European Research Area for Climate Services

ECLISEA

European advances on CLImate Services for Coasts and SEAs

Climate information needs from multi-sector stakeholders

Work Package 1 - Deliverable 1.B

***Deliverable Leader**: HZG*
***Participants:** HZG, UC-IHC, BRGM, CNRS, NCSRD.*
Relevant WP: WP1- Review of existing data sets and stakeholders needs
WP Leader: Insa Meinke (HZG)
Coordination of this report: Silvia Kodeih (HZG)
With contributions from: Silvia Kodeih (Germany, introduction & summaries) Gonéri Le Cozannet, Aurelie Maspataud, Benoit Meyssignac, Philippe Maisongrande (France), Ignacio Aguirre Ayerbe (Spain), George Emmanouil, Mandy Vlachogianni (Greece)

***Project acronym:** ECLISEA*
***Funding scheme:** ERA4CS Joint Call on Researching and Advancing Climate Services Development by Institutional integration (Topic B)*
***Date of the first version deliverable:** June 30th, 2018*
***Date of final version:** June 30th, 2019*

Project ECLISEA is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by UC-IHCantabria, HZG, BRGM, NCSRD and CNRS with co-funding by the European Union.

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1 Introduction

The deliverable D1.B is part of work package (WP) 1 of the ECLISEA project with the title "Review of existing data sets and stakeholder needs". More precise, the deliverable D1.B is a contribution to WP 1.2 "Climate information needs from multi-sector stakeholders". Its purpose is, according to the accepted ECLISEA project proposal (2017), to document of what is known about stakeholder needs in terms of coastal climate information in different sectors for French, Spanish, Greek and German coastal areas. This deliverable is based on experiences gained in previous projects and where possible, based on existing literature and experience available in the consortium. The results of the documentation are supposed to be used as orientation for a Pan-European coastal climate service, to be developed in ECLISEA.

Coastal zones have increasingly been effected by climate change impacts such as sea level rise, shoreline and beach erosion or flooding. Therefore, coastal stakeholders require coastal climate services to develop adaptation measures to these changes (Le Cozannet et al., 2017). In the recent years, several scientific articles have been published and studies have been conducted worldwide, with respect to coastal climate services. It has been discussed, for instance, how to develop and improve climate services, including a possible market uptake (e.g. Le Cozannet et al., 2017; Cavelier et al., 2017), how to support global ocean observation programs and coastal scenarios as climate information providers (e.g. Malone et al., 2010; Bindoff et al., 2010; Nicholls, et al., 2008). Moreover, the information needs of coastal managers and other decision makers in terms of climate change and its impacts on coastal areas were analysed (e.g. Tribbia and Moser, 2008; Goldsmith et al., 2015; UKCP18 project, 2017). However, coastal climate services are still in their infancy, and the ECLISEA project aims to support these kind of information services at a European scale.

With regard to coastal climate information, sea surface dynamics (SSD), such as mean sea level changes, storm surges, oceanographic currents, wind-generated waves and met-ocean phenomena, are of special interest for the ECLISEA project and the coastal climate service to be developed. The reasons is that there are still great uncertainties associated to regional and local mean sea level rise. Moreover, most sea surface variables have not received much attention by the climate science community, so far. Furthermore, more research at European level is needed on regional predictability and climate projections of sea surface components, such as surges and waves (see accepted ECLISEA proposal, 2017). However, stakeholder information needs according to coastal climate can be quite different to coastal climate information generated in science, e.g. in terms of context, format, language, spatial and temporal resolution. In this report, we document the broad range of climate information requests found in the literature and in the fundus of experiences at partner level. It not only contains the pure contents of information needed (as well as its temporal and spatial context), but also findings with regard to the reasons why or what for climate information is needed (such as for developing climate adaptation strategies, product development, or research), in which format it has been requested (e.g. measured data or maps/graphs or user group orientated prepared and easily

understandable information), and which obstacles exist at stakeholders' side to use climate information (e.g. uncertain climate change scenarios, lack of relevance).

The reason for the differentiation between regions and sectors is the strongly space- and sector-related aspect of climate information needs. According to the ECLISEA- proposal, tourism, energy (with focus on offshore energy), maritime navigation/ports, and insurance were assumed as strategic sectors. Coastal tourism, mainly beach tourism and cruise shipping, is presumed as very important economic factor in many coastal areas and has been effected by e.g. beach erosion and mean sea level rise (accepted ECLISEA project proposal, 2017). Moreover, the sectors related to maritime navigation and ports as well as offshore energy are also described as important economies in many European coastal regions. They have been influenced e.g. by wave climate, met-ocean conditions and potential changes in extreme weather events at coasts, such as storm surges (accepted ECLISEA project proposal, 2017). The risk insurance sector is directly related to natural hazards. Material and personal damages are caused by extreme weather events at coasts, such as flooding and storm surges, storms, extreme waves (accepted ECLISEA project proposal, 2017).

The documentation of stakeholder needs has been concentrated on those four sectors explicitly mentioned in the ECLISEA proposal, as in the project proposal is suggested to focus on them. However, this documentation has been expanded on other sectors if they are subject of the particular literature on climate information needs in coastal areas or if specific experiences at project partner level could be included. For example, in Spain it is also documented the water management sector and a multi sectoral view on coastal issues; and in Germany the coastal protection sector and the local and regional policy sector are frequently found in the literature. On the other hand, it should be mentioned that not every sector focused in ECLISEA could be included properly in the literature review by every partner, due to insufficient relevant documents found. Finally, there are probably additional sectors with needs for climate information but without any documentation about those requirements.

The documentation of stakeholder needs for climate information is based on i) experiences gained in previous projects in the four ECLISEA partner countries, ii) existing literature (e.g. project reports, policy documents, grey literature, scientific articles), and iii) experiences available at project partner level, which means the five research institutes contributing to ECLISEA.

For **Germany**, the literature research is mainly based on

- a review of project reports and workshop documentations (grey literature) from several projects aiming at climate change adaptation in different sectors and with a cross-sectoral view
- reports from companies (grey literature) on the risk insurance sector
- the registration of data queries from the model based data bank coastDat (managed by HZG) by the offshore wind energy and risk insurance sectors and by scientists (https://www.coastdat.de/client_list/index.php.en). The data bank

provides reconstructed marine climate data (such as for storms, waves, surges, currents) for several decades, and mainly for the North Sea and the Baltic Sea.
- scientific publications about topics related to all sectors, mainly identified on ScienceDirect

The documentation of stakeholder needs is based in large parts on project reports derived from four climate change adaptation projects shortly described below. These projects have been implemented during the last years at the German coastal regions (North Sea and Baltic Sea). The project work included topics and activities relevant for the sectors tourism, offshore wind energy, ports and maritime transport, and coastal protection as well as the local and regional policy sector. Three of the four projects, RA:dOst, nordwest2050 and Klimzug-Nord, belong to the German research program "Klimzug – Managing Climate Change in the Regions for the Future", funded by The Federal Ministry of Education and Research (BMBF), which supports the development of innovative approaches to climate change adaptation (www.klimzug.de/en/index.php):

- RA:dOst: Regional Adaptation Strategies for the German Baltic Sea Coast, project period: 2009 – 2014. Four of the six focus topics are relevant for ECLISEA: tourism and beach development, ports and maritime economy, renewable energies, and coastal protection.
  www.klimzug-radost.de/en
- nordwest2050: Prospects for Climate-Adapted Innovation Processes in the Model Region Bremen-Oldenburg in North Western Germany, project period: 2009 – 2014. The project cooperated with the sectors ports/maritime navigation, tourism, offshore-wind energy, and coastal protection.
  www.nordwest2050.de
- Klimzug-Nord: Regional Strategies Concerning Climate Changes in the Metropolitan Area of Hamburg, North Western Germany, project period: 2009 – 2014. The project cooperated with public authorities from port management and other sectors.
  www.klimzug-nord.de
- KLIWAS – Impacts of Climate Change on Waterways and Navigation – Searching for Options of Adaptation, project period: 2009 – 2013. Project activities, research and findings (especially from sub projects 3.01: Impacts of Climate Change on Navigation and Other Uses of the Sea, and sub project 3.02: Adaptation Options for Waterways and Ports at the German Coast and for Coastal Protection in Extreme Weather Events) are relevant for ECLISEA with regard to the sectors maritime navigation, coastal protection, offshore wind energy, and tourism.
  www.kliwas.de

Co-operation and dialogue between scientists and practitioners from business, administration and civil society were considered as important to strengthen stakeholders' awareness regarding climate change and to find regional strategies and measures to adapt to climate change impacts. Workshops, stakeholder interviews, standardised surveys and

practical projects were methods implemented during the projects' durations. Nevertheless, stakeholder needs in terms of coastal climate information were not in the projects' focus. Only very few surveys questioned stakeholders in Germany directly about their climate information demands (e.g. Eschenbach, 2017, about the potential demand of the offshore wind energy sector for oceanographic data and information with the aim to develop a Coastal Observing System for Northern and Arctic Seas (COSYNA) for data provision; Meinke, 2017, with a survey among mayors of municipalities about general aspects of climate change, preferred information channels and information demands; in parts, but with different focus, reports about stakeholder interviews during RADOST, see for instance Knoblauch et al. 2012, Schumacher et al., 2010a, Schumacher et al., 2012, Martinez & Bray, 2011a,b, Koerth & Sterr, 2012). However, stakeholder needs have been formulated quite often marginally in project reports, although mainly in more general terms.

The **Spanish** review on documented stakeholder needs is mainly based on experiences gained in previous projects by the University of Cantabria - IHCantabria (UC-IHC), one of the project partners in ECLISEA. Relevant literature on stakeholder needs could only be found marginally. UC-IHC is a university/research institution that represents three different sides regarding climate information. It produces its own climate data, is also a user and finally is a climate information provider.

Both, identification of stakeholders and their needs on climate information for Spain, is mainly based on its experiences obtained in previous activities, which implicitly include a scientific literature review, and on current policy documents on climate change and climate change adaptation. The information collected was drawn, above all, from dialogues made with around 20 researchers working on different research groups of UC-IHC. Climate information needs are reflected as the needs of the research institution to meet the needs of other stakeholders, which implicitly feed their own research activities.

The **French** review on documented stakeholder needs is based on

- a review of the grey literature on the tourism, harbor/maritime and risk & insurance sectors and the impacts of climate change, including in coastal areas
- a review of current policy documents on the adaptation of the same sectors to climate change impacts, including in coastal areas
- The identification of scientific articles with keywords:
  1. 'tourism' 'coastal' 'climate change' and 'France' (4 results, 2 of relevance for ECLISEA)
  2. 'harbour'/'harbor' or 'maritime transport', 'coastal' 'climate change' and 'France' (27 results, 1 of relevance for ECLISEA)
  3. "risk" "insurance" "coastal" "france" (5 results, 3 of relevance for ECLISEA)
     in the Web of Science complemented with additional articles known from the authors of this section (see reference list).

The **Greek** documentation is based above all on experiences gained from NCSRD Demokritos of Greece, the Greek project partner within ECLISEA. Literature about stakeholder needs could only be found marginally. NCSRD, Research Center for Nuclear

Research, Demokritos, is a research institution that produces its own climate data, but it is also a user and a climate information provider.

Both, identification of stakeholders and their needs on climate information for Greece, is mainly based on the experience gained in previous activities and a review of policy reports. Climate information is provided to meet the needs of the research institution and the needs of other stakeholders.

The report is structured in five main parts: one chapter for each sector (tourism, offshore energy, maritime navigation/ports and risk insurance), as well as one additional chapter about further relevant sectors in Spain (water management and multi-sectoral views) and in Germany (coastal protection and local and regional policy).

Each chapter contains the country-specific identification of sector-relevant stakeholders and the country-specific documentation of stakeholder climate information needs in the sectors, respectively. The reports finishes with an overall summary and conclusion.

All ECLISEA project partners contributed to this report: HZG is responsible for the coordination and review of this report, the parts about Germany, for the introduction and the summaries at the end of every sector chapter, for the summary and conclusion at the end of the report as well as for the final layout. UC-IHC composed the parts about Spain, BRGM and LEGOS are responsible for the French parts in this report, and NCSRD wrote the parts about Greece.

2 Climate information needs in the tourism sectors in Germany, Spain, France and Greece

In this chapter, relevant touristic stakeholders in Germany, Spain, France and Greece are going to be described, as well as findings from literature research regarding stakeholder needs for coastal climate information.

2.1 The tourism sector in Germany

2.1.1 Stakeholders in the German tourism sector

Coastal tourism is a very important economic sector in both German coastal regions. The coastal areas at the German North Sea and Baltic Sea with its islands and beaches, are very attractive destinations, especially for beach and summer tourism, and for both, overnight tourism and day tourism (Schumacher et al., 2012; Schuchardt et al., 2011; Filies, 2012).

Coastal tourism, as an interdisciplinary field, depends very much on coastal ecosystems and intact landscapes and is very vulnerable to climate change impacts, not only with regard to its natural resources but also in view of changing social and economic factors (Filies and Schumacher, 2013; Schumacher et al., 2012).

Some expected climate change effects on German coastal areas are a moderate temperature rise and higher water temperatures, which could lead to an extension of the tourist season into the spring and autumn. However, these positive effects could be exceeded by a decreasing bathing water quality through more algal blooms and jellyfishes, as well as by sea level rise and more dangers of extreme weather events (such as floods, storms, storm surges or heavy rains) with its potential risks for beaches, coastlines, coastal protection and touristic infrastructure (Ecologic Institute, 2014; Schuchardt et al., 2011).

German coastal areas have been identified as highly sensitive regions to climate change impacts in the German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie - DAS) (BMU, 2018). The tourism sector is mentioned as one vulnerable sector in this strategy, and the need for developing recommendations for action has been underlined (Die Bundesregierung, 2008). The DAS is the political framework for climate change adaptation in Germany and was adopted by the German federal government in 2008. It describes possible climate change impacts and options for action regarding adaptation in 15 different fields of action, besides the tourism sector also for, the energy industry, insurance industry, tourism, and flood- and coastal protection. An Action Plan for Adaptation (APA), developed in 2011, connects the adaptation strategy with specific activities at national level and has to be complemented by measures at federal and municipal level (UBA, 2013a). One example at federal level is the development of a climate impact monitoring in Hamburg (Hamburg Authority for Environment and Energy, 2018a). DAS and APA have been developed continuously in recent years.

The coastal tourism sector embraces many different stakeholder groups. The three main groups are the tourists itself, travel businesses (e.g. tour operators, transport companies) and the destinations (including local tourism companies such as leisure infrastructure, hotels) (Filies and Schumacher, 2013). Some of these stakeholder groups have been addressed during climate change adaptation oriented projects like RA:dOst or nordwest2050.

During the project RA:dOst, several guided expert interviews and workshops were conducted with actors from the tourism sector at the German Baltic Sea coast (federal states of Mecklenburg-Vorpommern and Schleswig-Holstein). The main objectives were to strengthen awareness regarding risks and elucidate chances of the tourism sector in a changing climate as well as to discuss possible adaptation strategies and measures in the sector to climate change impacts.

The topics discussed in workshops and interviews covered issues related to climate change and adaptation measures (Stelljes, 2012), beach management (Knoblauch et al., 2012; Schumacher et al., 2010a; Schumacher et al., 2012), conflicts of use between tourism and other sectors, such as coastal protection and nature conservation (Schumacher et al., 2010a; Schumacher et al., 2012), tourism development at the German Baltic Sea coast (Filies, 2012), as well as communication and awareness with regard to climate change, its impacts and adaptation measures in the tourism sector (Schumacher et al. , 2010c) (see also table 2 in chapter 2.1.2).

The stakeholders from tourism sector having participated in these interviews and workshops, mainly were representatives from the regional tourism industry and tourism

politics (Schumacher et al., 2010a; Schumacher et al., 2012), from tourism associations and ministries acting in the tourism sector on county and district level (Schumacher et al. , 2010c; Filies, 2012), and from tourist administrations on local and regional level (Stelljes, 2012; Knoblauch et al., 2012) (see also table 2 in chapter 2.1.2).

Because of the cross-sectoral nature of the RA:dOst-project and the discussed issues, the interview sections and workshops mostly were organized and conducted not only with actors from the tourism sector, but also from other sectors, such as local politicians, administration of different levels in charge of nature and climate protection, water management, coastal protection and spatial planning, as well as with scientists. This means that the literature on research findings related to stakeholder needs for coastal climate information, requested formats of information and obstacles in using climate information can not specifically attributed to the tourism sector but could also be raised to the other sectors mentioned above.

Regarding the German North Sea region, the project nordwest2050 considered climate change related issued of the tourism sector in the metropolitan region Bremen-Oldenburg in the northwest of Germany. Scientists of the project conducted a vulnerability study and assessed the sector's exposition to climate change and possible adaptation options (Schuchardt & Wittig, 2012; Schuchardt et al., 2011, see table 1 in chapter 2.1.2). The project reports cited (ibid.) do not differentiate among various stakeholder groups in the tourism sector in the metropolitan region Bremen-Oldenburg.

Additionally, some project reports and articles refer to the tourism sector in a general way by listing climate indices, parameters or factors important to describe and understand the sector's vulnerability to climate change or used for developing adaptation measures to climate change (Schuchardt et al., 2011; Bülow et al., 2017; von Storch & Claussen, 2011; KUNTIKUM, 2009, see table 1 in chapter 2.1.2). Apart from the scientific use of these indices, almost no information could be drawn about (possible) users from the tourism sector.

2.1.2 Stakeholder needs for coastal climate information in the German tourism sector

The review of literature about the tourism sector's climate information needs in the German North Sea and Baltic Sea region shows that climate change and its effects on tourism has not been considered very much until the end of the projects nordwest2050 and RA:dOst in 2014. More recent information could not be found. Apart from the activities in the projects, adaptation measures have hardly been discussed or implemented in the sector (e.g. Schumacher et al., 2010c; Schuchardt & Wittig, 2012; Schuchardt et al., 2011). The need for awareness raising regarding climate change effects, adaptation strategies and chances/risks for the regional tourism was determined by the researchers (e.g. Ecologic Institute, 2014; Schumacher et al., 2010c). In some cases researchers also pointed out the need for basic information, such as explaining the differences between weather and climate and between the terms "climate mitigation" and "climate adaptation" (Stelljes, 2012; Schumacher et al., 2010c).

Summarising, for the German North Sea region mainly the following information demands could be extracted (see table 1 in this chapter for references and more detailed information):

- More and improved weather information for tourists (e.g. heat warning systems and heat effects on health, “bad-weather tips” with alternative offers), whereas the term “improved” was not specified by stakeholders.
- More reliable weather forecasts for the tourism management.
- Climate information on longer time scales, especially on the development of air and water temperatures.

Regarding the German Baltic Sea coast, project activities and cooperation with stakeholders within the climate adaptation project RA:dOst could disclose especially the following information needs of the tourism sector (see table 2 in this chapter for references and more detailed information):

- More and precise information about climate change effects on and vulnerabilities of regions and communities as well as on the tourism sector at the German Baltic Sea coast, about occurrence of effects and possible solutions.
- More reliable and regionalized data, improved regional climate models and regionalized projections about climate change effects.
- Information about tourism development (economically, conserving the ecological basis) in a changing climate.
- Local options for action and strategies in the sector concerning climate change adaptation, such as adaptation measures for hotel industry, gastronomy, tourism entrepreneurs.
- Information about specific climate change related topics, e.g. handling and disposing of seaweed accusation at beaches, identification of flood areas with a view to buildings at beaches, drinking water shortage during summer season.

Referred to the tourism sector in general, climate indices or climate factors, such as hot days, days with torrential rain or storm tide water levels, have been developed and used by scientists (e.g. in the project nordwest2050) for describing the tourism sector’s exposition to climate change. They also have been used for developing measures concerning the German Adaptation Strategy (Bülow, et al., 2017) (see for a definition of these climate indices/factors Schuchardt et al., 2011; Bülow, et al., 2017). No information was found about the use or request of this format of climate information by actors from the tourism sector itself.

The requested information mentioned above has mainly been necessary for developing adaptation strategies and measures to climate change effects and for tourism development, in both German coastal regions. Some project participants in RA:dOst requested recommendations for action from science, directly.

Regarding the requested formats of climate information, nothing was mentioned in the reviewed literature related to tourism at the North Sea coast. Interviews and activities during the RA:dOst project at the German Baltic Sea coast reveal that information about climate change, its impacts and adaptation measures should be increasingly distributed in

the following formats and ways of information exchange (see table 2 in this chapter for references and further details):

- Knowledge exchange between communities and with regional initiatives, dialogue processes, thematic discussions and networking.
- Regional platforms for information exchange and cooperation between scientists and practitioners and for supporting public acceptance regarding adaptation measures.
- Customer surveys, journals, newsletters, members' circular letters, industry magazines.
- Good-practice-examples
- Training and certification programs.
- Compact, comprehensible and easily understandable presentation of scientific results (in "own language").
- Information tailored to stakeholders needs, distributed via brochures, workshops, thematic exhibitions.

This listing of requested formats and ways of information distribution shows that the direct information exchange between scientists and practitioners, as well as tailored and easily understandable information, have been preferred by the stakeholders.

Project activities and the work with stakeholders in the projects nordwest2050 and RA:dOst also revealed obstacles in using climate information regarding adaptation to climate change in stakeholders' day-to-day business. The obstacles mostly mentioned were the following (see tables 1 and 2 in this chapter for references and further details):

- Temporal missmatch: short-term, seasonal planning not corresponding with long-term strategic tourism concepts that consider future climate change effects and with long-term climate change impacts.
- Uncertainty: unreliable and uncertain climate scenarios and climate change impacts, as well as insufficient regionalized data about climate change effects
- Priority: adaptation to climate change not yet considered as necessary, still insufficient awareness regarding urgency for actions; other influences (such as changed leisure behaviour, demographic change, economic factors) are more important than climate change; profitable day-to-day-business most important; lack of financial, personnel, time resources.
- Allocation of responsibility to implement climate change adaptation to higher/lower administrative levels.

