Water conservation campaigns and citizen perceptions : the drought of 2007 – 2008 in the Metropolitan Area of Barcelona, 1951–1966. http://doi.org/10.1007/s11069-012-0456-2

(4) "Organization Climate Knowledge for Action: A Global Framework for Climate Services — Empowering the Most Vulnerable Report No. 1065 (WMO, 2011)," n.d.)

Demand Analysis

Following with the methodology developed, this section aims at identifying potential users of the climate services developed in the EUPORIAS project and their needs. It is also useful to detect barriers to use climate services.
This analysis is done for services with similar timescale than the ones developed in the EUPORIAS project, that is to say limited to seasonal to decadal timescale (S2D).

This analysis is structured into two tasks:

- The first task encompasses a general analysis of the demand in the water sector based on the answers gathered to the WP12 interviews
- The second task covers a specific analysis for the service offered by the S-Climaware case study in Spain

General analysis of the demand in the water sector
The first task encompasses a general analysis of the water sector in a table format. It is based on the available information on users´ needs gathered in WP12. A total of 10 answers have been gathered in WP12, and 9 of them were accessible for the WP45 analysis. The table is filled with information on the use and willingness to pay for different type of services that could be offered based on seasonal or decadal forecasts. It was attempted to discern between simple product and more advanced services (4 “levels”).

EUPORIAS

Category of Services		Potential Users									
		A private international company (America, Asia, Europe) with around 10,000 employees	A government organisation working at the river basin level and with approximately 1,000 employees	A government organisation working at the national level with more than 250 employees	A private company working at the regional level and with approximately 2,200 employees	A government organisation working at the national level with approximately 550 employees	A government organisation working at the national level with around 400 employees	A public company working at the regional level with approximately 700 employees	A public organisation with funding coming from consultancy working at the national level.	A private company working at the regional level with approximately 5,000 employees
(A) "Raw predictions of climatic variables" and (B) "Corrected predictions of climatic variables"	CURRENT USE (of seasonal forecasts)	YES (in a very qualitative way).	NOT YET. They don't use seasonal forecasting because of low confidence. They use weather forecast and climate change prediction.	YES. They use seasonal and monthly forecast to inform River Basin Agencies (RBA). RBA used it as an (informal) additional input to make decision on dam management rules and other ...	YES. Seasonal forecasts are used as additional information.	ALMOST. They have been looking into the ECMWF 4 week forecast but are not using it operationally.	NOT YET. They use ECMWF 10 day forecast (ISS model) and are adapting their operational model to use the 14 days forecast.	NOT YET. The organisation uses weather forecasts for the next 7 days (temperature and precipitation). They have heard of seasonal forecasts but do not use it (low confidence)	YES. They look into the 7-month forecast of ECMWF (for precipitation and temperature). They also use the European Flood Awareness System (EFAS).	YES. They use seasonal forecasts as an help to plan the water supply production and budgets. Still due the amount of uncertainty associated they treat them with care.They also use weather forecast and ...
	POTENTIAL WTP	They pay for some weather forecast, but most of the information they use is free. They believe that there isn't enough confidence in seasonal forecasts for having someone selling a service.	They have their own network of rainfall and temperature stations. They also use the informaton from the National Meteorological Services (NMS) and available studies from othe governemental entities about Climate Change.	They get the seasonal info for precipitation and temperature from the National Meteorological Services (NMS) website.	They have some interest in getting raw data (e.g. for ETP) and this information may be free or not depending on each case.	The organisation would be interested in seasonal information for precipitation, temperature and wind with a 5km2 grid resolution or lower (particularly for extreme events). They currently obtain weather information from their NMS, that processes and tailord it for free.	They have this information for free; and they also offer their services to their clients for free.	They get the weather forecast from the National Meteorological Services (NMS) website for free. They would consider paying for reliable climate information.	Currently they get this information for free. Any seasonal forecasts could be of interest to them even if only as qualitative information.	They obtain the information from their National Meteorological Services. They pay for some of this information.
(C) "Derivative variables" and (D) "Service tailored to the specific user's needs"	CURRENT USE (how they currently use seasonal forecasts)	NOT YET. They check the River Basin agency prediction for the next months (based on climatology).	NOT YET	NOT YET	YES. In 2011 some maintenance works were done in advance of the predicted cold winter	ALMOST. They run simulations for the spring season but are not using ECMWF 4 week forecast operationally.	The organisation is planning to integrate the ECMWF System 4 forecasts to generate stream flow forecast.		They use all the information to prepare 3-months hydrological forecasts	They use seasonal forecasts as an help to plan the water supply production and budgets
	POTENTIAL WTP	They might buy them in case the meteorological conditions would influence their annual accounts to a factor of a million € (which is not believed to be the case now).	They would like to have seasonal info on rainfall and temperature transferred to floods.	Having seasonal predictions would be really useful for updating the hydrological indicators currently used by river basin agencies for decision making.	They see a market in seasonal projections use and are interested in them.	(from the answer cited above, we can assume that they might have an interest for buying as service or developing the service internally)	(from the answer cited above, we can assume that they might have an interest for buying a service or developing the service internally)		They could be interested in indices related with temperature and specially precipitation	In some cases they could be interested in temperature and rainfall indices

CURRENT USE			WTP	
Current use of the service considered with seasonal or decadal forecast period	NO current use of the service considered with seasonal or decadal forecast period BUT YES with weather forecast or climate change predictions		They already pay for a service based on seasonal forecast	They are interested in paying for a service based on seasonal forecast or already pay for other kind of services (weather or climate change)
NO current use of the service considered with seasonal or decadal forecast BUT some first steps done	NO current use of the service considered even for weather forecast or climate change predictions		They are interested for a service based on seasonal forecast (and might pay for it)	They are not interested in a service based on seasonal forecast

From this analysis, the following conclusions can be given:

- The information gathered in WP12 is relatively scarce about WTP (especially for categories (C) and (D))
- It is difficult to discern between the current uses of services from category (A) and (B) from the information gathered in the interviews
- All the companies considered are already manipulating weather and climate information, some of them have developed advanced studies to adapt their activities to future weather and climate conditions.
- Five (out of 9) companies are currently consulting seasonal forecast (mainly basic information about temperature and precipitation) to adjust their decision.
- All companies see a potential benefit in new services based on seasonal prediction but only five seems to have some willingness to pay for such services.

<u>**Specific analysis for the service offered by the S-Climaware case study in Spain**</u>

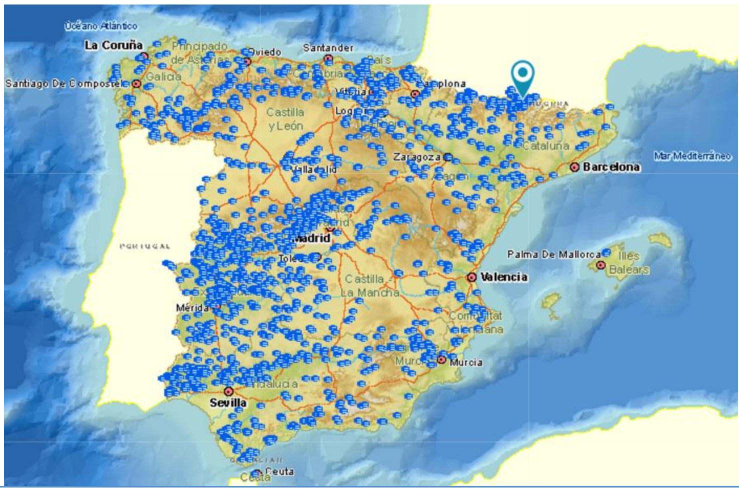
The second task covers the analysis of the S-Climaware Case study in development in EUPORIAS. In this case the product is oriented to dam management in Spain. The case study test the provision of forecast of dam inflow for the winter period (December-January-February). These inflow forecast are also use as input in a simplified model of the water system concerned. As a result, the dam manager can access the inflow forecast for winter and an information about the potential evolution of the dam (dam reserve) and the system (potential water restriction) during all the hydrological year (from December to next October).

This task analyse the potential clients through different criteria such as Maturity, Risk-adversity, Market Sizes, etc.

Criteria	Description
Maturity of the client	Approach of technology Adoption Curve (related with the type of information they use in their DMP)
Risk-adversity	Related with maturity of the client
Market size	Approach of Total Addressable Market (TAM)

Market size

Spain is the EU member state with the largest number of reservoirs (approx. 1200) ahead of Turkey (approx. 610), Norway (approx. 364) and the UK (approx. 570), Italy (approx. 570), France (approx. 550) and Sweden (approx. 190)[38].



[38] http://www.eea.europa.eu/themes/water/european-waters/reservoirs-and-dams

Figure 37. Geographical distribution of dams in Spain

Source: http://sig.magrama.es/snczi/

Most of the dams are multipurpose, that is to say that while they have a main function (e.g. hydroelectricity production) they also have secondary functions (e.g. flood control or water supply)[39]. The three main functions are irrigation (23%), hydropower (21%) and water supply (16%), which jointly account for the 60% of the dams, as shown in the following figure. Other functions include aquaculture, environmental adaptation, defence against floods, diversion, livestock, hydropower, industry, mining, recreational.

About 1/3 are operated by the government and 2/3 are operated by private companies under temporal license[40]. More than 380 actors can be identified, however the main actors/owners are the following: the Spanish Government owns the 22% of dams, followed by Regional Governments (9%), City councils (9%), Electricity companies such as ENDESA GENERACIÓN (8%) and IBERDROLA (6%), Irrigation Communities (4%).

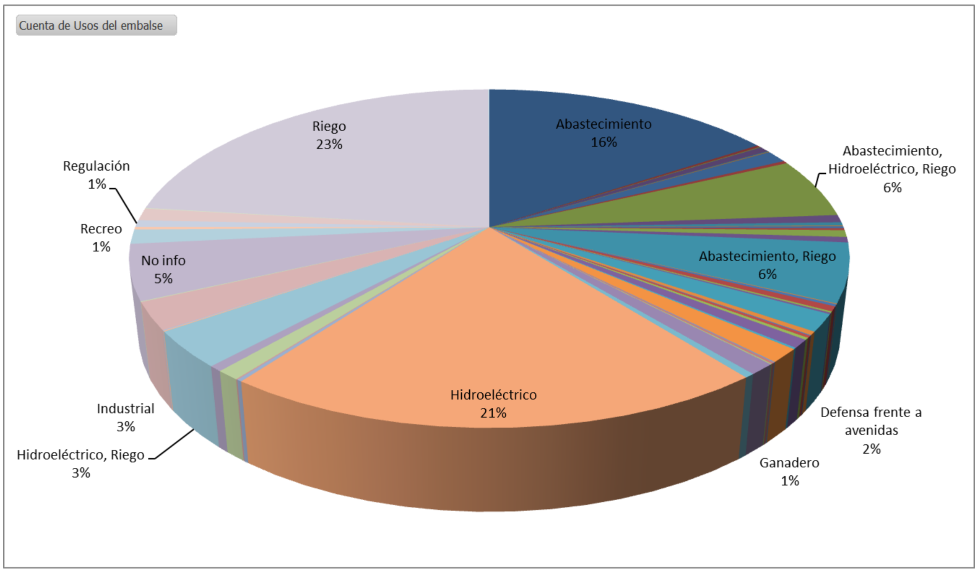


Figure 38. Percentage of dams per uses

However, if we focus on the profit generation linked with these three main purposes, it is worth mentioning that in 2007, water devoted to hydropower use accounted for a value of 2,312 million €, water devoted to water supply counted for 1,740 million € and water devoted to irrigation counted for 546 million €[41].

[39] http://sig.magrama.es/snczi/

[40] https://www.unece.org/fileadmin/DAM/env/water/damsafety/2013_11Nov._19-20_Almaty_regional_meeting/11_20_03_Fleitz_Dam_safety_management_in_Spain_Almaty.pdf

[41] ACEX. 2007. Documento base del estado del arte de la conservación de infraestructuras en España.

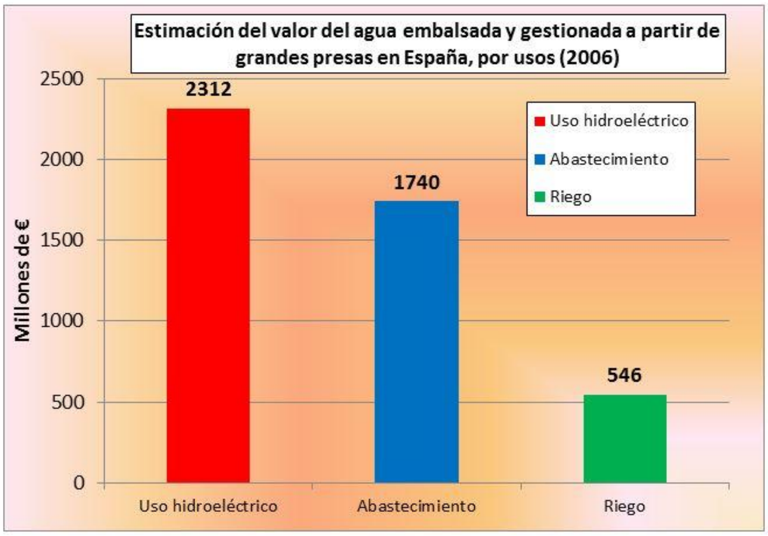


Figure 39. Estimation of water value in reservoirs

Maturity of the clients

The potential clients are mainly the owner of the dams and the river basin agencies (that regulate the water uses and dams release).

- Electricity companies: due to a competitive market of energy in Spain, the important part of hydroelectricity production (18% of total) and the adjustment to satisfy other uses, they should have interest in optimizing production by using a seasonal forecast system. This is out of the scope of the "water sector".
- Irrigation communities: they largely depend on superficial water (76%) but it is believed that most of the water volume used come from the large dams owned by public organization. Accordingly, they might be interested by the service proposed but would not be the client.
- Public organizations managing water supply for domestic and irrigation uses (Spanish Government, Regional Governments, and City councils): they are greatly interested in improving the management of the resources and its sharing between the different uses (including ecological flow requirements), as well as risk management (flood and drought).
- Others owner of dams (Industry, Recreation, etc.) might also be interested by the service but are not studied in this report.

Maturity: high, all catchment have SAIH (sharing of real-time information about water aspects), planning and operations rules well-defined in River Basin Management Plan (WFD), Actors have implemented state-of-the-art product in their activities (monitoring, modeling) to be as efficient as possible in managing a scarce resources and to generate as much as value as possible.

Barriers: Dam operation are strongly regulated since change in operation can have some cascade impacts (water deficits, inadequate ecological flow…).

Risk-adversity or how uncertain forecast can be accepted to perform decision making.

- For both private and public operator, the value of the forecast should be proven before to be implemented at full scale. In general, the higher the skill of the forecast and the decisions frequency, the easier it would be to demonstrate this value. E.g. If the skill of the forecasts is very high and that many decisions are taken considering this information, then even if the test are performed during a reduced period (a few years), we could expect that the forecast bring significant additional value. Meanwhile, if the forecast has a limited skill and that few decisions are performed

every year, then the demonstration of the value would have to consider a large period of time to get a suitable representativeness of the results. In this last case, this might not be either possible (structural change in the system to be tested) or convincing (e.g. this is much more obvious to express the potential benefits using as a reference the last year). This could explain the differences in the acceptance of the forecast between different users.

- Also the effects of taking wrong decisions (driven by wrong forecast) may sometime overcome the potential benefits. While for the decisions more related to economic gains (revenue from electricity production) are easy to access, the one related to environmental risk management (flood protection, drought measures) take into consideration more aspect (social impact, injuries,etc.) and cascade effect in all society (water restriction, flooded industry…).

Supply Analysis

Scope of the analysis

This analysis covers the services similar to the prototypes developed in the EUPORIAS project for the water sector. The usefulness of supply analysis is to gather information about your competitors and the services they offer, and then compare the service developed with the services they are currently offering. This will allow you to assess the competitive advantage of your climate service.

The following paragraphs describe those prototypes to define the scope of the study (a more detailed description has been performed in the Feasibility study).

Three prototypes or case studies are currently developed in the project for the water sector:

- S-ClimWaRe - SPAIN (AEMET + CETAQUA)
- RIFF - SPAIN (DHI)
- WRDSS - FRANCE (MFrance)

These services have the following general characteristics:

Table 8. Characteristics of water sector prototypes

	Overview	Function	Users
S-ClimWaRe	S-ClimWaRe is a new climate service to improve water management in Spanish reservoirs	S-ClimWaRe provides likelihood estimations of different reservoir conditions through the seasonal winter inflow forecasting	S-ClimWaRe can specially benefit reservoir managers and water users
WRDSS	WRDSS is seasonal forecasting system for water resources and reservoir management	WRDSS provides an operational framework for seasonal forecasting and combines model and measurement data with forecasts into decision information	WRDSS supports water resource and reservoir managers by providing inflow forecasting and water resource outlooks for hydropower, production, flood protection, irrigation, water supply and environmental flows
RIFF	RIFF is the new climate service experimented in France to manage water	By feeding a river-routing model by seasonal forecasts, RIFF provides river-flow forecasts at key period to anticipate the	RIFF addresses drought or flood risks for a best management of the reservoir refilling in spring and draining in summer

	resources at a seasonal scale over Seine Catchment and Garonne Valley	evolution of water-stocks	

These prototypes are very similar, all provide seasonal inflow forecasting based on seasonal climate forecast and are oriented to multi-purpose dam manager. Accordingly, they all try to improve decision related to dam filling and release, and therefore maximize the reservoir functions such as flood risk management, supply to agriculture and urban areas, and hydropower (but this latter aspect should not be the first priority to be considered in this study on the water sector). This defines the scope of our analysis.

List of competitors

Different services providing information for the water sector have been identified. They have been analyzed to check if they are within our scope of analysis.

Table 9. List of water sector competitors

Services	General description	References	Within our scope?
Hydrological Outlook UK	Provides an insight into future hydrological conditions across the UK: river flows and groundwater levels on a monthly basis, with particular focus on the next three months. Provide information at regional level (and river site).	Website	Not really .Dams are not mentioned in the service description but the information provided could be useful for dam management.
Prototype IRSTEA for the Arzal reservoir in France	Case study of the Arzal reservoir: low-flow forecasting and water management system to support reservoir management	Video Presentation done in HEPEX	Yes.
Prototype BfG in Germany	Different approaches are being tested for developing a seasonal forecasting service for the German waterways. The initiative is oriented to inland waterway transport.	Presentation done in HEPEX	No. Dams are not mentioned. The focus is for transport. Should be considered as competitor of the EUPORIAS SOSRHINE case study if not the same.
Case study of the Angat reservoir in Philippines	Development of a reservoir model that integrates seasonal climate forecasts to predict reservoir level three to six months in advance. Assess possible	(Brown et al., 2010)	Yes

	outcomes from particular allocation decisions.		
Case study of the Three Gorges Dam in China	This study investigated the predictability of the peak annual flood on the Yangtze River at the site of the Three Gorges Dam	(Kwon, Brown, Xu, & Lall, 2009)	Not really. Do not consider decision making processes.
Case study of the Murray-Darling Basin in Australia	Development of a forecasting system for water availability during the irrigation season (October-March) issued at the end of May	(Abawi et al., 2000)	No. The study only cover the forecasting system (it only mentions the decisions to be improved)
Seasonal streamflow forecast in Australia and operational use by water utilities	Provide catchment and site-based seasonal forecast at gauging station, including inflow to reservoir. This information has been used by Canberra's water and sewerage utility to remove water restrictions after the millennium drought in 2010.	Website BOM Website ACTEW WATER	Yes. The forecasting system provides information of dam inflows and has been used by water utilities for dam operation.
Seasonal streamflow forecast in USA and operational use by water utilities	Provide seasonal water supply forecasts for water management	Websites: River Forecast Centers	(no example of use found)

From the information gathered regarding current competitors, the following preliminary conclusions can be made:

- **Platforms** currently exist that provide to multi-purpose dam managers **seasonal inflow forecasting** based on seasonal climate forecast. These platforms exist for Australia and USA.
- Water operators use the information provided by national platform to improve their decision making. Still, no detailed information has been gathered on the processes of integrating this information.
- **Prototypes** currently exist to provide advices to multi-purpose dam manager to use **seasonal inflow forecasting in decision making**. Examples are the Arzal reservoir in France and Angat reservoir in Philippines.
- No operational software and platforms have been found that could provide tailored information to dam manager and provide them recommendation for decision making.

Detailed analysis of the competitors

The following table presents the characteristics of the IRSTEA service. Another attempt of methodology to perform a detailed analysis is presented below in the form of functional blocks.

Table 10. Characteristics of IRSTEA service

Relevant data from competitors		Prototype IRSTEA for the Arzal reservoir in France
Current state of the service	Operational or Prototype?	Prototype
Event predicted	e.g. Drought, floods, etc	Low-flow (volume below Q70)
Variables and indicators forecasted	e.g. Temperature, rainfall, other	Risk table (day and volume below Q70)
Forecast period	e.g. Seasonal, decadal	Seasonal
Frequency of delivery	e.g. Monthly, Quarterly, yearly	?
Climate model	e.g. System4	Seasonal forecasts from ECMWF
Impact model	e.g. Hydrological	GR6J model for hydrology Simple reservoir balance
Maintenance	e.g. CEH	?
Spatial coverage	e.g. River basin, region, country(ies), European Union	Focus on the Arzal reservoir (Vilaine basin) Hydrological forecast tested in 16 French catchments (since streamflow records at the Vilaine are too short for robust comparison)
Diagnostic measures	If possible, describe the degree of reliability of competitors' services	First conclusion for overall performance (CRPS for error in the cumulative distribution), Reliability (PIT for Forecast probability vs. Observed probability), Sharpness (IQR 90% for the « Width » of the ensemble)
Price	Try to identify if the service is free or is payment (and its price)	?

