Deliverable 3.4

WP3 final report: synthesis of cases, climate services, and lessons learned

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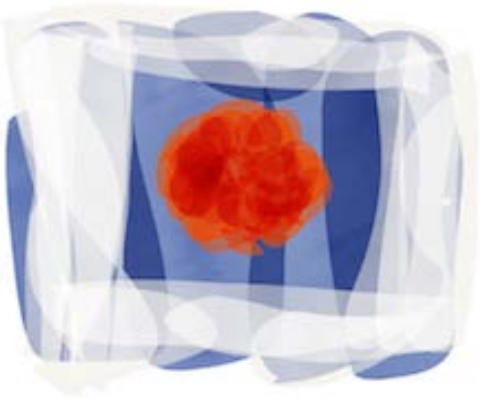

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Purpose of the document

This document presents a synthesis of the work done in Work Package 3 focusing on the assessment and evaluation of local climate information.

In the context of CoCliServ's aim to enable local communities to act with regard to climate change and support related local planning and adaptation, WP3 had the purpose to connect climate science with local communities. This contribution included:

- The systematic documentation of existing climate service practices and formats pertaining to the local case studies (D3.1), as well as scientific knowledge of local climate change (M3.1).
- The comparison of the local narratives of change (WP1) with current scientific knowledge of climate change on local scale (M3.2).
- The analysis of the local narratives of change with regard to entry points (matters of concerns connecting scientific and local perceptions) for climate services, as well as the evaluation of the existing climate information and services with regard to local needs (D3.2)
- The analysis of the feasibility of co-developing local climate services (options, gaps, limitations) with regard to local needs (D3.3)

This final report D3-4 is a navigator for the above WP3 results (available in the deliverables and milestones) regarding the assessment and evaluation of local climate services. The general results and conclusions are presented in the form of a short synthesis of cases, climate services, and lessons learned from the WP3 perspective. Corresponding references to the deliverables and milestones used for this report are referenced throughout the document. The discussions can be retraced in detail in these deliverables and milestones.

Relationship to the Description of Work (DOW)

The report meets the requirements of the requested deliverable D3.4: WP3 final report: synthesis of cases, climate services, and lessons learned. It provides a synthesis and overview about the work within WP3. It is based on the following

results and deliverables, as agreed upon in the CoCliServ DOW and delivered accordingly to the project management:

- M3.1: Literature review on scientific knowledge of local climate change in all sites
- D3.1 Assessment of climate service components for each study site
- M3.2 Comparison of local narratives in all sites with current climate science knowledge.
- D3.2 Evaluation of existing local climate service components
- D3.3 Feasibility study of local climate services

The WP3 analyses are linked to WP1 (narratives of change) and WP2 (Scenario design and development). The results of these two work packages were included in our work, as long as they were available by the date we had to realize a given milestone or deliverable, and accounted by referring to the published milestones and deliverables in order to ensure traceability between the different activities and work packages.

Introduction and structure

Investigations of WP3 aimed to connect available (physical) climate knowledge to local narratives as an entry point, and vision planning and adaptive pathways as co-construction locus to proactively connect and co-develop climate science with local communities. Moreover, WP3 analysis moves beyond the state of the art by evaluating scientific local climate knowledge and services against non-scientific knowledge claims.

The final report is structured along the development process in the project: The first chapter provides a synthesis about climate services referring to the assessment of climate service components worked out as the first major task of WP3. The second part gives a summary for the individual case study sites, summarizing the findings from: comparing local narratives with current scientific climate knowledge, the evaluation of existing climate services and the feasibility study for (improved or new) local climate services in each site. The last chapter focuses on the (general) lessons learned from our WP3 perspective. This also includes the discussion about the practical feasibility of the CoCliServ approach with regard to the experiences made during the project.

Synthesis of climate services

At the beginnig of CoCliServ, WP3 provided a systematic empirical study of climate service practices and formats currently applied in the research area. This was achieved by developing and applying an analytical framework to perform a detailed investigation of available climate services. This framework builds upon the scientific discussion in particular regarding climate service assessment and includes the authors' personal experiences as practical climate service providers.

The database of the inventory was built upon an available mapping of climate service providers: the Climate Knowledge Hub (CKH)[1]. The analysis of the climate service

A **detailed description of the framework** is presented in **D3.1**, p. 18-24.

[1] http://www.climate-knowledge-hub.org/ The CKH is an online map of climate service providers in the countries participating to ERA4CS and abroad. CKH was developed by GERICS (German Climate Service Center) and CCCA (Austrian Climate Change Centre) within ERA4CS activities

providers was conducted in all case study areas[2] if they are either directly located in the case study site or if their portfolio is addressing them:

Gulf of Morbihan and Brest (France)	12 providers from CKH (mostly in Paris)
Dordrecht (Netherlands)	5 providers registered in CKH for the Netherlands
Bergen (Norway)	9 service providers including two in the case study area and 6 others throughout the country
Jade Bay (Germany)	17 providers in the CKH (in Lower Saxony, Bremen, Hamburg and selected examples from Schleswig-Holstein)

Our findings from the inventory highlighted three major types of providers: (1) commercial enterprises (business ventures or corporates), (2) research institutions (universities and governmental research centers), and (3) institutions focusing on climate services and governmental agencies (administration).