Table 1: Stakeholder needs in the tourism sector in the German North Sea region

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Project nordwest2050: Tourism sector in the metropolitan region Bremen-Oldenburg, vulnerability analysis	Adaptation strategies and measures to the effects of climate change; development of new and climate-change adapted touristic strategies and offers (e.g. mix of outdoor and weather-independent indoor offers)	Climate change effects on tourism sector hardly considered up to now, adaptation measures hardly discussed and implemented; little knowledge about climate-change related alteration of landscapes and consequences for the choice of destinations; more and improved climate information for tourists (e.g. heat warning systems and heat effects on health, "bad-weather tips" with alternative offers) are necessary, more reliable weather forecasts are needed	Not precised	Short-term, seasonal planning instead of long-term strategic tourism concepts that consider future climate change effects; tourism sector is more influenced by changed leisure behaviour, demographic change, economic factors, fear of war or terrorism in other countries, than by climate change	Schuchardt & Wittig, 2012; Schuchardt et al., 2011
Project nordwest2050: Tourism sector in the metropolitan region Bremen-Oldenburg, scientific users	vulnerability analysis of the tourism economy in the metropolitan region Bremen-Oldenburg, describing the sector's exposition to climate change	Used climate factors and scenarios: thermal suitability, heat stress, cold stress, humid days, dry days, wet days, sum of mean sea level and mean high tide, sunny days, foggy days, days with torrential rain, stormy days, storm tide water levels; "nordwest2050"-climate scenarios for 2050 and 2085	Climate factors	Not precised	Schuchardt et al., 2011
Project KLIWAS – Impacts of climate change on waterways and navigation, here: Tourism at the North Sea coast	Planning and development of accommodation capacity and entertainment	Tourism management needs climate information on longer time scales, especially on the development of air and water temperatures, the main attractions for tourism; as short holidays at the coast become more frequent, weather forecasts are important	Not precised	Not precised	Bülow et al., 2015

Project ReKliEs-DE – Regional climate projections, ensemble for Germany: Tourisms sector, regionally independent	Developing touristic regions, adaptation measures to climate change effects	Indices developed for the tourism sector: Tourism Climate Index (TCI), Holiday Climate Index (HCI), Climate Index for Tourism (CIT); climate indices already used in measures concerning the German Adaptation Strategy: e.g. mean monthly air temperature, mean seasonal air temperature, hot days, frost days, ice days, tropical nights, summer days, sticky summer days, cold/warm nights, cold/warm days, NOAA heat index, days with cold stress, monthly/seasonal/annual precipitation height, precipitation intensity, (extreme) humid days, mean wind velocity, wind direction, days with heavy winds, stormy days, overcast days, sunshine duration, global radiation	Indices and parameters	Not precised	Bülow et al., 2017
Tourism sector in general, scientific use	Understanding the impact of climate change on tourism climate resources; summarizing the significance of climate for tourism	Factors of tourism climate, important for subjectively perceived “weather” and touristic activities: sunshine/cloudiness, range of vision, day length, wind, rain, snow, heavy storms, air quality, ultraviolet radiation, integral effects of air temperature and wind, sunlight, air humidity, longwave radiation, metabolism rate	Numerical factors	Not precised	Von Storch & Claussen, 2011
Project KUNTIKUM - Climate trends and sustainable development of tourism in coastal and low mountain range regions; case study for the North Sea region, scientific use; touristic destinations and tourism providers are supposed to use the climate parameters	Tourism-climatic and bio-climatic assessment of climate change impacts on a destination	Used climate parameters: thermal comfort, heat stress, cold stress, sultry conditions, days of clear sky, dry days, wet days, foggy days, stormy days, snow days	Climate parameters	Not precised	KUNTIKUM, 2009

Table 2: Stakeholder needs in the tourism sector at the German Baltic Sea coast

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
project RADOST – Regional adaptation strategies for the German Baltic Sea coast: Interviews with stakeholders from local politics and administration, civil society in the federal states Mecklenburg-Vorpommern and Schleswig-Holstein, about tourism and beach management, sectors: tourism, nature and climate protection, water management	Adaptation measures to climate change effects, tourism development	more information about climate change effects on and vulnerabilities of regions and communities at the German Baltic Sea coast needed, more reliable data, improved regionalized projections about climate change effects, local options for action and strategies concerning climate change adaptation desired	More intensive exchange of experiences and knowledge between communities, dialogue processes and networking necessary for developing and implementing adaptation strategies in a participative manner and leaded by politics	Climate scenarios not reliable and detailed enough, uncertainties about future sea level rise, changing temperatures and precipitation	Knoblauch et al., 2012
project RADOST, here: coastal tourism sector	Adaptation strategies and measures to climate change effects, tourism development	Lack of information and need for sensitization regarding climate change effects and adaptation strategies in the sector	Used information channels in the project: print media, newsletters, press releases, internet presentations, data bases, workshops, seminars, expert discussion rounds, business game with junior and teaching staff from the tourism sector, quality label with indicators for assessing destinations and their development opportunities (here especially beach management), exhibition about climate change effects at the coast; communicated information was plain and tailored to stakeholders' needs	Not precised	Ecologic Institute, 2014,
Stakeholder process within the projects RADOST and BaltCICA: interviews and 3 workshops	Adaptation strategies and measures to	More information needed about: climate change and regional effects, adaptation strategies in the	Desired information channels: more thematic discussions, more platforms	Planning period of ca. 10 years in tourism sector is opposed to long planning periods of	Schumacher et al., 2010a+b;

with actors from regional tourism industry and tourism politics in the federal states Mecklenburg-Vorpommern and Schleswig-Holstein, universities, Federal Environment Agency, about Baltic Sea tourism, climate change, beach management, conflicts of use between tourism, coastal protection and nature conservation	climate change effects, tourism development	sector, developing the tourism sector (economically, conserving ecological basis) in a changing climate, seaweed accusation at beaches (handling, disposing); identification of flood areas with a view to buildings at beaches, illustrating the necessity of adaptation measures, strengthening the cross-sectoral view with regard to climate change to e.g. spatial planning, coastal protection, nature conservation	for information exchange between scientists and practitioners	adaptation measures (problems in future decades not important for current planning), profitable day-to-day-business most important, adaptation to climate change not yet considered as necessary, more important for Baltic Sea tourism: mass tourism and economical crisis	Schumacher et al., 2012
Project RADOST: 11 expert interviews about climate change and communication in the tourism sector, with actors from tourism associations, ministries acting in the tourism sector, and science in the federal states Mecklenburg-Vorpommern and Schleswig-Holstein, county and district level	adaptation strategies and measures to climate change effects, awareness raising	Terms “climate mitigation” and “climate adaptation” often mixed by stakeholders, general interest in climate change information, e.g. about drinking water shortage during summer season, adaptation measures and responsibilities regarding beach cleaning from seaweed; awareness raising for interrelation between climate change and chances/risks for regional tourism is necessary; research needs: analyzing climate change effects on regional level, developing adaptation measures for hotel industry, gastronomy, tourism entrepreneurs, improving regional climate models	Authors: tourist associations should inform actors about climate change effects and adaptation on touristic events (discussions, talks), general meetings, conferences; information channels recommended by interviewees: customer surveys, journals, newsletters, members’ circular letters, industry magazines, speeches and discussions on events, good-practice-examples, communication with regional initiatives, training and certification programs, distributing information tailored to stakeholders needs via brochures, workshops, thematic exhibitions necessary	uncertainties about prognoses of climate change effects are problematically for stakeholders, insufficient regionalized data about climate change effects hamper development of adaptation measures, climate change effects on business level difficult to assess for decision makers, possible climate change effects on tourism sector and adaptation measures not yet perceived as important	Schumacher et al., 2010c
Project RADOST: 20 interviews about climate change and adaptation measures with representatives from different	Adaptation strategies and measures to	Interviewees’ information needs: regionalized data about climate change effects, recommendations for action from science regarding	Used information channels: professional publications, scientific working groups, professional events, authority publications, internet,	Topics climate change and adaptation not very important at ministerial level; barriers for implementing adaptation	Stelljes, 2012

administrative levels (e.g. ministry, tourist administration, sectors: tourism/economy, spatial planning, coastal protection, environmental protection) from the federal states Mecklenburg-Vorpommern and Schleswig-Holstein	climate change effects	climate change adaptation, researchers: specific information necessary about differences between weather and climate	direct exchange, project activities (such as from RADOST) much more known than pure information portals about climate change; preparation of research results in a clear and comprehensible manner necessary; information platform on regional level about adaptation measures useful to support public acceptance for adaptation measures (e.g. North German Climate Atlas)	measures: allocation of responsibility to higher/lower administrative levels, lack of financial, personnel, time resources, unknowingness about climate change effects, for some persons too much or too little or unclear information; uncertain prognoses and scenarios inadequate for spatial planning	
Project RADOST: 9 expert interviews about the development of the tourist region German Baltic Sea coast and climate change, with representatives from tourist associations in the federal states Mecklenburg-Vorpommern and Schleswig-Holstein	Adaptation strategies and measures to climate change effects	Interviewees: precise climate change effects for tourism sector and possible solutions should be pointed out/visualized as well as when effects will occur; author: scientists should convey urgency for climate adaptation, should point out already measurable climate change effects and clearly communicate the scope of change and limits of adaptation	Used information channels: seminars, workshops, project actions and events from climate change projects such as RADOST, tourism associations and climate change projects seen as multipliers for information exchange between science and decision makers; networking and cooperation between science and practice desired; scientific results should be presented in a compact and easily understandable manner (in “own language”), topic preselection by scientists desired because of too much information about climate change	Too many different statements about climate change; barriers for implementing adaptation measures: adaptation to climate change not important in day-to-day-operations for most touristic companies, climate change effects have to be more tangible before starting actions, still insufficient awareness regarding urgency for actions; planning periods of some years in the sector not corresponding with long-term climate change effects, unclear or complex competences;	Filies, 2012

2.2 The tourism sector in Spain

2.2.1 Stakeholders in the Spanish tourism sector

Tourism is a key economic sector in Spain, representing around 16% of Spain's GDP for year 2016, with 2.5 mill employees. Data from Ministry of Tourism reveals more than 75 million international arrivals in 2016 and 77 mill. € of tourist spending. The most demanded coastal areas for international tourists are the Mediterranean and the Southern coast of Spain: Cataluña, Valencia, Andalucía, in addition to the Balearic and Canary Islands.

The sensitivity to climate change impacts is very high in Spain, especially on coastal and mountainous areas, which are the main touristic products of the country, but also on water resources areas (rivers, lakes, reservoirs, etc.). This sensitivity is related to many of the aspects that are particular to this sector: attraction areas, calendar of events, infrastructure and general conditions for the well-being and enjoyment of tourists. As included in the Spanish National Climate Change Adaptation Plan (MAPAMA, 2016), some of the foreseeable effects of climate change related to the tourism sector are:

- Geographical impacts shall derive in alteration of ecosystems, and hence, existing social, economic and environmental benefits. Coastal and mountain areas are the most vulnerable areas in this sense, especially snow-based tourism.
- The increase in temperatures may modify the calendar of events or change the decision about the destination or the duration of the stay.
- Water shortages could endanger the functional or economic viability of certain tourist areas.
- The sea-level rise could threaten certain settlements and tourist infrastructures.

The first action lines related to the tourism sector included in the National Adaptation Plan are:

- Climate change impact assessment in the sector by areas and tourist products.
- Cartography of critical and vulnerable areas according to different climate change scenarios.
- Development of a system of indicators about the climate change - tourism relationship.
- Development of management models to implement the most significant adaptation measures.
- Assessment of the potential impacts of climate change in the cultural heritage and their effect on tourism.

Besides official reports from the Spanish Office of Climate Change (OECC, in Spanish), such as the Spanish National Climate Change Adaptation Plan and the report on Impacts , Vulnerability and Adaptation to Climate Change in the Tourism Sector (OECC, 2016), there are some studies addressing the impacts of climate change in the tourism sector in coastal areas of Spain, although not much work about stakeholders has been done. Among these studies are, Esteban Talaya et al. (2005), Hein (2007), Marcos et.al. (2009), Losada et. al. (2014), Rodrigues et. al. (2015), Olcina Cantos et. al. (2016) and Olcina Cantos and Vera-Rebollo (2016).

Based on data about employment in the tourism sector in Spain (Ministry of Tourism) the main economic stakeholders related to the sector include **accommodation companies** (hotels, hostels, rural houses, campsites, tourist apartments, etc.), **catering business** and **transport**. There are also other economic activities related to the sector such as **tour operators**, **recreational business** (leisure, cultural, sport) and **renting activities**. Besides, it should be included the **public administration** (governmental agencies at national, regional and local level), **civil and non-governmental associations**, **research institutions** and **users** of the touristic resource. Some initiatives emerged trying to promote research network and companies clusters involving all relevant stakeholders to define a sustainable touristic model, favouring mitigation and adaptation measures to climate change (Padron, 2008).

Finally, we should also consider other economic activities, uses and stakeholders sharing space with touristic activity.

The experience of IHCantabria based on previous projects and literature review related to the tourism include the entire Spanish coast: Northern-Atlantic, Mediterranean, and Southern-Atlantic Spanish coastal areas, including Balearic and Canary Islands, and the following stakeholders:

- Governmental agencies at national, regional and local level
- Private business
- Private research companies

The examples contained in this section of the report include projects related to the integration of human activities in the conservation objectives of the Natura 2000 network (Convive-Life), bathing water quality (bathing water profiles under the Directive on Bathing Water Quality) and the development of climate change adaptation strategies based on different climate related projects (among them, Climate Change Effects and Adaptation measures in the Delta del Ebro and Climate Change Adaptation in the coastal area of Asturias).

The projects included the entire Spanish coast: Northern-Atlantic, Mediterranean, and Southern-Atlantic Spanish coastal areas, including Balearic and Canary Islands.

Stakeholders participated in the projects in different ways:

- Meetings and workshops regarding the definition and specification of the scope of the project (at the beginning of the project), for monitoring and evaluation (intermediate meetings) and final presentation (end of project). These meetings are usually held with end-users.
- Interviews and questionnaires
- Workshops

Other research institutions sometimes collaborate in the development of the projects, usually as partners.

2.2.2 Stakeholder needs for coastal climate information in the Spanish tourism sector

Considering mainly UC-IHC experiences gained in previous projects, stakeholder needs are shown in the following table. UC-IHC is a research institution that produces, manages and transforms climate information into manageable information for other identified stakeholders, including the tourism sector. The examples shown below contribute to understand relevant information needs of stakeholders related to recreational and tourism activities.

With regard to the Spanish parts of the report, it should generally be noted, that climate information needs (not data) shown in the different tables refer to other (non-scientific) stakeholders needs (enclosed in the column "information is needed for"), but it is also included the data needed in the "information needs" column. These data are used by the "scientific" stakeholders to satisfy that need of other stakeholders but at the same time they are sometimes used by the "other" stakeholders, even if they are not researchers (for example, astronomical and meteorological tide variables are used to calculate the water quality profiles but the stakeholders are also interested in the variables, as they show it in their tourism website).

Table 1: Stakeholder needs in the Spanish tourism sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Governmental agencies at national, regional and local level. Private companies	Climate information, including data variables are needed to analyse compatibility of touristic related uses with environmental restoration. This information is used to inform and advise touristic private companies[1]. Information is used for decision-making purposes.	Climate data: Sea level variables, such as storm surge and sea surface temperature. Climate change scenarios at regional spatial scale (e.g. hundreds of meters) would be desirable.	Climate data are initially received through FTP interoperability channels. Final developed information is disseminated trough a web site, reports, maps and data.	lack of resources and qualified personnel, insufficient data with enough spatial resolution on the coast to evaluate tourism derived impacts	UC-IHC IHC Oceanography, Estuaries and Water Quality Reserach Group. IHC Coastal Management and Engineering Research Group.Juanes, JA et al. (2017)
Regional Ministry of Health;	Climate information, including data variables, are needed to establish	Climate variables: astronomical and	Climate data are received through FTP interoperability	lack of resources and qualified personnel	UC-IHC IHC Oceanography, Estuaries and

[1] Main goals are: Raise awareness of ecosystem natural and service value; reduce anthropic impacts to improve conservation status and restore favourable conservation status of habitats where needed; development of biodiversity management plans in coastal areas (local level).

National level government	sanitary quality of bathing water in beaches and define adaptation options for different risk levels. Information is incorporated into the decision- making process	meteorological tides and waves. Climate change scenarios are generated from databases and tide gauges data.	channels and attached to emails. Final developed information is distributed through a web site, reports, maps and graphics.		Water Quality Reserach Group.López, Iago et al. (2013a, b) National bathing wáter information system (Example Web link)
National, regional and local level government	Climate change adaptation strategies development. Information is incorporated into the decision- making process.	Statistical climate data associated to return periods, average values and identification of changes. Past, present and future information is needed at regional (sub-national) scale.	Data are received through external drive devices and attached to emails. Final data delivered include variables, text format, and maps	Insecurities of stakeholders in dealing with the uncertainty of scientific coastal climate results and scenarios. Lack of understanding of users about scientific information on climate change and its effects	UC-IHC IHC Marine Climate and Climate Change Research Group. IHC Coastal Management and Engineering Research Group.

Due to lack of qualified personnel and usually lack of understanding of users about scientific information on climate change and its effects also, climate data is transformed into easy-to-understand information regarding sustainable and environmental-friendly requirements for touristic and cultural use, considering the climate variability and climate change mitigation and adaptation options.

End- user confidence also involves the analysis and quantification of uncertainties related to climate change and clear ways to explain it.

2.3 The tourism sector in France

2.3.1 Stakeholders in the French tourism sector

The tourism sector in France represents a major economic sector, with 1.27 Million employees in 2015 and 160 Billion Euros of domestic tourism consumption, including transportation, accommodation and catering (Ministry of Economy, 2017a). From a macro-economic perspective, the domestic tourism consumption represents 159 billion Euros in 2016 (7.1% of the French GDP), among which 30% comes from foreign (non-French) visitors (Ministry of Economy, Directorate for Enterprises, 2017). The number of foreign visitors reaches 84.5 Million people in 2015, including 67 Million European visitors. The number of foreign visitors from others continents has grown by 12% in 2015, with a strong increase of the number of visitors from Asia and particularly China (Ministry of Economy, 2017b).

Overall, the sector is important for the trade balance of France, although the balance of trade in the tourism has dropped importantly since 2013 (from 10 Billion Euros in 2013 to 1.3 Billion Euro in 2016) (INSEE, 2016), which can be explained by a drop of revenue and stable expenditures abroad (Banque de France, 2017).

Today, three types of territories relevant to the tourism sector are identified as particularly vulnerable to climate change: mountains (impacts on snow cover), rivers (impact on low flows) and coastal areas (impacts on beaches) (ONERC, 2018)[7]. Coastal zones represent 22% of travels in metropolitan France, and an average stay of 7.3 days. The number of overnights stay is unevenly distributed along the coast of France, with a strong attractiveness of the Atlantic and Mediterranean coasts and fewer overnights along the English Channel and North Sea (Figure 1).

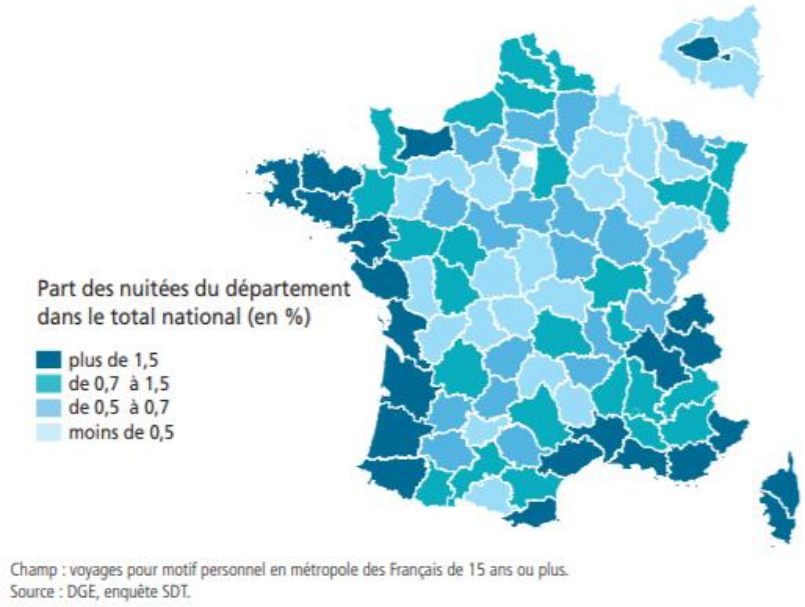

Figure 1: Distribution of overnight stays in metropolitan France. Source: ministry of Economy, Directorate for Enterprises.

The **economic actors** potentially concerned with **climate change impacts on beach tourism** therefore primarily include **transportation, accommodation and catering businesses**, which are often small and medium companies (source Ministry of Economy). However, it is considered today that while there is some awareness about the problem since more than a decade[8], the French stakeholders of the sector of tourism still needs to better consider climate change in its development strategies (ONERC, 2018). This lack of anticipation of climate change impacts is attributed to the short time horizons usually

[7] Note that earlier documents also mention cities (ONERC, 2008: http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/42/026/42026806.pdf).

[8] The study published by TEC on climate change impacts on tourism (*Le Scouarnec and Martin, 2008)* has been conducted in 2005/2006, following the 1st conference on tourism and climate change, held in Djerba in April 2003.

considered in this sector[9], but also to the multiplicity of economic actors of the tourism sectors, which include a number of small to medium enterprises (ONERC, 2018).

The academic contribution to the issue of adaptation of the French tourism sector has essentially focused on local scale. Social surveys were conducted in southern France (Languedoc-Roussillon) as part of the MISEEVA project (Rulleau et al., 2014; Rey-Valette et al., 2014; Data from Meur-Ferec et al., 2010, presented in Idier et al., 2013). The results highlighted for example, different perceptions and willingness to pay for coastal protection depending on whether interviewees are permanent or second-home residents, and that stakeholders are more influenced by their perception of risk than by socio-economic variables. Based on the results of this local study, a complete mapping of actors in the tourism sector concerned with climate change is not available today.

Hence, there is today little engagement of the French stakeholders of the tourism sector in coastal adaptation, and quantitative studies at national scales on the importance of this issue are still preliminary (ONERC, 2018). For this reason, **stakeholders are still imperfectly mapped, and roles and responsibilities could evolve a lot over the coming decades in this area**.

Initiatives to progress in this area of stakeholders engagement have been conducted at two scales:

- National scale: the interministerial mission on climate change of 2008/2009 included a group on tourism led by the ministry of Economy. This group involved public organizations such as the Ministry of Environment, the public organization coordinating the ecological and energy transitions (ADEME), a public organizations in the field of urbanism (DIACT), association of the French coastal municipalities (ANEL) and Atout-France (http://www.atout-france.fr/), the agency in charge of promoting the development of tourism in France, regions and departments. Since then, the national actions have been included in the National Adaptation Plan[10], which is now been renewed (ONERC, 2018) and extended to other actors such as the Economic Cluster "tourism in outersees territories and regions". An important recommendation for the second adaptation plan is to continue analyzing different stakeholders, share experience, and engage dialogue between scientists and stakeholders.
- Local to regional scales, such as the „territorial workshops" (Ateliers Territoires) led by the State organizations in the regions (e.g., DREAL, Directions Régionales de l'Environnement, de l'Aménagement et du Logement) and involving municipalities, regions and the economic actors.

[9] Note that the IPCC report for Europe (Ch 23, WG II) highlights that: „After 2050, tourism activity is projected to decrease in Southern Europe (*low confidence*) and increase in Northern and Continental Europe (*medium confidence*). No significant impacts on the tourism sector are projected before 2050 in winter or summer tourism except for ski tourism in low-altitude sites and under limited adaptation (medium confidence)."

[10] See https://www.ecologique-solidaire.gouv.fr/adaptation-france-au-changement-climatique and https://www.ecologique-solidaire.gouv.fr/adaptation-france-au-changement-climatique Note that the 2011 actions were focused on the development of cycling tourism and cross skying.