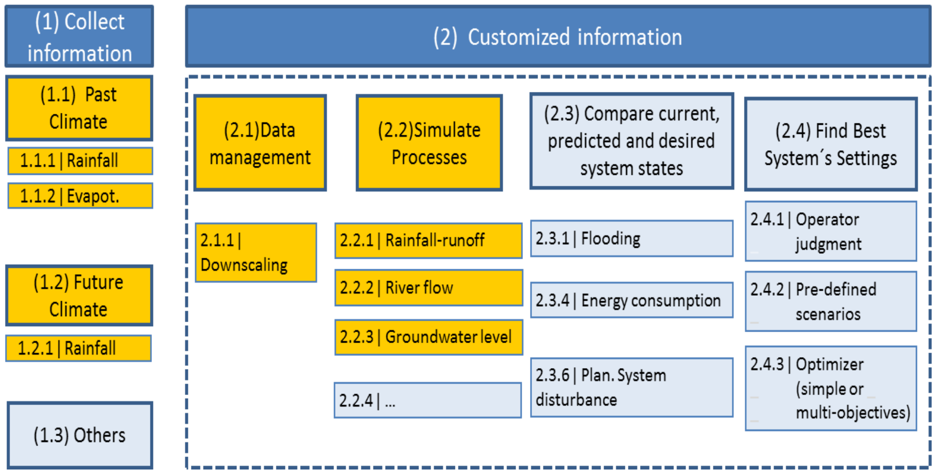


Figure 40. Detailed analysis based on functional blocks

Mapping of alternatives

Several alternatives oriented to multi-purpose dam manager are used to provide seasonal inflow forecasts not based on seasonal climate forecast.

a) Use of average values or reference years: the dam manager consider the current dam filling and use dam inflow average values (e.g. 10 years average) and demand average value to estimate the state of the dam for the next months
b) Use of climatology: different methodology exist such as extended Streamflow Prediction, or Conditional ensembles that use all or a selection of past observations to realize the forecast.
c) Use of stochastic model: it consists in developing a statistical model of the variable of interest based on past observation. Once the model has been developed, forecast can be made based on recent observations (e.g. use of SIMRISK in Spain)
d) Use of mixed approach: both statistic model and dynamical model are used (e.g. snow melting models)

Feasibility Study I

According to the methodology, this part consists in providing detailed information about the services developed in the EUPORIAS project regarding their potential benefits

- It was distinguished between direct and indirect benefits based on **(WMO, 2015)**
- It was detailled the characteristic of the S-Climaware service.
- A first SWOT analysis of the S-Climaware was done.

Table 11. Direct and indirect benefits for the water sector

Direct Benefits in Water resources management	Indirect Benefits in Water resources management
• Water savings due to anticipate water demand and water supply • Better allocate water resources between river basin users (articulators, industry, hydropower, domestic)	• Avoidance of loss of life and/or injuries/illnesses from natural disasters • Property damages avoided (crops, households, infrastructures)

• Avoided agricultural production losses • Prevent flooding	• Reducing insurance costs due to increase capacity to avoid losses

Table 12. Features and benefits of RIFF, S-ClimWaRe and WRDSS

		RIFF	S-ClimWaRe	WRDSS
FEATURES		RIFF is a climate service that aims at managing water resources at a seasonal scale over Seine Catchment and Garonne Valley. A SIM suit model is used for producing probability forecasts of river flows with different lead-times and for specific stations along the rivers	S-ClimWaRe is a climate service to improve water management in Spanish reservoirs. A probabilistic forecasting statistical model has been implemented to forecast the reservoir inflow. The forecast is ingested by SIMRISK, in order to produce a risk evaluation for each reservoir based on its initial situation, the forecasts and the historical demands.	WRDSS is seasonal forecasting system for water resources and reservoir management. The goal is to develop an operational framework for seasonal forecasting for the water resources sector that combines model and measurement data with forecasts into decision information. This system will support water resource and reservoir managers by providing inflow forecasting and water resource outlooks for hydropower, production, flood protection, irrigation, water supply and environmental flows. The prototype is being developed for the Urumea catchment.
BENEFITS	D	Water managers DMP: • Anticipate drought and maintain minimum rivers flows in Summer • Ensure the refilling of reservoirs at the end of the Winter. • Adapt the management in Winter to possible flooding events at Spring while ensuring efficient low flows support in Summer and	S-ClimWaRe can specially benefit reservoir managers and water users. Potential users: • Agricultural sector: the knowledge of the available water to irrigate and the drought risk evaluation can influence the crop election. • Power generation: decision making on the medium and long term energy markets. • Urban water: the managers could take different	There is an opportunity to optimize reservoir operations (gates opening) for flood management, hydropower generation and water use (reserve management). **Risks assessed:** • Inflow forecasting: Seasonal inflow forecasting for reservoir management including flood protection, hydropower generation and water use (reserve management). • Operational water resources management: Operational adaption of water resource systems with the ability to plan 1-6 months ahead, and

		Autumn. • Fresh water supply and • flood control over big metropolitan areas as Paris • irrigation for agriculture in sensitive regions as Garonne catchment	actions in advance to prevent the consequences of the shortage periods.	enable them to adapt the whole system to the changing climatic conditions in areas vulnerable to both too much and too little water. • Best use of water: Optimization of water resource allocation for water supply and hydropower generation and operational management of irrigation water demands and allocations. • Hazard reduction: Integrate short-term forecasting with seasonal forecasts for flood protection. Improved resilience of the system to drought and water scarcity. Environmental protection by ensuring ecological flow allowances.
	I	• flood control over big metropolitan areas as Paris → Protect citizens and benefit insurances. Avoided evacuation costs and reduced asset losses. • irrigation for agriculture in sensitive regions as Garonne catchment → Crop insurances. • Tourism → water sports	• Agricultural sector → Crop insurances • Hydropower → energy traders • Tourism → water sports (windsurfing, sailing, fishing); camping. • Ecosystems	• Agricultural sector → Crop insurances • Hydropower → energy traders • Flood protection → Protect citizens and benefit insurances. Avoided evacuation costs and reduced asset losses. • Tourism → Urumea river (canoening, kayak, etc) • Ecosystems

	(canoeing, sailing, windsurfing) • Ecosystems		

Table 13. Characteristics of the S-Climaware Service

Feature	S-Climaware
Forecast period	Dic-Jan-Feb (currently being extended)
Lead time	1 month (currently being extended)
Forecast range	4 months
Variables forecasted	NAO indice Inflow to reservoir Risk of deficit and low reservoir volume
Temporal resolution	Departure from climate values
Climate model	Statistical (AEMET): Snow indices is used to predict NAO, then correlation of NAO and inflows to dams is used to predict inflows
Impact model	Statistical/Deterministic (SIMRISK from UPV): the probabilistic info of dam inflow is introduced in a simplified water management model of the catchment. Scenarios a are simulated.
Spatial resolution	Site-based forecast
Spatial coverage	Climate model tested in various dams (currently extended)
Output type	Climate model: Graphics of terciles probability, text file with probability associated with each historical time series Impact model: Graphics of reservoir and demand state (probabilities), excel with results of each simulation
Diagnostic measures	Climate model: ROC Impact model: none (not possible: the system changed rules and demand during the hindcast period but we do not have this information)

Table 14. SWOT of the S-Climaware Service

Strengths	Weaknesses
• Provide a very useful information for the dam manager and the water users • Robust and low-cost methodology (do not required deterministic model or managing huge quantity of data...) • Co-design with end-users	• Forecast issued too late in some cases (e.g. dam management meeting generally in October) • Other variables would need to be forecasted to get full benefit of the inflow forecast (e.g. water demand). • Probabilistic forecast are difficult to communicate • Difficulty to link with decision making • Low skill in Mediterranean coast (prone to drought)
Opportunities	**Threats**
• Possibility to extend the forecast to other variables of interest for users (e.g. urban and agriculture demand, aquifer state, etc.) will generate much more added-value • Most of the Spanish dams (> 1000) could benefit from this prototype	• In some cases regulation acts as a barrier (pre-defined rules according to monitored variable that could not be changed) • Risk adverse position of dam manager that prevent decision that could increase benefits • Benefits of the prototype should appear on the long term (if applied only on 1 or 2 year this might not work)

Feasibility Study II

According to the methodology, this part consists in providing detailed information about the potential benefits and costs of the services developed in the water sector.
The analysis for the S-Climaware was performed in the specific case study of the Cuerda del Pozo dam. The avoided cost methodology was selected to estimate the benefits of applying the service. Still, an exhaustive application was not possible since the impact of modified DMP according to the forecast could not be simulated.

The Cuerda del Pozo reservoir is used for different purpose generating economic value

S-ClimWaRe

La Cuerda del Pozo Reservoir

Direct Uses

- ❑ **Douro River Regulation**
- ❑ **Water Supply** (to Soria and partially to Valladolid)
- ❑ **Irrigation** (provides water to 26,000 Ha
- ❑ **Hydropower production** (installed capacity of 6,080 Kw and average annual energy production 8.5 GWh)

Indirect Uses

- ❑ **Water sports** (windsurf, sailing, etc)
- ❑ **Camping**
- ❑ **Fishing**

Figure 41. Direct and indirect uses of Cuerda del Pozo reservoir

Cuerda del Pozo reservoir has been affected by several droughts and floods which have caused substantial damages to its users. In the following sub-sections, several examples of drought and flood economic costs are provided. A summary is presented in the following table. These numbers give a first idea on the potential benefits that the application of seasonal forecast could have in the river basin (avoided cost would be a % of the impact costs presented below).

Table 15. Summary of the of drought and flood economic costs

Direct costs	
Drought costs	**Flood costs**
❑ In 2004/05 Douro River Basin: • In the area irrigated by canal San José, **600 hectares of corn** were lost. • The Governing Council of Castile-Leon and the Council of Zamora planned to invest **300,000 €** during 2005-2006 for granting the urban water supply. • the drought caused the **hydropower production** to be **halved** in comparison with the previous year etc	❑ 117,000€ in February 2016 due to Douro river overflow (due to release in La Cuerda del Pozo).

a. Drought Costs[42]

During the last years, several droughts have affected the Douro Hydrographic Confederation, being the most remarkable ones, the 2001-2002; 2004-2005; 2005-2006;

[42] www.chduero.es

and 2012 drought episodes.
Unfortunately, no information was found about drought costs directly related with Cuerda del Pozo reservoir. However, some information related with drought costs and investments done for coping with the 2004-2005 drought episode was found for the Douro river basin.

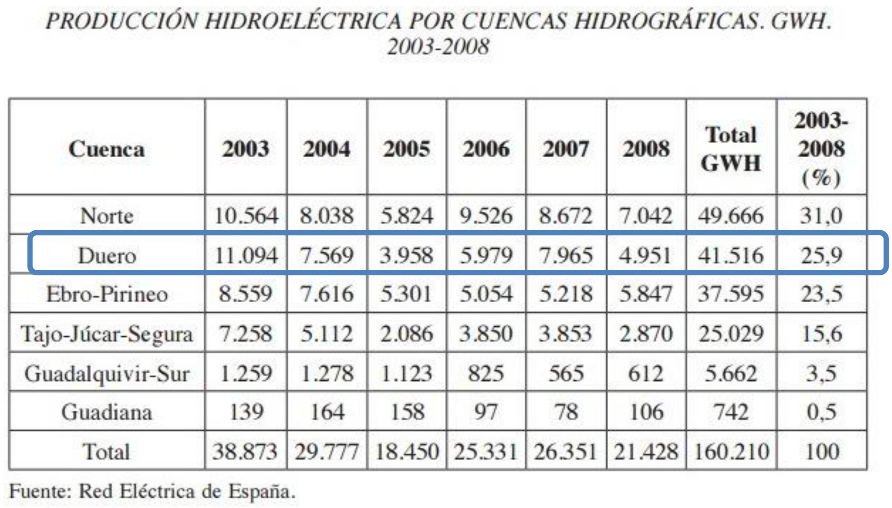
During the summer 2005, some **problems of water supply** emerged:

- In the area irrigated by canal San José, **600 hectares of corn** were lost.
- In Salamanca and Zamora, serious problems of urban water supply emerged, where nearly **4,000 inhabitants** had to get water from water tankers.
- Additionally, certain problems about water quality also arisen. For example in Sanchonuño (Segovia) faced problems of **arsenic in water**.

Some of the **measures taken** are summarised next:

- The Governing Council of Castile-Leon and the Council of Zamora planned to invest **300,000 €** during 2005-2006 for granting the urban water supply.
- The Ministry of the Environment invested **150,000 €** in boreholes in groundwater.
- Agricultural insurance policies increased. For example, the region of Cerrato lost more than **40% of its cereal crop**.
- The Governing Council invested **920,000 €** in boreholes in groundwater, so the Valdivia irrigation association and the inhabitants from Revilla, Pomar, Villarén and Porquera had enough water.

Finally, the drought caused the **hydropower production** to be **halved** in comparison with the previous year, and of the order of **55%** in relation to the average production of the last 10 years (Figure below).



PRODUCCIÓN HIDROELÉCTRICA POR CUENCAS HIDROGRÁFICAS. GWH. 2003-2008

Cuenca	2003	2004	2005	2006	2007	2008	Total GWH	2003-2008 (%)
Norte	10.564	8.038	5.824	9.526	8.672	7.042	49.666	31,0
Duero	11.094	7.569	3.958	5.979	7.965	4.951	41.516	25,9
Ebro-Pirineo	8.559	7.616	5.301	5.054	5.218	5.847	37.595	23,5
Tajo-Júcar-Segura	7.258	5.112	2.086	3.850	3.853	2.870	25.029	15,6
Guadalquivir-Sur	1.259	1.278	1.123	825	565	612	5.662	3,5
Guadiana	139	164	158	97	78	106	742	0,5
Total	38.873	29.777	18.450	25.331	26.351	21.428	160.210	100

Fuente: Red Eléctrica de España.

Figure 42. Hydropower production of river basins

a. Flood Costs

No information has been found on flooding costs link to Cuerda del Pozo. In 2009, flood event is reported upstream the dam but not downstream.

On the 13th and 14th February 2016, heavy rains caused a rise in the Cuerda del Pozo reservoir level, and Douro Hydrographic Confederation decided to release more than 100 cubic meters per second (being the average daily release lower than 10 cubic meters). As a consequence, the Douro River overflowed during its passage through Soria and caused

several damages along the river banks.
According to the Mayor of Soria, the direct damages caused by the river overflow counted for **117,000 €**[43].

Regarding the estimation of the impact that the service could have in avoiding the costs presented above, there is currently several limitation and barriers:

- the dam of Cuerda del Pozo is only one of the dam in the basin, while the information on the costs are aggregated for all the basin
- there is no big issues reported in the years simulated (1973-2013, 2015/2016 year with floods is not considered)
- the impact of the service on the decision making would be very limited in its current version.

Due to the limitation presented above, the estimation of the potential benefits cannot be completed.

Table 16. Potential integration of seasonal forecast into decision making

Decision	Potential integration of seasonal forecast
Minimum discharge from October to April	Necessary to extent forecast to the drought indicators used (precipitation and river discharge) and already pre-defined in the legal document (drought management plan). Need to get approval of Ministry.
Maximum discharge from October to April	Not a priority
Minimum safeguards in December, January, February, March and April	Some small changes could be done. Decision depends on the Dam Commission
Allocation of reserve in the next months	Might need forecast at an early stage for the seeding plan (September/October) then other organisms should be involved to predict irrigation water demand (such as the National irrigation association and corresponding administration)
Minimum volume in dam by the end of September	Not identified as priority – not discussed further
Irrigation period beyond September	Not identified as priority – not discussed further

An attempt was also done to estimate the potential benefits of the RIFF prototype with the information provided by METEO FRANCE. Still, the link between the value of the RIFF prototype (potential decrease of days below discharge threshold by upgrading the early programming of water release during summer and early autumn) and the economic benefit is too distant to realize any estimation (What is the real impact of the early programming in the daily operation of the dam? What is the impact of day below threshold on ecological status, drinking water guarantee, navigability, irrigation, energy production? What is the economic impact of a decline of the ecological status of the river (ecosystem services)?).

Business Models

According to the methodology, this sections provides recommendation on the most adapted Business Models. This section is based on the interview with experts.

Current situation

- National Meteorological services have competencies for selling meteorological services but not necessary for climate services
- Met office is maybe the exception in Europe. Météo France and DWD are starting.
- The lack of competency of National service what the reasons why the WMO develop

[43] http://www.eldiasoria.es/noticia/ZFD134A70-CE90-E99C-DA628D380613EB9A/20160301/desbordamiento/duero/soria/ocasiono/da%C3%B1os/valorados/117000/euros

the SEB document

Market for Climate Services and need of intermediaries:

- The difference with Meteorological services is the (limited) skill of the seasonal information, but even if not optimal there is opportunities to sell this information
- There is already a market, this information is being sold by companies
- As an example, private company currently use the services of private companies based in the US or in France (e.g. http://en.climpact-metnext.com/) to get seasonal info over Europe
- The gap in Europe is that there is no or few intermediaries (purveyor)
- National services have limited capacity to provide and maintain tailored services for all end-users (the tendency is to reduce personal and resources in those agencies….) so the need of intermediaries is obvious.

Benefit of COPERNICUS SIS

- It provides a data treatment and basic quality check (data service) which should help intermediaries to use those data
- Pretend to be the reference data portal in Europe

Current gap in the services delivered by National Meteorological Services:

- Interactive mapping
- Integration of different model results (dynamic and statistical) (at European level, EUROSIP do integration of Dynamic model only)
- Provide expert advice and interpretation: send “bulletin” for each of the region (Europe, USA, Middle east…) that consider end-user needs on these region (none of the National Service do it in Europe)
- Continuous forecast (that could be based on climatology or monitoring for the period with low skill)
- Demonstration of skill and benefits

Barriers to cover this gap

- Competition between National weather services
- Lack of resources of NWS
- Lack of communication between NWS and end-users
- Projects focus on adapting climate services developed by national services – while they should focus on answering end-user needs
- Few intermediaries

Best way to encourage business development through funding

- Funds should go to Intermediaries
- Funds should focus on solving end-user ISSUES
    - Climate is only ONE part of the issue (some project consider an issue such as energy mix in Europe without considering climate, other project focus only on climate → there is a lack of coordination!)

Type of intermediaries

- Companies specialized in weather and climate services (for all sectors)
    - e.g. Climpact-Metnext “Weatherproof and optimize your business. We specialize in the use of weather data in our weather-sensitive customers business processes”
- Companies specialized in weather and climate services for the water sector (e.g.

river flow forecast)
    - e.g. E-Dric "More than 200 different projects have been realized by e-dric.ch in numerous domains related to water management. We are leaders in Switzerland for hydrological modelling and online river forecasting, having dozens of clients using our predictive information and our Internet platform."
- Companies offering a portforlio of consulting services to water stakeholders, and that can incorporate a climate service into a more global service (market fit)
    - e.g. DHI "We have a 50-year track record in developing and implementing solutions that meet real-life challenges in water environments world over.So whether you need to save water, share it fairly, improve its quality, quantify its impact or manage its flow, we can help."

Transport Sector

Industry Analysis

Worldwide, the accuracy and value of weather and climate services (CS) are rising, bringing great economic benefits. In the transport sector, CS can help to promote safe aviation and transport by road and rail. In particular, short-to-medium-term operations can be made more cost-effective through the use of weather and seasonal forecasts, whereas the rate of return on investments in infrastructure could be improved by taking into account the projected changes in future climate conditions.

Scope of the transport sector:

The following points indicate potential business opportunities for CS in the transport sector:

- Transport-related companies are sensitive to determined weather and climate conditions. In particular, road, rail and maritime transport make use of information about slippery surfaces, obscured visibility and high winds. Despite this, there is a lack of meteorological data sharing by enterprises and other Government agencies so CS could help to bridge this gap.
- There is a need to mitigate transport losses associated to negative weather events. CS could help to this aim by delivering tailored climate information for the aviation, maritime, road and rail transport.
- Alongside its current use of weather forecast products to inform operational planning, long-range forecast information is of significant value to the transport sector and its increasing knowledge of impacts at the climate change time-scale.
- As a consequence of climate change (e.g. changes in frequency and intensity of extreme weather events), transport infrastructures are expected to face growing impacts in the coming decades. Moreover, there is a need to make them more resilient to keep pace with the growing mobility needs. In this context, CS could help for better investment decisions by public authorities.

Example of climate services in the transport sector:

The following examples of products might be delivered by CS in the transport sector:

- Transformation of historical data, monitoring data, weather forecasts, seasonal/decadal forecasts and climate change projections into transport-relevant indicators (e.g. freeze-thaw ratio, number of days when temperature is around zero...) for improving operation and planning.
- Climate risk assessments and impact studies including cost-effectiveness analyses of adaptation measures, risk management plans, guidance documents and decision support systems. For instance:
- Procurement of de-icing materials, snow-clearing equipments (e.g. snowploughs) and levels of stocks.
- Planning and publicity of public safety campaigns.
- Planning of maintenance during periods of suitable weather.
- Development of extreme weather management plans (e.g. emergency timetables for public transport).