A detailed discussion about the different types of providers and their presence in the different case studies is presented in **D3.1 p.30-36**.

Typical combinations of providers and formats in the research area are discussed in **D3.1 p.41-49**.

The landscape of available climate services includes a considerable range of climate services in the case study regions. It extends from formats building on information provision where often a provider supplies information and knowledge (e.g. processed data or products) for a user ('lay' person, decision-maker or the public at large), to formats characterized by an increased level of interaction between provider and users such as consultancy and educational activities. Differences in rationales of climate services extend from understanding them as pure data provision services up to participatory, capacity building processes (including online games and story maps). Depending on the provider, a climate service is understood as data, an advice, a tool (for example a web portal providing processed data), a product (maps of downscaled temperature projections for instance) or a process (e.g. workshop series to increase the resiliency of a local population against a climate risk).

[2] The database in the form of the CKH conveys the general impression that there are significantly more providers registered for the Jade Bay cases study (Northern Germany) than for three other countries. This distribution should however be treated with caution since this snapshot might be related to the German (and Austrian) supervision of the project during the development phase of the CKH (an above-average number of institutions are registered for Austria, too).

Most of the climate services considered can be characterized as long-term activities, contrasting with research-project activities that are limited in terms of time, money and personnel. Data and text related products (such as data services, web applications, and printed media) prevail in quantity over activities including communication processes and interactive formats (advisory, education). Many of the climate services that we mapped focus on knowledge transfer in order to achieve more awareness towards climate change impacts and the need for mitigation and adaptation to climate change. Additionally, many climate services, as described by the providers, aim to give an impulse for action or to support it scientifically. Recommendations and guidance given to the user, especially to start climate change adaptation and mitigation in practice, vary greatly between the different services. They range from very concrete instructions to rather vague statements.

A detailed **discussion about the different type of services** is presented in **D3.1 p.36-40**

A glance on the climate service landscape in each case study area is given in **D3.1** (p.49-55).

Synthesis of cases

Using narratives as entry points for local contextualization of climate science

CoCliServ aimed to connect climate science with local communities, using local narratives as entry points (DOW; Vanderlinden et al. 2017, p. 1). In order to find potential entry points for local climate services we had to find the concrete weather parameters,[3] which the WP1 narratives are related to. These parameters and their contextualization represent the interface between the narrations and the available scientific knowledge of climate change that CoCliServ has been looking for. In a second step, the WP 1 narratives are analysed according to the perceived issue related to the respective weather parameter. The analysis is focused on what is perceived (e.g. warming, changed precipitation patterns etc.) and on whether the perceived issue is addressed to a certain time horizon (year, season, and decade). This step is followed by the question if (according to the WP1 narratives) a link to climate change is perceived or not. Finally, the perceived issues on weather parameters and their perceived links to climate change are compared with the currently existing scientific knowledge on climate change in each case study site.

For each case study site, **the comparisons after the above described method are documented in Milestone M3.2**.

A table is summarizing the comparison of the extracted aspects from the narratives as described above and the corresponding scientific knowledge.

In order to evaluate the narratives of WP1 according to potential entry points for local climate services, leading questions are defined. They were directly related to the described work plan in the DOW (Vanderlinden et al. 2017). In this approach, narratives give meaning to facts and scientific calculations. They turn ‘matters of fact’ into ‘matters of concern’ (Vanderlinden et al. 2017, p. 1-5).

Matters of concerns are found in everyday conversations, in life stories, in eyewitness reports, legends and newspaper articles, as well as in archives,

[3] Weather parameters are understood as parameters of the climate system, like air temperature, precipitation, wind, sea surface temperature and water levels, which vary in time

documents, plans, leaflets, tourist information and blogs (Vanderlinden et al. 2017, p. 5). In accordance with the work plan, we understand “matters of concern” as individual consequences of climate change, a person or a group is concerned about. While impacts are countable, measurable and related to the source, matters of concerns are defined as individual consequences of the perceived climate issue, a person or a group is concerned about. For example, if their everyday live is changed by climate change or if climate change makes people feel in danger or if accidents or losses of people are related to certain weather conditions or climate change, these are matters of concern. In combination with a particular local focus, they may serve as entry points. In order to find potential entry points for local climate services, the WP1 reports are analysed according to these matters of concern, which are related to perceived weather parameters (see above and M3.2) and have a local focus. The structure of this analysis follows the respective aims of the tasks in WP 1 (cf. Figure 1). According to the CoCliServ approach, the results of this WP1 analyses should enable WP 3 to give meaning to facts and scientific calculations as ‘matters of fact’ are turned into ‘matters of concern’. For each task, leading questions are defined in order to localize potential entry points. In these questions, narrative based entry points (as described in the DOW) are connected with the respective task of WP1 (Figure 1).