To summarize, this subsection has highlighted that:

- tourism is an important sector for the French economy
- a high number of diverse private and public stakeholders are involved in the sector of tourism in France, including small to medium size companies
- the main economic actors in the tourism sector of France are those of transportation, accommodation and catering
- stakeholders of the tourism sector are currently generally not engaged in climate change adaptation
- initiatives at national and regional scales are ongoing to raise awareness, engage with stakeholders and prepare the sector to adapt to climate change

2.3.2 Stakeholder needs for coastal climate information in the French tourism sector

Although French stakeholders of coastal tourism adaptation have neither been fully identified nor engaged in coastal adaptation, the information needs have emerged from national adaptation strategic planning (after: ONERC, 2018; Ademe, 2008). Note that this information needs focus essentially on the priorities of the tourism sector and may not directly link to a climate service to be developed within ECLISEA. They include the following topics:

- In a context of development of tourism, especially from other continents (Asia), the greenhouse gas emissions induced by the transport component of the tourism sector will increase without a breakthrough in decarbonized transport technologies. However, the current national adaptation plan consider adaptation to a climate warming of 1.5 to 2° above the preindustrial temperature. How to reconcile a policy of tourism development with the climate change mitigation component of the Paris agreement? Can we produce scenarios and adaptation pathways for the tourism sector, in particular for outersees territories, that reconcile development of the tourism sector with the ecological and energy transition?
- In a context of losses of biodiversity and urbanization, how to protect coastal environmental zones from the local adverse impacts of tourism in order to maintain their attractiveness? Can a diversification of the tourism offer help reducing pressures to the ecosystems? How to maintain ecosystems in touristic areas? (e.g., transplantation of corals, restauration of vegetation, specific regulations…). In terms of adaptation, how to promote tourism and new activities (and sustainable tourism infrastructure) in the backshore area?
- How to anticipate the changing behaviors of tourism stakeholders and customers, including in response to climate change, but also for many other aspects (influence of culture, economical changes, etc.)? Will changes in water availability and quality alter the potential for tourism in some regions? What will be the geographical redistribution of tourism activities over the French territory given the new anticipated climate conditions? In parallel to possible deterioration of climate

conditions adapted to beach tourism in the Mediterranean (Amengual et al., 2014), could beach tourism become more attractive in the North Sea?

- How to support the emergence of a strategy of the actors of the tourism sector to address climate change adaptation and mitigation appropriately?

Some of the questions above have already partial answers in the IPCC report for Europe (IPCC, 2013, WG2, Ch 13): for example, it has been shown in this report that coastal tourism may be more attractive in Northern Europe during summer, and possibly (but not necessarily) less attractive in the Mediterranean. However, the spring and autumn tourism may become more attractive in the Mediterranean. Furthermore, beach tourism is recognized being very sensitive to rain occurrence. ECLISEA may provide more detailed information on these issues.

Further needs relevant to ECLISEA not only appear in policy documents, but also emerge from empirical research conducted in local coastal areas (e.g., MISEEVA project):

- Need for cross-sectoral adaptation pathways[11]: for example, adaptions strategies based on relocation or diking have different implications for the sector of tourism (Rulleau and Rey-Valette, 2017). This highlights the needs for a cross-sectorial vision linking adaptation of the tourism sector with the risk & insurance sector.
- Need for training, education and communication (Koutrakis et al., 2011), in order to get the tourism sector effectively engaged in adaptation and mitigation of climate change and protection of the coastal environment. This include communication to the public, raising awareness of decision makers (elected representative, representatives of the economic sectors…), proposing decision support, proposing scenarios for the professional of the tourism sector, for example through the “plan métier de l’économie verte” (green economy plan for professionals)

To summarize, climate change adaptation in the French tourism sector is largely still in its infancy: priorities identified at national and regional scales remain to improve communication of climate change adaptation, in particular with the public and the decision makers (elected representative, representatives of the economic sectors…). In this context, where climate change impacts are still little considered in the coastal tourism sectors, surveys have suggested that communication, education and training would be useful ways forwards (Koutrakis et al., 2011).

[11] Note that this need is also evoked in ONERC, 2018.

Table 1: Summary of needs identified in the French tourism sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
National group "tourism" of the National Adaptation plan	Adaptation pathways compliant with climate change mitigation	Socio-economic, climate change, biophysical scenarios as well as scenarios for the transport technologies and sector.	Includes: sea level change scenarios.	Need to engage the transportation sector	ONERC, 2018
National group "tourism" of the National Adaptation plan	Development pathways for the tourism sector that preserve the local environment and biodiversity	Socio-economic, climate change, biophysical scenarios as well as scenarios for the tourism sector.	Include: air and sea surface temperatures, waves and currents, ocean acidification, eutrophication…	Need to engage the tourism sector	ONERC, 2018
National group "tourism" of the National Adaptation plan	Potential changes in the geographical and seasonal distribution of tourism	Socio-economic, climate change, biophysical scenarios.	Mean and extreme temperatures, mean and extreme precipitations, effects of sea level rise, sea surface temperature and acidification, impacts to beaches and ecosystems…	Need to engage the tourism sector, which is difficult given the timescales involved (beyond 2050 according to IPCC WG2 Ch23)	ONERC, 2018
Social survey; National group "tourism" of the National Adaptation plan	Adaptation strategies for the tourism sector that consider cross-sectoral aspects	Socio-economic, climate change, biophysical scenarios as well as scenarios for the tourism sector.	Same as above	Need to engage the tourism sector	Rulleau and Rey-Valette, 2017; ONERC, 2018;
Social survey; National group "tourism" of the National Adaptation plan	Training, education and communication	Same as above	Same as above	Need to engage the tourism sector	Koutrakis et al., 2011; ONERC, 2018;

2.4 The tourism sector in Greece

2.4.1 Stakeholders in the Greek tourism sector

In Greece, the issue of climate information is still not a priority for the majority of potential stakeholders.

Private companies and associations refer to the great uncertainties in climate change policy at the national and international levels as an important problem to them thinking about climate change in any terms other than relatively short term costs and benefits. They do not think about climate change related risks in a manner similar to other business risks and opportunities. Yet, they should assess how climate change may affect their business and make decisions that allow them to protect their business against downside risks. On the other hand, tackling climate change is a main priority for the Greek government and the Ministry of Environment and Energy. The Greek state is aware of the climate information availability and its potential usefulness in defining strategic policy maps for climate adaptation and resilience. To that end, a number of relevant research projects and studies have been funded and performed.

Tourism, a key industry of the Greek economy, accounts for a large share of GDP and employment and a positive contribution to the country's current account balance, as also indicated in the Climate Change Impacts Study Committee (CCISC) report. At the same time, Greece's climatic factors are a major parameter that makes Greek tourism product particularly vulnerable to climate change. These two facts explain why the CCISC has chosen tourism as the starting point for its exploration of necessary adaptation measures.

The climate change impacts are of very high importance in Greece, especially on coastal areas, which constitute the main touristic product of the country, but also on water resources areas (rivers, lakes, reservoirs, etc.). The importance is related to attraction areas, infrastructure and general conditions for the well-being and enjoyment of tourists, etc. Some of the climate change effects related to the tourism sector are the following:

- The potential increase in temperatures could modify the frequency and intensity of extreme events or change the decision of the travellers about the destination or/and the duration of their stay.
- Water shortages could endanger the functional or economic viability of certain tourist areas, like Cyclades islands in Aegean Sea.
- The sea-level rise could threaten certain settlements and tourist infrastructures.

The study by Papoulis et al. (2015) surveys the opinion of the residents of the Athens area in Greece on a wide range of issues related to climate change, such as their environmental consciousness and awareness and their willingness to take action against climate change. This study was performed at a time of a severe economic crisis in Greece. Based on a questionnaire, this study examined the general trends reported on various environmental issues, more particularly concerning climate change. The main results are that Greek citizens are aware of the problems of environmental and of climate change and also believe that the environmental quality of Greece is quite poor. They believe they are fairly well informed about climate change. However, the current economic crisis in Greece has reversed the progress made in the past concerning the awareness of climate change. Also,

the citizens have very low confidence in the public authorities and the big enterprises to deal with climate change, while they have high level of trust in scientific and environmental organizations. They agree with public actions, but are against individual actions to protect the environment as they consider the main stakeholders (state, industry) to be mainly responsible for environmental degradation.

The main economic stakeholders related to the sector include **accommodation companies** (hotels, hostels, rural houses, campsites, tourist apartments, etc.), **catering business** (e.g. restaurants) and **transport**. There are also other economic activities related to the sector such as **tour operators**, **recreational business** (leisure, cultural, sport) and **renting activities**. The **public administration** should also be included (governmental agencies at national, regional and local level), as well as **civil and non-governmental associations**, **research institutions** and **users** of the touristic resources.

Finally, other economic activities, uses and stakeholders sharing space with touristic activity should be considered.

The experience of NCSRD based on previous projects and literature review related to the tourism sector included the following stakeholders:

- Governmental agencies at national, regional and local level.
- Research private companies

2.4.2 Stakeholder needs for coastal climate information in the Greek tourism sector

The national research program under the name “3 C’s, Climate Change Consequences”, funded under the “2007-2013 National Strategic Reference Framework”, and titled “The Study of Climatic Variations and Atmospheric Pollution in Greece: Assessment of Future Environmental and Socioeconomic Impacts at Local Scale”, placed emphasis on the design of a methodology framework for the estimation of climate change effects in Greece, by calculating the climatic parameters at rather high horizontal resolution and focusing on the social and economic impacts of the estimated climate variation at local scale (Western Greece) and especially at the tourism industry. The assessment of the impact of various effects driven by climate change in the case study areas was carried out based on various models incorporating environmental indicators and statistical local data. The “Development Municipal Company of Patras” and the “Tilos Park Association” participated as Stakeholders in the study. Their main interest was on the changing patterns of the tourism seasonal and monthly behaviour in the future period of 2040-2050, locally, due to climate change impacts on temperature and precipitation.

In the reports of the Bank of Greece, relevant issues are of great importance. There, it is mentioned that climate change is gradually shaping a new environment for Greek tourism. Its physical impact is expected to significantly affect the tourism industry in the medium and long term, aggravating some of its chronic weaknesses, while also highlighting new growth possibilities. Against this background, climate change considerations emerge as a key factor in policy making in the tourism sector. Starting with this sectoral study focused on the tourism industry, the Climate Change Impacts Study Committee (CCISC) of the Bank of Greece steps up its research into a climate change adaptation strategy.

Tourism is one of the most important sectors of the Greek economy in terms of both GDP and employment, and receipts from tourism offset part of the country's trade deficit. This, among other things, was shown by the 2011 CCISC Report "The Environmental, Economic and Social Impacts of Climate Change in Greece", an ambitious effort by Greek scientists that has offered much to the ongoing research on the impacts of climate change and serves as a point of reference in the relevant Greek and international literature.

The Report discusses how climate change can affect the country's tourism product and investigates the implications of human-induced climate change for sustainable growth and total quality management in tourism. It also attempts an evaluation of the impacts of climate change on tourism in financial terms, including by considering alternative sea level rise scenarios. Finally, it presents the sector's strategy and action plan for addressing the impacts of climate change, with a focus on growth policies and the challenges faced by Greek tourism, especially in the islands.

The analysis focuses on identifying the economic impacts of anthropogenic climate change on Greek tourism and on recommending policy measures for the sector in the context of a comprehensive strategy for the Greek economy's adaptation to climate change.

High temperatures, weather extremes, the redistribution or shortage of water resources and sea level rise (SLR) are just some of the physical impacts of climate change that are expected to have a considerable effect on the tourism industry. Two leading studies, one by the Deutsche Bank and the other by the World Tourism Organisation (WTO), forecast a redistribution of tourist arrivals in favour of countries with lower average summer temperatures, such as the Baltic, Scandinavian and Benelux countries, while the Mediterranean countries stand to lose their attractiveness.

The above-mentioned CCISC study examined the impacts of climate change on Greek tourism, both in physical and economic terms, and provided a model-based estimate of the economic impacts of anthropogenic climate change. However, it did not exhaust the subject, as the use of aggregate annual or nationwide data that lump together regions with very different climatic features was often found to be misleading.

In its conclusion, the 2011 report identified two primary objectives in respect of a strategic planning for Greek tourism: the need to extend the tourism season (reducing the pronounced seasonality of Greek tourism) and the need to geographically diversify Greece's tourism product to a larger part of the country. The achievement of these objectives requires that steps are taken to identify and market Greece's many, still unexploited, natural attractions, to develop and promote alternative eco-friendly forms of tourism, to attract new tourist target groups, and to enforce measures to reduce the industry's environmental footprint. Finally, the CCISC study also estimated that the operating costs to be incurred by accommodation establishments during the course of adaptation to climate change would increase by roughly 5-7% annually. Consequently, there is an urgent need to develop a long-term strategic plan for Greek tourism, in collaboration with State authorities and representatives from the tourism industry, on the basis of the two primary objectives outlined above.

The policies and actions for Greece's islands mainly involve the comprehensive management of coastal areas, combined with changes in land planning and in the legal framework governing construction with a view to reducing the risk of flooding, erosion, etc.

Actions are also needed to ensure the efficient use of resources, including land, water reserves, energy, and to replace fossil-fuel consuming vehicles at the local level with more eco-friendly means of transportation (e.g. electric vehicles, bicycles, public transportation). Moreover, production and use of local inputs with a smaller environmental footprint needs to be strengthened, as it would also help to diversify the tourism product. Businesses directly or indirectly involved with tourism must also be encouraged to improve their environmental performance. Local governments and public service providers in general can also play a crucial role not only by offering incentives, but also by undertaking information actions, encouraging social responsibility and implementing innovations for a better management of the climate change impacts on tourism.

In February 2013, the Climate Change Impacts Study Committee (CCISC) drafted an initial schedule for the development of a National Strategy of Adaptation to Climate Change. Below there are a few remarks concerning the next steps of the strategy development stage:

Although the in-depth analysis of specific adaptation policies in priority sectors, such as tourism, is in the initial phases carried out using "bottom-up" analyses, mitigation policy analyses may also be required, insofar as certain adaptation policies may directly involve emissions reduction. In any event, given the high uncertainty surrounding the impacts of climate change and matters such as cost, proper timing and efficiency of adaptation policies/measures, the recommended policies must, in the spirit of "adaptive adaptation", be flexible and adjustable to new developments and findings.

The sectoral adaptation policies need to be mainstreamed into broader public policies for these sectors, especially at times of limited available funding, economic recession or at best weak growth. It would therefore be useful to explore whether the banking and insurance sectors would be willing to support sectoral adaptation (and mitigation) policies, and to make an inventory and analysis of all initiatives regarding climate change and entrepreneurship.

Consultation with decision-makers, central and local government officials, professional associations and stakeholders in general should be held, with a view to incorporating feedback as input for future research proposals. Consultation is now recognised as an invaluable tool for (a) ensuring that research is oriented to users' practical needs; and (b) gauging and monitoring the social acceptance of research findings and (c) supplementing research data as well as keeping up-to-date on new options.

The Greek ministry of Environment and Energy considers the Climate Change as a major issue, as quoted below.

"Climate Change has already noticeable impacts, such as rising temperatures and sea level - due to the melting of Polar ice, and a more frequent occurrence of floods and storms. These impacts will have an effect, among others, on the balance of the ecosystem, water and food supply, public health, industry, agriculture and infrastructure. Evidence of recent scientific research on the 5th Assessment Report, by the Intergovernmental Panel for Climate Change (IPCC, AR5), has affirmed the negative impact of climate change. Dealing with climate change demands actions for the reduction of greenhouse gas emissions (mitigation) but also to prepare for the changes we cannot avoid (adaptation). On a national level, tackling climate change is a main priority for our Government and the Ministry of Environment and Energy. In order to deal with climate change, the actions

chosen will need to entail a change in the current development model towards a more sustainable low carbon economy. Developing such a model depends on the horizontal coordination of mitigation policies and adjustment in the sectors of energy, industry and agriculture. The cost of emission reduction and adjustment to climate change might be considered initially high, but it is lower than the cost if we take no action."

This adaptation policy by the ministry can be found in http://www.ypeka.gr/Default.aspx?tabid=303&language=el-GR, where the relevant legislation and the rules for the vulnerability reports and the adaptation strategy are considered in order to move to local plans according to the needs of each area.

A relevant decision of the Ministry was issued on 16/3/2017 where the specification of the regional plans for the adaptation in the climate change is described according to the relevant legislation, Article **43 of the Law 4414/2016.**

In the national strategy plan (April 2016) from the relevant report of the Ministry of environment, the vulnerability of the coasts to the sea level rise is declared and the adaptation to the climate change is set as priority issue. The same holds for the sector of tourism.

The following table includes some examples from NCSRD, a "research institution" which produces, manages and transform climate information into manageable information for other identified stakeholders in the "tourism" sector. These examples show significant climate information-related identified needs of other stakeholders.

Table 1: Stakeholder information needs in the Greek tourism sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Governmental agencies at national, regional and local level. Regional and local Development Agencies and Associations.	Climate information, including data variables are needed to analyse compatibility of touristic related uses with environmental restoration. Climate change adaptation strategies development.	Climate data: Sea level variables, such as storm surge and sea surface temperature. Climate change scenarios are at regional spatial scale. Impacts on tourism seasonal behaviour patterns due to climate change effects in temperature and precipitation (short and long term horizon).	Final information is disseminated trough cloud, web sites, reports and maps.	Main obstacle for the stakeholders is lack of qualified personnel	NCSRD (ref. 6)

2.5 The tourism sectors and stakeholder needs in Germany, Spain, France and Greece: summary of findings

Germany, Spain, France and Greece contributed to the review of stakeholder information needs in the tourism sector (see table below for a summary of findings in all four countries and tables in chapters 2.1.2, 2.2.2, 2.3.2, 2.4.2 for references).

Summarising, governmental agencies on local and regional level and companies were frequently found as stakeholders with documented climate information needs in the review of the four countries. The results reveal, above all, a need for climate information for developing climate change adaptation options in all four countries. One reason could be that this sector has been addressed in national adaptation plans and consequently, project reports and other relevant literature containing climate information needs have been published. Furthermore, climate information has been requested repeatedly to contextualize with environmental issues in and with plausible tourism development scenarios.

At several points, the review shows the need for more information about climate change effects and climate change scenarios at local and regional scale and for sea surface variables (e.g. sea surface temperature, waves). Against the background, that research institutes want to offer their own scientific data, the question arises whether only the offered data has been asked for, and therefore other information needs have been identified, less or kept unknown. Another reason could be that the documentation of stakeholder needs does not always distinguish between scientific information needs and the information needs of other stakeholders in the tourism sector. However, the need for specific climate data was not expressed in the German literature. There, it was described in more general terms as a need for more reliable and regionalized data about climate change effects (e.g. Knoblauch et al. 2012; Stelljes, 2012). Additionally, the scientific use of climate indices and parameters was mentioned in some German literature (e.g. Schuchardt et al., 2011; Bülow, et al., 2017; KUNTIKUM, 2009).

The review also shows preferred or requested formats of climate information, above all climate variables and scenarios, but also easily understandable information, summarized, for instance, in written form or as maps and graphics. German stakeholders expressed their need especially for information exchange between scientists, practitioners, communities and regional initiatives, and via networks, platforms, dialogue and discussions (e.g. Knoblauch et al. 2012; Schumacher et al., 2010a; Schumacher et al., 2012; Schumacher et al., 2010c; Stelljes, 2012; Filies, 2012).

Finally, frequently mentioned obstacles of using climate information by stakeholders in the tourism sector are: uncertainties in dealing with uncertain scientific climate information (e.g. related to climate change effects, coastal climate scenarios) as well as a temporal mismatch and minor priority, e.g. little consideration and lack of importance of climate change impacts on tourism.

Summary of stakeholder information needs in Germany, Spain, France and Greece: Tourism sector

	Stakeholders	Information needed for	Requested information	Requested formats	Main obstacles in using climate information
Germany	tourism industry, tourism administration, tourism associations, ministries acting in this sector, from local to regional level	climate adaptation and tourism development	more and precise information about climate change impacts on the sector and on local and regional scale, more reliable regionalized data/projections and regional climate models, climate indices/parameters (e.g. hot days, stormy days), local options for action, information on specific climate change related topics	information exchange between scientists, practitioners, communities and regional initiatives, and via networks, platforms, dialogue and discussions; print media; good-practice examples; trainings; information tailored to stakeholders' needs; compact, comprehensible and easily understandable	Short-term, seasonal planning instead of long-term strategic tourism concepts that consider future climate change effects; insufficient regionalized data about climate change effects; uncertainties about climate change effects; topic climate change and its effects not important enough
Spain	governmental agencies at national, regional, local level, private companies, Regional Ministry of Health	analysing compatibility of touristic related uses with environmental restoration to advice touristic private companies; establishing sanitary quality of bathing water at beaches; developing climate change adaptation options and strategies; supporting decision-making processes	sea level variables (e.g. storm surges, sea surface temperature, astronomical and meteorological tides, waves); climate change scenarios at local scale desired (e.g. hundreds of meters); statistical climate data; past, present, future climate information at regional scale	climate data, variables, scenarios; final developed information delivered as data, web sites, reports, maps, graphics, text format; easy-to-understand information	insufficient data at local level for evaluating tourism derived impacts; insecurity of stakeholders in dealing with uncertain scientific coastal climate scenarios; lack of understanding of scientific information about climate change impacts; lack of resources and qualified personnel
France	national group „Tourism" of the National Adaptation Plan (private and public stakeholders, small to medium size companies)	adaptation strategies for tourism sector that consider cross-sectoral aspects; tourism development compliant with climate change mitigation and environmental protection; assessing potential changes in geographical and seasonal distribution of tourism; training and communication	socio-economic, biophysical, climate change scenarios and information (e.g. sea level change scenarios, effects of sea level rise, air and sea surface temperatures, mean and extreme temperatures and precipitations, waves, currents, ocean acidification, eutrophication, impact to beaches and ecosystems)	climate data and scenarios	little consideration of climate change impacts on coastal tourism by the sector; need to engage the tourism sector and transportation sector (the transport component of tourism sector)

Greece	governmental agencies at national, regional, local level; regional and local development agencies and associations	analysing compatibility of touristic related uses with environmental restoration; developing climate change adaptation strategies	sea level variables (e.g. storm surge, sea surface temperature); climate change scenarios are at regional spatial scale; impacts of changing temperature and precipitation on tourism seasonal behaviour patterns (short and long term horizon)	climate variables and scenarios; Final information is disseminated trough cloud, web sites, reports and maps.	lack of qualified personnel

3 Climate information needs in the offshore energy sectors in Germany, Spain, France and Greece

In the third chapter, relevant stakeholders from the offshore energy sector in Germany, Spain and Greece are described, as well as findings from literature review regarding stakeholder needs for coastal climate information. It should be noted, that in Germany the "offshore energy sector" only includes findings from the offshore wind energy sector, whereas in Spain the marine energy sector (wind and waves) has been considered. In France, the energy sector is not included in the national adaptation plan. Thus, the offshore energy sector has not been addressed in projects on adaptation to climate change. Consequently, this sector was not subject of project reports or continuative literature. In Greece, the offshore energy sector is not very well developed, and the review findings are rather marginal.