Mapping of providers, purveyors and users:
Transport services are mainly offered by big (i.e. more than 1000 employees) governmental organisations pursuing activities at the national level (i.e. maintenance of roads, traffic control or prevention). Most of these organisations are generally sensitive to precipitation (i.e. rainfall and snow) and floods, particularly during winter months. Some are also sensitive to cold temperatures (i.e. freezing conditions for surface transport) and high winds, which can negatively affect infrastructures. Moreover, there is also potential to use transport-customized climate indices: freeze-thaw ratio, number of days when temperature is around zero, number of days with snow, number of days where precipitation is over a certain threshold, etc.

Most (92%) of the transport-related organizations rely on weather forecasts (up to one month), whereas a 58% rely on historical data/past observations, a 50% on climate change scenarios and just a 25% on seasonal forecasts. In what refers to forecasts (both on the short-to-medium- but also in the long-term), the National Meteorological/Hydrological Services (NMHSs) are usually the main data providers.

In particular, an important client of NMHSs is aviation. Among the most useful information for aviation, upper-air sounding poses a particular issue since many upper-air sounding stations have been closed in Europe and Central Asia (ECA) since the early 1990s as a consequence of the underfunding of the NMHSs, which is widely believed to have had a significantly negative effect on aviation safety. To overcome this, a public-private partnership designed to resolve the issue of financing the meteorological data requirements for aviation safety was forged about 50 years ago and secured by the global Chicago Convention. Since then, this partnership has been a key source for NMHSs financing, comprising 20 to 30% of revenue for the UK Met Office, Météo-France and Deutsche Wetterdienst. Sometimes, the immediate providers of forecasts are often private companies which pay the NMHSs for their forecast services. In this context, in the US, a number of agencies and enterprises undertake weather measurements for their own operations and comprise a MesoNet of mutual sharing that complements the monitoring made by regional weather forecast offices. This MesoNet provides for instance detailed weather information for the Transportation Departments of Idaho, Montana, Nevada, Utah and Washington.

Apart from aviation, there are other Europe-based users of CS products. For

instance, since winter weather conditions can have a significant impact on transport in the UK and Northern Europe (e.g. airport closures, road accidents and delays/cancellations of train services), the UK Government Department for Transport (DfT) is using the seasonal forecasts for winter provided by the “Seasonal Prototype: Risk of Impacts from NAO on Transport (SPRINT)” developed in EUPORIAS. Moreover, in the Netherlands, the Schipol airport is using seasonal/annual forecasts of wind conditions, fog and precipitation at operational/strategic level, and ProRail (the national railway company) makes a moderate use of annual forecasts of winter conditions. Finally, road maintenance (river transport) companies are aware of the potential use of monthly/sub-seasonal (seasonal) forecasts. Also, annual forecasts may have some potential for Ministerio de Fomento and ALVAC (Spain).

The following table provides information on the data providers identified for the transport sector. The information is grouped by the period (historic, forecasts with different horizons) and the type of the information provided (climate data, derived variables).

Time scale of forecasts	Providers of weather/climate variables (temperature, precipitation, etc.)	Providers of other climate-related variables
Historical Information	• NMHSs • *Often users have their own measurements (weather stations/sensors, etc.)*	
0-24 hours	• NMHSs • *Often users have their own measurements (weather stations/sensors, etc.)* • Private-public partnership (e.g. for international aviation)	• Private companies paying NMHSs for their information?
1-7 days	NMHSs	
1-2 weeks	NMHSs	
1 month	NMHSs	
1-7 months	NMHSs. However, the available information may not meet the lead-time, spatial resolution and skill requirements.	Not sure if this information is available. Moreover, if available, this information may not meet the lead-time, spatial resolution and skill requirements: • Research institutions? • Private companies (e.g. consultancies)?

1 – 10 years	There may be some interest for this kind of information (not sure if it is available yet) from some organizations; however, it seems they don't use it yet (mainly due to the lack of skill).	There may be some interest for this kind of information (not sure if it is available yet) from some organizations; however, it seems they don't use it yet (mainly due to the lack of skill).
10-100 years	• NMHSs • IPCC climate change scenarios (which are sometimes tailored to provide more specific scenarios)	Not sure if this information is available: • Research institutions? • Private companies (e.g. consultancies)?

Table 17. Providers of data for the transport sector

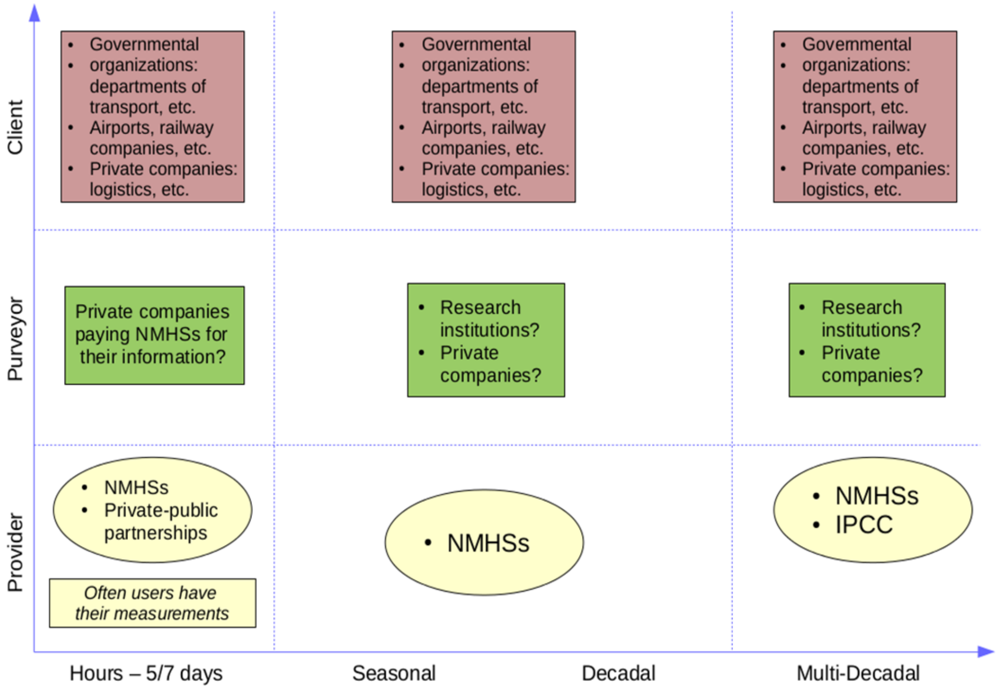


Figure 43. Mapping of providers, purveyors and clients for the transport sector

Overall, transport-related organisations seem to prefer using historical data (often their own data) and short-to-medium term weather forecasts rather than seasonal/decadal forecasts. Despite an increasing interest in integrating the latter predictions into their operational decision-making processes, the current lack of reliability seems to be the main factor which is hindering their use. Besides, it also seems that transport organizations are using climate change scenarios for strategic planning of long-term operations.

PESTEL analysis for the transport sector:

Political

ISSUES:

Transport management decisions related to planning and operation are

undoubtedly linked to political decisions. For instance, a new aviation policy, the *Single European Sky*, is being forged in Europe, which aims to minimize the distinct role of the many NMHSs and promote the evolution of a smaller number of aviation forecast providers (reducing thus the elevated budgets that make NMHSs unsustainable).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• Policy makers are expected to promote the use of forecasts and information about current conditions, which are needed to improve safety in aviation, road, rail and maritime transport (Mills 2007, Liljas 2007, Thornes 2007). • Globalization and the consequent development of international policies may facilitate the development of CS across all European member states.	• Revision/modification of current laws or agreements. For instance, appearance of unexpected taxes (ecological, linked to petroleum, etc.). • Some decisions do not depend only on technical information. That is, political vision has the last word, which is usually influenced by interest groups (e.g. lobbies). As a result, accepting reforms, innovations, etc. may prove difficult.

Economic

ISSUES:

Inevitably, the development of CS is constrained to the current and foreseeable shortages in public budgets as well as to the (possible) appearance of more stringent regulations in the banking system (decreased capacity lending).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• Need for innovate methodologies for risk management (promotion of cost-benefit analysis and search of cheaper solutions). • Need for alternative and cheaper transport options. • The serious capacity deficiencies found in NMHSs could be significantly remedied by relatively modest (but sustained) investments.	• Revision/modification of current laws or agreements. For instance, appearance of unexpected taxes (ecological, linked to petroleum, etc.). • Maladjusted relationship between the CS cost and their outputs in terms of higher cost-benefit ratios. • Limited budgets can lead to slow implementation of CS. For instance, many NMHSs services in ECA are in decline. As a result, the

	development of CS can be compromised. • NMHSs highlight that road transport agencies may not have the infrastructure or capacity to make use of the improved forecasts delivered by CS.

Social

ISSUES:

There is a need to engage the public in issues of transport and climate change using deliberative methodologies to deviate from traditional “top down” methods of information provision. New forms of research and communication need to be two-way, explore formats for learning on all sides of the issue and not necessarily strive to reach consensus (Anable et al. 2006).

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• CS can lead to improved safety on transport (e.g. aviation, road, rail, maritime) and better investment policies, helping to bridge the existing gap between climate researchers and society. • CS can help in providing technical explanations to justify the decisions to be taken.	• Lack of social confidence on climate forecasts (especially at seasonal, decadal and climate change time-scales), which can prevent policy makers/stakeholders to use CS. • Risk in using climate information lacking the required lead-time, spatial resolution and skill. • Need for optimal communication of risk-based forecasts to the transport stakeholders (and society in general) and subsequent provision and evaluation of these forecasts.

Technological

ISSUES:

Responding to the climate change challenge implies taking rapid and effective steps to reduce greenhouse gas emissions, in particular through new low-carbon energy and transport technologies. This requires climate-informed decision-making at all levels in order to minimise risks and costs and to seize opportunities.

In this context, recent advances in monitoring (e.g. low-cost sensors), climate modelling

(new Earth System Models), prediction skill (e.g. NAO in GloSea5), decision-making methodologies and tools (collaborative vision, risk-based and cost-benefit analysis) may help the rapid development of CS for the transport sector.

IMPACTS ON CS BUSINESS:

Opportunities	Threats
• Foreseeable availability of more skilful seasonal forecasts as well as (Copernicus C3S and others). • New electronic media (social media groups, interactive web platforms, mobile applications, etc.) may facilitate the delivery of CS to society in general.	• Strong need for upper-air sounding, specialized meteorological stations placed at key road locations, buoys and radar in coastal areas, maritime models. • Difficulty to meet the lead-time, spatial resolution and skill requirements for weather and climate information, especially in seasonal/decadal forecasts for Europe, which should be delivered in a friendly, common and low-cost way (not accomplished yet). • Difficulty to access climate and/or transport-related data, especially if it is owned by private companies. • The NMHSs of ECA highlight that road transport agencies may not have the infrastructure or capacity to make use of the improved forecasts delivered by CS. • Inadequate human resources to provide and maintain new sophisticated e-services.

Environmental

ISSUES:

The growing desire to protect the environment is having an impact on transport industries (for example, more taxes are being placed on air travel) and the general move towards more environmental friendly products and processes is affecting demand patterns and creating business opportunities.

IMPACTS ON CS BUSINESS:

Opportunities	Threats

- There is need to keep enlarging and improving transport infrastructures whilst taking into account aspirations of people and businesses to reduce their impacts on the environment (air pollution, fragmentation of ecosystems, health, noise, etc).
- Environmental regulations can promote the development of new hybrid (non-exclusively petroleum dependent) means of transport, which may depend on alternative, more sensitive to climate, energies.

- Changes in the use of transport infrastructures as a result of more taxes being placed on traditional (petroleum dependent) means of transport.

Legal/Government

ISSUES:

Governments may be forced to promote the creation of international laws which allow to rationally and efficiently address the effects of climate change on the European economy and society, and in particular in the transport sector (such as changes in tourist destinations which can have an impact on transport demand).

IMPACTS ON CS BUSINESS:

Opportunities

- One of the focus of H2020 is the achievement of a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.

Threats

- Transport is a very complex system with responsibilities distributed across many different stakeholders. This situation makes integrated adaptation approaches challenging to achieve and requires appropriate governance approaches.
- Rigid regulations: transport infrastructures construction is subject to several European laws.
- Lack of agreement between different countries may difficult the creation of international laws.

Maturity of CS in the transport sector:

The potential for growth of CS may be higher for sectors which traditionally use weather forecasts (e.g. agriculture, forestry and disaster risk management) as well as for those in which decision-making and investments planning rely on the long-term (e.g. transport infrastructures).
According to UKCIP[44], as compared with other sectors such as housing and health, the market in the transport sector is relatively mature. However, the level of maturity of CS in the transport sector highly depends on the particular application (e.g. aviation safety, road maintenance, etc.)

Identify business opportunities for CS in the transport sector:
The figure below shows a preliminary SWOT analysis for the CS industry in the transport sector is provided. Notice that it is not completed yet and needs to be further developed.

Strengths	**Weaknesses**
• Need for guidance on adapting transport infrastructures to the future climate, both to prevent disruption to the public and to decrease local authority maintenance costs (Willway et al. 2008). • Creation of a new need (demand), relevant to society: CS could help improving 1) public infrastructures (increased safety) and 2) public investments. • Possibility of a sustained demand of CS since they can help on both short-to-medium- and long-term decision-making processes.	• Difficulty to meet the lead-time, spatial resolution and skill requirements for weather and climate information, especially in seasonal/decadal forecasts, which should be delivered in a friendly, common and low-cost way (not accomplished yet). • Need for tailored decision-making processes for different applications: e.g. aviation safety, road maintenance, etc. • CS development depends on public budgets to a great extent, which are subject to foreseeable shortages. • Changes in regulations may be probably needed.
Opportunities	**Threats**
• Could match with safety campaigns, tourism demand, etc. • One of the focuses of H2020 is to achieve a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and	• Difficulty to translate the outcomes (and their usefulness) from CS to society in a clear and understandable way. • Lack of coordination and collaboration between the different agents/stakeholders involved. • Lack of competition in the

[44] http://www.ukcip.org.uk/projects/engaging-with-climate-services-providers/#.VsxQcPnhBki

society.	providers market.

Figure 44. Preliminary SWOT analysis for CS in the transport sector

Influence of Copernicus on the CS market for the transport sector:
Climate change (as represented by increases in temperature, sea level, changes in rainfall and the increase in frequency and intensity of some extreme weather events) will seriously challenge the transport system, which is an important pillar of the economy and society. A report by the European Environment Agency (EEA) on adaptation of transport to climate change in Europe outlines the following challenges for the transport sector:

- Rising temperatures and extended heat-wave periods increasing the problems of rail buckling, pavement deterioration and thermal comfort for passengers in vehicles.
- Weather extremes generating floods or landslides leading to delays, interruptions and detouring needs.
- Sea-level rise threatening harbours and other transport infrastructure and services in coastal areas.
- Air transport challenged by changing wind patterns, flooding of airport infrastructure and other weather events.

One of the challenges of H2020 is to achieve a resource-efficient, climate-and-environmentally-friendly, safe and seamless European transport system for the benefit of all citizens, the economy and society. In this sense, Copernicus (through its Climate Change Service: C3S) provides information in support of adaptation and mitigation policies regarding climate change and its effects on various sectors, including transport. In particular, the essential climate variables and derived sets of indicators, the near-real-time climate monitoring, the multi-model seasonal forecasts, or the climate projections at global or regional scales are just a few of the Copernicus services that are relevant for the transport sector[45]. Moreover, the C3S products are available to everyone so, in principle, Copernicus may be expected to positively affect the development of CS for the transport sector.

[45] http://climate.copernicus.eu/resources/information-service/climate-change-impact-transport-sector

Demand Analysis

		Governmental agency operating at a national level	Governmental agency operating at a national level	Governmental agency operating at a national level	Something in the middle between a governmental agency and a private company	Governmental agency operating at a national level	Governmental agency operating at a national level	Governmental agency (although they use a lot of contractors) operating at the regional/national level
(A) "Climate model outputs":	USE	**YES** They use precipitation, although in a qualitative way. Also, they think decadal forecasts would be interesting, but they are not widely available.	**IT DEPENDS** So far, they just use weather forecasts for short-term operations and climate projections for long-term planning.	**NO** They just use weather forecasts for short-term operations and climate projections for long-term planning.	**NO** They just use own measurements and weather forecasts for short-term operations, as well as climate projections for long-term planning.	**IT DEPENDS** They just use own measurements and weather forecasts for short-term operations, as well as climate projections for long-term planning.	**NO** They just use own measurements and weather forecasts for short-term operations.	**NO** They just use own measurements and weather forecasts for short-term operations, as well as climate projections for long-term planning.

	WTP	**NO** The forecasts they use are provided by the National Met Service, for free.	**IT DEPENDS** They are not sure if they are paying for the weather forecasts, which are mainly provided by the National Met Service.	**NO** They get the weather forecasts and the climate change projections from the National Met Service.	**NO**	**NO** Most of the climate-related information they use comes from the National Met and Hydrological Offices.	**NO** They don't pay for any of the weather forecasts they use, which are majorly provided by the National Met Service.	**NO** They say wouldn't pay neither for seasonal nor for decadal forecasts.
(B) "Customized information"	USE	**NO**	**NO**	**NO** Although they are not using any kind of information derived from seasonal forecasts, they use climate change scenarios.	**IT DEPENDS** Regarding weather forecasts, they receive the information directly from a private provider. In what concerns seasonal time-scales, they might be interested in testing if there is some value in using climate-derived indices.	**NO** Regarding seasonal time-scales, not. But they use climate information indices in order to define the road maintenance and isolation of rock tunnels.	**NO** Focused on short-term actions, they just interpret so far the weather forecasts they get from the National Met Service by themselves.	**NO** They say their providers do some tailoring before delivering the weather forecasts. Regarding the climate change projections, they mention the need of getting information at the finer spatial scale they actually need (current projections are too coarse).

	WTP	**NO**	**NO**	**NO** The National Met Service provides the information above mentioned, for free.	**NO**	**IT DEPENDS** They pay the National Met Service for the abovesaid short-term product they specifically developed for the agency. Also, they think information relying on the expertise of meteorologists and hydrologists who look into the special needs for particular projects should be paid.	**NO**	**NO** With respect to the weather forecasts, they say they pay for the above indicated tailoring process. They'd also probably pay for the downscaled climate projections.
(C) "Derivative variables"	USE	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**
	WTP	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**
(D) "Service tailored to the specific user's needs"	USE	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**
	WTP	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**	**UNKNOWN**

Figure 45. Demand analysis for transport sector

NOTE: Due to the large amount of information collected, for simplicity, only the most relevant aspects are shown in the figure.

Demand Analysis Task 2:

The transport sector (e.g. by road, rail, sea, etc.) is highly vulnerable to weather and climate conditions, especially in those regions where extreme events are observed (e.g. high wind/snow in northern Europe or heat waves in southern Europe). Therefore, a large number of potential users might benefit from proper climate information, from big national public companies to small private ones (which are sometimes subcontracted by the former). Among those considered for the first task of this demand analysis, rather than focusing on just one company, we went across all of them, providing therefore a general overview for the sector.

We've found that **most of the companies just use own measurements and weather forecasts for short-term operations and climate change projections for long-term planning**. However, **there is still some potential for the use of seasonal forecasts, especially with the aim of reducing the costs when hiring external contractors** (which are needed sometimes for the implementation of certain maintenance operations). Despite this, **the use of seasonal forecasts in the transport sector is very limited nowadays**. The main reason for this is **the lack of skill of forecasts** at this particular time-scale (users would explore their use if they were more reliable). Also, other limiting factors are the **insufficient lead-time and the lack of spatial resolution**. Therefore, and despite seasonal forecasts are usually freely distributed by national met services, there might be an opportunity for business in providing tailored seasonal forecasts. In particular, besides downscaled forecasts, climate-derived impact indices (instead of meteorological variables themselves) might be relevant for some companies. However, in all these cases, **it is not very clear if companies might be paying for these services, at least until they do not prove to be more reliable to what they are nowadays.**

Finally, another opportunity for business may be related to the immaturity of the potential users of seasonal forecasts. Very often, they do not have any experience with this kind of prediction so they cannot figure out how they may help them for better investment and planning decisions. Therefore, **there might be also some room for consultancy services** (e.g., help the user understand the uncertainties that are involved in these predictions).

Supply Analysis

Weather/climate services: The following Table describes the weather and climate services that, as far as we are aware, compete with the surface transport (i.e. road and rail) weather and climate services at the Met Office (MO).