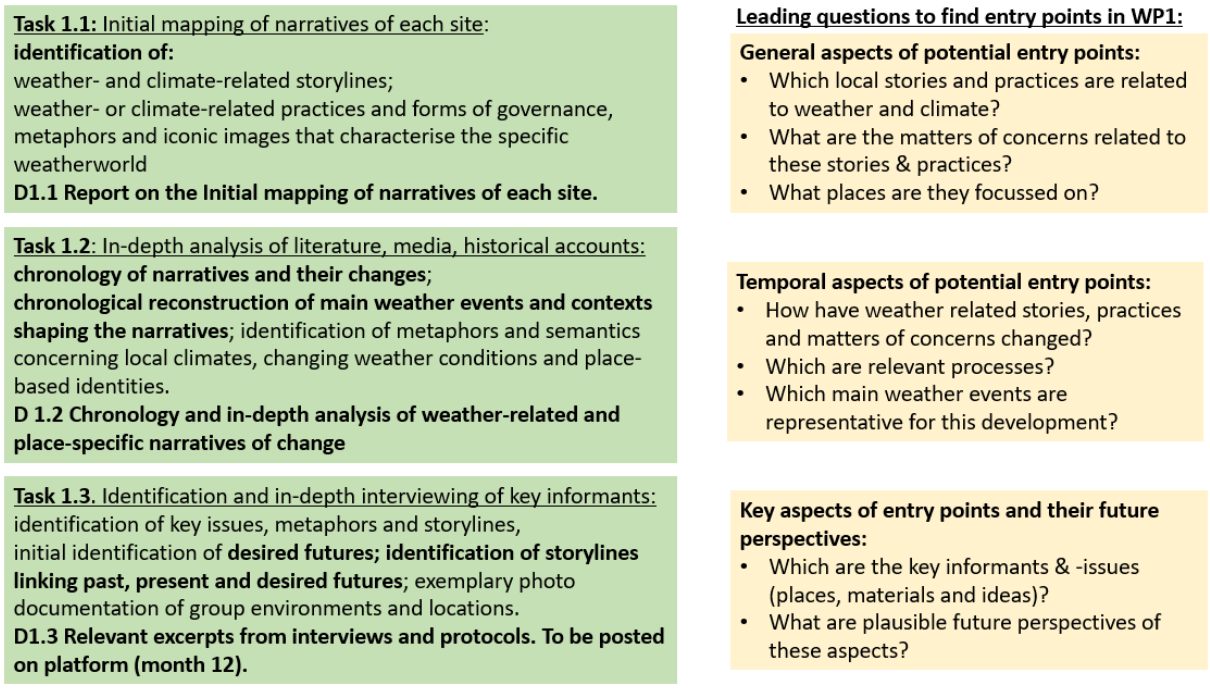

Figure 1: WP1 aims according to the DOW (left) and corresponding WP3 leading questions to localise potential entry points (right)

While the first part focuses on localizing potential entry points for connecting climate science with local communities based on the narratives of WP1, the second part analyses and evaluates the adequacy of related climate services. The guiding questions for this analysis and evaluation are:

- Are climate information and climate services available, which are related to the matters of concerns / aspects / frameworks, derived in the WP1 analyses or to knowledge needs identified from scenario activities (WP2)?
- Are there additional information needs; or are further service formats needed in order to enable climate related action?
- Which barriers or challenges can be identified (such as knowledge gaps)?

The WP3 investigations were completed by a discussion on the feasibility of additional local climate services (Deliverable 3-3), analysing to what extent the local needs can be fulfilled with the existing science and services, and options to overcome the gap and limitations that were identified.

Overview of the documents presenting each analytical step per case study

M3.1 Literature review on scientific knowledge of local climate change in all sites
M3.2 Compare local narratives in all sites with current climate science knowledge
D3.1 Assessment of climate services components for each case study
D3.2 Evaluation of existing local climate service component
D3.3 Feasibility study of local climate services

The following subsections are devoted to the main findings from these analytical steps for each case study. The details of each analytical step can be found in the referenced sections of the milestones and deliverables.

Dordrecht

The analysis of the narratives for Dordrecht highlighted that the weather parameters, which the WP1 narratives in Dordrecht are related to, are mainly precipitation and sea level, and temperature to a lesser extent. The perceived issues associated to these weather parameters are predominantly historical events and the present situation. The comparison of the local narratives with the current climate science for Dordrecht showed that consistencies between the perceived local climate issues and the scientific knowledge prevail in terms of warming, increased winter precipitation, sea level rise. Moreover, another main aspect in the Dordrecht case study are the perceived past river flooding events. Although it was not documented in WP1 whether a link between river flooding to climate change has been perceived, an increased river discharge is documented by scientific climate studies. The missing perceived link to climate change, which was also neither found for temperature, extreme precipitation and sea level rise, is the main inconsistency between the WP1 narratives and the scientific knowledge in Dordrecht.