3.1 The offshore wind energy sector in Germany

3.1.1 Stakeholders in the German offshore wind energy sector

In Germany, the documentation of stakeholder needs for climate information in the offshore energy sector is concentrating on the field of offshore wind energy, because it is the most important technique of offshore energy use in German marine areas. Other forms of offshore energy usage, such as natural oil and gas production, are of minor importance, as there are only two offshore facilities operating in German seas, so far. Apart from that, marine energy with its usable energy potentials from tidal ranges, waves, currents, salinity and temperature gradients, have not been developed so far in German marine areas (UBA, 2010).

The offshore wind energy sector is an important and still growing sector in the German North Sea region. In the German Baltic Sea region it is of minor relevance, but an expansion has been planned, too (Knoblauch et al., 2012). The expansion of offshore wind energy mainly takes place in the German Exclusive Economic Zone (AWZ), where deep waters and long distances to the coasts impose high technical and logistical demands on installation and maintenance procedures. Since the end of 2017, 15 offshore wind energy parks have been in operation in the German North Sea and 3 in the German Baltic Sea (UBA, 2014).

The offshore wind energy sector has not been addressed explicitly in the German Strategy for Adaptation to Climate Change (DAS). Nevertheless, the energy sector as a whole (including wind energy) is an important part of DAS (Die Bundesregierung, 2008).

Wind energy plants and production in offshore areas can be influenced by climate change related effects. On the one hand, higher mean wind velocities can lead to higher electricity yields (Dunkelberg, et al., 2011). On the other hand, more extreme weather events, stronger storms and higher waves can cause an increased risk of damages at the wind farms, long shutdown periods and extensive repairs. Higher wind speeds and higher waves

can also impede the installation and maintenance of offshore wind energy plants (Dengler, 2014; Ecologic Institute, 2014). However, frequency and duration of weather windows, that allow construction, repair and maintenance operations in offshore areas are not going to be changed significantly in the North Sea region in the future beside their natural fluctuations (Bülow et al., 2015).

The offshore wind energy sector incorporates a wide variety of stakeholders and connected interest groups, such as companies acting in the field of wind energy production and network industry, public authorities, research institutions and environmental organizations (Hoffman et al., 2011).

The offshore wind energy sector is an important sector in the German North Sea region, but also in the German Baltic Sea the expansion of offshore wind energy plants has been planned (Knoblauch et al., 2012).

In the German North Sea region, several projects involved stakeholders from the offshore wind energy sector in their project activities, such as the climate change adaptation oriented projects nordwest2050 and KLIWAS as well as the project COSYNA (Coastal Observing System for Northern and Arctic Seas). COSYNA, managed by HZG, develops an observing and modelling system for investigating mainly the coastal areas of the North Sea and of the Arctic region (HZG/COSYNA, 2018). The data portal of COSYNA provides meta data, observed data and model data about currents, waves, sea surface temperature, salinity and chlorophyll. During COSYNA project activities, interviews and workshops were carried out with representatives from offshore wind energy enterprises and also from other interest groups related to the offshore wind energy sector, such as scientists, engineers, regulatory bodies, insurance companies, and consulting (Eschenbach, 2017). The aim was to know more about their demand for oceanographic data and related products.

Interviews related to offshore wind energy were also conducted in the RA:dOst project in the German Baltic Sea area, interviewees were ministry representatives from the department of renewable energies and from other sector, such as climate protection.

Apart from that, scientists from research institutes and universities have been using oceanographic data and information for research activities related to offshore wind parks and offshore wind and marine energy. The data base coastDat at HZG provides such data, and the data requests have been registered (HZG/coastDat, 2018), although mainly in a very general manner. Information about downloaded data from the coastDat data bank that have been used in research related to offshore wind and marine energy can be found in several scientific articles (such as Weisse et al., 2015; Wiese, 2008; and Marx, 2010 for marine energy potential).

3.1.2 Stakeholder needs for coastal climate information in the German offshore wind energy sector

The review of project reports and scientific articles as well as the registered data downloads from the coastDat data bank (downloaded above all by offshore wind industry and research institutions) give some insight in used and needed climate information and their application by stakeholders from the offshore wind energy sector.

Climate information and data are mainly needed for (see tables 1 and 2 below for references and further details):

- designing, planning, installation, operation and maintenance of offshore wind farms
- realistic project scheduling
- research related to offshore wind parks (e.g. simulation tools for offshore wind park planning and weather dependent offshore activities, design and installation concepts for offshore wind parks)
- adaptation to increasing extreme weather events in the Baltic Sea
- expansion of offshore wind energy plants in the Baltic Sea

Stakeholders need above all the following data and information to realize the activities mentioned above (see tables 1 and 2 below for references and further details):

- current weather conditions and short-term forecasts (for several hours needed) about atmospheric and oceanographic conditions that allow safe operation (weather windows)
- forecasts of extreme events (e.g. storm surges)
- climate data such as wind speed, wind extremes, wind fields, storm scenarios, pressure, surge heights, sea water level, wave heights, currents, thermodynamic data, future changing sea conditions, temperature and precipitation
- information about climate change effects (such as stronger storms) on technical and economical wind energy potentials in the Baltic Sea region, offshore and onshore
- reliable climate scenarios
- climate data in high quality, freely available, current state as well as short,- medium- and long-term, historical climate data

The use of climate indices (e.g. frost days, stormy days) for developing adaptation measures to climate change effects and increasing extreme weather events by the energy sector was mentioned in Bülow, et al. (2017). However, this report does not reveal the explicit use of climate indices by the offshore wind energy sector.

Climate information is mainly requested as raw, processed or evaluated data, hindcasts and scenarios, above all by offshore wind energy companies and scientists. (see tables 1 and 2 below for references and further details). Complete, accurate and reliable data are preferred, as well as in high resolution, and provided by a user-friendly interface with

filter function (requested by potential COSYNA product users). The data should be provided for 24 hours a day and 7 days a week and with warranty, which has not been feasible by COSYNA (Eschenbach, 2017). With regard to the COSYNA data, it should be mentioned that only a small portion of data has been downloaded from industry and small and medium enterprises, the highest data download has been carried out by scientists, followed by administration (ibid.). These findings (the focus on requested data and scenarios) can partly be explained because most references included in the review about this sector refer to registered data requests at the coastDat data base or to data products offered by the COSYNA data portal. This means that stakeholders with a need for climate information in other formats than data or scenarios would not request it at these portals. These stakeholders might not be included in this review.

With regard to possible obstacles in using climate information, the literature review shows the following main obstacles (see tables 1 and 2 below for references and further details):

- Uncertainty: unreliable climate change scenarios
- Priority: climate change and adaptation not very relevant topics
- Temporal mismatch: data not provided on 7 days a week over 24 hours, no warranty given regarding the data

The literature review indicates that climate information has been used regularly in the sector, mainly for offshore installation, operation and maintenance activities and research. However, the sector seems not very engaged in activities related to climate change adaptation yet.

Table 1: Stakeholder needs in the offshore wind energy sector at the German North Sea coast

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Project nordwest2050: Wind energy company in the metropolitan region Bremen-Oldenburg, interviews with 5 persons (3 of them with leading positions in the company)	Planning, construction, maintenance and repair of wind parks onshore (and probably offshore)	Weather and long-term specifications of the parameters temperature, wind speed and precipitation; reliable climate scenarios	Not precised	Reliable climate change scenarios do not exist, current scenarios should not be basis for concrete action; climate change and climate adaptation are not considered as very relevant topics; “climate” and “climate adaptation” are very complex topics	Fichter et al., 2013
Project KLIWAS – Impacts of climate change on waterways and navigation, Sub-project 3.01: Impacts of climate change on navigation and other uses of the sea	Construction and operation, insertion of cables, material supply and maintenance traffic; energy production; economic planning of wind parks; securing stability of offshore structures	Information needed about current weather conditions and short-term forecasts about atmospheric and oceanographic conditions that allow safe operation; medium-range wind forecasting; long-term possible wind yields; long-term mean changes and short-term wind extremes; information about future changing sea conditions in German Bight (e.g. higher waves) especially important for offshore industry	Not precised	Not precised	Bülow et al., 2015
Offshore wind energy companies	Designing, planning, installation and maintenance of offshore wind farms	Used data: information about extended periods with wave heights below a given threshold to enable installation and/or maintenance (weather windows); return periods of extreme wind speed, surge and	Data from coastDat data base, hindcasts, scenarios	Not precised	www.coastdat.de

		wave heights; offshore wind, wind and sea state statistics/data, currents			
Offshore wind logistics	realistic project scheduling	Used data: realistic assessments of the probability of weather windows	Data from coastDat data base		Weisse et al., 2015
Universities, research institutes with research related to offshore wind parks and offshore wind energy	e.g. developing simulation tools for offshore wind farm planning and weather dependency of installation, operation and maintenance activities; maritime logistics and concepts of realization to install offshore wind farms; modeling offshore statistics; testing design concepts for installation methods of offshore platforms; potential of refitting offshore wind farms; assessing potential of wave power in the North Sea; modeling optimized energy systems	Used data: wind and sea state data/statistics, wave spectra, sea wave state, currents, offshore wind and pressure, storm scenarios, water level North Sea and Baltic Sea, thermodynamic data	Data from coastDat data base	Not precised	www.coastdat.de
Scientific users	To estimate marine energy potential along the German North and Baltic Sea coasts	Used data: data from waves and currents: significant wave height, wave period and water depth	Data from coastDat data base: numeric models; wave model, circulation model, climate scenarios	Not precised	Marx, 2010
Scientific study, scientific users	To simulate the impacts on the national grid for a scenario in which all planned offshore wind farms in the German exclusive economic zone in the North Sea are fully operational	Used data: modeled wave data set in hourly resolution and 50x50 km grid of the year 2006	Data from coastDat data base: modeled data	Not precised	Wiese, 2008
Scientific users: Renewable Energy Pathway Simulation	Developing renpass for solar, wind and water power, for simulating different	Used data: historical climate information, solar and wind feed-in calculated on an	High resolution climate data and information from coastDat-2 data base	Not precised	Weisse et al., 2015; www.coastdat.de

System - renpass, University of Flensburg	transition pathways between present and future energy systems	hourly basis; offshore and onshore wind and cloud cover data			
Project COSYNA: Interest groups from offshore wind energy sector (scientists, engineers, regulatory bodies, insurance companies, consulting, offshore wind energy enterprises) as (potential) users of the COSYNA product "Surface Current Fields in the German Bight", interviews and workshops with participants	Planning, construction and operation of offshore wind farms, maintenance procedures under different weather and oceanographic conditions in the North Sea	regularly used: weather forecasts, including oceanographic data; demand for additional high-quality and freely available meteorological and oceanographic data, especially on currents and wind fields, forecasts for several hours, forecasts of extreme events, e.g. storm surges; information on currents, waves, and winds to enable safe construction and maintenance operations; information on sea and wave conditions along the shipping routes that will be regularly travelled to perform maintenance of offshore wind farms	raw, processed and evaluated data in various formats are used and required; consistent and complete data sets (without gaps) as well as accurate and reliable data are essential; user-friendly interfaces with elaborated filter functions are helpful; time slots with certain weather conditions should easily be identified; data should be provided 24 hours a day and 7 days a week (24/7) and with warranty	COSYNA cannot provide 24/7 and with warranty; highest data download from scientists, followed by administration, only a small portion of data download from industry and small and medium enterprises	Eschenbach, 2017
Project ReKliEs-DE – Regional climate projections, ensemble for Germany: energy sector in Germany	adaptation measures to climate change effects and extreme weather events, such as stronger storms, heavy rainfall, hail, increasing temperatures, heat and droughts	climate indices show future climate development; climate indices already used in measures concerning the German Adaptation Strategy: e.g. mean monthly air temperature, mean seasonal air temperature, hot days, frost days, ice days, days with extreme high precipitation, days with heavy winds, stormy days; further useful climate indices: days with snow cover, (extreme) humid days, frequency distribution of multi-day sums of precipitation, drought index, temperature	Indices and parameters, hydrology models, regional climate model data	Not precised	Bülow et al., 2017

Table 2: Stakeholder needs in the offshore wind energy sector at the German Baltic Sea coast

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
project RADOST: interviews with representatives from the Ministry of Economics Schleswig-Holstein (department renewable energies), representatives from other sectors (e.g. climate protection, agriculture, nature protection)	Planned expansion of offshore wind energy plants	Research needs: Does stronger wind mainly create more wind energy, or do storms rather endanger the offshore wind energy plants?	Not precised	Adaptation measures to climate change implications not seen yet as necessary and mainly unknown	Knoblauch et al., 2012
project RADOST: wind energy sector (offshore and onshore) in the German Baltic Sea region	Adaptation measures to increasing extreme weather events, stronger storms, higher waves; planning of new plants	More information needed about climate change effects on technical and economical wind energy potentials, offshore and onshore	Not precised	Not precised	Ecologic Institute, 2013; Ecologic Institute, 2014; RADOST poster

3.2 The offshore energy sector in Spain

3.2.1 Stakeholders in the Spanish offshore energy sector

With just 0.1% of the potential energy of the oceans, the world's energy demand could be satisfied fivefold. Studies estimate that marine offshore wind energy devices would be able to produce 70% of the world renewable energy by the year 2020 (WindEurope). By 2050, marine renewable energies (e.g. waves, wind) should supply 15% of the European energy requirements, creating 470.000 new jobs and avoiding the emission of more than 130 million tons of CO2.

Such an important sector has several stakeholders involved. **National governments**, including several agencies (which may often become a problem, as stated in Simas et al. (2012), energy **test centres**, and **private companies/developers** are maybe the main entities. **Environmental** and **socio-economics** actors are also necessary together with **universities** and **research institutions**, both public and private. Finally, we should also consider **other economic activities, uses and stakeholders** operating around energy generation areas (local communities, commercial fishing, surfing, and other users of marine areas for recreation and commercial purposes) as reflected in Simas et al. (2012).

Main stakeholders identified on the experience gained by IHCantabria in the offshore energy sector are related mainly to private energy companies, energy test centres and developers. Main activity regarding test centres is located in the north coast of Spain (BIMEP) and Canary Islands (PLOCAN).

Stakeholders involvement is mainly performed through workshop during and after projects development with the objective of disseminating and raising awareness on the different issues related to ports and navigation.

3.2.2 Stakeholder needs for coastal climate information in the Spanish offshore energy sector

Considering mainly UC-IHC experiences gained in previous projects, stakeholder needs are shown in the following table. The examples shown below contribute to understand relevant information needs of stakeholders related to offshore energy sector. Energy test centers in Spain, in which UC-IHC is involved, are included as relevant examples of climate information demanded by the sector. Besides, it is also highlighted some information needed by private energy companies, based on different projects and on specific requests made to UC-IHC regarding climate data and information.

Table 1: Stakeholder needs in the Spanish offshore energy sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Energy test centres managers; Developers; Research institutions	Research activities, development of: Management tools for ocean renewable energy test sites; Methodologies for small- scale testing; Prototypes design. Product development: design of test campaigns for pre-commercial devices and components of marine renewable energy converters. Information is incorporated into the daily business and the decision- making and planning process.	Climate data: wind, waves, marine currents and sea level. Historical climate data (~30 years) and short term predictions are needed. High spatial resolution (from 600m to 50m)	Information is received and transferred through online provider and attached to emails.	Users do not get used easily to use developed tools.	UC-IHC IHC Offshore energy research group http://bimep.com/ http://dss.trlplus.com/ http://www.plocan.eu/index.php/es
Private companies	Research; Product development Information is incorporated into the daily business and the decision- making and planning process.	Climate data: waves, wind, marine currents, sea level. Past, present and future. Local scale.	Climate data received through interoperability access (FTP, OpenDap), attached to email and external drive devices. Final developed information is delivered to the stakeholders in the form of data, reports, websites, and personal interviews.	Lack of resources and qualified personnel. Stakeholder needs tailored and easily to understand products.	UC-IHC IHC Offshore energy research group

Climate data is essential for developing this offshore energy related studies, and transformed information is essential for the daily business and decision-making process in the sector. Stakeholders need tailored and easily to understand products. Even if target stakeholders (as some developers and research institutions related to this sector) are more familiar and have knowledge on climate data, final products must be tailored, useful, attractive and easy to use.

It is remarkable that all climate information developed (historical and predictions) in some of the projects (related to energy test centres) is open access (see links in table above), which make a clear difference with other test sites of the same type. This open accessible climate information is also a focus of attraction for other developers, so it seems that other test sites around the world have adopted the same strategy.

Interaction with stakeholders is mainly performed by meetings regarding the definition and specification of the scope of the project (at the beginning of the project), for monitoring and evaluation (intermediate meetings) and final presentation (end of project).

3.3 The offshore energy sector in France

In France, the energy sector is not included in the national adaptation plan. Thus, the offshore energy sector has not been addressed in projects on adaptation to climate change. Consequently, this sector was not subject of project reports or continuative literature.

3.4 The offshore energy sector in Greece

3.4.1 Stakeholders in the Greek offshore energy sector

National government and **private companies/developers** are maybe the main entities. **Universities** and **research institutions** should also be considered, as well as **other economic activities, uses and stakeholders** operating around energy generation areas (local communities, surfing and other users of marine areas for recreation and commercial purposes).

Main stakeholders identified on the experience gained by NCSRD in the offshore energy sector are related mainly with private energy companies. Hellenic Petroleum S.A. (HELPE) is one of the largest oil companies in the Balkans and operates all its refineries on coastal areas. Moreover, the oil company is also engaged on offshore oil and gas exploration as well as on trading and transportation. Long term sustainability and infrastructure protection is of key interest to the particular industry.

3.4.2 Stakeholder needs for coastal climate information in the Greek offshore energy sector

In Greece, the offshore energy domain is not well developed. The state regulations are confusing and do not allow the development of such activities. However, a number of renewable energy related research projects have been performed like MARINA and MOSEP.

The objective of the MARINA Platform project was to establish a set of equitable and transparent criteria for the evaluation of multi-purpose platforms for marine renewable energy (MRE) all focussed on system integration and reducing costs. One way of reducing costs is to exploit synergies with other technologies. One effective choice is to combine

offshore wind with other Marine Renewable Energy (MRE) technologies; primarily wave energy, but also ocean and/or tidal currents at sites where these resources are concentrated. If costs can be reduced to a competitive level, the potential for wind farms in deeper waters is huge. These will be brought to the level of preliminary engineering designs with estimates for energy output, material sizes and weights, platform dimensions, component specifications and other relevant factors. This will allow the resultant new multi-purpose MRE platform designs, validated by advanced modelling and tank-testing at reduced scale, to be taken to the next stage of development, which is the construction of pilot scale platforms for testing at sea. Recognising the complexity of the challenge, and the significant development risks, MARINA is primarily a research project focused on the longer-term benefits and synergies of integrating deep-water wind and ocean energy. However, its progress will be greatly assisted by the ambition of industrial sector.

The program "Monitoring the Wind and Sea Wave Energy Potential" (MOSEP) had as main target the development of an integrated, high resolution system for quantifying and monitoring the energy potential from wind and sea waves in the region of Eastern Mediterranean Sea with special emphasis to the Greece sea area.

The project was funded by the General Secretariat for Research and Technology of Greece and was hosted by the Hellenic Naval Academy and the Oceanography Center of Cyprus.

The main goals of the project were:

- To develop new-advanced models for the estimation of the energy potential from wind and waves over sea areas.
- To test and use atmospheric and sea wave numerical models for monitoring the wind and wave conditions that are necessary for estimating the corresponding energy potential.
- To produce a detailed, high resolution digital atlas containing complete maps for the coastal and offshore areas of Greece, in which sea wave and wind climatological characteristics as well as the relevant distribution of the wave energy potential will be monitoring.

These targets were being pursuit by the use of advanced multi-disciplinary tools, combining statistical techniques with recent advances in atmospheric and wave modeling, in order to provide a state-of-the-art physical wind and wave analysis monitoring system. The latter are able to provide high resolution analysis of the sea state characteristics as well as accurate estimation of the wind and wave power potential.

The results of previous international projects were being employed and especially those of CIRCE (Climate Change and Impact Research: the Mediterranean Environment), POW'WOW (Prediction Of Waves, Wakes and Offshore Wind), MyOcean (Ocean Monitoring and Forecasting) and Marina Platform, where high resolution studies were performed in the Mediterranean Sea.

The following table includes some examples from NCSRD, a "research institution" stakeholder who produces, manages and transforms climate information into manageable information for the other identified stakeholders in the "offshore energy" sector.

Table 1: Stakeholder needs in the Greek offshore energy sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Research institutions. Private Companies (Hellenic Petroleum SA)	Climate information is mainly developed for research activities and product development. Infrastructure sustainability and protection.	Climate data: Extreme precipitation, Floods, Sea level rise, Extreme temperatures, Extreme wind	No particular format /cloud, ftp, websites	Users do not get used easily to use such information.	UoA (ref.1), Hellenic Naval Academy (ref.2)

3.5 The offshore energy sectors and stakeholder needs in Germany, Spain, France and Greece: summary of findings

The documentation of stakeholder needs from the offshore energy sector for climate information is based on contributions by Germany, Spain and Greece (see table below with a summary of review findings).

Whereas the contributions from Germany are related to stakeholder needs from the offshore wind energy sector, the Spanish and Greek review findings concentrate on stakeholders engaged in the field of marine renewable energy (e.g. wind, waves). Private companies (in Germany: offshore wind energy companies), research institutes and energy test centres for renewable energy in Spain were the main stakeholder groups where information needs could be documented. In Germany, weather and climate information has been requested mainly for installation, operation and maintenance of offshore wind farms and developing adaptation measures to increasing extreme weather events. In Spain and Greece, climate information needs are mainly related to supporting the usage of marine renewable energy (see tables in chapters 3.1.2, 3.2.2 and 3.4.2 for references).

The requested climate information in the three countries mainly embrace past, present and future climate information (e.g. wind, waves, marine currents, sea level), historical climate data, short term predictions and possible future climate scenarios. The preferred formats are, especially in Germany, high resolution climate data as well as predictions, in Spain and Greece also information provided in an easily understandable way, for instance as reports and web sites. The review findings indicate that preferably these climate information have been requested that also have been offered by research institutions and data base providers. This means that information requests beyond these offers have not been determined.

Obstacles in using climate information were found in the reviews but vary between the three countries. For the German offshore wind energy sector, a missing operational service is one obstacle in using the data, whereas in Spain and Greece above all difficulties in using tools and products related to ocean renewable energy impede the use of climate information.