Table 18. Competitors of Met Office weather and climate services

Questions for analysis	Traditional Road	Independent gritting	Rail
What is the competitors' advantage?	**Weather services:** Company A: Forecast accuracy in road, simplified provision of data	**Weather services:** Company A: Strong relationships with larger Independent gritters	**Weather services:** Company A: Online system portal for rail services Company B: Price

	Company B: Price and flexibility of technology applications Company C: Visual weather and data handling **Climate services**: Company A: Focus on the 30-day time period using probabilistic weather data for their sites	Company B: Price and flexibility Company C: Low cost, simple data product Company D: Low cost, online subscriptions	and flexibility Company C: Strong links to Network Rail personnel Company D: Strong European Rail presence **Climate services**: Company A: As with Road, rail services also include probabilistic weather data out to 30-days for their sites
How does the MO differ from the competition?	**Weather services**: Expert scientific capabilities focused on road Dedicated forecasting bench for road services **Climate services**: MO provide the only impacts-based seasonal forecast in the market (currently).	**Weather services** Model capability and clustering methodology used for forecast site selection	**Weather services**: Scientific capability Cross-office skills base (e.g. observations) Alignment to national severe weather information and advice. **Climate services**: As with Road, the MO provide the only impacts-based seasonal forecast
What weather, climate services do our competitors provide?	**Weather services:** Company A: Bespoke services, tailored to provide customer solutions Dedicated team of highways meteorologists available 24/7/365 days a year. Hence both winter and summer services	**Weather services**: Company A: See Road column.	**Weather services**: Company A: Similar forecast capabilities as for road, but for rail customers **Climate services**: As with Road, there is the provision of 15-30 day ensemble forecasts tailored to

	offered. Bespoke meteorological information includes: precipitation type radar forecasts **Climate services**: Ensemble forecasts for up to 30 days ahead.		the rail industry

Conclusions:
In summary, much of the competition stems from the weather services other companies provide. In terms of climate services, particularly **at the 3-month timescale, the Met Office's DfT/EUPORIAS seasonal transport prototype is the only climate service in the market currently**. **However**, given that **customers are very much interested in the 1-month timescale**, and our competitors offer services at this timescale, there may be a need to assess whether the MO can provide potential customer impact information on a monthly timescale.

Feasibility Study I

Features, Benefits and Value
The following Table describes the current seasonal forecast prototype for the transport sector co-funded by both the Department for Transport (DfT) and EUPORIAS.

Table 19. Description of SPRINT prototype

What is SPRINT and what does it do?	What are the SPRINT benefits?	How can you translate SPRINT benefits into value for the customer?
Seasonal Prototype: Risk of Impacts of the NAO on winter Transport (SPRINT) is a seasonal prototype that provides transport stakeholders with a risk-based impact forecast at lead times of 1 – 3 months. Unlike many other prototypes, which have a single stakeholder or a small stakeholder group, SPRINT has a large stakeholder group coordinated by the UK Government Department for Transport (DfT). An in-person briefing is	These depend on the transport stakeholders (e.g. road, rail, aviation) but in the main the ultimate benefit is on optimising planning decisions. A couple of examples are provided here. These are based on Palin et al., (2016). • **Aviation**: de-icing of planes; flight delays • **Road**: tonnes of salt used; road accidents • **Rail**: incidents on the railway network	Potential benefits: • **Aviation, Road, Rail**: ££ saved through better planning decisions

provided to stakeholders in November, for the DJF period. Subsequently there are also monthly teleconferences that take place between the Met Office and the DfT-led stakeholder group. SPRINT uses the latest Met Office seasonal forecast system (GloSea5) that has proven predictability of the winter NAO (Scaife et al., 2014) and its link to northern European winter climate, to determine the risk of transport impacts to DfT stakeholders (aviation, road and rail sectors). This impact-based forecast has been trialled in the winter of 2015/16 in the UK. Briefings are based on (a) the Contingency Planners' Outlook material (CPO, which predates the prototype) and (b) bespoke impact forecasts (designed during EUPORIAS)		

SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
Advanced warning (up to lead times of 3 months) of potential winter impacts to transport sector (examples given above)	Forecasts are currently delivered in ~October through to February covering the period ~November-April. Extending the period covered from September-April would be better	Potential to extend geographical coverage of prototype to other Northern European countries (but this depends upon customer data availability)	Customer 'willingness' to use an impacts based forecast in the first place. The stakeholders may still prefer to use the Contingency Planners Outlook (CPO) to base their winter planning decisions on (i.e. infer what the potential impact on their operations is from the weather parameter based CPO forecast) rather than using the impact forecasts directly.

As a consequence of the above, this should reduce costs to the relevant transport sectors	Information at 3-month lead time was considered by some stakeholders to be too uncertain to be useful	As a result of the above, the market potential might be large but this needs to be determined through uptake of such impact based forecasts	Competition from other weather service providers in the road and rail sectors
	Some stakeholders would prefer 'plainer English' in communicating the forecast	Potentially increased predictability of winter NAO through enhanced super-computing power (due to procurement of new HPC) and thus potential for further predictability of sector-related impacts.	
	Stakeholders are often reticent to make decisions based on the information presented in the prototype. Reasons include (a) "cost" of a wrong decision (whether financial, reputational, etc), (b) insufficient skill / too large uncertainty in the information provided	Applicability of method to other sectors, depending on customer data availability and statistical link between the winter NAO and customer impact.	

Conclusions:

Key advantages:

- It is the first impact based risk forecast for the transport sector and therefore links a proxy for the large-scale atmospheric circulation in winter (the winter NAO) to the impacts likely to be experienced by road, rail and aviation customers.
- Monthly briefings from September through to March.

Market share:

- Based on the winter 2015/6 impacts-based seasonal forecast trial, there may be potential for future growth and thus increased market share. However, there is a need to better communicate seasonal forecast information to interested parties. As customer understanding increases, this should facilitate the incorporation of seasonal forecast information in their decision-making processes, although this will also depend on their level of risk aversion. Stakeholders that are (very) risk averse are less likely to use forecast information to alter their decision-making. Since the trial service was provided via DfT and EUPORIAS co-funding to a group consisting of multiple stakeholders across transport modes and functions, the willingness of individual stakeholders to pay for this service has not been assessed.

Market opportunities:

- As stated in 'Market share', there is significant market potential but this depends on the factors identified (e.g. seasonal forecast communication and level of risk-aversion). Remaining gaps/improvements:
    - The service should span a larger part of the year, even if the skill of the forecast is lower for some of this period
    - The stakeholders would like different types of briefing material depending on their desired level of detail – hence this would further enhance customer needs.

Alternative uses:

- The alternative use and also biggest opportunity would be to apply this method to other sectors (see 'Opportunities' in SWOT analysis).

Feasibility Study II

Introduction

As part of the EUPORIAS WP45 package, the Met Office has been tasked with determining the value for money of the co-funded Department for Transport (DfT)/EUPORIAS seasonal transport forecast prototype. A description of this prototype was given in the Feasibility Study Part 1 EUPORIAS WP45 document.

It is important to note at the outset, that the value for money calculations reported in this document is highly uncertain. This is primarily due to very limited data availability for calculating both the costs and benefits of the DfT/EUPORIAS seasonal transport prototype. This is due to the fact that the seasonal transport prototype has only been trialled for one winter season (2015/16). In addition there are, as of yet no impacts data with which to verify the seasonal transport prototype against (see section 4). Therefore, in order to accurately depict the value for money associated with this prototype, a targeted study needs to be undertaken that is based on much more comprehensive cost and benefits data.

Notwithstanding these limitations, the report highlights a possible methodology that could be used to capture the value for money of a particular climate service.

Rationale for the choice of socio-economic benefit method used

For a complete description of the wide ranging SEB methods available, it is

recommended that the reader refer to '*Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*'[46](GFDRR, 2015). Here we present the rationale for choosing a **value chain analysis approach**, compared to decision theory and avoided costs.

Avoided costs

As described in (GFDRR, 2015), avoided costs is a good approach to use when attempting to quantify the direct monetary benefits associated with a weather/climate service. Although it is one of the easier methods to implement, it has the disadvantage of only representing the core monetary value of a service. It is therefore unable to include the indirect benefits associated with a climate service such as lives saved or avoided livestock losses. For the DfT seasonal transport prototype, there is a significant communication element (the monthly autumn/winter briefings) the effectiveness of which cannot be captured using this method. In addition, the DfT stakeholders are generally (very) risk averse, another trait which cannot be included using avoided costs.

Decision theory

This SEB method is used frequently since it is able to examine decisions at household or firm level. However, the cost-loss model generated using such a method is heavily data dependent and unfortunately the DfT prototype has only been trialled over the last couple of winters. Therefore, there is insufficient stakeholder information with which to properly frame such a decision theory framework.

Value Chain Analysis

Value chain analysis is concerned with quantifying the value of climate information through various filters or steps, whilst recognising that information is lost at each step of the process. Value chain analysis starts with forecast accuracy, then is usually followed by dissemination of weather/climate information through various communication channels. This method can also incorporate the risk aversion characteristics of the end-user. Further details on this method can be found in GFDRR, (2015). Given that the DfT prototype significantly relies on briefing material and that a significant fraction of the end-users are risk averse, we have chosen this method to attempt to quantify the SEB.

DfT seasonal transport prototype costs

The costs associated with developing this prototype are based on limited data availability and as such should not be considered final.

Table 20. An estimate of the costs associated with developing the prototype

Staff time (development)	Staff time (maintenance and ongoing delivery)	Computer use (data storage)	TOTAL
£145,000	£ Up to 70,000/year	£5,000	~£220,000

It should be stressed that these prototype costs constitute a very rough estimate. In particular, the computer use (data storage) element is extremely difficult to acquire

[46] https://www.gfdrr.org/valuing-weather-and-climate-economic-assessment-meteorological-and-hydrological-services

accurate information on. These costs exclude the production of the Contingency Planners Outlook (CPO)[47] on which the DfT seasonal prototype is partly based.

DfT seasonal transport prototype socio-economic benefits

As discussed previously, due to lack of impacts data from the DfT stakeholder group it was not possible to capture the SEB of the recent seasonal transport prototype in this manner. It is hoped that acquiring this data will be possible in the next couple of years so that this component of the seasonal prototype can be evaluated in terms of the SEB. However, the seasonal prototype is partly based on the CPO. Verification information on this component of the prototype is available in terms of forecast accuracy based on the CPO's performance since 2011 for monthly forecasts and since 2005 for seasonal forecasts. Forecast accuracy[48] in this case is calculated based on whether a raised probability of either 'below average' or 'above average'[49] weather variable (e.g. temperature) corresponds with what was observed. The frequency that the forecast corresponded with what was observed equates to the forecast accuracy. Here we focus on both the 1-month and 3-month temperature forecasts. The monthly forecasts are based on 43 forecasts from Dec 2011 to Jun 2015 and the seasonal forecasts on 36 independent forecasts from winter 2005/06 to spring 2015. We also only consider temperature as the variable to which we assign a first-order estimate of forecast accuracy. This was done primarily because the DfT stakeholders are more concerned with a below average temperature signal (i.e. a cold winter) which would increase the chances of a significant snow event occurring. This first-order estimate of forecast accuracy is considered to be conservative since all seasons are included, whilst the highest skill in the GloSea5 forecast system is in winter (Scaife et al., 2014). The winter season was not examined in isolation since this would have provided too small a sample to base the forecast accuracy statistics on.

1-month temperature forecast accuracy: 0.75

3-month temperature forecast accuracy: ~0.70

In the absence of impacts data from stakeholders, we use the Winter Resilience Review published in 2010[50] to estimate the costs of severe winter weather across the transport network (i.e. aviation, road and rail). Whilst it is acknowledged that this report is rather outdated, it estimates the economic costs of winter transport disruption by '*using the analysis of mild, average and severe winters, based on their different frequencies, coverage and intensity*'[51].

The economic costs are partitioned in two categories: a) 'hard' costs (e.g. lost output, increase in vehicle accidents, increased costs to the NHS and b) 'welfare' costs (i.e. effects which are detrimental to individuals but which are estimated based on a 'willingness to pay to avoid' basis and which do not impact the economy). An example of a welfare cost might be travel delay experienced by an individual. As

[47] The CPO consists of a temperature and precipitation forecast issued once a month for the following 1 and 3-months.

[48] There are many ways in which forecast accuracy can be measured but we have focused on a first-order estimate of the forecast system.

[49] Compared to the 1981-2010 climatology

[50] Winter Resilience Review 2010 (https://www.gov.uk/government/speeches/winter-resilience-review).

[51] The exact methodology by which they calculate the winter economic costs were not available to view

such the welfare costs are essentially a metric of well-being of an individual.
Based on the Winter Resilience Review 2010, the central estimate of the average annual winter costs are £450 million for the hard costs and £500 million for the welfare costs across the transport sector. This gives an annual average total of £950 million. This is considered to be a high end estimate since the impacts of severe weather disruption to DfT stakeholders' operations cannot represent the total fraction of these costs given that the DfT stakeholders do not account for all of the transport stakeholders in the UK.
In order to determine the value of climate information pertaining to the DfT seasonal transport prototype, we propose to use the value chain analysis method in order to account for information decay (Nurmi et al., 2013). It is important to note that we are assessing the forecast accuracy of the impacts based forecast using the CPO 1-month and 3-month temperature forecasts. This is because there is, as of yet, no impacts based verification of the DfT seasonal transport prototype.

Table 21. 3-month and 1-month temperature forecast value of information prediction

Value Chain step	***Percentage of useful information***
Forecast accuracy	70% (based on the 3-month outlook)
Communication of information (through DfT briefing materials)	Based on the outcomes of a DfT workshop which trialled the DfT seasonal prototoype in winter 2015/6, the following proportion of attendees thought that the October briefing for NDJ was useful (55%), the November briefing for DJF was useful (75%), the December briefing for JFM was useful (60%) and the January briefing for FMA was useful (100%). Therefore through the whole winter season the usefulness of the briefings was ~72.5% (55% + 75% + 60% +100%/4).
Access to weather information (in this case the briefings)	Briefings are undertaken largely by teleconferences, and hence should be accessible to all. It is reasonable to assume that unforeseen circumstances could prevent some people from attending; we therefore set this parameter to 90%. We assume the same proportion of stakeholders to be able to attend these briefings in the future, though this may be affected by any changes in delivery mechanism for the briefings (e.g. switching to web conference).
Comprehension of information	The survey results of the winter 2015/6 trial revealed that 70% of respondents found the briefing material for DJF issued in November 'easy to understand'. In the absence of information for the other briefings (e.g.

	October, December and January for NDJ, JFM and FMA respectively) we assume the same level of comprehension of briefing information.
Effectiveness of response (i.e. the ability with which the end-user can or is willing to act upon the forecast)	After an initial workshop held at the Met Office in July 2015, it was apparent that there was a wide range of risk aversion attitudes. This ranged from highly risk averse (i.e. where the end-user would always plan for a cold winter irrespective of the seasonal forecast) to significantly less risk averse (i.e. where the stakeholder was in principle willing to incorporate the seasonal forecast information into their decision making). In the absence of information on the proportion of individuals that were either risk averse or not, we propose to set this value chain component at 50%.
Total estimated cost savings (per year)	Annual average winter transport costs: £950 million[52]. We take this figure and run it through the value chain to estimate the potential cost savings (per year) that could be attributed to the DfT seasonal prototype. First we establish the percentage of value left at the end of the value chain. This follows the approach taken in Nurmi et al., (2013): 0.70 (forecast accuracy) *0.90 (access to weather information) *0.70 (comprehension of information) *0.50 (effectiveness of response) = ~0.22 or ~22%. Thus, the cost saving per year to the transport sector of using the DfT seasonal prototype based on the 3-month temperature forecasts is estimated to be: £950 million *(0.22/0.78) = **~£266 million/yr.** For the 1-month temperature forecasts, the cost savings are slightly higher due to the slightly higher forecast accuracy component of 75%. The value

[52] As mentioned previously, this is considered an upper-bound cost estimate since the DfT stakeholders cannot represent all of the stakeholders within the transport sector.

	remaining at the end of the value chain in this case is: 0.75 (forecast accuracy) *0.90 (access to weather information) *0.70 (comprehension of information) *0.50 (effectiveness of response) = ~0.24 or ~24%. As such, the cost savings per year from the DfT seasonal prototype using the 1-month temperature forecasts is: £950 million *(0.24/0.76) = **~£304 million/yr.**

Conclusions

The value for money estimate of the DfT seasonal prototype obtained in this work is based on the Winter Resilience Review 2010 estimate of £950 million cost associated with severe winter weather disruption across the transport sector. Given that the DfT stakeholders do not represent the total fraction of all UK transport stakeholders, the SEB calculated is likely to be an over-estimate of the value for money for this prototype.

Furthermore, our estimate of potential cost savings through a value chain analysis is based on information received from DfT stakeholders after trialling the prototype during winter 2015/6 (i.e. just one winter). In addition, some of these value chain estimates, such as risk aversion are based on a subjective view of the limited information provided from the DfT seasonal prototype workshop. As such, the value chain components with which we estimate the final cost savings cannot, at this early stage, represent the complete socio-economic benefits of this prototype.

Importantly, the forecast accuracy component is based on the 1-month and 3-month temperature forecasts which directly feed into the CPO forecasts and the DfT seasonal prototype. Whilst there are many years with which to estimate this forecast accuracy, there is currently a lack of impacts data with which to verify the impacts component of the DfT seasonal prototype. As such, if one were to define forecast accuracy in terms of the number of impacts predicted compared to those that occurred, many more years of impacts data is required to do this. Given that this impacts based forecast accuracy metric would likely differ from the current temperature-based version, the current socio-economic benefits estimate would likely under or over represent the SEB.

Finally, whilst it is tempting to estimate a cost-benefit ratio of the DfT seasonal prototype, we have decided to refrain from this here given the large uncertainties associated with both the cost estimate of developing the DfT prototype and the calculation of the final cost savings. Despite the aforementioned shortcomings, it is clear that the DfT seasonal prototype could enable large SEBs across the UK

transport sector in winter.

We would recommend a more thorough analysis of each of the value chain components listed, once the DfT seasonal prototype has been in operation for several years, at the earliest. This could be achieved through extensive surveys of the components of the value chain outlined, which would provide more accurate and complete data for a value for money study.

Energy Sector (with a special focus on wind energy)

Industry Analysis

Energy sector – the scope

Climate conditions and weather are critical factors for the supply and demand of energy (Boulahya, 2010; Rothstein and Halbig, 2010; Dubus, 2013). The majority of operations and activities in the energy sector are affected by climate, from energy demand, over prospecting and development, to supply, transport and distribution of energy. This emphasises the potential economic value of using climate services in the energy sector. As electricity cannot be stored, it is crucial for this sector to ensure a balance between energy production and consumption, as well as a reliable energy production, combining available energy resources. Energy production is based on a range of energy resources (each with different emissions, efficiency and reliability) and mechanisms (e.g. nuclear reactors, hydro power units, thermal, wind farms, and solar plants) all of which involving different processes (e.g. stock management, demand forecasts or forecasts of production from renewable energy). In addition, all of these processes are affected, to different extent, by weather and climate conditions. The effect of weather and climate raises a number of challenges that need to be considered for operational management of energy production, as well as for the development of policies and long-term investments (Dubus, 2010).

With decreasing reliability of conventional energy resources on the one hand, and growing environmental problems related to climate change and pollution on the other, renewable energy (RE) is becoming the focus of many national and global strategies. Renewable energy production is, however, particularly weather and climate dependant. In this analysis, we will focus on wind energy as a growing energy sub-sector in Europe as well as on the global scale. In 2015 there were 142 GW of installed wind energy capacity in the EU (WindEurope, 2016). Wind power industry installed more than any other form of power generation in 2015 and it accounted for 44.2% of total 2015 power capacity installations. With a 15.6% share of total power capacity wind power provided 11.4% of the EU electricity consumption in a normal wind year (ibid.). Its production is expected to rise further to reach 21% in 2020 and 24% in 2030 (EC, 2014).

Securing reliable energy production is of a vital importance for the functioning of any economy, making energy one of the main national strategic sectors. However, the scope of the energy sector goes beyond national boundaries, since energy security and trading have a global dimension. Furthermore, energy developers have broad

interests, while energy resources play the main factor here. Similarly, wind energy producers are nowadays operating on the global scale, led by the availability of wind energy resources.

Climate services for energy sector

The role of climate information in energy sector has been obtaining an increasing attention, as witnessed by recent publications such as Climate impacts on energy system (World Bank, 2010), Climate Change: Implications for the Energy Sector (WEC, 2014) or Building a resilient power sector (WBCSD, 2014).

The energy sector can benefit from climate services for:

- improving planning;
- providing evidence required to support new investments and increase profits;
- security reasons;
- strategic planning and support of decision-making (e.g. forecast energy prices);
- anticipating supply and demand.

For wind energy in particular, following weather and climate information could be used at different temporal scales:

- Historical data (past)
- Weather forecasts (hours to days ahead)
- Seasonal to decadal forecasts/predictions (months to years ahead)
- Climate change projections (decades to centuries ahead)

The main climate variable used in the wind energy sector is surface wind speed, and to some extent, temperature and pressure.

Mapping main agents in the wind energy sector (providers, purveyors and users)

Understanding and quantifying the evolution of weather and climate information is a key element to multiple actors in the wind energy sector, both in the pre and post-construction phases, as shown in the following figure.

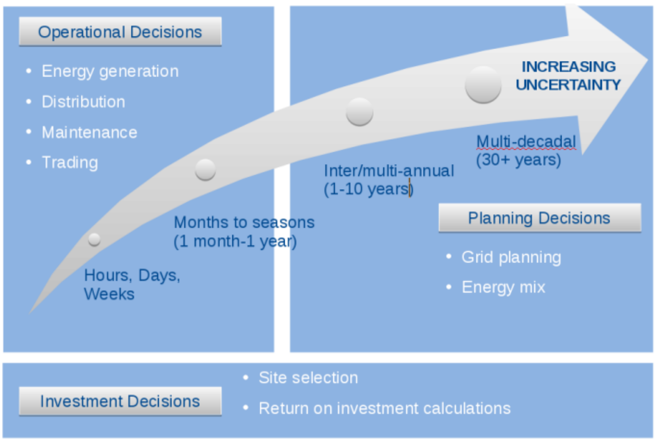


Figure 46. The use of climate and weather information by different actors in the energy sector

The following table identifies the main groups of agents and their relation to weather and climate data that are also presented graphically in the figure below.