Milestone 3.2 presents the **detailed comparison of local narratives with current climate science** for Dordrecht on page 11-13

Although the perceptions of climate change are very coarse and general in terms of magnitude, time and local impact and although no matters of concerns are directly related to climate change, the community in Dordrecht appears to be already acting regarding climate change. Because of its direct past, present and ongoing vulnerability to water, which is part of the inhabitants' identity, Dordrecht is already acting without any further specific connection or localization of climate change information to the community. Therefore, it seems that it is *not* climate change information, which is predominantly needed for action. Instead, it is the real existing personal impairment, the individual experience from past events combined with a diffuse perspective of increasing threats, which triggers people to act.

In summary, the overarching CoCliServ aim to enable local communities to act seems to be already reached in Dordrecht. However, although this situation is, compared to the other case study sites, rather advanced in terms of climate change

related action, some specific knowledge needs were localized in the WP2 scenario workshop and some further promising scopes for additional climate service formats were discussed in the local case study.

A detailed **evaluation of the related existing climate information and services regarding questions about changes in the seasons** is provided in Deliverable 3.2, p. 28-29

The available climate services covering the Dordrecht site offer a wide range of information regarding climate parameters and climate change adaptation. Most information needs identified from WP2 ask specifically for local-scale information (e.g. neighbourhood or street). The evaluation (D3.2) investigated whether this information already exists and under which formats, while the feasibility discussion (D3.3) examined the need and room for improvement for the most relevant thematic issues.

Changes in the seasons: Changes in the seasons represent changes in precipitation and temperature (cf. WP1 results). This topic is covered by available climate services (evaluated in D3-2) which sometimes offer information at very high spatial resolution. However, we see a deficiency in the presentation of the findings since there is a mismatch between the scale of the maps and of the accompanying descriptive text. If the present scenarios actually suggest a very high spatial resolution, the descriptive texts should match this level of detail. Otherwise, a high resolution of the data is misleading and not useful. In addition to the climate scenarios, information on local social and cultural geographic developments should be included in the climate service portfolio.

Deliverable 3.3, p. 6-9 provides the **detailed feasibility discussion for improved local climate services for changes in the seasons**

Being surrounded by water: With regard to water-related risks, two major issues became apparent from the WP2 workshop results (D2.2) and the D3.2 analysis: a) Information about local probabilities and local impacts of extreme events (not only

extreme disasters but also small disasters on the local level), and b) Information about the sensitivity of the affected neighbourhood to water-related risks became necessary for decision-makers.

Climate extremes

The discussion about climate extremes mainly refers to precipitation (e.g. extremes become more intense). The WP3 analysis (D3.2) showed that the required information are only partly available in the already established climate services. Therefore, the demand for the quantification of disaster impacts (extreme as well as small disasters) is not yet sufficiently covered (supplied) by services.

A detailed **evaluation of related existing climate information and services** with regard to information about impacts on local scale, information about smaller disasters is provided in Deliverable 3.2, p. 29-30

In this context, the major challenge for improving local climate services resides in the practical implementation of local impact assessments for extreme and smaller disasters.

From the WP3 perspective, the possible improvement of available climate services with regard to the demand for more local insights includes two aspects: a) Increase the visibility and integration of existing information into climate services, and b) include the estimation of values (ideally determined by joint negotiation), unless these can be quantified as monetary or tangible information. The latter ideally requires a sufficiently transparent discussion and an improved cooperation (co-development) to jointly determine these values. This will in turn increase the level of acceptance of the results by decision-makers and make the results more usable in practice.

A **detailed feasibility discussion for improved local climate services addressing climate extremes** is provided in Deliverable 3.3, p. 9-11

Sensitivity of affected (Vogelbruut) neighbourhood to water-related issues

This aspect includes questions about information on acceptation and perception of risks. The WP3 analysis (D3.1, D3.2, M3.2) showed that nearly all available climate services focus on the objective presentation and description of the physical changes; but most of them neglect the discussion and presentation of the available knowledge about the perception and awareness of the changes and risks. This local demand hence suggests the need for a new or at least an additional aspect of climate services.

D3.2 (p.31-32) provides the detailed **evaluation of related existing climate information and services** with regard to knowledge needs in terms of being surrounded by water, including the sensitivity of Vogelbuurt neighbourhood to water-related risks.

Challenges related to an integration of sensitivity analysis as well as risk perception and risk awareness assessments for climate service mainly evolve out of the fact that sensitivity towards risks is not static, but constantly changing. This constant change requires, above all, regular recording and a continuous survey and continuous analysis of the data.

The **detailed feasibility discussion focussing on the stakeholder's demand for improved information about the sensitivity of affected neighbourhoods to water-related issues** can be found in Deliverable 3.3, p. 11-14

Information need on political and social trends

The knowledge needs highlighted in the WP2 workshop include the need for information about political trends and social sensitivity concerning options or activities and legal issues related directly and indirectly to climate change. Such knowledge requires focussing mainly on non-climate aspects (but impacts decision-making on climate change, such as policy developments, economic and pricing information, and

social and technical trends) which are typically not addressed by classic climate services.