Summary of stakeholder information needs in Germany, Spain, France and Greece: Offshore energy sector

	Stakeholders	Information needed for	Requested information	Requested formats	Main obstacles in using climate information
Germany	offshore wind energy companies including logistics; regulatory bodies; ministry acting in the field of renewable energy; universities and research institutes	designing, planning, installation, operation and maintenance of offshore wind farms; adaptation measures to climate change effects and increasing extreme weather events; realistic project scheduling; research related to offshore wind parks	current weather conditions and short-, medium-term forecasts about atmospheric and oceanographic conditions that allow safe operation (weather windows); forecasts of extreme events (e.g. storm surges); climate data e.g.: wind speed (short and long term), wind extremes, surge heights, sea water level, wave data, currents; storm scenarios; historical climate data; thermodynamic conditions; future changing sea conditions; climate change effects on technical and economical wind energy potentials	raw, processed or evaluated data, hindcasts, models and scenarios; climate indices; complete, accurate and reliable data and data sets; high resolution climate data; data should be provided for 24 hours a day and 7 days a week and with warranty	data not provided on 7 days a week over 24 hours; no warranty for data; unreliable climate change scenarios; climate change and adaptation very complex and not very relevant topics
Spain	energy test centres managers, developers; private companies; research institutions	research and developing management tools for ocean renewable energy test sites (e.g. waves, wind), methodologies for small-scale testing, prototypes design, product development	past, present and future climate date at local scale (e.g. wind, waves, marine currents, sea level); historical climate data (~30 years) and short term predictions needed; high spatial resolution	climate data, predictions; final developed information delivered as data, reports, websites, and through personal interviews	users do not get used easily to developed tools; lack of resources and qualified personnel; stakeholders need tailored and easily to understand products
France	No information available	No information available	No information available	No information available	No information available
Greece	research institutions; private companies	research activities and product development; infrastructure sustainability and protection	extreme precipitation, floods, sea level rise, extreme temperatures, extreme wind	climate data	users do not get used easily to use such information

4 Climate information needs in the maritime navigation and ports sectors in Germany, Spain, France and Greece

In the following, relevant stakeholders of the maritime navigation and ports sector in the four project partner countries are described. Findings from the literature review regarding stakeholder needs for coastal climate information are documented.

4.1 The maritime navigation and ports sector in Germany

4.1.1 Stakeholders in the German maritime navigation and ports sector

Ports and connected industries, such as logistics, and maritime navigation are central socio-economic factors in the German coastal areas and adjacent regions. Ports function as economical and logistical hubs in the global economy, they are industrial and service locations of high relevance and very important employers in the German North Sea and Baltic Sea region (Osthorst and Kupczyk, 2014). Mayor seaport locations at the German North Sea coast are for instance Hamburg, Bremerhaven, Wilhelmshaven and Bremen, and at the German Baltic Sea coast for instance Rostock, Lübeck, Wismar and Kiel. The big German North Sea ports are characterized by oversea traffic, at which the container transport is of special importance for Hamburg and Bremen/Bremerhaven, and the oil import has a high relevance for Wilhelmshaven. In contrast to that, the German Baltic Sea ports are characterized mainly by ferry traffic between Baltic Sea neighbouring states and the regional transport of bulk goods. The economic importance of seaports and maritime transport can also be shown by the following numbers: about 60% of Germany's exports are seaborn, as well as nearly 100% of the raw material imports (FIS, 2017).

Ports and maritime navigation have been addressed in the German Strategy for Adaptation to Climate Change (DAS) as part of the traffic sector (Die Bundesregierung, 2008). Because of their high economic significance and geographical position at coasts and rivers, ports are especially vulnerable to climate change effects such as sea level rise and increasing extreme weather events like storm surges, storms, floods, heavy rain, hail, and extreme heat periods. Port infrastructure can be flooded and damaged, loading and unloading of ships can become considerably more difficult, increasing temperatures can complicate the cooling of perishable goods (Schuchardt and Wittig, 2012). More storms and changes in currents and sea state (such as more high waves) as well as changes in sedimentation in estuaries and maritime shipping routes may influence the economic viability of these shipping routes and the technical requirements of shipbuilding and can impede navigation and mooring of ships (Ecologic Institute, 2014; Die Bundesregierung, 2008).

In the German North Sea and Baltic Sea region several projects (e.g. nordwest2050, KLIWAS, Klimzug-Nord, RADOST) have interacted with stakeholders from the ports and logistics and marine traffic sector. These projects were focusing on the development of adaptation strategies to climate change.

Stakeholder groups involved in these projects included ports industries and logistics, ports in Lübeck (Baltic Sea coast), port authorities and management, public authorities, waterways and shipping offices, companies from the maritime navigation sector, such as transshipping companies, shipyards, shipping companies, shipbuilding companies, as well as research institutions.

Stakeholders (mainly from port management, port authorities and shipping industry) were involved in project activities through interviews, talks, workshops and online surveys, other stakeholders were engaged in networking activities, initiated by the RADOST project. KLIWAS initiated sensitivity studies and research in a cooperation between universities, research institutes and public agencies about climate change impacts on maritime navigation routes (Seiffert et al., 2014; BMVI, 2015).

Apart from the project reports generated in the projects mentioned above, further literature could reveal insights in information needs of Hamburg Port (river Elbe estuary, North Sea coast region) (von Storch et al., 2017).

4.1.2 Stakeholder needs for coastal climate information in the German maritime navigation and ports sector

As the projects nordwest2050, Klimzug-Nord, KLIWAS and RA:dOst focused on climate change and adaptation aspects, the literature research shows a strong stakeholder demand for information with regard to this topic. Referring to the focus of the projects' activities and discussions, stakeholders from the ports/marine traffic sector need climate information mainly for developing adaptation strategies and measures to climate change impacts, above all to the effects of increasing extreme weather events, such as higher risk of damage and malfunctions through more stormy days and higher maximum wind speeds, increased number of flooding events of port infrastructure through sea level rise, and higher mean high tides (see tables 1 and 2 below for references and further details).

More precisely, weather and climate information are needed and used for (see tables 1 and 2 for references and further details):

- Climate-adapted port management, port development planning and construction projects, technical and non-technical adaptation measures.
- Site-specific vulnerability studies for ports at the Baltic Sea coast, with regard to climate change.
- Sensitivity and vulnerability studies of maritime navigation routes, with special regard to the effects of storm surges on estuaries and the effectiveness of flood barriers.
- Navigation and operation in the day-to-day business.

- Addressing further research on climate-adapted transport logistics at ports as well as about climate change impacts on traffic areas, depots, quay walls, irrigation and drainage systems.
- A deepened research on early warning of extreme weather events.
- Intensifying estuary systems research, such as about the effects of climate change on mudflats.

Referring to the reviewed literature, stakeholders from ports and maritime traffic related industries and institutions need climate information such as (see tables 1 and 2 in this chapter for references and further details):

- more reliable information about regional climate change impacts on ports in Hamburg and Lübeck (such as more extreme storm surges, sea level rise, higher mean wind velocity) as well as about risks and chances of climate change
- general recommendations for action as well as specific planning proposals concerning climate change and adaptation
- current, short- and medium term weather information, especially for navigation purposes
- changed rated values for safeguarding the port infrastructure

During research activities conducted in the projects mentioned above (e.g. on optimized ship design to improve navigation and customers' comfort, for sensitivity studies related to maritime navigation routes), a wide variety of climate data and information have been used, for instance (see tables 1 and 2 below for references and further details):

- current sea state conditions
- historical wave climate and wave climate extremes
- historical storm surges, storm surge model
- water level data, water inflow and runoff
- wind field data
- sea level rise scenarios

The requested format of information depends, of course, on the specific needs of the different user groups. Scientists need and use climate information in the format of e.g. measured data, hindcasts, scatter diagrams, scenarios and model simulations. In contrast, representatives from public and port authorities as well as from the shipping industry requested prepared, target-group specific and comprehensible information about climate change impacts and adaptation measures (see tables 1 and 2 in this chapter for references and further details).

Main obstacles in using climate information by stakeholders that could be found in literature are (see tables 1 and 2 below for references and further details):

- Uncertainties and vague information about climate change effects and its occurrence
- Temporal mismatch: a short time horizon for planning purposes that does not correspond with long-term climate change prognoses, as well as

- Minor priority: personnel, time and financial constraints to implement climate adaptation measures.

The literature review indicates that climate information (such as weather forecasts or information about climate change) has been used regularly in the day-to-day business, especially in the areas of marine navigation and port development. Though, the knowledge about climate change and its probable impacts on the sector is still quite fragmented.

Table 1: Stakeholder needs in the maritime navigation and ports sector in the German North Sea region

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Project nordwest2050: Ports industries and logistics (e.g. Niedersachsen Ports) in the metropolitan region Bremen-Oldenburg	Adaptation measures and strategies for port infrastructure regarding the effects of climate change such as higher risk of damage and malfunctions through more stormy days and higher maximum wind speeds, increased number of flooding events of port infrastructure through sea level rise and higher mean high tides; climate-adapted port management; development of integrated and innovative concepts	changed rated values for safeguarding the port infrastructure should be considered; research and development is needed in the areas of climate-adapted transport logistics and early warning of extreme weather events	Not precised	Not precised	Osthorst et al., 2014
Project Klimzug-Nord: stakeholder interviews with representatives from public authorities and associations from the sectors water management, port management, urban planning, public transport in Hamburg-Wilhelmsburg	Adaptation measures to the effects of climate change in the district of Hamburg-Wilhelmsburg	stakeholders are interested in information about water level development of the river Elbe, water run-off, adapted dyke heights, recommended management measures; general climate projections; general recommendations for action concerning climate change and adaptation measures as well as specific planning proposals and impact models of specific measures and their effects; documentation and communication of	Project results should be prepared and tailored to the interest groups' needs, e.g. range of outcomes for the planning sector, extreme events and frequencies for political decision makers; overview map	Not precised	Schlünzen & Linde, 2014

		uncertainties of the project results important for decision-makers in politics and administration	or maps with 1km-grids		
Project KLIWAS – Impacts of climate change on waterways and navigation, Sub-project 3.01: Impacts of climate change on navigation and other uses of the sea; here: Maritime navigation	Navigation and operation	Fishing vessels need short-term and medium-term weather forecasts to decide whether fishing will be possible; Navigation rather needs current and short-term weather information	Weather forecasts	Not precised	Bülow et al., 2015
Project KLIWAS – Impacts of climate change on waterways and navigation, Sub-projects 2.04/3.02 about possibly affected maritime navigation routes by climate change; Cooperation between universities, research institutes and public agencies	Sensitivity study about the effects of storm surges in the estuaries Elbe, Jade-Weser, Ems; development of adaptation measures for federal waterways to climate change	Used information and models: historical storm surges, storm surge models of Elbe, Jade-Weser, Ems, measured time-series of the water level at the edge to the North Sea, sea level rise (+25, 80, 115cm), water runoff, scenarios of upstream water inflow, wind fields during storm surges, calculation of peak water levels during storm surges	Used: measured data, scenarios, model simulations	Not precised	Seiffert et al., 2014; BMVI, 2015
	Sensitivity study about adaptation options to climate change: effectiveness of flood barrages at different sea level rises and upstream water inflows	Used information and models: historical storm surges, storm surge models, sea level rise (+80cm), water levels at the edge to the North Sea from North Sea model simulations plus measured data, wind fields, measured upstream water inflows			
	Research for a better understanding of estuary systems	Research needs regarding estuaries: interactions between sea level rise and morphological changes (e.g. growing mudflads) to better describe the possible future state of estuaries; long-lasting morphodynamic simulations as there still exist big uncertainties; development of	Not precised		

		dynamic modelling with global models with higher resolution (7.5 – 10km). Are changes in design specifications for infrastructure and operation necessary?			
Hamburg Port	Developing an adaptation strategy to climate change impacts and extreme weather events	Scientists: Research need to develop a reliable basis for decision making: more reliable information about potential threat and probability of occurrence of climate change impacts (e.g. storm surges, sea level rise) as well as about vulnerability of Hamburg Port needed, evaluation of risks and chances for Hamburg Port with regard to climate change adaptation useful	Not precised	Lack of concrete information about climate change impacts and their probability of occurrence, differences between short planning periods (5-10 years) for decision makers and long-term prognoses (50-100 years) in climate research	Von Storch et al., 2017

Table 2: Stakeholder needs in the maritime navigation and ports sector in the German Baltic Sea region

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
project RADOST: network developed with about 40 representatives from port authorities, waterways and shipping offices, transshipping companies, shipyards, other companies located at German Baltic Sea ports	Developing site-specific adaptation strategies to climate change effects and vulnerability studies for every port necessary	Information about risks and chances of climate change needed	Used information channels: professional events for network partners with suitably presented up-to-date information about climate change in the Baltic Sea area, bilateral talks with representatives from port authorities and port industries about challenges for ports regarding climate change	Not precised	Ecologic Institute, 2014,
project RADOST: public ports of the Hanseatic City of Lübeck, talk with terminal operators	Developing an adaptation strategy to climate change effects	Knowledge about climate change effects at location Lübeck (e.g. higher mean temperature, changes in precipitation patterns, less ice cover, sea level rise, higher mean wind velocity, more extreme storm surges) are supposed to be considered in future investments	Not precised	Planning period for day-to-day-operations (about 5-10 years) does not correspond with long time periods of potential climate changes, climate scenarios referring to the end of the century not very important for the ports' current decisions and investment plans	Ecologic Institute, 2014; Wenzel & Treptow, 2013; von Storch et al., 2017
project RADOST: application project with Flensburger Schiffbaugesellschaft (FSG), a vessel manufacturer in the city of Flensburg	Optimizing ship designs by integrating sea state and flow calculations in the design system	Used information: current sea state conditions important as lifetime of ships shorter than time period of climate change; historical information on the wave climate in	Used data and methods: met-ocean hindcasts from coastDat-2, scatter diagrams showing long-term distribution of expected	Not precised	Ecologic Institute, 2014; Wöckner-Kluwe et al., n.n.; Weisse et al., 2015

		the region the vessel is going to operate, wave climate extremes for assessing the behavior of vessels in extreme situations, recorded sea state conditions from 1958-2002, data on wind directions,	wave height/wave length combinations, numerical simulations of ship movements		
project RADOST: online survey with representatives from 10 port authorities in the German Baltic Sea area about impacts of climate change on ports and adaptation measures	About half of the ports use knowledge about climate change in own construction projects, port development planning, technical and non-technical adaptation measures	Ports desire: locational vulnerability studies concerning storm surges (>2m above sea level) and, if necessary, development of adaptation measures, information about climate change effects, technical adaptation measures and examples, funding programs; researcher: research needs regarding climate change impacts on traffic areas, depots, quay walls, irrigation and drainage systems because of planned investments in these areas within near future	Researcher: more application-oriented and comprehensible information about impacts of climate change and possible adaptation measures necessary, targeted dissemination of information	Uncertainty and incomprehensibility regarding climate change information, doubts about climate change effects	Schröder et al., 2013
project RADOST: 8 expert interviews with representatives from port authorities, transshipment companies, shipping companies, shipbuilding companies about climate change and need for adaptation, 3 workshops, online survey, talks to stakeholders	Developing adaptation strategies to climate change effects	Researchers: data and information about regional climate change and its effects needed for climate impact analysis and	Target-group specific preparation of current and relevant information concerning results of climate research	Uncertainty and rejection regarding climate projections, climate parameters with broad ranges of change and long-term climate scenarios; personnel, time, financial constraints to implement climate adaptation measures	Schröder & Hirschfeld, 2014

4.2 The maritime navigation and ports sector in Spain

4.2.1 Stakeholders in the Spanish maritime navigation and ports sector

Ports and marine traffic are not identified as specific sectors in the Spanish National Adaptation Plan or National Communications. However, they are included as part of the transport sector and the coastal areas field. In addition, Spanish National Port Authority edited in 2016 the book entitled *Vulnerabilidad de los puertos españoles ante el cambio climático* (Vulnerability of Spanish ports to Climate Change), since ports have a significant relevance within the country economic activity.

Ports are indeed strategic infrastructures for a city, a region and a country. They represent a significant resource for employment, as well as a focus of attraction to other economic activities, besides the transport and the navigation. Several other economic sectors have some relationship with ports, so that maintain them fully functioning is an important policy priority. According to MAPAMA report (2016), ports are the main channel in Spain for imports (85%) and exports (around 60%).

Ports and navigation are very sensitive to climate variability and climate change since they determine both port operability and establishment of efficient and secure maritime routes. These issues, in turn, may affect several other dependant sectors, with significant economic implications.

According to the previous ideas, there are several topics involved within this sector, such as water quality, environmental impacts, sediment transport, weather forecast, port operability, navigation, oil spill prevention and response, etc.

Main stakeholders identified by UC-IHC in this sector in Spain, are **national, regional and local government**, **port authorities** (also at national, regional and local level), **public works agencies**, **civil protection**, **maritime rescue agencies** and **oil and gas companies**. Other international **research institutions** as well as research private consultancies are also involved. These stakeholders, just as ports, are distributed all-across the Spanish coast.

Stakeholders involvement is mainly performed through workshop during and after project developments with the objective of disseminating and raising awareness on the different issues related to ports and navigation. Sometimes, only experts meetings are carried out with decision-makers and responsible of monitoring the project.

4.2.2 Stakeholder needs for coastal climate information in the Spanish maritime navigation and ports sector

Considering mainly UC-IHC experiences gained in previous projects, stakeholder needs are shown in the following table. The examples shown below contribute to understand relevant information needs of stakeholders related to ports and navigation activities. Even if several topics may be included within these activities, the information shown below belongs to three relevant issues: environmental protection, building related impacts, and operability.

Table 1: Stakeholder needs in the Spanish maritime navigation and ports sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Oil and gas companies. National, regional and local government agencies and port authorities. Civil Protection. Maritime rescue agency	Prevention and response management of oil spills in the marine and port areas. Research. Product development. Information is incorporated in the daily business and decision –making process.	Climate data: marine currents, waves, sea level, wind and others. Local scale. Past and present information. High resolution (<100m)	Climate data received through FTP and OpenDap. Final developed information is delivered through specific designed tools, reports, maps and data.	Lack of understanding of users about scientific information on climate and its effects. Lack of awareness identified in some ports regarding climate change and oil spill issues.	UC-IHC IHC Oceanography, Estuaries and Water Quality Research Group. Examples: Project ATHENEA http://athenea.ihcantabria.es/ Project SPRES http://spres.ihcantabria.com/objective/
National government and local port authorities	Analysis of impacts of port building works on water quality and sediment transport. Information is incorporated in the decision-making process.	Climate data: marine currents, sea level, wind. Local scale. Past and present information. High resolution (<100m)	Climate data received trough FTP and OpenDap. Final developed information is delivered through reports, maps, data.	Lack of high-resolution data.	UC-IHC IHC Oceanography, Estuaries and Water Quality Research Group. IHC Hydrodynamics and Coastal Infrastructures Research Group. Example: Cartagena and La Palma port extension building works.
National government and local port authorities	Real-time high-resolution wave-currents prediction system to facilitate navigation (including entrance channels) and port operations. Product development for institutions Information is incorporated into the daily business and the decision-	Climate data: marine currents, sea level, wind. Port wave agitation. Local scale. Past and present information. High resolution (<50m)	Climate data received trough FTP, OpenDap, attached to emails and external drive devices. Final developed information is delivered through specific designed tools, reports, maps and data.	Insecurities of stakeholders in dealing with the uncertainty of scientific coastal climate results and scenarios. Lack of resources and qualified personnel. Lack of awareness. Lack of understanding	UC-IHC IHC Hydrodynamics and Coastal Infrastructures Research Group IHC Oceanography, Estuaries and Water Quality Research Group. Example: project Nowcast-Santander

	making and planning process.			of users about scientific information on climate and its effects.	Project MARUCA (Climate characterization of Marine Physical Environment for the optimization of maritime navigation and port works). Project SAMOA (Oceanographic and Meteorological Support System for Port Authorities)

Stakeholders need tailored and easy to understand climate products to support port operability, navigation and decision-making process under conditions of climate variability and climate change. It is also necessary to analyse environmental impacts, including sediment transport issues related to port constructions and to assess and identify prevention and response strategies in case of oil pollution events.

Even if it has been identified some kind of difficulty for the related stakeholders to access, understand and use the generated information, climate information results and designed channels to disseminate them are very well valued within this sector.

4.3 The maritime navigation and ports sector in France

4.3.1 Stakeholders in the French maritime navigation and ports sector

Harbors and the maritime transport are not explicitly identified as an economic sector in the recommendations for a second national adaptation plans of France (ONERC, 2018). However, the maritime sector was addressed through the 1st adaptation plan. As a possible explanation to this, a survey conducted for the French network of research organizations concerned with environment ("Allenvi") concluded that the sector of transport was more impacted by the energy transition than by adaptation measures (Cavelier et al., 2017).

The stakeholders mentioned in the 1st adaptation plan include: the DGITM (land and sea transport directorate) at the ministry in charge of Environment, public organization performing applied research and development in the area of transports (Certu, Iffstar, Cerema, …), and port managers. Other relevant stakeholders include the public or private companies delivering studies to support coastal risks and environmental impact assessments in harbours and coastal infrastructures (e.g., Creocean, Artelia, BRL, DHI, etc…).

The adaptation plan mentions maritime harbors as stakeholders to be engaged in adaptation. In metropolitan France, these harbors represent an annual tonnage o 360 millions of tons. The 11 "grands ports maritimes" of metropolitan France are Marseille (80Mt), Le Havre (70Mt), Dunkerque (45Mt), Nantes/St-Nazaire (25Mt), Rouen (22Mt), La Rochelle (10Mt) and Bordeaux (8Mt). Outerseas harbors in Guadeloupe, Guyane, Martinique and La Réunion also have this status of 'Grand Port Maritime' (see Budoc, 2018 for a review of environmental issues for maritime ports in outerseas regions and territories).

The PIANC/AIPCN-France (World association for waterborne transport infrastructure) is also acting for better including consideration of climate change in the community of harbors and maritime transport, with an initiative called "think climate" focused on the maritime navigation sector contribution to mitigation of climate change as well as adaptation (http://navclimate.pianc.org/).

4.3.2 Stakeholder needs for coastal climate information in the French maritime navigation and ports sector

Specific actions relevant for the Port and maritime traffic sector in France in the 1st adaptation plan include:

- "Reviewing and adapting the technical standards for construction, maintenance and operation of transport infrastructures and equipment in continental France and overseas territories" (Action 1 of the transport action sheet): this includes acting on the European standards and particularly the Eurocodes construction rules.
- "Studying the impacts of climate change on transport demand and the consequences for reshaping transport provision", including potential changes of major freights corridors and sea routes (Action 2 of the transport action sheet).
- "Developing appropriate vulnerability analysis methodologies for transport networks and specific points", including ports (Action 3).
- "Establish a statement of vulnerability for (…) sea (…) transport networks in continental France and overseas territories and prepare appropriate and phased response strategies", which includes sharing experience and providing methodological support to infrastructure managers and transport operators (action 4).

The evaluation of the 1st adaptation plan (CGEDD, 2015) recognizes that the plan has been successful in identifying the relevant technical conception and operation guides of transport infrastructures that need to be updated to adapt to climate change. However, the same evaluation report recommends further prospective studies to be conducted for the sector of transport. No specific recommendation for the sector of maritime transport and harbors is provided in this evaluation.

The academic literature relevant for French harbors and climate change mitigation identifies specific variables such as extreme waves, surges and total water levels and sea level rise scenarios (Pirazzoli, 2000). The AR5 (WG2, Ch 23) recognizes that “systematic and detailed knowledge on the impacts of climate change remains limited in Europe”. It also notes that the northern polar maritime routes may not necessarily become a reality, as this will depend on other factors such as fees and taxes applied for these routes and other maritime routes, and that shipping and containers companies actually have a very low interest for polar routes (Lasserre and Pelletier, 2011).