Table 22. Main groups of agents in the climate services market for wind energy

Time scale of forecasts	Providers	Purveyors	Users
Past	NMHS	NMHS Research centres	Energy planners WF developers Investors Research centres
Weather forecasts (hours - weeks)	NMHS	NMHS	Investors WF Operators Energy producers Energy traders
Seasonal - decadal weather predictions	NMHS ECMWF NOAA MeteoFrance Met Office	NMHS MeteoFrance Research Centres	Turbine manufactures Energy consultants WF Operators Energy producers Energy traders Research centres Insurance companies
Climate projections	IPCC EU projects	IPCC EU projects Research centres	Research centres Insurance companies

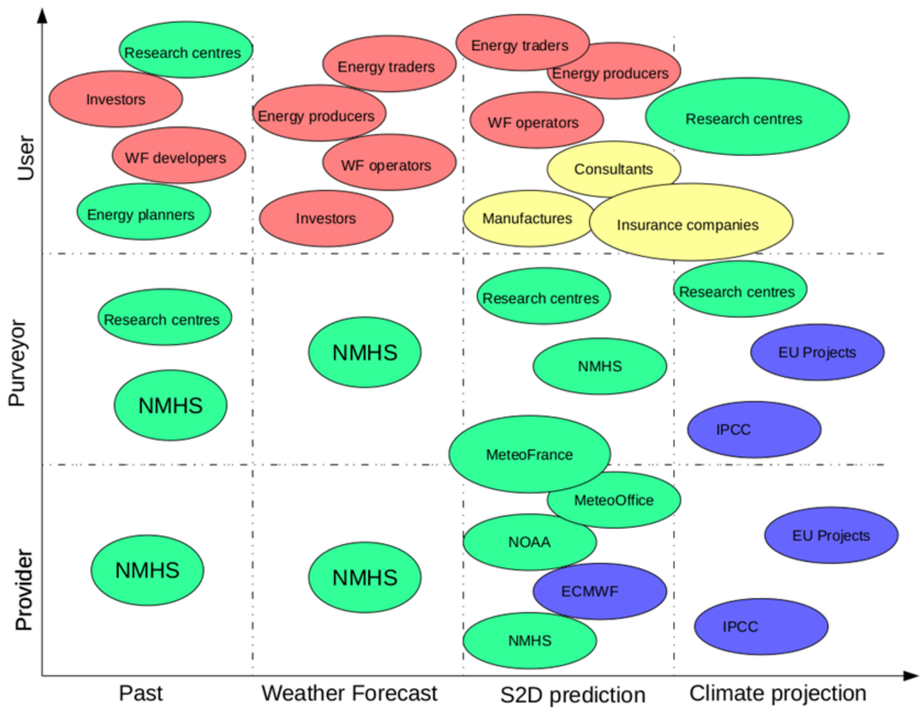


Figure 47. Main agents in the climate services market for wind energy

X-axis represents the type of weather/climate data, y-axis is the agent's role related to climate services. Color is determined by the type of agent: green for

governmental, yellow for private, red for public/private, blue for EU/international bodies.

PESTEL analysis for the Renewable Energy (RE) and Wind Energy (WE) sector.

<table>
<tr><td colspan="2">

POLITICAL

Issues:

- Energy security is a priority sector for most government. Energy security as defined by the International Energy Agency is “the uninterrupted availability of energy sources at an affordable price” (IEA, 2016). Renewable energy sources (RES), including wind energy, are valuable for ensuring energy security. When available, RES can provide energy independence and a secure energy production in a case of e.g. oil supply disruption. Instability of the conventional energy resources market can be an incentive for more investments in RES. However, political interests and priorities and support to diverse options when it comes to RES regulation will also determine the effectiveness of RE use (National regulations, tariff system).
- Climate change mitigation goals and targets and decisions on how to meet them can also determine intensity of investments in and use of RE.
- Decisions in the energy sector can be long-lasting – technological lock-in with coal, nuclear or hydro-power plants for the coming decades.
- Political decisions related to improvements of grid capacity and connections to neighbouring counties can also affect profitability of investments in RE.

</td></tr>
<tr><td>Opportunities</td><td>Threats</td></tr>
<tr><td>

- Energy security goals
- Climate change mitigation targets
- EU2030
- RES are a distributed energy source and less sensitive to disasters

</td><td>

- Each government within one country has its own energy agenda
- Energy strategy not always clearly followed
- Regulations vary from country to country (e.g. current regulation in Spain does not support small energy producers)
- RE incentives regulation changes each (few) years in some countries
- Lack of clear rules demotivates investment
- Lobbies from oil and coal sectors
- Carbon market may discourage strict domestic mitigation measures
- Affinity towards localised systems (e.g. nuclear power plants, large hydro), rather than scattered resources

</td></tr>
<tr><td colspan="2">

ECONOMIC

Issues:

- Wind energy (WE) can represent a new industry in some countries and an opportunity for economic development providing new employments.
- Costs of operation and manufacturing of wind power plants is decreasing

</td></tr>
</table>

(particularly for offshore WE). In addition, RE can add to stabilising prices of energy production in the long run, if the markets are designed properly with clear information.

Opportunities	Threats
• WE is becoming profitable without subsidies • Once the technology becomes mature, the risk is lower as prices are stabilised • Climate services can decrease uncertainty regarding WE productivity • Projects with low uncertainties have better starting position when applying for bank loans • WE can provide new jobs • Land owners are compensated from wind farm operators • When externalities are considered, costs of RE are even lower	• Undefined polices and lack of legal framework make investments more risky • Costs of investment, maintenance and operation is still (mis)perceived as high

SOCIAL

Issues:

- Awareness about negative health effects of coal-power plants, large dams' effect on ecology and nuclear risk, make general public more favourable to RE.
- A wind farm (WF) does not have long term environmental impacts, once a WF stops working, it is dismantled and the original landscape is re-established. There is hence a growing green energy market in many countries.

Opportunities	Threats
• Social perception and attitude towards RE • Possibility to generate your own energy with RES • RE crowdfunding • Green energy market • Anti-nuclear movements after large catastrophes • General public (i.e. voters) can push green energy agenda	• NIMB (Not in my backyard attitude) – residents' opposition to WF construction in some areas or countries (e.g. the UK) • Lack of adequate information sharing leading to misperception that RE is more costly, than it really is

TECHNOLOGICAL

Issues:

- Grid capacity is still a limitation factor when it comes to flexibility of the network for accepting new energy sources.
- In large systems, balancing electricity production from WF can stabilise the network, however in small systems RE can affect balance of the network.
- In the regions with a weak or undeveloped electrical grid, micro grids powered by RES can be a cost effective solution.

Opportunities	Threats
• Storage capacity – opportunity in the future (batteries) • Merging wind with pumped-storage hydropower system • Potential for technology to improve • It is a dispatchable electricity generation • Improvements in the electrification in the transport sector can raise need for new energy resources	• Technological lock-in with coal power plants, nuclear power plants and large hydropower plants • Grid capacity

ENVIRONMENTAL

Issues:

- Ecological concerns related to hydro, coal and nuclear power plants can raise support for RE.
- Environmental beliefs, or just affinity towards green image, make users chose electricity coming from RES.
- Ever growing environmental movement – including environmental NGOs with facilitated communication with broad public through their online social networks – supports RE and raises awareness about real costs of conventional energy production.

Opportunities	Threats
• Impact can be more easily mitigated – e.g. you can stop turbines that are particularly damaging for birds • New systems in WF for bird protection	• WF impact of birds and bats • Lack of knowledge on cumulative impact of WF (e.g. on birds' migrations)

LEGAL/GOVERNMENT

Issues:

- Many countries lack a stable legal framework and clear long-lasting regulations for RE which discourages investment in RE.

Opportunities	Threats
• International regulations and obligations to UNFCCC • Lower barrier to entry in WE business than in conventional energy production • TSO demand estimation and WE production estimation will benefit from climate services	• Time and procedures necessary to receive a permit for developing a WF • Lack of stable legal framework and frequent changes

Maturity of climate services in the wind energy sector

Wind energy sector is still relatively young and could be defined as being in the **growing phase**. As such, it might be expected to include some companies (although not the majority) that could be considered early adopters of climate services for

better planning processes.

Business opportunities for climate service in the wind energy sector (SWOT analysis)

Strengths	Weaknesses
• Life-cycle of windfarms expands for more than 10 or 15 years so seasonal to decadal predictions can be relevant for return on investment assessments • Strong acknowledgement of the energy sector's dependency on climate variability • Investors already require an assessment of future performance of windfarms	• A field very related to academia or Meteorological services. Lack of a closer knowledge of the energy business • Perception of high uncertainty of climate predictions (using past climatology has also a lot of limitations but since it is the accepted method nobody challenges its limited performance)
Opportunities	**Threats**
• Anomalous years, like 2015 for wind power production in the USA, foster the interest of the industry in climate predictions • EC pushes Climate services development and Copernicus initiative might give more sectoral visibility to climate services for the energy industry	• Each company might want to use its own confidential method to have climate predictions included in their decisions to have a competitive advantage • Users might not understand the need for a climate service if they already can have direct access to official predictions form ECMWF or other providers and highly technical departments to make their own estimations • Limited collaboration on the validation of predictions of climate services if that requires firms to release confidential information about their processes (power generated in a particular wind farm, real observed data of wind, etc.)

Demand Analysis

Task 1. Potential market

The following results are obtained from the interviews with the EUPORIAS stakeholders and other potential users of seasonal to decadal (S2D) climate predictions across Europe (WP12). The energy sector was presented with 14 interviews. The analysis summarises the general weather and climate data use by each interviewed agency and lists use/potential use and willingness to pay for the following four categories of climate services: climate model outputs, customized information, derivative variables and services tailored for specific users' needs. Since the analysis is based on the previously conducted interviews, instead of a contingent valuation, we estimated the willingness to pay for the services through the qualitative analysis of the interviews. In particular, we considered the fact that the data is already being bought as a signal that the interviewed agency would also pay for S2D predictions data in the future. Similarly, the interviewees' position regarding the question whether climate data and products should be supplied as a public service freely available, or as a private service with an associated cost, could also suggest their position regarding paying for this type of data in the future.

AGENT Category	Electricity generation companies (sometimes also working on electricity distribution, transmission and trading)				
		Agent 1	**Agent 2**	**Agent 3**	**Agent 4**
AGENT description		A private energy company operating around the world. The organisation has around 30,000 employees. The company operates in most areas of energy	A private energy company working at the international level and with more than 1,000 employees. They work on generation of energy, distribution, down to the Customer	A stated owned electric power company which is part of a larger group working across Europe. It has around 12,000 employees. It is responsible for electricity production and trading.	A private energy company (largely government owned) working worldwide but with main activities in Europe. They work on production and distribution of electricity.
Current use of weather and climate data		Uses historical observations from MERRA (Modern-Era Retrospective Analysis for Research and Applications)	They use historical observations and climatology	They use weather forecasts (next day and 2 weeks forecasts) as well as past observations. They also use seasonal forecasts but only as qualitative	They use weather forecasts (days up to 2 weeks looking at a range of parameters including temperature, precipitation, wind), historical data and climate change projections
Category of Services (specific use and potential use in the future)		**USE & Willingness To Pay (WTP)**			
Climate model outputs	USE	NO. They used historic data, but might be interested in forecast a decade ahead and that's the maximum horizon that they could be interested in. They are doubtful about the weight seasonal forecast has, although it could be useful for planning, maintenance of gas turbines.	Interested in the use of seasonal forecast. So far, the use was limited because of low reliability of data. They are particularly interested in a few months forecasts.	YES. Use seasonal forecast but qualitatively, more like guidelines. Higher time resolution seasonal forecast would be useful for them.	YES. They use weather forecast, but would be interested in seasonal forecasts focusing on the same variables as those used for short-term forecasting (e.g. temperature, precipitation, wind) to better understand power demand.
	WTP	NO. Mainly use historic data (e.g. from MERRA) which they obtain for free.	IT DEPENDS. They consider that all that can affect the public should be freely available. They would however consider paying for data that would be used for commercial purposes.	No. They think that simple climate outputs should be freely available. Generally all prediction that can affect citizens should be public.	YES. They already pay for weather and climate data that they get from. However, they consider that raw data should be available free of charge from national services.
Customized information	USE	They have in-house capacity for processing historic data.	UNKNOWN	UNKNOWN	YES. They have in house capacity for some data processing,
	WTP	YES. They would be interested in offshore wind conditions and the impact of that on wind energy generation	UNKNOWN	UNKNOWN	YES. They also obtain processed that from other providers. They are interested in statistical downscaling of climate predictions.
Derivative variables	USE	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN
	WTP	UNKNOWN	UNKNOWN	NO. They get indices from NHMS	UNKNOWN
Service tailored to the specific user's needs	USE	UNKNOWN	UNKNOWN	UNKNOWN	YES. They have in house capacity for some data processing
	WTP	MYABE for decadal predictions with high skill	UNKNOWN	Yes. They already pay for some tailored data from NHMS.	YES. They consider that data processed to fill the user demand should have cost attached.

AGENT Category		Transmission system operator		
		Agent 5	**Agent 6**	**Agent 7**
AGENT description		Transmission system operator, partially public-owned, working at the national level with around 8000 employees.	A transmission system operator (private company but largely government owned) working at the national level and with around 3,000 employees.	A transmission network (private company) working at the national level with approximately 27,000 employees. They are responsible for the transmission electricity network and gas distribution network.
Current use of weather and climate data		They use historical data to forecast seasonal variability. Weather forecasts is in their operational models.	Historical records are used to forecast the peak load of a particular day	They uses probabilistic weather forecasts to help them forecast wind power.
Category of Services (specific use and potential use in the future)		**USE & Willingness To Pay (WTP)**		
Climate model outputs	USE	YES. They use seasonal forecast. They look in particular in temperature as the main parameter for demand. Also cloud cover is an important parameter for them. They are interested in forecasts from very short term up to 15 years.	They use historical records, but might be also interested in seasonal forecast.	They are interested in seasonal forecast (e.g. 6 months) for for our longer term planning.
	WTP	YES. They already pay for weather data that they use on a daily bases and for some of the climate data (e.g. decadal).	UNKNOWN	YES. They already pay for information. However, they are of the opinion that weather information should be publicly available, since it affects
Customized information	USE	YES. They use different scenarios and perform probabilistic analysis.	UNKNOWN	UNKNOWN
	WTP	UNKNOWN	Maybe. Graphical presentation of uncertainty would be useful for them.	UNKNOWN
Derivative variables	USE	YES. They have in-house capacity	UNKNOWN	YES. They derive their own indices.
	WTP	UNKNOWN	UNKNOWN	UNKNOWN
Service tailored to the specific user's needs	USE	UNKNOWN	UNKNOWN	UNKNOWN
	WTP	UNKNOWN	Maybe. They would be interested in information focused on their activities.	UNKNOWN

AGENT Category		Research and Consultancy				
		Agent 8	Agent 9	Agent 10	Agent 11	Agent 12
AGENT description		Government research institute working on resource assessment determining the environmental impact of energy and dissemination of information.	Research institute working on a range of different contracts and projects. Research on what kind of information energy industries need and how to provide it to them.	Research institute working at the national level. They work on bioenergy technologies and the assessment of bioenergy pathways.	A centre of Expertise in Economic Studies and Modelling. The company has approximately 147,000 employees and the centre around 85	A private consultancy company working at the national level with around 18 employees. It helps companies take into account the impact of weather on their operational
Current use of weather and climate data		They use weather and climate information, as well as past data to help them understand inter- seasonal values	Their clients tend to use historical data.	The organisation uses weather and climate change information for making predictions on future energy crop systems (but they don't use any operational models).	They uses historical data and observations (aggregate, reprocessed data) as well as weather forecasts to feed their operational	They use past observations and weather forecasts (up to one or two weeks ahead) and seasonal forecasts for some customers
Category of Services (specific use and potential use in the future)		**USE & Willingness To Pay (WTP)**				
Climate model outputs	USE	YES. At the moment, they use variables and not aggregated indices. They do not use seasonal forecast at the moment nor see the need, but could benefit from decadal (e.g. 10-20 years) to provide an evolution of resources.	No, but there would be a strong interest in seasonal and decadal forecast if better ones are produced, with better skill. They perceive decadal forecast to be still very much under development.	YES. They use decadal prediction. They use climate change information for making predictions on future energy crop systems At the moment, there is no interest in the seasonal weather forecast, but it would be helpful to have seasonal forecast on agricultural yields in general.	Need for ten-years forecasts for investments processes. At present data quality is the main barrier for using forecasts.	YES. They use some decadal forecasts for research and development, but not operationally. They would like to have reliable S2D temperature related data on national scale.
	WTP	NO. They think that data should be freely available.	NO. they have strong links with ECMWF and Met Office. They generally think that S2D forecast should be freely available public service.	NO. They think that dacadal information should be public.	YES. They already pay for data, but they thing that in the future raw data should be freely available	YES. They have in-house capacity and do most of the raw data processing by themselves, but also buy some processed data. They consider that seasonal predictions could be charged for. They are willing to pay for high quality S2D data.
Customized information	USE	YES. They use freely available information form e.g. ECMWF.	UNKNOWN	YES. They use climate change information for making	UNKNOWN	YES. They use processed data (e,g, on temperature)
	WTP	Maybe. They are interested in visual information. Also graphical presentation of uncertainty.	NO. They don't think it should be private information.	UNKNOWN	NO. They have in house capacity to process data.	YES. They have in-house capacity and do most of the raw data processing by themselves, but also buy some processed data.
Derivative variables	USE	UNKNOWN	YES. They use climate indices	Yes	UNKNOWN	UNKNOWN
	WTP	UNKNOWN		YES.. They pay for some climate indices.	UNKNOWN	UNKNOWN
Service tailored to the specific user's needs	USE	UNKNOWN		UNKNOWN	UNKNOWN	UNKNOWN
	WTP	NO. they use freely available data and have in house capacity for the analysis.	Maybe. They could be interested in high frequency and high resolution data.	NO. They have in-house capacities.	YES. Services with added value: forecasting, the processing of data missing in this raw data, etc could be paid for.	UNKNOWN

Task 2. RESILIENCE prototype

Task 2 looks into the EUPORIAS prototype RESILIENCE and the linked clients from wind energy sector. The RESILIENCE prototype aims to support users to better understand the future variability in wind power resources. RESILIENCE provides seasonal wind speed predictions tailored to the wind energy sector. The analysis is based on the results reported in: EUPORIAS seasonal wind prediction prototype: User evaluation (Makri, 2015).

Client characterization

Client characterisation is conducted through the following aspects: maturity of the client, risk-aversion, market size and barriers.

Maturity of the client

Wind energy sector is still relatively young and, as such, it might be expected to have some companies that would be early adopters of RESILIENCE service for better development, planning, maintenance and trading decisions. These clients have a greater need for a solution and might opt for an immature service that will satisfy their need for more informed (and less risky) decisions that provide a strategic advantage towards other competitors. Early adopters can help testing the service and improving it while accelerating the service broader adoption in the sector.

In particular, the clients considered that the service would be useful for:

1. Planning and development:

- Energy yield assessment for the purpose of preparing a case for negotiating loans with banks for new wind farm projects;
- Predicting wind farm performance and profitability;
- Identifying potential geographical regions for development;
- Decisions related to the time of wind farm construction (construction demands a minimum condition of wind and rain);
- Making energy trading decisions.

2. Maintenance:

- For scheduling maintenance of wind farms;
- Pre-plan purchases of the necessary maintenance parts to mitigate typical wind farm breakdown issues (resulting from accidents provoked by extreme wind conditions).

3. Investment decisions:

- Improving financial plans based on the findings about wind variability in a geographical area;
- Making cash flow predictions;
- Assessing financial risks (i.e. assessing how much wind energy production, and therefore income and profitability, differ from financial plans);
- Indicating potential future income – these predictions are at the moment based on past averages rather than on predictions.

Risk-aversion

Although early adopters are characterized as low risk averse, use of the seasonal climate forecast in the wind energy sector actually have the potential to lead to less

risky and better informed decisions.

Market size

The total addressable market (TAM) is the whole energy sector. The served available market (SAM) is the part of the market with a particular interest in wind energy, which includes:

- Wind farm developers
- Wind farm owners
- Operation and maintenance teams
- Wind resource assessment consultancies
- Energy traders.

The target market (TM) should include the early adopters. Since seasonal predictions are perceived by most potential users as lacking reliability (Dessai and Bruno Soares, 2015; Makri, 2015), our target market will include those users that at the moment do not have suitable alternative data. This includes energy traders and large wind energy providers (those owning multiple wind farms in diverse geographic locations). In addition, offshore wind farms maintaining plans demand longer forecast data comparing to their onshore counterparts and, thus, maintaining teams might be ready to used seasonal predictions. Moreover, the cost-saving associated to better seasonal predictions could be large enough to incentivize the early adoption of new methods such as seasonal predictions.

Main barriers

The main reason for not using seasonal wind predictions so far, as perceived by the clients, is their **lack of predictability** (Makri, 2015).