The **related analysis** can be found in Deliverable 3.2, p. 32-33; and in Deliverable 3.3, p. 14-16.

From a WP3 perspective, we do not see a typical knowledge gap here since the knowledge already exists (at least partly) in other parts of the climate science community. We rather see a missing aspect in the conception of climate services (extension of climate services) and a gap in the transfer of information from different parts of the climate science community to (local) climate services. The major challenge is to (better) involve the social and political constituents of the climate science community in the development of climate services. In order to enable expansion in practice and to be able to provide concrete answers, it is essential to further clarify together with the stakeholders what information they explicitly expect when they are asking for ‘Information about political and social trends’ (since this demand is still broad and very general).

If we are able to jointly formulate more precise research question and provide relevant scientific information answering these questions, we see communicative and capacity building activities to be one of the most promising climate service formats here. This format supports and facilitates a direct exchange between the stakeholders, the providers and the scientists.

Bergen

Following the aim to localize consistencies and inconsistencies between the narratives and the existing scientific knowledge at an early stage for further analyses, WP3 extracted the major weather-related parameters and perceptions from the narratives of change for the Bergen case study and compared them with the existing scientific knowledge on climate change for that particular region. The extracted major parameters and perceived issues include precipitation, heavy rainfall events and the resulting risk and impacts of landslides and torrential downpours, shift in seasons, and exceptional seasons.

The **comprehensive debate about potential formats to deal with this information need is presented in** Deliverable 3.3, p. 40-49.

According to our findings, there are no significant inconsistencies between the perceived issues and the results and projections from scientific investigations (particularly high awareness for precipitation and temperature, consistent with the available climate science knowledge). However, there are differences in the degree of awareness for different parameters in society (wind and air quality are less present in the narratives, also the databases for scientific analyses are smaller and less findings are currently available).

A **detailed comparison of local narratives with current scientific knowledge** for Bergen is presented in Milestone 3.2, p. 14-20.

Deliverable 3.2 discusses further in detail whether the **expressed needs and demands are entirely, partially, or not addressed at all with already existing climate services** (Deliverable 3.2, p. 62-105)

Several narratives refer directly to precipitation, highlighting perceived changes in the seasons, in particular in terms of winter becoming wetter, warmer with less snow than before. These perceived changes correlate with scientific findings, available on national and regional level. Especially remarkable for this parameter is the high awareness of changes (today and future) presented by the WP1 narratives.

Landslides and torrential downpours (impacts of increasing precipitation and runoff rates) receive increased attention in the narratives and in the (climate) science community, as well as in the field of engineering and planning and administration. The assumption, expressed in the interviews that the magnitude and frequency of landslides has increased and will continue to do so in the future is consistent with the current regional scientific findings.

Sea level and its impacts are briefly referred to in the WP1 narratives. The assumption of a massive increase of sea level until the end of the century corresponds with findings from available data, model calculations and the resulting publications. However, the vertical land motion of the Norwegian coastline is another important factor in addition to the global uncertainties in the future rate of sea level rise. Another important issue (deduced from the WP1 narratives of change) relates to the high sensibility of Bergen's inhabitants to seasons. Bergen narratives describe a few exceptionally cold and snowy winters (2010/2011, 2017/2018). These exceptional events are mainly associated to unusual conditions of temperature and precipitation (including snow). The evaluation in D3.2 made clear that there is less information available for exceptional seasons (classified as rare events) than for shifts in seasons, and they are characterized by a high level of uncertainty. Moreover, these exceptional winters are in strong contrast with the long-term winter trend (observed in the past and projected in the future). Seasons and their general shift present essential, indirect links for Bergensers to the local climate.

For the Bergen case study, the analysis of the narratives made clear that weather- and climate-related topics are closely interlinked and interwoven in societal debates. The evaluation within D3.2 indicated a few places where there is a potential need for expansion of existing or even newly developed climate services. Building on these findings, the feasibility discussion (D3.3) described potential knowledge gaps and recommendations for how to bridge them, highlighted missing climate service formats, and identified challenges for communicating climate change on local scales, and options for the (co-) development and improvement of sustainable local climate services. Regarding Bergen in particular, the debate about improved local climate services includes the call for local climate services that are more participatory and social, and for processes that enable the exchange of different actors on climate-relevant topics.

Seasonal changes: Exceptional seasons and shifts in seasons

The WP3 assessment and evaluation made clear that available climate services in Bergen do not address the distinction between shifts in seasons (long-term trend) and the occurrence of exceptional seasons. There is no service that exclusively focuses on the topic of seasonal changes, related impacts and adaptation options for Bergen (considered in the WP3 assessment and evaluation activities). Nevertheless, we found related climate services about the topic of seasons.[4;5] However, we consider the establishment of a local climate service for Bergen on the topic of seasonality to be sensible and necessary in order to do justice to the topic sufficiently.

The **comprehensive discussion about potential formats to deal with this information need is presented in** Deliverable 3.3, p. 40-43.