Maritime harbors need to develop sustainable development policies and environmental impact assessments studies. These studies are often supported by coastal consultancies, which address all environmental and regulatory issues related to harbor planning and environmental protection and compensation. In outerseas territories, these assessments are importantly limited by a lack of knowledge regarding the current state of biodiversity, and the focus of these plans on the topic of adaptation to climate change remains focused on “low regret strategies’ (Budoc, 2018).

We identify a major difficulty, which is barely addressed in the literature and in adaptation planning: for the sector of transport, adaptation to a 1.5° to 2°C of global climate warming as planned in the French adaptation plans requires a complete refoundation of the transport infrastructure and network in order to decarbonize it to the scale required by climate change mitigation scenarios (Roeckstrom et al., 21017). Consequently, the infrastructures that would need to be adapted to a 1.5 to 2°C world do not exist at present. In other words, there is no strong baseline to plan for adaptation in the transport network as long as the transport networks and infrastructures compliant with a 1.5 or 2° world remain unclear. Conversely, individual exchanges with officials in harbors (e.g., Jarry in Guadeloupe, Figure 2) suggest that there is currently no plan or idea to adapt for sea level rise rates in the order of 1cm per year as planned for high greenhouse gas emission scenarios.

Figure 2: 2017 photograph of Jarry, Guadeloupe, where the harbor and many critical infrastructures are located. These infrastructures are built on a former mangrove, just a few tens of centimeters above present sea level. They are already affected by the geotechnical impacts of saltwater intrusions (BRGM, 2015).

Table 1: summary of needs identified in the French port and harbors sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
National group "transport" of the 1st National Adaptation plan	integrating climate change in construction standards (e.g., Eurocode)	Methods and reference values (demonstration studies?)	Not precised	Not precised	ONERC, 2011
National group "transport" of the 1st National Adaptation plan	Impacts of climate change mitigation and adaptation on maritime transport	Global socio-economic scenarios, climate change scenarios	Global scale study	Not precised (may exist already)	ONERC, 2011
National group "transport" of the 1st National Adaptation plan	Appropriate vulnerability assessment methods for harbors	Methods	Demonstration studies?	Not precised	ONERC, 2011
National group "transport" of the 1st National Adaptation plan	Macro-scale vulnerability analysis of French harbors and proposition of adaptation pathways	Global and regional socio-economic scenarios, climate change scenarios	Study	Not precised	ONERC, 2011
National group "transport" of the 1st National Adaptation plan	Formation, training and communication	To be defined	To be defined	Maritime ports engagement (?)	ONERC, 2011
PIANC/AIPCN-France and "Think-Climate" initiative	Potential changes in frequencies and intensities of extreme events	Extreme value analysis of waves and surges at harbors	Not precised	Not precised	http://navclimate.pianc.org
PIANC/AIPCN-France and "Think-Climate" initiative	Sea level rise scenarios	Mean sea level rise scenarios at harbors	Not precised	Not precised	http://navclimate.pianc.org
Maritime harbours	Environmental impact studies and support to prospective planning	Biophysical impact scenarios, including impacts of sea level changes, ocean warming, pollution and dredging on the biodiversity	Environmental impact studies	Not precised	Individual interviews Budoc, 2018

4.4 The maritime navigation and ports sector in Greece

4.4.1 Stakeholders in the Greek maritime navigation and ports sector

Ports and marine traffic are not identified as sectors in the Greek National Adaptation Plan.

From the experience of NCSRD and the discussions with other research institutes like the National Centre of Marine Research, ports are infrastructures of great importance for a city like Piraeus or Thessaloniki and even for the whole country. They represent a major resource of employment, as well as a focus of attraction to other economic activities, besides the transport and navigation. Several other economic sectors have relationship with ports, so maintaining them fully functioning is an important policy priority.

According to the previous, there are many topics within this sector that have been or should be addressed in the near future, like water quality, environmental impacts (HCMR, Dr. Takvor Soukissian), sediment transport, weather forecast, port operability, navigation, oil spill prevention and response (University of Athens, Department of Physics, Oceanography Laboratory, Prof. Sofianos Sarantis), etc.

Some stakeholders identified by NCSRD in this sector in Greece, may be **national, regional and local government**, **port authorities** (also at national, regional and local level), **public works agencies**, **civil protection**, **maritime rescue agencies** and **oil and gas companies**. Other international **research institutions** as well as research private consultancies are also involved.

4.4.2 Stakeholder needs for coastal climate information in the Greek maritime navigation and ports sector

Table 1: Stakeholder needs in the Greek maritime navigation and ports sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Oil and gas companies	Prevention and response management of oil spills in the marine and port areas. Research	Climate data: sea level, wind and others. Local scale. Past and present information.	Final developed information is delivered through reports, maps, internet platforms and data.	Lack of understanding of users about scientific information on climate and its effects. Lack of awareness identified in some ports regarding climate change and oil spill issues.	NCSRD ref.1

4.5 The maritime navigation and ports sectors and stakeholder needs in Germany, Spain, France and Greece: summary of findings

The review of documented stakeholder needs for climate information in the maritime navigation and ports sector includes contributions from Germany, France, Spain and Greece (see tables in chapters 4.1.2, 4.2.2, 4.3.2 and 4.4.2 for references).

The stakeholder groups mentioned in literature and projects in connection to climate information needs are, above all, government agencies, maritime harbours, port authorities, port management, private companies, and research institutions.

Climate information have mainly been requested for conducting vulnerability assessments and environmental impact studies and for analysing climate change impacts and developing adaptation strategies for ports and maritime transport, as well as for supporting port development planning. A specific information request was noted for instance in Spain, where climate information are needed for preventing and managing oil spills in marine and port areas, or in France for assessing potential changes in extreme events for harbours.

The requested information in the four countries mainly refers to impacts of sea level rise on ports and to climate data, such as waves, see level, and wind. The literature review reveals, especially for German stakeholders of the sector, a need for short- and medium term weather information and for a better early warning system of extreme weather events. French stakeholders expressed for instance a need for socio-economic scenarios to support climate change impact assessments and vulnerability studies on harbours and maritime transport systems.

The requested formats of information are above all observations, hindcasts and scenarios. German literature illustrates differences in the preferred information format between scientists on the one hand and authorities and industry on the other: scientists request scientific data, scenarios, models, and simulations, whereas authorities and industry rather want to use prepared, target-group specific and comprehensible climate information, e.g. text and diagrams.

Obstacles in using climate information that were mentioned in more than one country are above all the uncertainty of stakeholders in dealing with uncertain coastal climate scenarios and climate change effects and a lack of personal and financial resources (minor priority). Especially in German literature it was mentioned that the mismatch between short-term planning processes in the sector and long-term climate change scenarios hinder the use of climate information. In Spain, the lack of awareness of some ports regarding climate change and oil spills was found as one specific obstacle in using climate information.

Summary of stakeholder information needs in Germany, Spain, France and Greece: Maritime navigation and ports sector

	Stakeholders	Information needed for	Requested information	Requested formats	Main obstacles in using climate information
Germany	ports; ports industries and logistics; port management and authorities; waterways and shipping offices; transshipping companies, shipyards, shipping companies, shipbuilding companies; research institutes	developing adaptation strategies and measures to climate change impacts on ports; sensitivity/vulnerability studies of ports and maritime navigation routes; port development planning; navigation and operation; research	short- and medium term weather information; better early warning of extreme weather events; more reliable information about regional climate change impacts on ports (such as storm surges, sea level rise); recommendations for action concerning climate change and adaptation; data for research, e.g. about storm surges, water levels, water runoff and inflow, wind fields, current sea state conditions, (historical) wave climate, sea level rise scenarios	scientists: measured data, hindcasts, scatter diagrams, scenarios and model simulations; authorities and industry: prepared, target-group specific and comprehensible information	uncertainties about climate change effects and its occurrence; short-term planning vs. long-term climate change prognoses; personnel, time and financial constraints
Spain	national, regional and local government agencies; local port authorities; oil and gas companies; civil protection; maritime rescue agencies; research institutions	prevention and response management of oil spills in marine and port areas; analysis of port building works on water quality and sediment tranport; wave-currents prediction system to facilitate navigation and port operations; product development; research	past and present high resolution climate data at local scale (e.g. marine currents, waves, sea level, wind); port wave agitation	data; final developed information delivered through specific designed tools, as reports, maps, data	lack of understanding regarding scientific climate change information; lack of awareness of some ports regarding climate change and oil spills; lack of high resolution data; insecurity of stakeholders in dealing with uncertain coastal climate scenarios; lack of resources and qualified personnel
France	national group „Transport“ of the 1st National Adaptation Plan (land and sea transport directorate at ministry, public research organizations, port	vulnerability assessments and adaptation strategies for harbors; environmental impact studies and prospective planning for harbors; analyzing impacts of climate change	reference values to integrate climate change in construction standards; socio-economic and climate change scenarios (global, regional); extreme value analysis of waves and surges	Studies and scenarios	not precised

	managers); public and private companies; maritime harbors; „Think-Climate“ initiative	mitigation/adaptation on maritime transport; assessing potential changes of extreme events; training and communication	and mean sea level rise scenarios at harbours; biophysical impacts on biodiversity		
Greece	Oil and gas companies	prevention and response management of oil spills in the marine and port areas; research	climate data such as sea level, wind; local scale; past and present information	Final developed information is delivered through reports, maps, internet platforms and data.	lack of understanding of scientific information on climate and its effects; lack of awareness of some ports regarding climate change and oil spill issues

5 Climate information needs in the risk insurance sectors in Germany, Spain, France and Greece

In the following chapter, relevant stakeholders of the risk insurance sector are going to be mentioned, as well as findings of the literature research in Germany, Spain and France. Greece did not contribute due to a lack of relevant literature review results.

5.1 The risk insurance sector in Germany

5.1.1 Stakeholders in the German risk insurance sector

Insuring risks related to natural hazards and extreme weather events such as storms, floods, hail or heavy rain, are very important for the economy and society, especially in climate prone and vulnerable areas, such as coastal regions. Whereas these natural hazards are covered by insurance products (see for instance the Natural Hazards Report, GDV, 2017a), storm surges have hardly been covered by insurance products, with only a few exceptions, such as the Itzehoer Insurance (see Itzehoer Versicherungen, 2014).

Insurance and finance industry agitate on global markets and have increasingly been influenced by climate change effects not only at regional, but also at global scale. Both branches have been addressed in the German Strategy for Adaptation to Climate Change (DAS) (UBA, 2013b).

The insurance sector is mainly effected by increasing extreme weather events which cause steadily rising financial losses. Yet, climate change related impacts are not the only reason for these increasing financial burdens, but also a growing population especially in urban areas and a general increase in insured values. Consequently, more insurance products are claimed and insurance payments are rising. Challengingly for insurances are the climate change related higher uncertainty of occurrence of natural hazards and extreme events, because it complicates the calculation of appropriate insurance premiums. Thus, an improved data availability and innovations in modelling and risk assessment are of special importance for insurance companies (UBA, 2013b).

Adaptation strategies are necessary in this sector, but very high potential losses can question the general insurability of such losses. Sectors with particular vulnerability to climate change effects, such as the tourism, renewable energy or water sector, could increasingly request insurance products that cover extreme weather events, such as floods or heavy rain, so there is a growing market potential in these fields (UBA, 2013b).

Relevant stakeholders in the insurance sector are for instance insurance companies, reinsurance companies, reinsurance brokers, but also connected stakeholders such as research institutes and public authorities.

Reinsurance companies like Munich Re or Swiss Re have been using information related to natural hazards and also climate change for decades. Big insurance companies employ teams with natural scientists who regularly use scientific data and information for assessing

the natural hazard potential und potential loss burden for the portfolio (see for instance Munich Re which set up a natural hazards department in 1974; Munich Re, 2018a). At the same time, insurance companies are information providers about natural hazards and related risks to help their clients assessing their specific risks of natural hazards (see for instance the NATHAN Risk Suite of Munich Re, Munich Re, 2018b; or a zoning system for floods, backwaters and heavy rains – ZÜRS-Geo, GDV, 2017b).

Munich Re and Swiss Re are two big reinsurance companies acting in Germany and other countries. Climate information demands in the risk insurance sector could mainly be identified in reports published by these two companies, but also in some other publications and from registered data downloads at the coastDat data base. Further stakeholders of the sector that were found in the literature research with relation to documented stakeholder needs for climate information are scientists of the university of Berne, a reinsurance broker and the Itzehoer insurance company (see table 1 in chapter 5.1.2 for more detail).

5.1.2 Stakeholder needs for coastal climate information in the German risk insurance sector

Risk insurance companies' demand for climate information relevant for ECLISEA are the information related to extreme weather events.

The literature review showed that stakeholders connected to the risk insurance sector need climate information mainly for (see table 1 below for references and further details):

- calculating current and future damages, expected losses, premium levels and risk potentials through extreme weather events (e.g. hail, storms, floods, storm surges, extreme precipitation, and droughts)
- identifying hazard zones for floods (e.g. storm surges, river floods) and developing hazard maps
- risk assessment for offshore wind parks
- risk insurance related research (e.g. constructing storm surge loss models for the German North Sea and Baltic Sea coasts and estuaries)
- measures concerning climate change adaptation

The climate information used and needed for conducting risk assessments and other activities mentioned above comprise for example (see table 1 below for references and further details):

- parameters for describing the intensity of hazards (e.g. for windstorms: gust speed, sustained wind speed; for floods: maximum water levels, flow velocity, quantities of bed-load, flood duration), used in probabilistic models to simulate possible future events
- other climate data, such as hydrological data for hydrological risk models, storm surge data for storm surge risk models, storm frequency, tidal sea levels, wave

heights, atmospheric conditions, long-standing series of measurements of water levels and water run-offs for probabilistic models
- sea level rise scenarios
- historical natural hazards catalogues (events in the last 100 years or less)
- high resolution digital terrain-models
- climate indices, such as mean monthly air temperature, mean seasonal air temperature, days with heavy winds, stormy days, extreme wet days

The climate information formats requested and used by stakeholders and scientists related to the risk insurance sector comprise for instance measured data, hindcasts, scenarios, numerical models and simulations, hazard maps and hazard catalogues, and climate indices (see table 1 below for references and further details).

Obstacles in using climate information were hardly mentioned in literature, apart from hesitating to use data with high uncertainty levels by risk insurances and high computational costs to develop high resolution scenarios by scientists (see table 1 below for references and further details).

Table 1: Stakeholder needs in the risk insurance sector in Germany with relation to extreme weather events

Stakeholders/ projects	Information is needed for	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Project ReKliEs-DE – Regional climate projections, ensemble for Germany: insurance and financial sector	Calculating current and future damages and risk potential through extreme weather events	Insurances expect growing damages and losses through extreme events such as hail, storms, droughts, and extreme precipitation, use and collect information about these events; climate indices already used in measures concerning the German Adaptation Strategy: e.g. mean monthly air temperature, mean seasonal air temperature, days with heavy winds, stormy days, extreme wet days	Used formats: indices and parameters	Not precised	Bülow et al., 2017
Munich Re and other insurance companies	Risk assessments based on hazards maps for calculating premium levels, modelling of flood damages	Insurance sector usually uses information for identifying hazard zones for floods (storm surges, river floods, flash floods), using hydrological data (extreme water run-offs, different return periods) for hydrological model to model flood accumulation losses per country (MRFlood, developed in 1997 by Munich Re), using digital terrain-models; insurances developed a zoning system for flood, backwater and torrential rain (ZÜRS), with which the flood exposure can be classified for any address in Germany	Used formats and methods: maps with exposure zones, data, models, simulations	Not precised	Munich Re, 2005
Munich Re	Risk assessment for offshore wind parks	Not precised	Data from coastDat data base	Not precised	www.coastdat.de/client_list/index.php.en
Swiss Reinsurance Company	Assessing storm surge risk	Not precised	Data from coastDat data base	Not precised	www.coastdat.de/client_list/index.php.en
Swiss Reinsurance Company	Risk assessment, assessing the annual expectation of losses and losses through extreme events, developing hazard maps of	Using probabilistic natural catastrophe models (such as for storms, floods, earth quakes) for damage modeling, using parameters for describing the intensity of such hazards (windstorms: gust speed, sustained wind speed, floods: maximum water	Used formats and methods: data for models and simulations	Not precised	Swiss Re, 2003

	natural hazards (e.g. flood maps)	levels, flow velocity, quantities of bed-load, flood duration), using historical natural hazards catalogues and scientific knowledge about development and dynamic of natural hazards, using risk assessment methods for flood risks, based on high-resolution digital terrain-models, using long-standing series of measurements of water levels and water run-offs for probabilistic models			
Scientists from Berne University and Swiss Re's natural catastrophe professionals, study about coastal flood damage in the North Sea region	calculating annual expected loss and loss frequency curve for a wind insurance portfolio representative of today's market	Used data and models: global climate model for modeling the potential future climate in the North Sea area, hydro-dynamic model for modeling storm surge events, local tidal cycles, 3 different sea level rise parameterisations (27cm, 0cm, 50cm), modelled inland water depths based on surge heights, Swiss Re's probabilistic storm surge loss model transformed local water depths into financial losses; reference period: 1961-1990, scenario period: 2071-2100	Used formats and methods: global and regional climate models, half-hourly water elevations (PRUDENCE dataset), surge scenarios, numerical simulations	Not precised	Swiss Re, 2009
	constructing a storm surge loss model, estimating the impact of climate change consequences on the insurance loss burden for the North Sea region	Scientists used: storm surge data set as a hindcast or reference historical data set (simulated sea levels for the North Sea region, 1958-2002, hourly resolution), storm surge scenarios and numerical models, simulation of present day conditions (1961-1990) and future conditions (2071-2100), water level data (10x10km regular grid), atmospheric conditions (resolution of 50x50km for the European region)	Used formats and methods: data sets, scenarios, numerical models	high resolution scenarios (e.g. in areas with complex coastlines and topography or in river estuaries) have very high computational costs, presently realized only for local and short-term studies	Gaslikova et al., 2011
Itzehoer Insurance	risk reduction, increasing demand for natural hazard insurances	Development of storm surge model (probability based model) with parameters such as storm frequency, wind speeds, tidal sea levels, wave heights, considered against background of existing coastal protection system; long term developments	Using ocean and meteorological parameters, models	tolerance of uncertainty seems very low in this sector, hesitation to use data with high uncertainty levels	Eucleia project, n.n.

		and specific patterns of an event are more relevant to insurers than assessing single events			
Aon Benfield Germany (reinsurance broker), interview with Jan-Oliver Thofern, chairman of the managing board ("Welt" online, January 2012)	Development of a probability based storm surge model (for private households and industry) for reproducing risks from storm surges at the German North Sea coast and Baltic Sea coast and in the estuaries of Elbe, Weser, Schlei, Trave and Warnow, calculating storm surge risks and damages	Used model parameters: storm frequency, wind speeds, tidal sea levels, wave heights, considered against background of existing coastal protection system	Used formats and methods: parameters and models	Not precised	Die Welt, 20th of January, 2012

5.2 The risk insurance sector in Spain

5.2.1 Stakeholders in the Spanish risk insurance sector

The insurance sector is greatly affected by climate variability, climate extreme events and climate change. The Spanish National Climate Change Adaptation Plan refers to the sector as finance and insurance.

The Consorcio de Compensación de Seguros (CCS) of Spain is the main public body within the risk insurance sector in Spain, having its own legal personality and enjoying full capacity to act. It is linked to the Ministry of the Economy, Industry and Competitiveness under the Directorate-General for Insurance and Pension Funds.

The Consortium is a tool at the service of the Spanish insurance sector in which it is fully integrated. Insurance coverage is one of the main financial instruments designed to help recover from and compensate for the damage caused by these types of catastrophic loss.

CSS is the main public stakeholder regarding climate derived risk insurance, which is considered under their "natural hazards" category, which covers earthquakes, tsunami, flood (fluvial and coastal), volcanic eruption, windstorms and falling of sidereal bodies or meteorites. Coastal flooding account for 25% of the losses and the 70% of the total amount assigned for natural hazards.

We may consider the risk insurance somehow cross-sectoral, so many other stakeholders may be considered here, as for example, insureds, insurance and capital markets and governments at different scales.

5.2.2 Stakeholder needs for coastal climate information in the Spanish risk insurance sector

According to the Spanish National Climate Change Adaptation Plan, the eastern area of Iberian Peninsula will be the most affected in terms of climate change impacts to the agricultural sector, and therefore one of the main objectives of the insurance sector. In general, storms and floods are the most frequent events in Spain and are indeed which cause the greater demand for the sector.

There are several measures, activities and lines of work proposed in the Spanish National Climate Change Adaptation Plan to perform a vulnerability, impacts and adaptation assessment related to the insurance sector. Some of them are:

- Risk assessment and mapping for the different areas of insurance in Spain under different climate change scenarios.
- Promotion of a revision of the framework related to the basic standards of construction and design, and territorial planning and land use, according to the previous cartography.

- Development of specific models for the insurance sector, combining risk and financial parameters of insurance and reinsurance, to recreate historical events and estimate future losses.
- Evaluation of the vulnerability of structures and crops in the different areas geographic, to the main meteorological and climatic phenomena in their more extreme manifestations.
- Promotion of insurance as an instrument of prevention Viability analysis of the agricultural policy in the climatic scenarios futures

The effects of climate change, such as meteorological variability, new and more intense extreme events, will have a considerable impact on the insurance industry, for which a deeper investigation of this sector and the problems is necessary.

As for the experience of UC-IHC, stakeholders related to the insurance sector have a clear idea about the information they need. From the research/scientific perspective, there is the need to identify the climatic data needed to obtain the requested information.

Table 1: Stakeholder needs in the Spanish risk insurance sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
National government agencies National Insurance Consortium	Product development (Storm surge damage assessment) Information is incorporated into the decision-making and planning process.	Climate data Past Regional scale	Climate data received attached to email and external drive devices.	Lack of resources and qualified personnel.	UC-IHC IHC Hydrodynamics and Coastal Infrastructures Research Group
National government agencies. National Insurance Consortium	Climate change adaptation: to evaluate the impact of climate change in the frequency and intensity of extreme events affecting the risk insurance sector. Based on the previous point to establish adaptation measures to address the new risks projected. To extend the knowledge on the uncertainties related with non-standard variables related with risk assessment.	Climate data. Indices. Past and present. National scale.	Climate data received through interoperability access (FTP, OpenDap), attached to email and external drive devices. Final developed information is delivered to the stakeholder as: data, report,	High uncertainties of the climate change signal projected.	UC-IHC UC Santander Meteorology Group. Example: Project Climate change regional projections of events of extreme wind in Spain for the XXI century.