The EUPORIAS stakeholders and other potential users of seasonal to decadal (S2D) climate predictions from the energy sector interviewed within WP12 also specified the following barriers:

- Lack of availability or awareness of S2D predictions;
- Scepticism about the quality of S2D predictions and its value comparing to traditional approaches (e.g. climatology and weather forecast);
- Dealing with a probabilistic approach;
- High uncertainty associated to S2D predictions;
- Low skill of S2D predictions;
- Insufficient number of case studies and best practices examples;
- Low reliability and lack of guarantee that all uncertainty sources is being accounted for;
- Entrenched habits linked to the operation of information systems that do not include managing scenarios (probabilistic approach);
- Limited geographical and time resolution of S2D predictions

Supply Analysis

List of competitors:
At present, a few providers of seasonal weather predictions provide maps on temperature and precipitation (e.g. Meteo France, NOAA NCEP, IRI, CCCma), we thus could not detect a real "competitor" to EUPORIAS RESILIENCE service, i.e. a provider who processes seasonal weather forecasts for wind. Met Office Seasonal Prediction prototype provides storm prediction, among other data, and we used this service as an example of a potential competitor to RESILIENCE. The RESILIENCE prototype uses the ten-metre wind speed forecasts from the ECMWF System 4 (S4) operational seasonal prediction system. In the future, ECMWF could however provide different services in the framework of Copernicus C3S and become a competitor. In addition, Meteo France and Met Office provide raw seasonal wind data. This data could in the future be customised in a competing climate service.

Table 23. List of competitors for RESILIENCE prototype

NAME	Met Office: Seasonal Prediction	ECMWF[53]: SEAS	ECMWF: EUROSIP	Meteo France
Current state of the service	Prototype	Raw data available	Raw data available	Raw data available
Timescale	6 months ahead	1 to 7 months	1 to 6 months	
Event predicted	Different, e.g. Seasonal tropical storm predictions; Predictability of extremes on monthly to decadal timescales			
Variables	Various meteorological variables (e.g. temperature, rainfall)	Monthly mean 10m U-velocity and 10m V-velocity (m/s) 10 metre U wind component anomaly, 10 metre V wind component anomaly	U- velocity at 925 hPa V-velocity at 925 hPa	10m U- velocity 10m V-velocity
Frequency of information delivered	NA	8th of each month 12:00 UTC	15th of each month 12:00 UTC	NA
Climate	GloSea 5. It is an	Ensembles of	Multi-model	System 4

[53] http://www.ecmwf.int/en/forecasts/datasets/set-v
http://www.ecmwf.int/en/forecasts/datasets/set-viii

models	ensemble prediction system using a coupled ocean-atmosphere model (variant of HadGEM3), to generate probabilistic forecasts up to six months ahead.	individual forecasts coupled to an ocean model and post-processed products of average conditions (e.g. monthly averages) with the associated uncertainty	Seasonal Forecasting System. Average of the ensemble monthly mean anomalies from contributing models (ECMWF, Météo France, UK Met Office).	
Geographical scope	At the moment, it supports seasonal predictions in Africa	NA	Global	Global

Mapping of current best alternative options

NAME	Service	Time scale	Geographic scale	Prospect	Other Characteristics
Met Office[54]: UK Wind map	Wind speed and wind direction	From today to up to 5 days ahead	UK		Units can be selected: mph, kph or knots
VAISALA[55]: Premium Wind Forecasting	Wind power; Meteograms for air temperature, precipitation, and hub height wind speed	Hour, day, and week-ahead forecast for wind power	WF location (incorporates the climatology and terrain for a project location)	A seasonal wind power forecast can be added to wind forecast, which projects 12 months into the future and is based on 40 years of site-specific climatology and climate	Compares the current forecast with previous predictions

[54] http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/seasonal-prediction
http://www.metoffice.gov.uk/wind-map#?tab=map&map=Wind&zoom=9&lon=-4.00&lat=55.71&fcTime=1474239600
http://www.metoffice.gov.uk/energy/decider

[55] http://www.vaisala.com/en/energy/Energy-Marketing-Services/Energy-Scheduling-and-Trading/Pages/Premium-Wind-Energy-Forecast.aspx

				index forecasts	
METEOLOGICA[56]:Wind farm generation forecasts	Wind power output	Hourly up to 15 days ahead forecast with hourly updates	WF location		Observation vs forecast graphics
AWS TruePower[57]: Wind Data Management Dashboard	Wind speed at custom height (80-140m). Statistics (mean speed, data recovery, shear, turbulence intensity, and temperature) ; Plots (hourly and daily average wind speed, speed frequency distribution, wind rose)		Resolution 2km. Provides virtual met masts (VMMs) and wind resource grids (WRGs)		Provides wind statistics including Weibull values, wind roses, and monthly and diurnal distributions
MeteoGroup[58]: Wind&Solar Power Generation	Hub-height weather data for all relevant parameters, providing forecast for power output	Up to 15 days ahead, with 15 minute granularity and intra-day updates	Single wind farms, regions or portfolios		
DNV-GL[59]: Wind and Solar short-term power forecasting	Wind farm power production and site-specific meteorology	From 5 minutes up to 15 days ahead		Predictions of power consumption for a specified region or a country	Turbine blade icing forecasts. High wind speed shutdown and ramp event warnings. Severe weather alerts

56 http://www.meteologica.com/meteologica/content/wind-farm-generation-forecasts
57 https://www.awstruepower.com/products/dashboards/wind-data-management/
58 http://web.meteogroup.com/sites/default/files/windpowergeneration_eng_web_2.pdf
59 https://www.dnvgl.com/energy/brochures/download/Windsolarshorttermpowerforecasting.html

					(lightning, extreme gusts, snow, etc)
Vortex INSIGHT[60]	Mean wind, temperature and production. Focus on wind resource inter-annual variability	Downscaled to a specific location		One season ahead	Long-term (20-year) reference baseline
Met Office Decider	Summarises the most likely forecast scenarios, based on 30 Met Office defined weather regimes, predicting future trends and consequences and advising forecasting teams or traders working in weather-sensitive trades	Up to 32 days ahead, updated daily	Europe		

Feasibility Study I

Table 24. Description of the RESILIENCE prototype

Brief description of RESILIENCE	Main benefits	Value for the customer
The RESILIENCE semi-operational prototype is a decision-support tool for the wind energy sector, based on seasonal wind speed predictions. The aim of the	Current energy practices use a deterministic approach based on retrospective climatology to estimate future climate variability over coming weeks or seasons.	Understanding and quantifying wind resource is a key element to multiple user profiles in the wind energy sector, both in the pre and post-construction

[60] http://www.vortexfdc.com/solutions/monthly.htmlhttp://www.vortexfdc.com/solutions/monthly.html

RESILIENCE prototype is to strengthen the efficiency and security of wind power supply within energy networks, by providing information on the future variability in wind power resources based on probabilistic climate predictions. Manufacturers, project developers, project investors, consultants and energy trading companies are among the users from the wind energy sector that have shown interest in seasonal to decadal prediction products and particularly in the outcomes of the RESILIENCE prototype on wind speeds.	Most energy sector firms use their own measurements or reanalysis databases to obtain average past observations to inform their decisions. Predicting the future variability of energy resources beyond the first two weeks could allow end users to take justified, precautionary actions with potential cost savings. The seasonal predictions rendered by RESILIENCE could thus provide additional information to the approach based on the past climatology and result in better informed decisions in the wind energy sector.	phases. Operations and Maintenance (O&M) teams of offshore wind farms need to schedule operations during the less windy periods in order to minimize the risk of storms and swell conditions. For grid operators, being aware in advance of the amount of renewable energy that will go into the grid can help schedule traditional power plant operations. For the financial teams running the wind farm business, having a budget of the energy they will produce in the coming months is of crucial importance to anticipate the cash flow.

SWOT analysis of the RESILIENCE prototype

Strengths • A visual platform makes it more easy and dynamic to present the predictions • All energy users take into account weather or climate data to foresee what will happen in the future for making decisions • More skilful climate predictions can directly impact the economic benefits of firms using them • Traders are used to read complex information	**Weaknesses** • Each user profile in the energy sector requires different information that we are not showing (Either we focus in only one role or we add layers of tailored information to the prototype) • We don’t have a clear evaluation of how to incorporate the probabilistic prediction in the decision making process • We have not been able to calculate the economic value of using climate predictions instead of using climatology • Sub-seasonal and decadal predictions are also relevant for energy users and are not shown in the prototype
Opportunities • Anomalous years like 2015 for wind power production in USA foster the interest of the industry in climate predictions • ECMWF freely releasing their System4 data may facilitate the creation of operational products • We have the knowledge and technological capacity to “grow” the	**Threats** • Traders are already users of the seasonal predictions provided by the NCEP or the ECMWF, they might think that the prototype does not add value • Perception of different wind-energy stakeholders that seasonal to decadal predictions lack predictability • Stakeholders' scepticism regarding reliability of seasonal to decadal

prototype to provide in some years a multimodel for seasonal predictions • A prediction that provides some advantage in the decision making for traders can be a significant benefit for the firm in the economic terms	predictions • Visual interface could be perceived as oversimplified by advanced analysts used to work with data • Lack of budget or a strategy to adapt the prototype to show additional data requested by different profiles of users in the industry (e.g. what if a client wants an aggregated output for a particular area?) • Using past climatology might be less skilful, but easier to use • Large businesses dedicated to weather masts and measurement equipment that benefit from the industry using their own past measures to predict the future

Conclusions

As any other new knowledge source and innovative product, seasonal to decadal predictions, including the RESILIENCE prototype, need to reach a large enough number of users in order for the innovation to be more broadly accepted. Rather than through simple knowledge transfer, innovations are more effectively adopted through stakeholders' interactions, i.e., through knowledge exchange (Fazey et al., 2014). More active communication and collaboration with these early users could thus make them aware of the service and motivate them to use it. Most importantly, we should address those aspects that are at the moment perceived as the main obstacles to using seasonal to decadal predictions: low predictability and reliability. Promotion and popularisation, as well as better communication could result in improved understanding and more accurate perception of what is the added value of this service.

Technical aspects of RESILIENCE prototype

In order to assess the predicted wind speed, the RESILIENCE prototype evaluates the 10-metre wind speed from the European Centre for Medium-Range Weather Forecasts (ECMWF), Seasonal Forecast System (System-4). The system has 51 ensemble members, makes forecasts up to seven months into the future, and the predictions are issued with at least one-month lead. A calibration method using the "one-year-out" cross-validated mode is considered for the post-processing of the ensemble forecasts, providing corrected forecasts with improved statistical properties. To better characterize the wind speed prediction for the key event, three equiprobable categories (below-normal, normal and above-normal wind speed) are determined by obtaining the lower and upper tercile values of the distribution of the wind speeds hindcast over the full period. The percentage of the 51 ensemble members of the forecast inside each tercile category is detailed (blue colour for below-normal, orange colour for normal and red colour for above-normal category).

To evaluate if the RESILIENCE prototype is able to provide information of the

chosen key events in relation to what really happened, a forecast quality assessment of the predictions is being done. In this assessment, the simultaneous predicted and observed values are compared over the entire period (1981-year of the specific key event). This is a fundamental step in climate prediction because it assesses whether the forecast systems lead to an improvement forecast with respect to a standard or not, which is usually the climatology or a simple persistence forecast. Due to the high dimensionality of forecast verification, three verification measures were obtained: the ensemble mean correlation (Corr) and the ranked probability skill score (RPSS), and the continuous ranked probability skill score (CRPSS).

Feasibility Study II

The aim of the feasibly study is to set a potential price of the climate service prototype and to identify externalities such as social, economic and environmental, in a qualitative way. In this section, we will try to grasp the value of the RESILIENCE climate service, taking into account the wider *value chain* associated with it. In particular, when analysing the economic benefits of weather/climate services, it is important to determine how the service will enable end users to make better decisions (GFDR, 2015). These benefits can be assessed by comparing the outcomes of the decisions/actions taken based on the additional information coming from the climate service with the likely outcomes of decisions made without that information.
One of the approaches used for the socio-economic benefit analysis is **Decision theory** and in particular **cost-loss** model.

Decision theory represents the value of a climate service by the difference between the payoffs when the information from the service are used and the payoffs when only prior knowledge is applied (Rubas et al., 2006). We will provide a simple example of avoided loss for a hypothetical use of the RESILIENCE prototype for an offshore wind farm maintenance. Seasonal weather predictions can help avoiding production losses due to downtime losses related to the turbines maintenance during the period of favourable wind speed conditions.
In order to quantify losses in monetary terms, Scheu and colleagues (2012) used data from 5 MW reference turbine developed by the National Renewable Energy Laboratory (Jonkman et al., 2009) multiplied with the local feed-in tariff (FIT), coming up with a compensation of 0.1801 €/kWh for British waters (Koeppe and Schulze, 2010).
We will present potential losses from the maintenance of a wind farm of 10 5MW turbines scheduled for a period of five days that turn to have good wind conditions for producing electricity. We assume an average capacity factor of 75% for these five days and that each day (for 10 hours) two wind turbines were turned down for the maintenance purposes. The hypothetical loss due to scheduling the maintenance in the period of good wind is:
2 x 5 x 10 x 180eur x 75% = **13 500eur**
This loss can be avoided if the information from the service – predicting probability of higher wind speed than average in the season under consideration – is used.

Qualitative socio-economic benefit analysis for RESILIENCE climate service

In order to understand all the aspects of potential benefits of using the RESILIENCE

climate service in the wind energy sector, we need to assess the full suite of financial, social and environmental benefits and consider whether the climate service will result in downstream impacts. In addition, we will try to identify all benefits regardless of to whom, when or where they accrue. CarbonTrust (2013) conducted a study of socio-economic benefits of climate services in the context of the renewable energy sector. The rest of this section elaborates potential benefits of using RESILIENCE in the offshore wind energy sector deriving from the analysis of the CarbonTrust study.

Main sources of economic benefit for offshore wind industry are:

1. Increase in debt financing reducing the cost of capital
2. Incremental capacity deployment through unlocking capital
3. Indirect socio-economic and carbon benefits
4. Reduced costs associated with installation vessels
5. Reduced overhead costs associated with operation and maintenance
6. Increased turbine availability from better operation and maintenance scheduling

1. ***Lower cost of capital through increased debt financing***

Seasonal to decadal climate projections can lead to more accurate planning and resource modelling by developers and consultants. This aspect will then make banks more comfortable with the risk profile of offshore wind projects. As a result, banks may increase their amount of lending to the off-shore wind projects.

2. ***Incremental capacity deployment through unlocking capital***

The increased bank lending frees up capital that developers would have otherwise had to fund from their own balance sheet. This unlocked capital can be invested in additional offshore wind capacity.

This can finally accelerate the pace of the offshore wind development. We should also account for the benefits coming from the revenue associated with the investment in additional installed capacity.

3. ***Indirect socio-economic and carbon benefits***

New offshore wind capacities acquire the indirect benefit associated to avoided emissions from conventional energy sources (including GHG and pollutants). The estimated electricity production can be thus used to calculate the emissions that are avoided due to these new capacities. The increased capacity from unlocked capital will also result in jobs creation and the associated economic revenue generation. This revenue includes both direct and supply chain benefits.

4. ***Reduced costs associated with installation vessels***

Weather conditions, i.e. wave height and wind speed, restrict the use of installation vessels approximately 30% to 40% of the year (CarbonTrust, 2013). Better climate information on a seasonal or annual basis would allow project developers to better plan the hiring of vessels and more efficiently use the vessel during the period they are hired.

5. ***Reduced overhead costs associated with operation and maintenance***

Offshore wind farms hire technicians, ships or cranes to perform routine and unscheduled maintenance on a long-term basis. This represents a high fixed cost. Better weather information on a monthly or seasonal basis would allow for better scheduling of operation and maintenance activities and support hiring technicians and the equipment on a flexible basis. This would reduce costs from overhead expenditures, while increasing revenue from increased turbine availability.
In particular, better climate information will allow for better scheduling to avoid routine maintenance around periods of particularly stormy weather and higher waves, reducing the time that technicians are kept on active duty for a site. According to the Met Office study, days technicians spend waiting due to weather conditions could be reduced from 5% to 15% as a result of better climate information.

6. ***Increased turbine availability from better operation and maintenance scheduling***

As presented in the hypothetical case of the cost-loss model, availability of turbines can be increased by better scheduling routine maintenance around periods of increased storminess and also around times of projected no wind. This would result in the generation gain due to higher turbine availability. The increase in turbine availability also results in avoided carbon emissions.

Finally, from the **Value Chain Analysis** perspective, the value added in the supply chain for climate services occurs in three phases (Perrels et al., 2013; GFDR, 2015):
1. When combining data, models and expertise to generate weather forecasts and adjacent services. In this regard, characteristics of the service, such as predictability and lead time are particularly important in determining the services' adoption.
2. When editing and distributing weather information through media or other communication channels. How well the service is communicated to end users is one of the detrimental factors for its adoption.
3. When weather information is interpreted by end-users and used in decision-making. This aspect will in particular depend on decision-makers characteristics (e.g. risk aversion, or prior knowledge of information), decision-maker environment (e.g. government programmes and policies that might affect the adoption of services, community norms), and availability of resources and management options for changing behaviour in response to information (e.g. sustained collaboration between service providers and users).

Business Models

We present the RESILIENCE climate service using the business model canvas. The canvas' main objective is to help companies move beyond product-centric thinking and towards business model thinking (Osterwalder, 2013). The structure below allows looking at the all nine building blocks of a business model at once.

<table>
<tr>
<td rowspan="2">Key partners

- Global Producing Centres of seasonal predictions
- Scientific institutions with interest in climate services – this could help levering the production and/or promotion of the service
- Large wind-energy companies – can help further tailoring of the service for users' needs and gaining new customers</td>
<td>Key activities

- Forecasting seasonal wind speed based on raw seasonal prediction data
- Developing and maintaining the user-friendly interface
- Providing additional information about seasonal predictions
- Promoting and commercialising the service
- Maintaining relationships with customers</td>
<td rowspan="2">Value Proposition

- Prediction of seasonal variability of (or better seasonal mean) wind speed
- Probabilistic predictions able to simulate the physical processes governing the whole climate system
- User-friendly interface for assisting the use of this service
- The service improves current practice based on a retrospective climatology
- The service can decrease uncertainty related to the future wind speed conditions that hinder well informed decisions about production, use and maintenance of wind energy and its facilities</td>
<td>Customer Relationships

- There is already a community of interested stakeholders that were engaged in collaboration during the development phase of the project
- Direct engagement with prospective customers, e.g. through workshops, may gain their interest
- Reaching potential customers by participating in wind-energy related events
- Maintaining relationships with customers, e.g. through the support activities, or annual meetings
- Online support</td>
<td rowspan="2">Customer Segments

Wind energy sector, in particular:
- Turbine manufactures
- Energy consultants
- Wind farm operators
- Energy producers
- Energy traders

and:
- Insurance companies</td>
</tr>
<tr>
<td>Key resources

- Seasonal prediction data
- Computational and designing skills
- Resources for sustaining customer relationships, promotion and popularisation of the service</td>
<td>Channels

- Online – the service is available as an online platform
- Direct engagement with potential clients, through invitation to take part in events, workshops, interviews</td>
</tr>
<tr>
<td colspan="2">Cost structure

- Costs of high quality raw seasonal forecast data
- Data processing and tailoring costs
- Costs related to maintaining the online service
- Customer relations costs – participating in wind-energy related events, organising events</td>
<td colspan="3">Revenue Streams

- Potential for charging the used of the service – processed and tailored seasonal wind speed predictions
- The service could be commercialised by introducing subscription pricing model
- Potential additionally tailored services to answer users' demands
- Customers will presumably be willing to pay for improved knowledge on seasonal predictions
- Currently, most of the potential customers pay for some types of raw or tailored weather and climate related data</td>
</tr>
</table>

Note:
We would recommend reading the table in the following order:
1. Value proposition; 2. Customer segments; 3. Channels; 4. Customer relationships; 5. Key resources; 6. Key activities; 7. Cost structure; 8. Revenue stream; 9. Key partners

Tourism Sector

Industry Analysis

Industry structure

International frame

Scott et al. (2012) provide a conceptual framework of the supply of climate information and services and interactions with end users in the tourism sector.

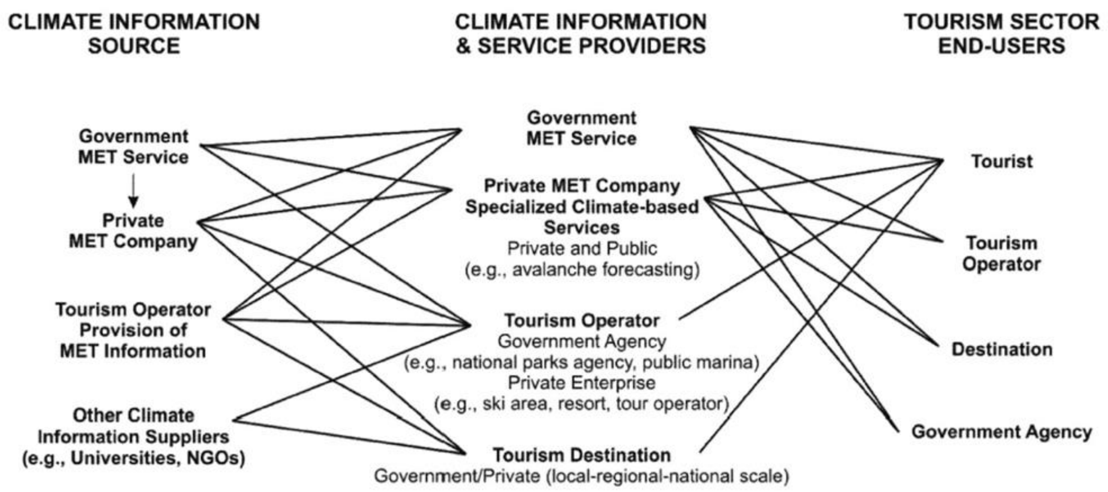


Figure 48. Conceptual framework of climate information in the tourism industry

The main evolution concerning the provision of weather and climate information in the world of tourism and interactions between providers and users:

- **National meteorological services** (NMS) and private meteorological companies (e.g la chaîne météo – the weather channel) are the primary sources of data;
- Even if the quantity of weather and climate services provided by NMS to the tourism sector is currently limited, these offices are **key players** in providing climate information to the mass media and other tourism-specific outlets (tourist guides, travel planning websites etc.)
- “Private-sector climate service providers have led the way in terms of innovation of specialized climate services tailored to specific tourism destinations, individual tourist activities and subsectors” e.g. iSki App, The North Face® Snow Report, SkiResort, and SnoCountry, boating (TideApp), surfing (Oakely® Surf Report), and fishing (Fishing Calendar).