The narratives of WP1 show that in the Bergen community access to the topic 'seasonal changes' is mainly addressed by fields or topics such as health and social activities. Although these topics are not in conflict with the scientific impact assessment, they have not yet been the focus of current scientific debates and impact assessments, which mainly focus on natural systems and economic dimensions rather than on social dimensions. WP1 and WP2 highlighted seasons as essential cognitive schemes in local (climate) contextualization. So far, such an entry point has not been used in a climate service format in Bergen (included in the inventory); no empirical values are available. Advanced research activities are needed here, to gain in-depth knowledge of cognitive scripts in the population in order to achieve proper knowledge of users' requirements.

Landslides and torrential downpours

Local narratives in Bergen emphasize the challenge of living with abundant rainfall, especially the intensity of torrential rains (summer and autumn) that is challenging for water and sewage management (as well as associated landslides). Several climate services are already implemented that address the topic of vulnerable areas and

[4] https://www.eea.europa.eu/data-and-maps/indicators/#c0=30&c12-operator=or&b_start=0&c12=climate-change-adaptation
[5] https://climateknowledgeportal.worldbank.org/country/norway/climate-data-projections

recorded landslide events. A need for improvement was localized in local climate service offers, particularly with regard to *impacts* of landslides.

From our WP3 perspective, we conclude that already a great deal in terms of methodology for impact assessment and evaluation (national and international analysis) is available and potentially applicable to answer this local demand for enhanced information. However, starting such local examinations should be accompanied by clarifying some important questions between provider and user. In our view, the latter are crucial in order to generate information that are actually useable in practice for local decision-makers and stakeholders. As long as both sites, scientists and providers, and users, do not have a joint understanding about limitations and possibilities of such an analysis, expectations can be raised (on both sites) that will ultimately not be met by a local climate service.

Deliverable 3.3, p. 43-45 provides a more detailed discussion about **potential practical improvement for local climate services addressing the topic of landslides and torrential downpours (including important questions of joint, local debates)**

Physical arenas and meeting places to jointly discuss and develop local adaptation activities

This topic concerns a demand raised independently by several participants from the WP2 stakeholder workshop. Stakeholder in different contexts raised the claim for physical arenas and meeting places to jointly discuss and develop local adaptation activities. This relates to several of the matters of concern and perceived risks, and appears to be an important (climate) service that is not yet sufficiently available, but is crucial for local communication about climate change. In our analysis, we did not find any climate service available for Bergen (recorded in D3-1), nor a format in the inventory in any of the case study regions so far, corresponding to the demand. Although we are aware that the WP3 research is not exhaustive, this shows that the local stakeholders actively ask for (currently lacking) communicative and direct exchange-based climate services in Bergen. They call for local climate services that are more participatory and social, and processes that enable the exchange of different actors on climate relevant themes.

The detailed **discussion about available climate service in Bergen** can be found in D3.1, an overview for Bergen is given in figure 12 (annex of D3.1)

Deliverable 3.3, p. 45-49 discusses insights from WP2 and presents **WP3's conclusion in terms of the resulting claim for improved participatory and social local climate services**

In order to compile information about which aspects might be essential for implementing new local climate services in this context, WP3 researched similar events and service offers in order to learn from existing examples. Taking into account the structural restrictions the WP3 work is subject to[6], we found a few activities that include the idea of a 'climate café' (as suggested by the stakeholders) or are similar.

WP3's research findings for local community activities related to the idea of a climate café or meeting space for joint discussion of climate change (adaptation and mitigation) can be found in Deliverable 3.3, p. 47-48, table 1

The activities that we found share the aim of bringing people together to exchange ideas about climate change and the sustainable use of resources. However, the goals of these services range from creating a place for discussions without any further evaluation, to the collection of ideas and wishes, up to the joint discussion and planning of concrete initiatives and measures. In many cases, the latter primarily relates to climate change mitigation; climate change adaptation is less prominent in these examples.

[6] our research is initially focused on the English and German language offers, which can be searched with relevant terms

Jade Bay

The analysis of the WP1 reports for the Jade Bay region showed that the found narratives are mainly related to the weather parameters temperature, precipitation, wind and sea levels / storm surges. The warming, the unusual winter precipitation amount in 2017/2018 and (partly) the sea level rise have been linked to climate change. This is in accordance with scientific knowledge on climate change in this region. Moreover, WP1 describes the perceived winter storm activity of 2017/18 in the Jade Bay region. However, there is no information about whether this was just perceived as unusual weather conditions or as systematic change. One source mentioned that stormy weather with intensive rainfall is becoming more frequent in general. This is only partly consistent with the current scientific knowledge. A substantial inconsistency found between the local narratives and science-based knowledge on climate change in the Jade Bay region is the perceived increasing uncertainty since – according to the narratives - old weather proverbs are no longer valid. However, from the scientific perspective, this is not mandatory due to climate change since old weather proverbs have always been uncertain.