	To contribute to the new generation of Climate change scenarios for Spain. Information is incorporated into the decision- making and planning process		maps, website publication		

5.3 The risk insurance sector in France

5.3.1 Stakeholders in the French risk insurance sector

As a preliminary note, we remind the specificity of the risk and insurance sector in France. In other countries such as the UK or the USA, whenever the costs of a specific disaster exceed the capacity of the insurance companies, the reinsurance companies cover the losses. In some countries, the state backs the insurance or the reinsurance sector. In France, the system is a mixed public/private sector, in which the compensation system for natural catastrophes is financed by an obligatory contribution in the insurance. In case of a major disaster, a decree of "Natural catastrophe state" is pronounced and the costs are covered by the public reinsurance company, the CCR. Municipalities where a decree of "national catastrophe" has been pronounced are required to implement a "risk prevention plan" after the event, in order to prevent future losses to the extent it is possible. The coastal risk prevention plans mechanism is presented for example in Deboudt (2010) and as a case study with specific attention to the sea level rise scenarios considered in Le Cozannet et al. (2017). However, based on surveys and theoretical developments performed within the FP7 THESEUS project, Dàvila et al. (2014) concluded that "from a resilience point of view, and within the general framework of risk management, the current French insurance system does (…) not seem to support the reduction of individuals' risks, nor the adoption of business continuity plans."[12]

In addition to the major private insurance companies (represented by the FFA; https://www.ffa-assurance.fr/), the CCR therefore constitutes a major stakeholder of the risk and insurance sector in France. Furthermore, the mission for natural risks (http://www.mrn.asso.fr/en/) is an association connecting the scientific community with the insurance and risk sector. Public organizations are also engaged with the insurance and risk sector in France, particularly the ministry in charge of Environment, territorial authorities, research organisations such as Meteo-France and the BRGM as well as IGN, the SHOM or CEREMA.

[12] Davila et al. (2014) also write that "Furthermore, [this mecanism] does not support prevention policies since the latter introduce planning restrictions on building on prevention". This is arguable because once the compensation system is implemented, municipalities are required to implement coastal risk prevention plans.

Other relevant actors, which are not identified in the adaptation plan include the modeling agencies such as RMS, which provide risk assessments to the insurance companies, including in France.

5.3.2 Stakeholder needs for coastal climate information in the French risk insurance sector

The first adaptation plan recommends identifying where insurance cover is currently constitute an incentive to implement inappropriate adaptation (e.g., people build houses in low lying flood plains because their insurance covers their risks). This requirement resonates to the comments of Dàvila et al. (2014) that the French risk policy does not always constitutes a strong incentive to better prevent future disasters. While this high-level requirement first raises questions in the area of laws and regulations, there is still a need for coastal impact information needs, including coastal flooding and shoreline change models.

In the second adaptation plan, the risk insurance sector is presented as a potential provider of services to the wider sector of finance, which could provide it with tools to assess their vulnerability to climate change. Examples of such tools in the area of coastal flooding damage assessments are presented in Naulin et al. (2015). The existing risk assessment tools within the insurance community is presented as sufficiently advanced to respond to the information needs of this community, although the need for more specific economic analysis is identified. In fact, the French insurance data have not allowed to establish robust vulnerability functions allowing to compute the costs of flooding damages so far (André et al., 2013). Comparing the hazard module of Naulin et al. (2015) with the best practice on coastal risks prevention plans (as in Le Roy et al., 2015) suggests that there is still room for improvement of the climate change and coastal hazards modules of economic coastal impact assessments published so far. This includes detailed topography and bathymetry, hydrodynamic modelling tools that allow for the computation of flows and instantaneous water levels as well as sea level, waves and surge projections and modelling tools.

Much of the information produced on coastal risks comes from studies stimulated by the regulation. Le Roy et al. (2015) provides an example of a modeling framework typically implemented for coastal risks prevention plans (Deboudt, 2010). Examples of studies that have attempted to provide information in support to other risk regulations (e.g., climate change adaptation aspects in the land use planning regulation) have attempted to identify the most vulnerable locations (Le Cozannet et al., 2013) or identifying the timescales relevant to climate change and sea level rise (Le Cozannet et al., 2015). However, only the coastal risk prevention plans include strong guidelines so that adaptation in other public policies such as land use planning have been applied in a heterogeneous manner in France so far. At a higher level, the national strategy for coastal zones management includes measures that are relevant to risk assessment and potentially to the insurance sector.

Other relevant requirements can be considered from the perspective of the disaster management system: besides prevention (see previous paragraph); tools in support to

preparedness and risk management as well as post disaster information collection are relevant for risk policies and potentially for the insurance (see e.g., André et al., 2013).

From the insurance companies perspective (as expressed during the user workshop of the "Climate services convention" of France held in Paris on 04/06/2018, the main issue is the lack of accessibility and the heterogeneity of information on hazards. Currently, the need for risk maps is fed with products provided by modeling companies such as RMS. In the future, there could be some inclusion of seasonal predictive models to better anticipate risks of losses. These needs from insurance companies complements those expressed at the level of the French adaptation plan.

Overall, the regulation seems to constitute both an incentive and a limitation to include more scientific climate data in risk and insurance policies. For example, on the one hand, detailed flood maps need to be produced for coastal risk prevention plans, On the other hand sea level scenarios are fixed to 60cm by 2100, preventing from referring to recent work on sea level rise.

Table 1: summary of needs identified in the French risk insurance sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
National group "finance and insurance" of the 1st National Adaptation plan	Assessing where the current risk and insurance mechanisms encourage inappropriate adaptation	Social science studies (regulations, laws…). Flooding and shoreline changes hazard and risk maps	Not precised	Not precised	ONERC, 2011
Regional and national organizations in charge of implementing the coastal risk prevention policy	Coastal risk prevention plans	Flooding, shoreline change and Aeolian dune migration hazard maps.	Examples relevant to ECLISEA: extreme value analysis for centennial events, storm reconstructions. See the guidelines for coastal risk prevention plans[13].	The regulation has established uniform climate change scenarios (in fact sea level scenarios) applicable at national scale.	Deboudt, 2010 Le Cozannet et al., 2017
Municipalities, regional and	Other relevant policies related to coastal risks	Same as above, plus maps of vulnerable	Examples relevant to ECLISEA: same as above + extreme	Except for the inundation directive, the	e.g., Le Cozannet et al., 2013

[13] http://www.side.developpement-durable.gouv.fr/EXPLOITATION/ACCIDR/doc/IFD/IFD_REFDOC_0520781/plan-de-prevention-des-risques-littoraux-guide-methodologique

state organizations	prevention (e.g., land use planning policies and their adaptation component, inundation directive)	areas as a function of the time	value analysis of millennial events	policy promotes best efforts and does not provide guidelines for implementation.	
Municipalities, regional and state organizations	National strategy for integrated coastal zones management	Observations, modeling and expertise to guide coastal zones management	Not precised	The need for scientific information is not always obvious in policies considering very wide objectives	-
Civil security, prefecture, ministry of interior, regional and state organizations	Tools for risk preparedness and management	Real time waves, surge and flooding modeling capabilities	Appropriate alert systems	Would deserve more investigations	e.g., Lecacheux et al., in press Nicolae Lerma et al., in press
Risk management stakeholders and research organizations	Validation of models and return of experience from events	Post-event surveys	Inventories and quantified assessment of damages, water levels, indicators of flow velocities…	Would deserve more investigations	e.g., Garcin and Pedreros,
CCR and MRN	Assessments of hazards and risks	Sea level, waves, surge and river flows projections and reanalysis, precise topography and bathymetry, hydrodynamic modelling tools, morphodynamic models.	Not precised	This need is not expressed explicitly by the stakeholders but comes from analysis of the studies published by the coastal risk insurance community in France.	See text
Insurance company (Groupama)	Hazard maps superimposed with exposed assets, in order to evaluate risks, potentially in a probabilistic form	Coming season to coming decades	The format is not precised, but the user insists on the need for easily manipulable information (Shape files?) and for making all public information accessible	Accessibility and heterogeneity of the information	User meeting of the "Climate Services Convention" in France, 4/06/2018

5.4 The risk insurance sector in Greece

5.4.1 Stakeholders in the Greek risk insurance sector

No stakeholders have been identified possibly due to the lack of scientific personnel in the risk insurance sector with related expertise.

5.4.2 Stakeholder needs for coastal climate information in the Greek risk insurance sector

No relevant information on stakeholder needs for coastal climate information could be found.

5.5 The risk insurance sectors and stakeholder needs in Germany, Spain, France and Greece: summary of findings

Documented information about stakeholder needs for climate information in the risk insurance sector was found in the German, Spanish and French reviews. Greece did not contribute because of a lack of relevant literature (see table below for a summary of findings and tables in the chapters 5.1.2, 5.2.2, 5.3.2 for references).

As the reviews reveal, stakeholders, such as reinsurance companies, national organizations and governmental agencies and research institutions, need climate information very often for assessing risks and damages with regard to extreme weather events and in France, as a special example, for developing coastal risk prevention plans and policies and integrated coastal zone management.

Climate information such as data about sea level, waves and surges, have been requested frequently in all three countries. The preferred formats of information mainly are climate data, indices and models. For France, the literature review showed a special need for easily handable and public accessible information. In Spain, the review of experiences at IHC showed for example, that climate information products have been delivered to national governmental agencies and insurance companies, not only as data, but also as reports, maps and website presentations.

Some points that hinder using climate information could also be shown in the reviews: the high uncertainties of climate change and its effects has been mentioned as one obstacle in the German and Spanish review. In France, obstacles can be found also at the policy level, for instance is the need for scientific information not always obvious in policies.

Summary of stakeholder information needs in Germany, Spain, France and Greece: Risk insurance sector

	Stakeholders	Information needed for	Requested information	Requested formats	Main obstacles in using climate information
Germany	reinsurance companies; universities and research institutes	calculating damages, losses, premium levels and risk potential through extreme weather events; identifying hazard zones for floods and developing hazard maps; risk assessment for offshore wind parks; risk insurance related research (e.g. about storm surge loss models)	parameters for describing the intensity of hazards; climate data, such as hydrological data, storm surge data, storm frequency, wind speeds, tidal sea levels, wave heights, water runoffs, atmospheric conditions; climate indices; sea level rise scenarios; high resolution digital terrain models, historical natural hazard catalogues	measured data; hindcasts; scenarios; models and simulations; indices	hesitation to use data with high uncertainty levels; high computational costs to develop high resolution scenarios
Spain	national governmental agencies; National Insurance Consortium	storm surge damage assessment; risk assessment; evaluating the climate change impact on frequency and intensity of extreme events; establishing adaptation measures	past and present climate data on regional and national scale	climate data; indices; final developed information delivered as data, report, maps, website publication	high uncertainties of climate change and its effects; lack of resources and qualified personnel
France	Regional, national and state organisations; municipalities; reinsurance companies; civil security; risk management stakeholders; research organisations	assessing current insurance mechanisms; coastal risk prevention plans and policies; integrated coastal zone management; tools for risk preparednes and management; model validation; risk assessments	flooding, shoreline change; hazard and vulnerable area maps; real time waves, surge and flooding modelling capabilities; post event surveys; hydrodynamic and morphodynamic models; sea level, waves, surge and river flows projections; precise topography and bathymetry	extreme value analysis; models and projections, reconstructions; alert systems; inventories and assessments; indicators; need for easily manipulable information and for public accessible information	uniform climate change scenarios in regulation; lack of guidelines for policy implementation; need for scientific information not always obvious in policies; accessibility and heterogeneity of the information
Greece	No information available	No information available	No information available	No information available	No information available

6 Climate information needs in other sectors relevant for coastal areas: examples from Germany and Spain

Besides the four sectors relevant for coastal areas having been described in the chapters above, the projects partners could also include further sectors important for coastal areas in the literature review. Germany chose the coastal protection sector because of its major importance for German coasts for hundreds of years, and included findings from municipalities and regional policy because of their cross-sectoral positions. Spain did a further review in the water management sector because of its importance for society, economy and natural systems and its vulnerability to climate change impacts. Spain also included a multi sectoral perspective in the literature review.

6.1 The coastal protection sector in Germany

6.1.1 Stakeholders in the German coastal protection sector

Coastal protection measures have been of existential importance for protecting settlement, economic and cultural areas at the German North Sea and Baltic Sea coasts for several hundreds of years.

Coastal protection has been effected by climate change related impacts. Mean sea level rise, higher mean high tides, stronger winds and waves, and more and longer lasting storm surges may expose the coastal protection structures to greater loads. Consequently, the risk of flooding larger areas, which would cause more damages, would increase. Especially the coastal regions at the German North Sea are sensitive to storm surges (Schuchardt & Wittig, 2012). Because of its vulnerability to climate change imposed impacts the coastal protection sector has been addressed in the German Strategy for Adaptation to Climate Change (DAS) as one part of the field of action “water, flood- and coastal protection” (UBA, 2013c).

At a scientific level it has been discussed, whether the traditional coastal protection strategy (protecting everything with equal protection status behind the dyke line) can still be favoured with regard to a future sea level rise and more storm surges, especially at the North Sea coast. Scientists recommend alternative coastal protection strategies (e.g. second dyke line, partial dyke realignment, object protection and others), but the public administration prefers to adhere to the previous strategy and adjust the dyke heights as long as this is economically viable (Nibbe, 2013; Schuchardt, 2011).

The coastal protection sector embraces a wide variety of different stakeholders, such as authorities and ministry departments at different levels and related to that field, dyke associations, dyke construction companies, politics and administration from local to federal state level etc. (see e.g. references below).

Several projects (such as nordwest2050, KLIWAS, RA:dOst) and research with regard to topics relevant for coastal protection had been carried out in the German North Sea and

Baltic Sea regions and could give hints about stakeholders' and scientists' demand for climate information (see tables 1 and 2 in chapter 6.2.1 for more details).

The projects and the research focused on coastal protection in a changing climate with regard to aspects such as the effects of future storm surges and sea level rise at the German North Sea coast, the effectivity of coastal protection structures at the German Baltic Sea coast and possible adaptation strategies in all coastal areas.

In the RADOST project, stakeholders (above all representatives from coastal protection authorities, ministries from departments for coastal and flood protection, local politics and administration, civil society and universities) were involved in working group meetings, interviews and case studies.

Besides that, two online surveys were carried out in the North Sea region about storm surge risk perception of representatives from institutional authorities, public agencies, private sector and NGOs and from different sectors (e.g. environment, agriculture, coastal protection, emergency management, administration) and administrative levels (from community to national) (González-Riancho et al., 2015 and 2017).

Another survey (including workshop and interviews) was carried out with regional decision makers from the German Baltic Sea coast concerned with climate change and storm surges, who represented different sectors (e.g. coastal protection, maritime/port industry and tourism). Participants in this survey were asked about their need for Extreme Event Attribution (EEA). However, the stakeholders' statements show that EEA is not very relevant to the participants' work. They need to know how extreme events might change rather than what the change has been caused by, that means whether it is caused by nature or by human activities (Schwab et al., 2017).

6.1.2 Stakeholder needs for coastal climate information in the German coastal protection sector

Climate information and information about climate change effects on coastal protection systems have been used by stakeholders in the coastal protection sector (e.g. authorities) for years, for instance for adapting dyke heights to increasing future sea levels.

As the projects mentioned above focused on adaptation to climate change impacts on coastal protection it is not surprising that the literature review reveals the need for more information regarding climate change aspects (see tables 1 and 2 below for more details).

According to the literature review, stakeholders need and use climate information mainly for (see tables 1 and 2 in this chapter for references and further details):

- discussing and developing adaptation measures and strategies to climate change effects, e.g. for coastal and flood protection structures
- analyzing the effectiveness of coastal protection structures at the Baltic Sea coast, e.g. for specialist planning to protect sandy coasts
- conducting a vulnerability analysis of the coastal protection sector at the German North Sea coast

- research, e.g. on storm surges and coastal protection levels in a future climate, and on storm surge risk perception, both at the German North Sea coast

In the RA:dOst project, stakeholders involved in working group meetings and interviews expressed their needs for climate information related to climate change and coastal protection at the German Baltic Sea coast, such as (see table 2 below for references and further details):

- more reliable information about regional and local climate change impacts with focus on rising water levels and flood protection
- more data and information about sea level rise, sediment transport parallel to the coastline, lee side erosion, wave set-up at the coast, and long-term availability of marine sands
- more information and research about using dredged materials from fairway channels for dyke constructions and beach nourishment

The stakeholders also expressed their needs from science especially for more reliable, clear, regional and local climate change information, as well as for more applied research and for ways how to better deal with uncertain scientific climate information.

Apart from the information needs expressed directly by the stakeholders, the review of project reports and scientific articles also revealed researchers' and scientific authors' conclusions regarding stakeholders' climate information needs and further research needs with respect to the German North Sea coast, above all (see table 1 below for references and further details):

- further research on climate-induced regional and local changes in tide and storm surge water levels, sea level rise and local wave climate
- further research on morphology of coastal areas and on reaction of tidal areas and embankment forelands to accelerated sea level rise
- further research concerning coastal protection constructions and strategies and climate change adaptation
- improved storm surge risk information for administration, authorities, private sectors and NGOs, for instance about potential social and economic impacts of storm surge events in the North Sea region, risk reduction measures, and potentially flooded areas

The literature review also shows a wide variety of climate data/information and climate indices/parameters, regularly used by scientists in research projects and studies related to coastal protection and climate change, for instance (see tables 1 and 2 below for references and further details):

- historical storm surge and measured water level data, water inflow and runoff data, sea level rise scenarios and wind fields, used in a sensitivity study about storm surges in estuaries in the German North Sea region, or
- morphologic and hydrodynamic basic data, regional sea level rise scenarios, wave overflow rates and wave data, and statistically determined flood levels,

used in studies about coastal protection structures and strategies at the German Baltic Sea coast

- climate indices/parameters such as mean sea level, mean high tide, stormy days, maximum wind velocity, wind direction, used in vulnerability analysis and other studies concerning coastal protection and climate change adaptation
- climate impact indicators for Hamburg, such as tidal conditions and storm surges, whereas no information about users were given

Used and requested formats or communication strategies of climate information regarding coastal protection range from data, indices, models, simulations and scenarios used by scientists to organizing information events and disseminating specialized and tailored information according to the different types of stakeholders and their needs (see tables 1 and 2 in this chapter for references and further details).

Finally, the literature review gives also hints regarding obstacles in using climate information in the sector (see tables 1 and 2 below for references and further details): main obstacles are stakeholders' difficulty to deal with uncertain information about climate change effects, such as sea level rise, on regional and local level in the planning processes, and the illusion of security behind the dykes. That means, for instance, that storm surges have not been considered by stakeholders as an important problem.

Table 1: Stakeholder needs in the coastal protection sector in the German North Sea region

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Project nordwest2050: Coastal protection sector in the metropolitan region Bremen-Oldenburg	Adaptation measures to climate change effects	Knowledge about climate change effects on coastal protection and the importance of adaptation measures is large due to many research projects, but uncertainty is high regarding the future sea level rise, rising tide water levels and storm surge water levels; further research is needed on climate-induced changes in tide water levels, sea level rise, morphology of coastal areas, reaction of tidal areas and embankment forelands to accelerated sea level rise, as well as on long-lasting integrated coastal protection strategies and optimized assessment approaches for coastal protection constructions		Willingness to adapt to the effects of climate change is impeded by uncertain sea level rise scenarios and the illusion of security behind the dykes	Schuchardt & Wittig, 2012; Schuchardt et al., 2011
Project nordwest2050: Coastal protection sector in the metropolitan region Bremen-Oldenburg	Adaptation measures to climate change effects	Authors of the report suggest: further research is needed regarding climate-change related changes of regional water levels (e.g. tide water levels, storm surge heights, frequency and intensity of storms), improving knowledge about possible limits of climate adaptation, continuous research on harmless overflow capacity on dykes, bearing capacity of the underground during dyke construction, research on alternative options for coastal protection is necessary (stakeholders of provincial administration in the field of coastal protection do not see need in alternative options for coastal protection); population should be informed about flood risks in their residential areas	needed format: multipliers, publishing of specialized information and information events are necessary for development of cross-sectoral problem-solving strategies	Consideration of climate change effects with high uncertainty of occurrence (such as specific water levels) in planning is difficult, dealing with uncertainty of climate scenarios is difficult among the institutional system of coastal protection	Nibbe & Wittig, 2013

Project KLIWAS – Impacts of climate change on waterways and navigation, here: sensitivity study about storm surges in the estuaries Elbe, Jade-Weser and Ems in the German North Sea region	Research questions: What are the characteristics of storm surges in a future climate? Is the current protection status against storm surges sufficient, or are additional adaptation measures necessary?	Used data: historical, extreme storm surges, storm surge models of Elbe, Jade-Weser, Ems, upstream water inflows, water-level development at the open edge to the North Sea with measured water level time series, sea level rise of 25, 80, 115 cm, water run-off during historical storm surges, wind fields, wind scenarios with higher wind velocities	Used formats: data, models, scenarios	Not precised	Seiffert et al., 2014
Online-survey with 16 stakeholders in the district Dithmarschen from the following sectors: agriculture, tourism, industry, culture, environment, coastal protection, emergency management, local administration, NGOs, business sector, administrative levels: national, state (Länder), county (Amt), district (Kreis), community (Gemeinde), about storm surge risk perception and resilience	Assessing storm surge risk perception	Study indicates a lack of storm surge risk information by responsible authorities; information should be improved concerning potential social and economic impacts of storm surge events in the North Sea region, preparedness/recovery options, responsible authorities working within storm surge risk management, storm surge risk consideration in sectoral planning	Not precised	storm surge is not considered an urgent or important problem by the stakeholders; more important are livelihood-related difficulties, demographic change and migration, and climate change	González-Riancho et al., 2015
Online-survey with 116 stakeholder from the German North Sea coast from institutional authorities, public agencies, private sector, NGOs about storm surge	Assessing storm surge risk perception	Study shows a lack of information among stakeholders concerning: social and economic impacts of storm surges, risk reduction measures, potentially flooded areas, consideration of storm surge information in sectoral planning, availability of preparedness and recovery options (e.g. evacuation planning, temporary shelters,	improved communication strategy is needed, not only information provision, but tailored	storm surge and immediate action is not perceived as an urgent issue to deal with, much more important are issues such as:	González-Riancho et al., 2017

resilience and risk perception, main sectors: emergency, administration, coastal protection, environment, agriculture and farming		economic instruments), level of information differs among sectors	information according to the needs of different types of stakeholders and with special attention to specific topics and sectors	unemployment, private problems, general political problems, demographic change, followed by environment, energy, and climate change	
Scientists: scientific article about changing North Sea storm surges (focus Southern North Sea) and coastal protection	Assessing current and future safety levels of coastal protection, discussing possible adaptation strategies	Research needs: detailed studies about changing extreme sea level and adaptation strategies, provision of comprehensive projections of regional mean sea level change, assessing potential regional and local changes in tidal regimes and their interaction with changes in underwater topography, mean sea level, storm surges and extreme waves, assessing potential changes in local wave climate (especially wave set-up and run-up that influence coastal processes), developing sampling strategies to provide improved estimates of uncertainty ranges, combining dynamical modelling with statistical approaches, transferring knowledge about changing sea levels and waves into knowledge about measures for coastal protection, offshore operations, or about near-shore processes (e.g. erosion, sedimentation), assessing chances and risks of a strategy for a wide range of scenarios	Needed formats: data, models, scenarios	Not precised	Weisse et al., 2012
Project nordwest2050: Coastal protection sector in the metropolitan region Bremen-Oldenburg, scientific users	Vulnerability analysis of the coastal protection sector in the metropolitan region Bremen-Oldenburg, describing the sector's exposition to climate change	mean sea level, mean high tide, water levels caused by wind surge, storm surge water levels, stormy days, maximum wind speed, wind direction; climate factors used with regard to today and to climate scenarios for 2050 and 2085	Climate factors or climate parameters from current regional climate models, model ensembles; climate scenarios	Not precised	Schuchardt et al., 2011