Industry structure in France

In France, Météo-France is leading the industry as main provider/ purveyor of weather and climate services for a general public as well as for local stakeholders in specific sectors through the web site. They can provide specific services for some sectors but tourism is not identified as one of them. Météo-France also has local

agencies that provide local services to stakeholders: local weather forecast, local alerts, etc.
A few climate services also exist through non-profit or commercial web sites and blogs, some of them focusing on mountains areas and snow related information.
Climate services generally do not address the tourism sector specifically. Some services, that focus on tourism areas (coast/ beaches or mountains) can be considered as designed for the tourism sector.
METEO CONSULT is a private consultancy. They offer paying services including detailed forecast up to 14 days, focus on beach, golf and mountain areas, marine weather for sailing activities, alert services. The PRO services include tailored information through phone and email contact. They provide information on temperature, weather type, rainfall, wind, pressure, humidity, degree-days, isotherm and limit rain-snow.

Table 25. Providers and Purveyors of the industry

Timescale	Providers/ purveyors of temperature and rainfall	Providers of derived variables
Historical data	Météo-France	Météo-France
0 – 24 hours	Météo-France Meteo Consult Pro www.meteo-alpes.org Meteo-des-neiges.com	Météo-France Meteo Consult Pro www.meteo-alpes.org Meteo-des-neiges.com (snow depth)
1-7 days	Météo-France www.meteo-alpes.org Meteo Consult Pro Meteo-des-neiges.com	Météo-France www.meteo-alpes.org Meteo Consult Pro Meteo-des-neiges.com
1-2 weeks	Météo-France Méteo Consult Pro	Météo-France Meteo Consult Pro
1 month	Météo-France Meteo Consult Pro Meteo-des-neiges.com	
1-7 month	Météo-France Meteo Consult Pro Meteo-des-neiges.com	
1 – 10 years		
10 – 100 years	Météo-France/ DRIAS + ClimatHD Universities, Consultancies	Météo-France (data base on past and future climate in mountain areas for tourism national agency) Universities, Consultants

PESTEL Analysis

Political factors Political factors have little influence on the tourism industry in France/ UE		**Economic factors** Economic factors are very important in the tourism industry.	
Opportunities	***Threats***	***Opportunities***	***Threats***
Political instability in other countries ("competitor" countries): in case other Mediterranean countries (beach tourism) or Alpine countries (mountain tourism) encounter political instability,	*Petroleum tax*	*Climate service may improve value of the destination ("I may pay more because I have more guarantee on the weather")*	*Lower disposable income* *Foreign exchange rates* *Foreign economic trends (in countries of*

tourists would rather choose more stable destinations. This factor is minor inside Europe.		*Foreign exchange rates* *Foreign economic trends (in countries of origin)*	*origin)* *More taxes on fuels*
Social Tourism is very much link to social behaviours		**Environmental**	
Opportunities *Consumer buying patterns on tourism products (not only ski in the mountains)* *More visibility and guarantee on health and security issues (major issue for tourists)* *Change in Lifestyle: tourism patterns have evolved a lot in tourism history*	***Threats*** *Consumer opinions and attitudes: mountains are linked to snow, beaches are linked to sun…* *Views of the media: over exposure of weather issues in destinations*	***Opportunities*** *Health and security issues*	***Threats*** *Customer values* *Water resource issues: low water level* *Landscape changes* *Gobal warming related issues*
Technological		**Legal/ Government**	
Opportunities *Technological development for snow-making technology*	***Threats***	***Opportunities***	***Threats***

Maturity of the climate service industry

Climate service industry must be differentiated from weather service industry regarding maturity level (in reference to the Maturity approach for good and services of Euroconsult, 2007):

- Services in cyclical phase: weather services (0-10 days) for beaches (air and sea temperatures, rainfall, UV index) and for mountain area (air temperature, snowfall, snow depth, avalanche alert) and general weather services (forecasts, alerts…)
- Services in technology phase: climate services at seasonal/ decadal scales, future climate

General SWOT Analysis

Strengths Possibility of a long term demand of climate services. Creation of a new need (demand). Part of the tourism sector strongly depends on climate	**Weaknesses** Low technical skills of decision makers, need for training Low skill on snow seasonal forecast
Opportunities Could help improve product design and communication for destinations and tourism companies as well as facilities management and investment Changes in tourism demand, consumer pattern, etc.	**Threats** Weather/ climate not considered as a major factor, (depends on type of tourism) Tourims is a very heterogeneous sector in terms of stakeholders, decision-makers Need for very local climate information

Demand Analysis

PROSNOW addresses the tourism sector in the Alpine area. The Alps cover 5

European countries (France, Italy, Switzeland, Austria, Germany) but the study has been limited to the French part so far.
If there are very few users of S2D forecasts, there is a growing interest for this kind of products. 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 S2D may be very different from a stakeholder to another.
Two main segments have to be addressed by the service:
Ski resorts
Communication/ promotion structures, at different scales

Target Market

Potential market
The Alpine ski industry is famous worldwide. Ski resorts play a major role for mountain economics. According to Vanat (International report on Snow and Mountain Tourism[61], 2015), 35% of the ski resorts in the European Alps represent 44% of the worldwide market share. 82% of the largest resorts in the World, i.e. receiving more of one million skier visits a season, are in European Alps. Regardless of the country sizes, France (2nd), Austria (3rd), Italy (5th) and Switzerland (6th) lie in the top six in terms of the number of skier visits (the other ones are USA and Japan, respectively 1st and 4th).
In France, mountain tourism takes place in six mountain ranges, which cover 25% of the country's surface area. Mountain regions generate 15% of tourism GDP, 120,000 jobs and 55.3 million skier days each year. France has 357 resorts, over 200 of which are located in the Alps. They range in size from village facilities to large international stations. Experts generally distinguish between the Northern and Southern Alps, which together account for around 80% of the country's ski areas. The Alps are spread across two administrative régions (Rhône-Alpes and Provence-Alpes-Côte d'Azur) and eight administrative départements (Savoie, Haute-Savoie, Isère, Hautes-Alpes, Alpes-de-Haute-Provence, Alpes-Maritimes, Drôme and even Vaucluse, which has two small resorts).
Economic conditions in mountain resorts are almost entirely dependent on tourism. In Northern Alpine resorts especially, winter is often the main season.

Organisation of the agents

The world of tourism stakeholders **is diversified and complex**. Unlike other less centralised forms of tourism, mountain tourism involves a range of relatively well-identified and structured stakeholders. These include:

- **Ski areas**, which manage ski trails and ski lifts.
- **Municipalities**, the administrative areas in which resorts are located, which are members of the Association Nationale des Maires de Stations de Montagnes (ANMSM), an association for mayors of mountain resorts.

[61] http://www.vanat.ch/RM-world-report-2015.pdf

- **Socio-economic stakeholders**, which run activities in resorts: accommodation providers, restaurant owners, transporters, ski-hire companies, shopkeepers, instructors, activity providers, etc.
- **Communication and promotion organisations**.
- **Academic, research and consulting bodies**, which examine natural and anthropogenic factors affecting Alpine environments, snowfall and mountain tourism. They include the Snow Resear ch Centre (Météo-France/CNRS), laboratories linked to the Université Joseph Fournier in Grenoble and the Université de Savoie, the National Research Institute of Science and Technology for Environment and Agriculture (Institut national de recherche en sciences et technologies pour l'environnement et l'agriculture or IRSTEA), the Alpine Network of Natural Hazards and Risks Prevention (Pôle Alpin d'études et de recherche pour la prévention des risques naturels or PARN), public works agencies (such as Rhône-Alpes Tourisme and CEREMA) and private companies (consulting agencies, etc.).

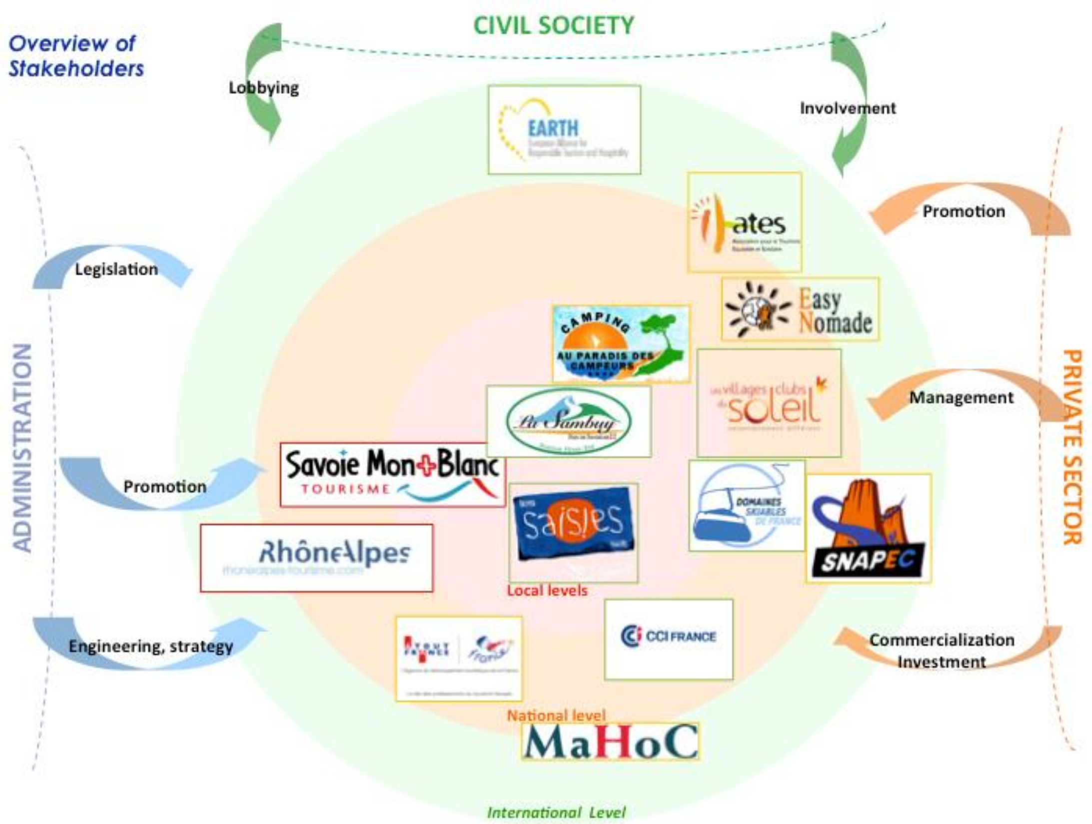


Figure 49. Tourism stakeholders

<u>Description of target market</u>

1. Ski resorts

Economic conditions, employment and earnings at hundreds of Alpine winter sports resorts depend almost entirely on one thing: snow. Winter tourism is, by nature, seasonal. It is therefore affected by inter-annual variations in snowfall frequency and duration, as well as snow cover quality. While the term "ski resort" is still widely

used, activities are now being diversified in response to this variability – for some stations at least – and customer demand.
This segment represents about 200 resorts located in the French Alps.
Resorts range in size from village facilities to large international stations.
A resort gathers several agents but they can be considered as one entity because they are very interdependent:
Ski areas, which manage ski trails and ski lifts.
Municipalities, the administrative areas in which resorts are located.
Socio-economic stakeholders.
The ski area is a key player in resorts, and central to economic activity. It is also the entry point for weather and climate information. Therefore, it will be considered as the main target for PROSNOW service.
They have various legal structures. This does not change the demand for climate service in terms of content but may influence the business model:
44% of operators are publicly owned;
43% are private companies;
13% are semi-public companies (sociétés d'économie mixte or SEMs, where the local government holds a majority interest).
Almost all resorts are members of Domaines Skiables de France (DSF), an association of French ski areas.

2. Communication/ promotion structures

This segment represents few agents. They range in size from local tourist offices to regional tourism boards such as Savoie-Mont-Blanc-Tourisme (which operates across both Savoie départements) and Rhône-Alpes Tourisme (which operates across the entire région). These structures are all members of the France Montagne association, which promotes French mountain tourism on the national and international levels.

<u>Geographic location</u>

The PROSNOW case study is focused on the French Alpine area that accounts for around 80% of the country’s ski areas. Experts generally distinguish between the Northern and Southern Alps. The Alps are spread across two administrative régions (Rhône-Alpes and Provence-Alpes-Côte d’Azur) and eight administrative départements (Savoie, Haute-Savoie, Isère, Hautes-Alpes, Alpes-de-Haute-Provence, Alpes-Maritimes, Drôme and even Vaucluse, which has two small resorts).
However, the proposed prototype could certainly be exportable to other alpine domains (Italy, Switzerland, Germany, Austria) and may be to other mountainous areas (Pyrénées…) provided some data exist in these areas and that climate drivers relationships with snow cover are well understood.
As the weather conditions in the mountains are influenced locally by the slope and altitude, geographic scale of interest is both regional (per mountain range) for global trends, and very local (at the ski area level or even the ski trail level) for snow cover quality for example.

<u>General activities and scale of intervention</u>

Activities of the organizations can be divided into 2 groups:

- **Activities at a strategic level**: information & awareness of tourist’s actors, promotion, communication, and engineering, business planning, strategy and

investments, destination, travel management.

- **Activities at an operational level**: maintenance of ski resorts, implementation of tourist activities (hiking, skiing etc.), investments, implementation of action plans (promotion, communication etc.) etc.

These activities are carried out for several target groups:

- Tourists (communication, implementation of activities, etc.);
- Professionals of tourism (engineering, consulting, awareness, etc.);
- Organisation in itself (planification, business strategy, investment etc.).

The scale of intervention of those operators mainly depends of the type of the activities:

- Activities of awareness, communication, promotion, consulting and travel are realized at different geographical scales (from local up to European level);
- Business activities, planning and strategies, operational management are realized at local or destination scales.

Governance

Communication and promotion activities are ruled by market and tourism competition and linked to regulation affecting tourism operators. Engineering, management and development are related to laws, spatial planning and economic development as well as construction norms (for new accommodation projections), plus labour regulations (training, employment). Rules and regulations of public transport may also affect indirectly the tourism sector (the price of the transport for coming to the destination is an important factor of decision). At a ski resort level, in particular maintenance of the station, they are regulated by the public laws (like local plan of urbanism) and also dependent on environmental rules (impact studies for instance).

Decision-making processes

Several specific characteristics of the tourism sector that can have an influence on the analysis of the decision making processes can be underlined:
a large representativeness of stakeholders located in the mountain region (Alpine Area);
Majority of small to medium size organisations, one of the main characteristic of the tourism sector except for national organisations (e.g consular organisation).
Strong seasonal employment at a destination level (winter/summer) ;
Actors often plays different roles, acting both at strategic and operational levels (eg : resort manager and ski instructor at the same time).
Most stakeholders have a short term vision and, as a result, have difficulties in planning for the future due to the uncertainties in the sector. These uncertainties include not only economic and political factors (e.g. employment, access to government subsidies); the decision-making process of consumers regarding tourism; climate trends both at the destination location but also the market of origin. Tools to manage risk and uncertainty are generally not used in the sector.

Table 26. Representation of the decision-making processes within tourism actors

Time scale	**1 month**	**seasonal activities (1 to 6 months)**	**6 month up to 1 year**	**2 years up to 5 years**
Types of decision	• Adjustments of activities • Artificial snow management • Outdoor activities planning • Building management	• Management board to adjust the action program • Annual meetings etc.	• Marketing and communicat ion action plans • Investment plan (Luge equipment etc.)	• Long term communication strategy (brand destination) • Pluri annual investments (machinery, extension of the resort) • Engineering
Main horizon of implementation	**Summer seasons** **Winter seasons**			
Degree of uncertainty in the decision process	Very High	Very High	High	High
Type of tools	Observations (socioeconomic & weather or climate data) / very short term weather forecasts	Observations	Observations Empirical Experience	Observations Empirical decision

Characteristics of users and behaviour

Sensitivity to weather events and impacts

Mountain tourism stakeholders are sensitive (to different extents) to weather and climate conditions, either directly (e.g. ski resorts) or indirectly (e.g. through number of customers).

« I often say that when we are lucky to have snow with good weather at the beginning of the season, that's 50% of the turnover. Indeed, turnover is deeply dependent on weather."

The tourism sector faces different types of impacts (Scott et al. 2012):
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 reputation).
The main parameters of concern for these organisations are:
temperature (summer and winter): average as well as minimum and maximum;
precipitation (rainfall in summer; snowfall in winter): global amount per season and number of days;
sunshine: duration and regularity (particularly during summer);
extreme events such as storms and floods.
Risks are seasonal but also may affect the viability of a destination in a long timescale.

The use of weather and climate information

If the tourism sector shows on one hand, a growing perception of the issue of climate change as a key issue affecting on-going 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” (Scott et al, 2012).

Climate information could potentially be used for various activities, at different spatial scales and by different stakeholders. The ways in which actors currently access climate information vary greatly from one person to the next. This is in terms of the approach used, and the kinds of information sought (political, technical, etc.). There is no real homogeneity or clear structure in the approaches adopted, which are mostly dominated by in-house or personal monitoring of the general situation, despite the use of traditional information circuits in the tourism sector. Information on the past / current climate situation appears to be dominated by subjective views and information (for instance, perceptions or collective memory), despite the scientific data available.

Scott et al. (2012) tried to represent the potential use of weather and climate information by tourism operators and travel planners according to the time horizon.

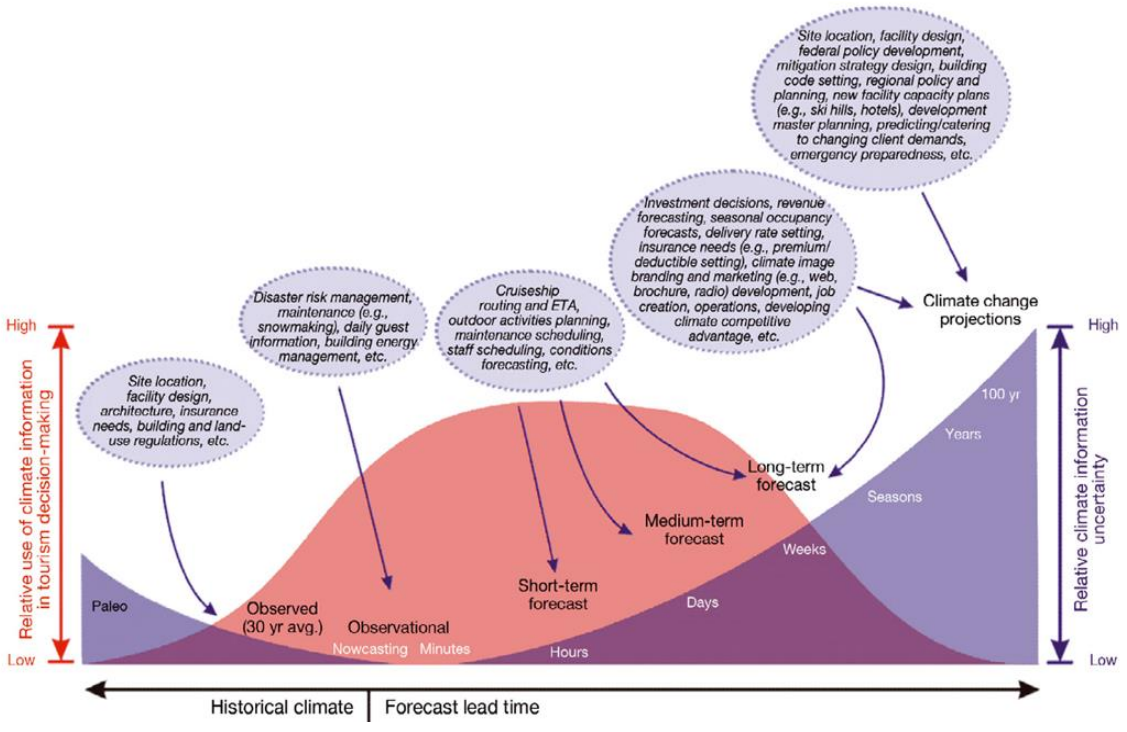


Figure 50. Potential uses of weather and climate information by tourism operators and travel planners

The use of weather and climate information mainly revolves around observational data (past observations) and a posteriori analysis whilst climate scenarios are used for planning long-term investments. During the winter season, stakeholders rely on short-term forecasts (for the next 4 or 5 days) to manage resorts on a daily basis.

They use specialist free websites and local weather services. A few organisations have formal relationships with national met services. More informal sources of information are also used by some of these organisations including national met services websites, other weather provider websites (e.g. Chamonix.org, La Chaîne Météo), and newspapers, reports, and observatories.