Milestone 3.2 presents the **detailed comparison of local narratives with current climate science knowledge** for the Jade Bay region on pages 5-11

As described above (and according to the CoCliServ DOW), matters of concern are essential for contextualizing and localizing climate change information, more especially, they were assumed to provide entry points for co-developing climate services. Thus, the WP1 narratives of the Jade Bay region were further analysed according to matters of concern, which are articulated with regard to the localized weather parameters.

A detailed **analysis of the WP1 narratives in the Jade Bay region regarding matters of concerns** is provided in Deliverable 3.2, p. 32-42

To summarize this analysis, the identified personal climate-change-related matters of concern described in WP1 for the Jade Bay are not suitable as direct entry points to contextualize climate information as suggested in the CoCliServ DOW. For this

purpose, they are too fragmented, not focused and too general. A contextualization of scientific results along these “entry points” would lead to an incomplete picture of local climate change with a questionable prioritization of aspects. On the basis of the WP1 reports for the Jade Bay, the CoCliServ aim to add meaning to scientific facts by using narratives for contextualization can neither be reached for the public nor for particular stakeholder groups. Entry points, allowing a place-based individual contextualization of climate information through the WP1 narratives, cannot be derived since the further context of the narratives as suggested in the DOW is not provided in the WP1 reports. The leading questions formulated according to the WP1 DOW to localize entry points (cf. Figure 1) could not be answered: localization devices cannot be derived since the narratives are not allocated to specific places in the Jade Bay region. A basis for bottom up co-creation is not given since the key persons are not mentioned in the WP1 reports.

Therefore, instead of directly using the WP1 Jade Bay climate-related matters of concern as entry points, some general aspects of local relevance have been derived. These aspects are related to the WP1 narratives but allow for a coverage of all aspects of climate change that may have impacts on society in the Jade Bay region:

- Climate change and seasonality in the Jade Bay: the perceived weather- or climate-related aspects are mainly referring to “unusual” phenomenon of the actual or most recent season.
- Interaction with water: the interaction with precipitation, run off and sea levels are prevailing issues within the perceived aspects in the WP1 Jade Bay reports.

Related to these general aspects, a workshop on “climate change in the Jade Bay region” was carried out in Dangast, with the participation of about 30 regional stakeholders, to present, reflect on, and evaluate the existing climate information and services. The participants covered a broad spectrum: from governmental agencies to science, politics, civil society organizations, education, citizens and economy.

A detailed analyses **regarding potential climate information needs in the Jade Bay** is provided in Deliverable 3.2, p. 42-55

The workshop clearly showed that the reason for lacking action related to climate change is not due to a knowledge gap about climate change or to missing place-based climate information (or services).

According to the needed climate-related action, discrepancies within several societal areas were discussed. In particular, huge discrepancies were perceived between political long-term climate targets and actual political decisions. Reducing these discrepancies would require a broad acceptance for the needed decisions and measures within society. It was assumed that this could only be achieved by meeting the challenge of combining rising prosperity with decreasing CO2 emissions.

Moreover, discrepancies were seen between the potential of technical innovation with regard to reduce greenhouse gas emissions and the actual use of technical innovation that follows the laws of the free market economy. Powerful marketing strategies of the respective companies were seen as source for this discrepancy.

Furthermore, the significant gap between existing personal knowledge on climate change and missing personal action as consequence of this knowledge was discussed. There was agreement among the participants that changes would only be expected as a consequence of a strong personal impairment and increased suffering pressure.

The discussion also showed that the participants do not perceive that climate change is affecting their personal everyday life, so far. Moderate local impacts of climate change impacts (heat) and efficient local adaptation measures (coastal protection) were referred to in order to associate strong matters of concerns in remote regions of the globe, where the impacts of climate change are already stronger. Whereas the matters of concerns raised according to participants' own life appeared to be limited to single perspectives and seemed to vary or contradict within one sector (e.g. agriculture). Participants interpreted the uncertainty of future scenarios mainly towards worst possible climate change, in order to estimate plausible consequences,

possibly due to presently missing personal impairment (and associated lack of action).

Moreover, the increased isolation of different living environments was mentioned as an obstacle to co-develop strategies or define joint actions regarding how to deal with climate change.

There was no additional fundamental information need beyond the existing status addressed to physical climate research. Most of the articulated additional information needs could be met by already existing climate information. The IPCC reports served as an important basis regarding the methods of climate research and questions related to global climate change. For the regional and local climate information needs, the existing regional climate service (Norddeutsches Küsten- und Klimabüro) served as adequate basis.

Additional interests for information referred to the sources of anthropogenic greenhouse gas emissions and to the direct personal impairment of climate change. The agricultural sector has been identified as a group with particular and diverse information needs. Seasonal forecast and ecosystem service were found as important research fields, here, as matters of concerns were related to them.

There was no discussion according to specific missing formats. However, since isolation was raised as one of the main obstacles, it is plausible that formats promoting participation (in order to share life backgrounds and experiences with regard to climate change) could be useful.