Project ReKliEs-DE – Regional climate projections, ensemble for Germany: sectors water management, coastal and marine protection	Permanent protection against sea level rise and extreme floods at coasts and inland waters, long-term usability and management of waterways, adaptation measures to climate change effects	climate indices already used in measures concerning the German Adaptation Strategy: e.g. mean monthly air temperature, mean seasonal air temperature, monthly/seasonal/ annual precipitation height, precipitation intensity, highest precipitation, days with (extreme high) precipitation, dry days, wet days, (extreme) humid days, drought index, mean wind velocity, wind direction, days with heavy winds, stormy days	Used formats: indices and parameters	Not precised	Bülow et al., 2017
Actors in the field of coastal flood protection in Hamburg, scientists?	Climate change impact monitoring with regard to coastal flood protection in Hamburg	Four IMPACT-indicators have been developed for Hamburg: “tidal conditions” (long lasting time series of water levels with e.g. mean high tide, mean low tide, mean tidal range), “storm surges” (development of number and intensity of storm surges in Hamburg), “lock tides” (number of lock tides and chain tides at rivers in Hamburg), “coastal wind” (change in wind intensity, with duration and wind force, over time)	Climate impact indicators	Not precised	Hamburg Authority for Environment and Energy, 2018b,c

Table 2: Stakeholder needs in the coastal protection sector in the German Baltic Sea coast

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
project RADOST: sensitivity analysis of coastal protection structures in the federal states Mecklenburg-Vorpommern and Schleswig-Holstein	Analyzing the effectiveness of coastal protection structures (dykes, dunes, revetments, sea walls)	Used information: morphologic and hydrodynamic basic data, regional sea level rise scenarios (+30, 60, 90 cm), simulations of dune erosion, assessing mean wave overflow rate	Used formats: Data, scenarios, simulations	Not precised	Ecologic Institute, 2014
project RADOST: working group meetings between representatives of coastal protection authorities of the federal states Mecklenburg-Vorpommern and Schleswig-Holstein and universities: strategies and options of coastal protection planning	Developing adaptation strategies for coastal and flood protection constructions, reducing sea state at the constructions	Information needs: sea level rise, sediment transport parallel to the coastline, lee side erosion, wave set-up at the coast, long-term availability of marine sands	Data	Not precised	Ecologic Institute, 2014
project RADOST: preliminary work for specialist planning to protect sandy coasts, 4 case studies at the German Baltic Sea coast; scientific users	Assessing effectiveness and containment performance of dunes; examining changing flood risk and developing adaptation measures for coastal and flood protection	Used information: scenarios about changing sea level rise (+0,3m, +0,6m, +0,9m) and mean/extreme sea state (wave heights, wave direction); statistically determined storm surge hydrographs, statistically determined flood level with a return period of 200 years	Used formats: Data, scenarios, numerical simulations	Not precised	Ecologic Institute, 2014
project RADOST: Interviews about coastal protection with representatives of ministries from departments for coastal and flood protection, representatives from local politics and	Coastal protection, protecting living space, settlements and economic uses (e.g. agriculture, tourism) at	More reliable information necessary about regional and local climate change impacts; With rising water level - when can pumping stations not work effectively	Not precised	Uncertainty about future climate change impacts means no planning security for spatial planning; designating	Knoblauch et al., 2012

administration, civil society in the federal states Mecklenburg-Vorpommern and Schleswig-Holstein, other sectors: nature conservation, water management, tourism, agriculture	the coast in a changing climate	anymore? When will drainage be useless?		floodplains and examining water drainage not possible because of unknown climate change impacts on regional and local level	
Project RADOST: interviews with representatives from ministry and lower administrative levels from the federal states Mecklenburg-Vorpommern and Schleswig-Holstein about implementing adaptation measures to climate change impacts in coastal protection, sectors: coastal protection, environment, marine protection	Developing adaptation strategies to climate change effects in coastal protection	Reliable and clear information from science needed, not only ranges of climate change effects; science should reduce uncertainties and show ways to better deal with them; more applied research needed, more regionalized climate data, further research needs: Can dredged materials from fairway channels be used for dyke constructions and beach nourishment?	Not precised	Dealing with uncertainties regarding climate change impacts is difficult	Stelljes, 2012
Workshop and 9 interviews with regional decision makers, concerned with climate change and storm surges, at the German Baltic Sea coast, about Extreme Event Attribution (EEA) and regional climate services, sectors: coastal protection, emergency management, spatial planning, tourism, nature protection, climate change mitigation, maritime/port industry	Adaptation planning	respondents need to know how extreme events occur and change rather than why they change, more important to understand the causes of vulnerability than of the hazard; emergency management and coastal protection: need extreme values, like worst-case scenarios, planners of large infrastructure: need certain information with one concrete value rather than results depicting large margins	scientific information, translated into salient and credible information, needed	scepticism that EEA is actually possible or able to produce reliable results, EEA is interesting but not directly relevant to respondents' work, no real added value from EEA results; problem of uncertainty	Schwab et al., 2017

6.2 Municipalities and regional policy in Germany

6.2.1 Stakeholders from municipalities and regional policy in the German Baltic Sea region

Stakeholders such as regional politicians and municipality representatives are important decision makers at regional and local levels with a cross-sectoral perspective, especially with regard to developments and problems in the municipality or community they are responsible for.

Activities in the RADOST project as well as another scientific survey aimed at these stakeholders and conducted interviews and surveys with different stakeholder groups, such as mayors of municipalities and administrative staff as well as municipal political decision makers. They were questioned mainly about their awareness, opinion and information demands regarding climate change and adaptation aspects at regional and local level (see table 1 in chapter 6.2.2 for references and further details).

6.2.2 Stakeholder needs for coastal climate information at municipal level and regional policy in the German Baltic Sea region

According to the literature review, municipality representatives (mayors, administrative staff, political decision makers) need climate information mainly for developing strategies and planning measures to adopt to climate change impacts at regional and local level, for example in the area of beach management and flood protection (see table 1 below for references and further details).

The stakeholders expressed mainly the following information needs (see table 1 below for references and further details):

- more information about regional and local impacts of climate change and sea level rise, about adaptation measures and options for action
- more information about consequences of climate change for society
- more information about mitigating greenhouse gas emissions and funding options for mitigation measures
- solutions how to manage the growing amount of seaweed at beaches
- more information about existing values in flood-prone areas and external help with value assessment

Regarding the preferred format of climate information, municipal representatives need information with a close connection to their own community. The scientific information should be reliable and comprehensible and tailored to their needs and beach sections (see table 1 in this chapter for references and further details).

Reasons that prevent the stakeholders from using climate information for adaptation measures are mainly (see table 1 below for references and further details):

- uncertainty about climate change and its concrete impacts
- difficulties to understand scientific information
- insufficient utility of scientific information in the decision finding process
- lack of importance regarding the climate change and adaptation topic

Table 1: Stakeholder needs in municipalities and regional policy in the German Baltic Sea region

Stakeholders/ projects	Information is needed for:	Information needs / already used information	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Project RADOST: 11 interviews with municipal representatives (mayors of municipality and administrative staff) from Climate Alliance Bay of Kiel about awareness of climate change and adaptation in the community, communication and knowledge transfer	Beach management, flood protection	Solutions desired from scientists relating to dealing with growing amounts of seaweed at beaches; more information needed about flood-prone areas and existing values within these areas, extern help with value assessment	Scientific information should have a close connection to the community's own situation; elaboration of concrete concepts and proposed solutions by projects, scientists desired; reliable scientific statements desired; used information channels about climate change and adaptation: above all press and internet, also radio, TV, specialist publications and events, conferences, seminars, internet presence of Climate Alliance Bay of Kiel	Uncertainty regarding climate change and its concrete impacts	Koerth & Sterr, 2012
Project RADOST: survey among municipal political decision makers from the federal states Mecklenburg-Vorpommern and Schleswig-Holstein about awareness of climate change and adaptation to it at the German Baltic Sea coast	Adaptation to climate change	Information about climate change and adaptation needed; respondents have none to moderate information about regional climate change effects and adaptation measures	Researchers: access to comprehensible information about climate change and climate impacts needed, tailored to their needs and beach sections; used information channels about climate change and adaptation, above all: TV, newspapers, radio, less: scientific presentations, conferences and journals, hardly: working groups, personnel contact to scientists; projects/internet presences/reports about public dissemination of scientific information is mostly unknown or not useful	Barriers to adaptation: uncertainty about occurrence and nature of climate change impacts, other important topics; insufficient understandability and utility of scientific information regarding climate change and adaptation for decision finding	Martinez & Bray, 2011a,b
Survey among mayors of municipalities at the German Baltic Sea Coast about general aspects of climate change, preferred information channels and information demands	Climate change issues	Information needs: regional and local impacts of climate change and the sea level rise, mitigation of greenhouse gas emissions, consequences of climate change for society, options for action, funding options for mitigation measures	Information sources on climate change issues: media (print, radio and TV) are most important, only about 4% use scientific information services	Not precised	Meinke, 2017

6.3 The water management sector in Spain

6.3.1 Stakeholders in the Spanish water management sector

Water resources are limited and represent a major issue due to its importance in regulating the state of natural systems and because it condition the development of many socio economic sectors. Therefore, specific knowledge of the possible effects of climate change is key to propose adaptation strategies and measures. Their integration in water management policies allows minimizing possible impacts or taking advantage of the opportunities that could arise. Besides, climate information is also necessary for day-to-day business to keep supply processes and disposal procedures safety, to meet industrial demands, to ensure reliable supply of energy and to keep natural systems unpolluted.

Main stakeholders identified on the experience gained by IHCantabria in the water management sector, including related literature, are those related to **decision-making and planning processes** (public administration agencies within national, regional and local governments, including river basin authorities), **water supply and sewage disposal companies** (both public and private), **hydropower private companies** and **agricultural associations**. Other stakeholders that should be in this sector are **environmental**, **agrarian associations** and **end-users (general public)**, even if, as stated by Hernandez Mora et al. (2016), they play usually a marginal role and have little influence in the decision-making process. In this regard, it is interesting the approach developed by Martínez-Santos et al. (2008), a model based on coupling hard-science modelling approaches with the involvement of key water actors.

6.3.2 Stakeholder needs for coastal climate information in the Spanish water management sector

The following table include some examples from IHCantabria, a “research institution” stakeholder who produce, manage and transform climate information into manageable information for the other identified stakeholders in the “water management” sector. These examples show significant climate information-related identified needs of other stakeholders.

In the various studies carried out in this topic, meetings and workshops are held with the stakeholders below mentioned. At the beginning of the project, to reach consensus in the definition and specification of the scope of the project, at the middle of the project life (monitoring and evaluation meetings) and at the end of the project including final presentations and discussion about future lines of work.

Table 1: Stakeholder needs in the Spanish water management sector

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Regional level government	Climate information, including data variables are needed to analyse and predict beach and water pollution coming from sewage spills. Information is incorporated into the decision- making process through a specific tool. Climate information is used to prove that water quality will meet official standards and predict pollution in future.	Climate variables: sea level, flow, wind, salinity from re-analysis databases and field campaigns. High resolution (<50 m).	Format: Data are received through FTP interoperability channels and attached to emails. Final developed climate information is distributed through data, reports, maps and meetings	Main obstacle for the stakeholder is lack of resources and qualified personnel	UC-IHC IHC Oceanography, Estuaries and Water Quality Reserach Group. Bárcena et al. (2017)
Regional Wastewater management agency	Climate information, including data variables needed to assess wastewater discharges over lakes and coastal water bodies, considering eutrophication processes. Information is incorporated into the decision- making process. Climate information is used to test water quality and to establish environmental-friendly strategies to control wastewater.	Climate variables: sea level, precipitation, temperature, radiation, evaporation, continental water flow. Data obtained from national public hydrology information systems, National Metorological Service and field campaigns. Medium resolution (100m)	Format: Data are received through FTP interoperability channels, OpenDap and attached to emails. Final developed information is shown via reports, maps and graphics. Final data is also distributed	Not precised	UC-IHC

Climate information is used to test and certify water quality official standards and to predict pollution in future, to identify water related hot spots (generally regarding water areas polluted or at potential risk of pollution) and to establish sustainable and environmental-friendly strategies to control them under climate-variability and climate change conditions.

6.4 The multi sectoral perspective in Spain

The term "multi sectoral" applied to the identification of stakeholders needs on climate information is addressed in this section. Accordingly, some examples are shown below in which several sectors are the objective of the same study or may benefit from the results obtained. Corresponding stakeholders identified previously in the different sectors can also be considered as "identified stakeholders" in this section.

Therefore, the following table include some examples considering UC-IHC experiences gained in previous projects. Main sectors and/or areas of work considered below are disaster risk reduction, coastal areas management and biodiversity, covering in some cases other sectors such as tourism, energy, infrastructure, transport or agriculture.

Table 1: Stakeholder needs regarding a multi sectoral perspective in Spain

Stakeholders	Information is needed for	Information needs	Requested format of information / already used information channels	Obstacles in using scientific/ climate information	References
Sectors: Coastal areas management, disaster risk reduction and biodiversity. **Stakeholders**: Local (council) and national government. Private consulting company	Adaptation options to reduce coastal erosion and flooding due to climate variability and climate change. Information is incorporated into the decision-making and planning processes	Climate data: waves and sea level to determine the coastal dynamics. Past climate data information and local spatial scale.	Climate data received through interoperability access (FTP, OpenDap). Field data collected for validation. Final developed information is delivered to the stakeholder in reports, maps and graphs.	Lack of resources and qualified personnel. Stakeholder needs tailored and easily to understand products.	UC-IHC IHC Coastal Management and Engineering Research Group. Several local projects related to coastal erosion and beach nourishment
Sectors: Coastal areas management, disaster risk reduction and biodiversity **Stakeholders**: Local (council) and national government. Private consulting company	Analysis of coastal dynamics and options for beach equilibrium considering climate variability and climate change. Information is incorporated into the decision-making and planning processes	Climate data: waves and sea level to determine the coastal dynamics. Past climate data information and local spatial scale.	Climate data received through interoperability access (FTP, OpenDap). Field data collected for validation. Final developed information is delivered to the stakeholder in reports, maps and graphs.	Lack of resources and qualified personnel. Stakeholder needs tailored and easily to understand products.	UC-IHC IHC Coastal Management and Engineering Research Group. Several local project related to coastal and marine dynamics
Sectors: Disaster risk reduction, Coastal	Climate change adaptation strategies development.	Statistical climate data associated to return periods, average values and	Data are received through external drive devices and attached to emails.	Insecurities of stakeholders in dealing with the	UC-IHC IHC Coastal Management and Engineering

management, biodiversity, tourism, energy, infrastructure, transport, agriculture… **Stakeholders**: National, regional and local level government	Information is incorporated into the decision-making process.	identification of changes. Past, present and future information is needed at regional (sub-national) scale.	Final data delivered include variables, text format, and maps	uncertainty of scientific coastal climate results and scenarios. Lack of understanding of users about scientific information on climate change and its effects	Research Group. IHC Marine Climate and Climate Change Research Group. Examples: Climate Change Effects and Adaptation measures in the Delta del Ebro, and Climate Change Adaptation in the coastal area of Asturias

7 Climate information needs in relevant coastal sectors in Germany, Spain, France and Greece: overall summary and conclusions

The review of literature, former projects and experiences on project partner level with regard to documented stakeholder needs for coastal climate information gives insights in information needs in the sectors tourism, offshore energy, maritime navigation and ports, and risk insurance in all four countries. Additional sectors important for coastal areas have been included by Germany (coastal protection, municipalities and regional policy) and Spain (water management, multi-sectoral perspective). The review concentrates mainly on information regarding the following questions: a) Who are the stakeholders with documented climate information needs?, b) What is the information needed for?, c) What kind of information has been requested (e.g. content, time, spatial resolution)?, d) What is the preferred format of the requested information (e.g. climate data, maps, text, prepared and easily understandable information tailored to the stakeholders' needs), and e) Which obstacles exist in using climate information.

The review includes a big variety of stakeholders from local to national level in all four countries, who belong to the economic sector, administration, government agencies, politics, non-governmental organisations, and research. These very different stakeholder groups have different backgrounds and experiences in using climate data and information, and the review results indicate that the complexity and scientific level of requested information vary very much between the groups. Many stakeholders are not familiar with using climate data but rather prefer information tailored to their needs and easily understandable. It might be necessary to investigate more deeply these differences in using climate information.

The review findings could reveal a wide range of information needs that differ between and within the sectors as well as between the countries, so that describing communalities of all sectors in all countries is quite difficult.

However, with view on the reasons what climate information is needed for and used, there emerge three main areas in all countries and sectors: strategic planning and acting, adaptation to climate change impacts and, less often, sector-related research (not in the tourism sector, hardly in the risk insurance sector). It can be shown that nearly every sector (apart from the documentation referring to the water management sector in Spain) needs and requests climate information to discuss or develop measures and strategies for adapting to climate change impacts. These results are not very surprising, as most of the sectors have been addressed in the National Adaptation Plans to Climate Change in the respective countries. Furthermore, climate change adaptation oriented projects have been carried out, addressing several sector-relevant issues, having organized dialogues and interviews with stakeholders and having published many project reports, as in the German case.

The review shows that the requested (and offered) climate data and information in every sector and country comprise mostly regional and local variables such as storm surges, tides, waves, sea state, currents, sea level, storms, wind data, sea surface temperature, precipitation and water run-off. Thereby, the preferred time horizon embraces past, present and to a lesser extent, future climate information, whereas the requested present information often include short and medium range weather forecasts. Apart from that, information about specific climate change impacts on the sectors at regional scale have been requested quite often. And finally, the desire for information on options for action have been expressed. However, it seems that especially information about specific climate change impacts on the sectors are lacking, because for assessing these, many different factors have to be taken into account, and the scientific basis on these questions is still scarce (see for instance chapter 4.3.2 about the French maritime navigation and ports sector).

With regard to the preferred format of climate information, the review results show in every country and sector that data, indices, predictions, scenarios, models and simulations have been requested (and offered) very often. This raises the question whether, by offering climate information in data formats (e.g. via data portals like coastDat) and using corresponding references in the review, other potential user groups simply do not become obvious. To a lesser extent the need for prepared, target-group specific, comprehensible and easily understandable information (for instance as web sites, maps, graphics, brochures) has been formulated, especially in the tourism sector in Germany and Spain, and the maritime navigation and ports sectors in Germany. Occasionally, stakeholders expressed their wish for dialog and information exchange, for instance via networks, discussions, training or the direct exchange between scientists and practitioners, like in the German tourism sector.

And finally, obstacles in using climate information are manifold and have been mentioned in every sector and every country. The five main categories of obstacles are uncertainties about climate change effects and unreliable climate information, a minor relevance and priority of the topic climate change and adaptation, including a lack of resources and qualified personnel to deal with the topic, and the temporal mismatch between short-term

planning and long-term climate change prognosis or long-term strategic concept development. These are obstacles climate service providers cannot change. Furthermore, in many cases there are not sufficient climate information available about sector-specific regional and local climate change effects that would be needed for developing adaptation measures, and more research would be necessary. Finally, some of the offered formats of information (especially data and scientific information) seem to be inappropriate for many stakeholders, which can be seen in the review results by formulations such as "lack of understanding of scientific information", "insecurity of stakeholders in dealing with climate scenarios", "lack of qualified personnel" or "users do not get easily to developed tools". That is in contradiction to the requested format, which is in many cases "scientific data". One reason can be that obviously those climate information have been requested that are offered, and requests of other formats have been expressed and documented to a lesser extent. Another reason could be that the review results do not distinguish sufficiently between scientists as regular users of scientific data and other stakeholders who are not so much familiar with the use of scientific data and information.

In view of these results it should be mentioned that the review of stakeholder climate information needs in the four countries had to face some limitations that makes an interpretation and generalisation of results difficult. One important point is that only very few studies could be found where stakeholders had been asked directly about their climate information needs. Instead, these needs have often been formulated as conclusions or interpretations by researchers or text authors. Generally, stakeholder information needs seem to be not well documented. Although the reviews give some insights in the sector specific information needs, the findings are not at all sufficient as the sectors are very diverse within themselves and contain many different stakeholder groups with diverging information needs (such as port administration versus port related research).

A further limitation refers to the extent and depth of literature research that differs much among the project partners. Due to a lack of relevant literature, Spanish and Greek partners have mainly been concentrating their documentation on the experiences of their home institutions, whereas French and German partners were able to include a wider perspective in their reviews. The Greek partners did not found relevant information at all about the risk insurance sector; the French partners did not find literature regarding the offshore energy sector. With a view to experiences and knowledge about stakeholder information needs available at research institutions, a further limitation becomes obvious: every research institution has its own research agenda that limits the possible portfolio of climate services. Apart from that, stakeholders will probably not ask for specific climate information when they know that this information will not be offered. These points restrict the knowledge about stakeholders' climate information needs at research institutions.

Finally, information regarding the five main points of the literature review (stakeholders, information needed what for, information needs, formats of information, obstacles of using information) could not always be found in every sector and every country. Especially statements about requested formats of climate information, time-related and spatial references of climate information have been lacking or expressed quite often in very general terms. In some cases, the connection between the requested information (column 3 in the tables) and the reasons why the information is needed (column 2 in the tables) is

not documented clearly. Furthermore, in some cases it is not obvious whether the requested format of information mentioned in the tables results from the way stakeholders wish to receive the information or whether this is just the way the information has been offered by the research institution. And finally, in some cases it was obviously difficult to clearly distinguish between the requested information (the content) and the requested format of information (such as raw data, maps, graphics, brochures, dialogues etc.). This suggests the conclusion that stakeholders do have specific information needs but that these needs have not been well documented in literature and are not sufficiently investigated and well known so far.

In conclusion, it can be said that the reviews of documented stakeholders' climate information needs can reveal some insight in the sector specific climate information needs, but the results remain very general, incomplete and fragmented. Especially with regard to the huge variety of stakeholder groups within the sectors themselves, the results are too unspecific. In order to receive detailed knowledge on stakeholder needs for climate information and to develop a coastal climate information service that considers stakeholders' real information needs, a more intensive cooperation with relevant stakeholders (such as via interviews or workshops) would be necessary. Nevertheless, the review results can be used as a basis for developing an interim list of potential coastal climate indicators for a pan-European coastal climate service web tool (deliverable D1.D in WP 1.3 Knowledge, research and identification of gaps).

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Offshore energy

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2 MOSEP: http://www.oceanography.ucy.ac.cy/mosep/