There is a **very low level of awareness and use of climate services** in the world of tourism:

- **Lack of knowledge about the existing climate products**

Stakeholders are not familiar with the concept of climate services and often do not know they can access to a range of products that could be interesting for them. Climate providers need to better communicate about what they can provide and what they are not able to provide. They also have to communicate about the potential benefices of these products for the sector. Awareness should be improved as well as communication between providers and users. The role of intermediaries can be very relevant in this case.

- **Complexity and level of uncertainty of the products**

Tourism stakeholders are not familiar with the use of climate and scientific information. The information is sometimes too complex and quite difficult to interpret. There's a need to communicate the information in an appropriate and understandable format for the stakeholders. There’s also a need to better understand what level of uncertainty each stakeholder can accept to take a decision.

<u>The use of S2D predictions</u>

Very few organisations use S2D predictions. Reasons given are mainly related to the lack of reliability of the information provided (uncertainty, low skill) and also the accuracy of the products provided (too large scale, not enough parameters).

> *«The few probabilities we get are honestly too much uncertain to base some promotion and communication. So we don’t use them »*
> *«They are not reliable enough, so they are not used. Perhaps due to a lack of knowledge/awareness of their existence, and due to the need of high spatial resolution: our region has a diversity of environments and climates, and therefore requires some resolution, due to “micro-climate”. A general outlook on S2D at regional level might not be relevant at a very local one. »*

For medium-term information (from ten days to a season), they have few options, especially at the start of the season. They mainly use reference climatology, plus information from historic data series based on local records. Some ski resorts may consult monthly and seasonal forecasts on national weather organisation website as well as specialist blogs and forums to try and identify trends. But there are no specific services in this range that are accessible to a non-specialist. Only a person that have developed the skill to interpret relatively raw date can use this source of information. Ski area management organisations generally do not have a full-time position on this issue. Therefore, stakeholders recognise that designing and implementing such a service would have a clear added value, provided the service relies on a detail interpretation and explanation of the climate information.

Potential use of seasonal information to make decisions

Potential to use S2D climate predictions are largely associated with:
Potential to anticipate future climate conditions and use it to communicate and promote destinations;
Operational management towards adaptation such stock optimization (e.g. artificial snow) and alternative strategies (e.g. encouraging indoor activities, organizing events);
Medium-term planning (5 years) – reorganization of the offer, strengthening the diversification of the activities, creating new brand;
Long-term planning (5-20 years) – structural adaptation.

Depending on the years, if there are clear trends at a seasonal time-scale, the tourism industry would be able to anticipate specific situations (e.g. very warm winter with bad skiing conditions, very cold winter, etc.), adapt human and technical resources, adapt product design and pricing and communicate toward their clients. This could have a direct impact both on operational costs and on turnover.

> *Situation: the opening date of the resort (ski area, accommodation, restaurants and other services) has been set to December 10th. By mid-September, reliable forecasts show that skiing conditions will probably good as from mid-November. The resort may open some ski trails earlier, with little costs (not all the ski area, no accommodation, reduced team, etc.), and set a specific 1-day skipass low-cost product for the local clients*.

Forecasts of temperature and evolution of the snow cover at a 1-month time scale would probably not have significant impact on operational costs of the resort. However, stakeholders are positive about the impact that it would have on the quality of the product on one hand, and on the management process on the other hand. A better knowledge of the quality of the snow pack, of the temperature conditions that have great influence on the artificial snow production and conservation, would be of great interest for the ski area, allowing more anticipation:
in human resources management, leading to less pressure on the teams,
in technical management of the slopes, leading to better quality of the snow cover at all points of the ski area,
in management of the snow making activity, leading to less emergency decisions or loss of useless snow.

Purchase determinants and willingness to pay

Mountain tourism stakeholders do have a genuine interest in weather and climate information. It would be an additional support to manage activities on a day-to-day basis as well as at a strategic level. Reduction in the forecast uncertainty could lead to economic benefit: energy saving, reducing labour costs, optimization of seasonal hiring and improved management of natural resources (especially water), quality of services provided by resorts.
The PROSNOW service would contribute to increase the competitiveness of this economic sector as well as promote the visibility and economic attractiveness of climate services. It has clear capabilities to increase the resilience of the tourism industry in mountain regions, as well as to foster the development of tailored climate

services addressing manyfold applications in the Alpine human-environment mountain systems. As a multiannual perspective shows the stagnation of skier visits and the growing economic pressure on resorts, also strengthened by the threat of climate change and decrease in mean snow conditions, such a service represents a valuable asset to tourism stakeholders.

Financial benefit assessment relies on a risk analysis, i.e. the risk of a loss of earnings versus the risk to waste resources in the context of uncertain forecasts. Moreover, benefits cannot all be directly evaluated as direct financial impacts but would more probably rely on quality improvement for the tourist. Although the overall financial impact of the service is still difficult to assess, organisations are willing to pay for improved and accurate service.

The issues of interpreting and formatting data are key in transmitting climate information. It is important to use a **pedagogical** approach. In addition, stakeholders state “sometimes, if the information is technical, a few words resuming the situation are enough.” This does not only mean facilitating reading, but also **assisting interpretation**, by translating the main message through graphics, a set of projections, high resolution maps (at the local scale) as well as data represented according to levels of confidence with a percentage attached to it (or indice). This should allow “autonomy” of the user in understanding information.

The main purchase determinants for seasonal prediction services in the mountain tourism sector seem be related to:

Reliability of climate information

Detailed and tailored interpretation of the data

Quality of the graphical interface

Geographical scale (ski resort to slope scale)

Synthesis

- Short-term weather forecasts are generally used, with a generally limited level of tailoring.
- Long-term climate projections are sometimes used through regional and national initiatives (local climate action plans) to increase the awareness of the necessity to adapt to changes. However, the still important uncertainty, inadequate tools to communicate this uncertainty, and the lack of downscaling of climate projections to the resort level, limit their practical use for decision-making (e.g. whether to invest or not in a new ski lift).
- There is a general lack of awareness of predictions from one week to several months ahead, and the confidence in such forecasts is generally low.
- The interest perceived is more towards improving the quality of the product (quality of snow conditions, comfort for the tourist), than saving operational costs.
- There is a need to develop intermediaries, since most ski resorts do not have high level skills in climate data interpretation, and therefore seasonal forecasts might not be beneficially used if not provided in a proper way.

Supply Analysis

There are **no direct competitors** to the PROSNOW service.

There are, however, some alternative solutions. But the quality of the information that is available today relies on the ability of the resort to collect, compare and

interpret data and information from various blogs and web sites, and, for some of them, to process raw data. The presence, within the management team of the resort, of a specialist or, at least, a person that have a personal interest in weather and climate science, is a key factor.
Most resorts rely on historical climate information. It can be either collected on site, or at a local level by weather professionals.
Local agencies of Météo-France (for France) or other local professionals (like avalanche services, etc.) are the main providers of weather and climate services for mountain areas on a day-to-day basis for the resorts, but are generally focused on weather information and on the avalanche risk analysis.
Some resorts that have a person with the related competences use all the means that are available on the internet through professional web sites, personal blogs and scientific platforms to gather and interpret information for their own use. They can then have access to tailored climate information but this cannot be considered as a general situation.
Several research centres are currently working on emerging services, like climatology based snow pack provision, but there are no products on the market yet.
Stakeholders seem willing to get structured in order to share information and mutualised efforts to improve knowledge on climate issues. Some initiative at local (observatory of Savoie-Mont-Blanc Tourisme, Rhône-Alpes Tourisme…) or Alpine level should allow stakeholders to cooperate and rely on existing engineering competences. Such initiatives could facilitate the structuration of a climate service at the local or Alpine scale in relation with scientific organisations.

<u>Innovation potential of PROSNOW</u>
PROSNOW's objective is a direct transfer on the market of developed products after project completion, depending on the results of a demonstrator implementation and evaluation. The innovative highlights of PROSNOW not only lies in the combination of so far separated modelling tools (climate forecasts and snow models, remotely-sensed information), but also in the improved translation and visualisation of new information, and in its targeted channelling through adapted communication tools. The economic and legal conditions for a commercial service (consortium agreement, IPR, data property, business model…) still have to be detailed and tested.

Feasibility Study I & II

Description of the climate service PROSNOW
PROSNOW will cover climate forecast lead times not addressed by operational weather forecast information already widely used by mountain professionals. Three main types of information will be delivered: information about the future conditions, information about snow conditions on the ground (natural conditions, or accounting for snow management techniques such as grooming and snowmaking), and water supply levels, accounting for the various sources of water used for snowmaking (domestic network, dedicated lakes, creeks etc.). Long-term in-situ meteorological observations are needed to properly downscale the forecast model. Better initialization of the forecasts will be achieved through the use of in-situ information (local snow depth recordings in particular, provided by the ski resorts including observations from grooming machines, or remotely-sensed information measured

by satellite or ground-based systems).
Additional products like long term high resolution climate projections, downscaled to the resort level, will not be provided as a regular service, but will help framing the debate on the necessity to adapt to a changing climate for the resorts considered.

PROSNOW will utilize a wide range of existing forecast information to deliver a seamless prediction of meteorological and snow conditions in the Alpine ski resorts. PROSNOW products will be based, by order of increasing complexity, on various combinations of tools and sources of information, such as:

- Climatology-based derivation of a snow making efficiency index which characterizes periods potentially very well (or not) suited for snow making in view of energy and water costs, based on long-term observations in the area of interest. This does not require real-time observations or forecast.
- Climatology-based evolution of snow cover from a given current state, to provide the potential evolution of the skiing conditions, integrating meteorological observations with snowpack models (Morin et al., Proceedings of the ISSW Grenoble, 2013). This requires real-time observations of snow conditions but not real-time forecasts.
- Sub-monthly forecasts (from 4 days to 1 month lead time), of temperature, humidity and precipitation, to take into account upcoming meteorological conditions in the short-term management of the ski resort, in particular technical snowmaking. This requires real-time forecasts (see e.g. Vernay et al., Cold Reg. Sci. Technol., 2015).
- Seasonal forecasts (service compatible with the specifications of the upcoming Copernicus Climate Services Seasonal Prediction Service in 2017), from 1 month to 7 months, applied to temperature, humidity and precipitation, e.g. to forecast the expected snowmaking conditions during the season,. This requires real-time forecasts.
- Seasonal forecasts of snow cover and anticipated water amount in reservoirs before the season, coupling the above-mentioned seasonal forecast system with snow models. This requires real-time observations of snow conditions and real-time forecasts.

An example of data flow supporting the product delivery is outlined in figure below:

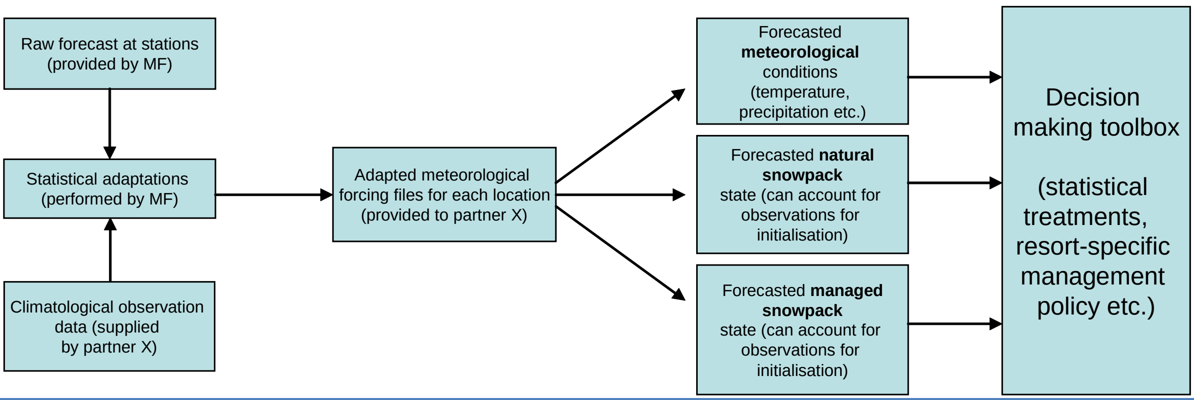


Figure 51. Example of data flow supporting the product delivery

Technical feasibility

Seasonal prediction: Multimodel evaluation of seasonal skill of Seasonal Forecasts (month 2 to 4) in the FP7 project SPECS, as well as in former experiments, have shown that northern mid-latitudes (30°N-70°N) show a maximum predictability in winter, which is particularly favorable for the PROSNOW service. This is explained by the presence of warm/cold events in the tropical Pacific and of enhanced teleconnection patterns during this season. On average, the time correlation is 0.30-0.40 for averages in January-February-March, which does not permit a successful deterministic predictability of temperature and precipitation on a particular location, but offers probabilistic forecasts showing an added value with respect to the prediction based on climatological conditions only. Teleconnection indices like NAO (North Atlantic Oscillation) show time correlations of about 0.50. This allows expanding seasonal predictions beyond the limit of deterministic predictability of the atmosphere (10-15 days). Appropriate downscaling/correction methods are to be employed, in order to extract relevant information from large-scale atmospheric models to local scale mountainous regions. Such approaches have been implemented for various socio-economic applications but not specifically for mountain snow conditions hitherto. Seasonal prediction data provided by Météo-France after appropriate downscaling will cover a broad range of already available or upcoming state-of-the-art prediction systems operating over the European domain (including the Copernicus Climate Change Service –Seasonal Prediction).

Snowpack modeling: Several physically based models have been developed during the last few decades, which represent processes at play in the natural snowpack. Recently, scientists have presented modeling approaches which also account for snow management practices. Such models have mostly been used with observed or re-analyzed data. PROSNOW aims to apply the mentioned snow cover models AMUNDSEN, Crocus and Alpine3D in forecast mode. The models will be driven by meteorological and climate predictions at different time scales and will be used to translate the expected weather and climate situations to snow cover conditions, its seasonal evolution and the related implications for snow management.

Remotely-sensed and in-situ observations: Remotely sensed data can provide twofold key information to the models. On one side, they can be used to correctly initialize the state variables of the models. On the other side, they can be used to cross-compare the results of the forecast and evaluate them. In this case, remotely sensed snow maps will be considered as reference data. Remote sensing data can be provided on two scales: on a scale of 250m resolution we will use a time series of 14 years snow cover based on MODIS data developed by EURAC. On the scale of 10m – 20m we will use latest ESA Sentinel 1 and 2 data (radar and optical) with 5 to 10 days repetition time. Three types of in-situ observations will be used from ski resorts and used to further refine PROSNOW output. In-situ meteorological observations acquired in ski resorts, when available, will be used to characterize local climate and perform the statistical adaptation of large scale seasonal predictions. In-situ, long term monitoring of snow conditions (in particular snow depth) will be used to assess snow model output performance. When available PROSNOW will harvest and use snow depth measurements increasingly carried out by grooming machines during their daily operations, allowing real time assessment

of snow condition on ski slopes and allowing to take them into account to forecast their time evolution into the future.

Statistical post-processing: Seasonal prediction systems rely heavily on ensemble forecasting methods, because deterministic forecasts cannot be used beyond a few days. Even at short lead-times, probabilistic frameworks make it possible to incorporate several components including cost assessments and thresholds, to provide a decision-making framework accounting for the various elements to consider and acknowledging the uncertainty held by some of its key constituents, in particular the meteorological/climate prediction part. PROSNOW thus builds on cutting edge statistical approaches to develop the decision making framework, and will package their results in visualization toolboxes amenable to non-expert users.

Benefits for the users

The ambition of PROSNOW service is to develop better anticipation capabilities of ski resort and winter tourism managers by providing information about snow conditions and snow making potential from one week to several months ahead. Appropriately visualized and communicated, such forecasts can help ski resort managers in anticipating important decisions: identification of the trade-off between water resources for snow making and concurrent uses and of periods with production halt, maintenance decisions to ensure reliable conditions on the slopes etc.
PROSNOW has been developed as a case study within the EUPORIAS project. It leaded to the development of a new project (H2020) aiming at developing a demonstrator.

SWOT analysis and conclusions on opportunities

Strengths Combinations of tools and sources of information to produce tailored information at low scale level	**Weaknesses** Low skill on snow seasonal forecast for snow fall Decision-making process time schedule may not correspond to the service time-scale on some operational decisions
Opportunities Strong dependence on climate of the ski activities Better management of human and technical resources for the ski resort Possibility to develop new products (early opening for local customers)	**Threats** Low technical skills of decision makers, need for training

Forecasts at a 1-month time scale would probably not have significant impact on operational costs of the resort but on the quality of the product on one hand, and on the management process on the other hand. The PROSNOW service, allowing more anticipation, will generate positive externalities:
on human resources (anticipation in resources allocation and workload);
on product quality (skiing conditions, side products in relation with specific weather conditions, etc.);
on product design and pricing (opening date, specific offers towards local

customers, etc.)
This would lead to potential benefits on turnover and on customer loyalty.

Economic feasibility

1. Investment costs

Investment costs involve costs of development and test of a demonstrator. A H2020 innovation project has been drafted in order to develop this demonstrator. The total cost has been evaluated to around 2.3 M€. Investment costs can be approached as this project cost.

2. Maintenance and operation costs (M&O)

Maintenance and operation costs involve annual costs of running the prototype annually to provide the climate service properly. A tool has been used to approach this cost as following:

Staff costs

	Number of full time, from year 1 to year 8	Net monthly salary (€)
Technical staff		
Technical director	1	3500
Climatologist	1	2500
Data specialist	1	2000
Developer	1 to 3	2000
Research officer	½ to 1	2000
Administration staff		
Administrative agent	½ to 1 ½	1800
Marketing and sales staff		
Sales director	1	3500
Sales engineer	From 0 to 3	2500
Communication specialist	1	2000

Other costs

Rent and utilities	16000 €/ year
Marketing	40000 to 20000 €/year
Other administrative costs	23000 to 39000 €/year

Hypothesis: no royalties on data, no purchase of data.

3. Depreciation

Assets and services suffer depreciation during their cycle life. From an economic point of view, depreciation has to be included as a way of recovery climate service investment.

Depreciation period	**8 years**
Depreciation	287500 €/year

4. Total annual cost

Description of Costs (€):

	Total	Year 2018	Year 2019	Year 2020	Year 2021	Year 2022	Year 2023	Year 2024	Year 2025
Raw Matherials Expenses	**0,00**								
% of Total Sales	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Personnel Costs	**4 291 872,00**	**377 928,00**	**432 228,00**	**497 388,00**	**571 236,00**	**571 236,00**	**571 236,00**	**625 536,00**	**645 084,00**
Administrative Team	273 672,00	19 548,00	19 548,00	19 548,00	39 096,00	39 096,00	39 096,00	39 096,00	58 644,00
Technical Team	2 302 320,00	238 920,00	238 920,00	304 080,00	304 080,00	304 080,00	304 080,00	304 080,00	304 080,00
Sales Team	1 715 880,00	119 460,00	173 760,00	173 760,00	228 060,00	228 060,00	228 060,00	282 360,00	282 360,00
Other Operating Expenses	**554 800,00**	**79 000,00**	**66 100,00**	**62 200,00**	**64 300,00**	**67 400,00**	**69 500,00**	**71 600,00**	**74 700,00**
Rent and Utilities	128 000,00	16 000,00	16 000,00	16 000,00	16 000,00	16 000,00	16 000,00	16 000,00	16 000,00
Rent	96 000,00	12 000,00	12 000,00	12 000,00	12 000,00	12 000,00	12 000,00	12 000,00	12 000,00
Heating and power	12 000,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00
Cleaning	8 000,00	1 000,00	1 000,00	1 000,00	1 000,00	1 000,00	1 000,00	1 000,00	1 000,00
Maintenance	12 000,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00
Other utilities and associated costs	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Marketing Costs	185 000,00	40 000,00	25 000,00	20 000,00	20 000,00	20 000,00	20 000,00	20 000,00	20 000,00
Advertising & Promotions	140 000,00	30 000,00	20 000,00	15 000,00	15 000,00	15 000,00	15 000,00	15 000,00	15 000,00
Other marketing costs	45 000,00	10 000,00	5 000,00	5 000,00	5 000,00	5 000,00	5 000,00	5 000,00	5 000,00
Other Administrative Costs	241 800,00	23 000,00	25 100,00	26 200,00	28 300,00	31 400,00	33 500,00	35 600,00	38 700,00
Telephone	10 800,00	1 000,00	1 100,00	1 200,00	1 300,00	1 400,00	1 500,00	1 600,00	1 700,00
Internet	4 000,00	500,00	500,00	500,00	500,00	500,00	500,00	500,00	500,00
Insurances	12 000,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00	1 500,00
Travel	135 000,00	10 000,00	12 000,00	13 000,00	15 000,00	18 000,00	20 000,00	22 000,00	25 000,00
Maintenance	80 000,00	10 000,00	10 000,00	10 000,00	10 000,00	10 000,00	10 000,00	10 000,00	10 000,00
Other	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

5. Climate services profit

At this stage of the case study, expected profits are defined 0%. Selling the climate service will cover the minimum annual depreciation cost and annual operating costs.

6. Set a potential price

Product	Price	Clients
		600 resorts
Standard subscription (seasonal provision on main climate parameters)	2000 €/ year	20% market share after 6 years
Premium subscription (standard + snow pack evolution at resort scale)	10000 €/ year	10% market share after 8 years
Ad hoc study	30000 €	1 or 2 up to 8 or 9

7. Delivery period

PROSNOW service should be an annual subscription. This subscription includes the delivery of information at different period of the year (from April to April).