Although the D3.2 analysis for the Jade Bay region clearly showed that the reason for lacking action regarding climate change in the region is not due to a knowledge gap about climate change or about missing place-based climate information (or service), several climate-related issues were identified which show particular relevance to local stakeholders and reflect interest for information.

A detailed documentation **of additional climate related issues,** which are of **interest in Jade Bay,** is provided in Deliverable 3.3, p. 17-39

Furthermore, the climate-related topics that we discuss in D3.3 are wide-ranging and might be interesting for other case studies considering similar or the same topics.

Gulf of Morbihan

The analysis of the local narratives of change for the Gulf of Morbihan highlighted several local topics associated to climate parameters: changes in seasonal rainfall and humidity, shifting of seasons (crops in agriculture), storms and sea level rise (coastal changes and submersion), extreme events (territory planning), heavy rainfall and flooding, and the water resource. The comparison with the current climate science showed that most local perceptions are consistent with the current scientific knowledge, regarding the issues and their link to climate change, except for storms and coastal submersion (due to the large scientific uncertainty concerning their future evolution). Some of the local narratives were difficult to link to the scientific literature and climate change, such as the summer tourism causing more pressure on the water resource, the development of anoxia and toxic algae in relation to water warming, and the erosion of the coastal path. A striking difference between the science and local perceptions is the topic of heatwaves, which is under-represented in the narratives but well represented in the science, possibly due to the timing of the interviews outside summer.

Milestone 3.2 presents the **detailed comparison of local narratives with current climate science** for the Gulf of Morbihan on page 24-29

The stakeholders' concerns (results from WP2 workshop) are similar to the topics from the narratives: impact of storms and sea level rise (coastal risk management, occurrence of extreme events (agriculture, tourism, territory planning), seasonal changes (primary activities and tourism), air and water warming (primary activities, tourism, territorial planning), rainfall changes (agriculture), and attribution to climate change. The analysis (evaluation and feasibility) of the climate services and scientific knowledge was conducted as deeply as allowed by the details of the information needs from the local narratives and stakeholders' concerns.

The available science and climate services already offer a lot of information regarding the local topics in the Gulf of Morbihan, but with different levels of uncertainty depending on the climate parameter (e.g. more confidence in future evolution of heatwaves and droughts than storms). The evaluation activity (D3.2)

investigated how the available climate services address the local topics (according to different criteria) and the feasibility discussion (D3-3) examined the current limits between the local needs and the climate services (knowledge gaps, missing formats, challenges for communication), and discussed options for overcoming these limits.

Impact of storms, sea level rise and marine submersion for coastal risk management

Storms and sea level rise are both perceived in the local narratives as threats and linked to climate change (D1.1 and D1.2). The Xynthia storm for example strongly impacted the coast (D1.1), and the shoreline footpath appears to be retreating (D1.3). The vulnerability of the coastal population and economic activities are expected to increase in the future with climate change (D1.2), while local subsidence could also increase the risk from sea submersion (D1.2). The main weaknesses of the climate services that we evaluated are that they give little information regarding future coastal risks, uncertainty and storm intensity (Climat HD), or are not usable due to coarse scale (Copernicus). The other most relevant climate services that we found are Tempêtes (storms) and Surging Seas (sea level rise).

Deliverable 3.2, p. 121 shows the results of the **evaluation of climate services** regarding the impact of storms, sea level rise and marine submersion for coastal risk management.

Deliverable 3.3, p. 50-55 provides the related **feasibility discussion for improved local climate services.**

Based on the scientific literature and the climate services, we found three knowledge gaps for the adaptation to coastal risks: the large uncertainty in the future evolution of coastal hazards, the lacking representation of local features (hazard, vulnerability, exposure), and the lack of translation of coastal risks for adaptation measures (consequences for territory). The lack of a service integrating the different aspects of coastal risks and local features can be considered as a potential missing format, which is addressed by certain services in other countries (USA, Germany) that can serve as examples. Regarding the challenges for communicating climate change on local scale, the approach of presenting information according to several models and scenarios appears essential to cover the future uncertainty but can be complex to understand for non-experts and must therefore be explained appropriately in the

climate service. The three main limitations to scientific confidence of future coastline changes that we found are: the limited understanding of coastal processes and how they are influenced by climate change, the large variability of storms and difficulty in understanding their link to climate change, the regional variation of sea level rise and limited understanding of extreme sea level events. Two limitations for stakeholders are that current risk or experienced disasters (rather than future risk) often shape the implemented response, and that different coastal management decisions might require probabilistic information about sea level rise or impacts, which is lacking in climate services.

Based on the limits identified from science, services and stakeholders, we see the need for a better understanding of shoreline changes and coastal risks (impacts) at local scale, in close collaboration with local stakeholders in order to identify the information required for decision-making, which could be facilitated by a co-development process.

Occurrence of extreme events for agriculture, tourism and territory planning

Local decision-makers in the Gulf need to prepare the territory for future climate change, including extreme events (D1.2). In the Gulf, summer corresponds to strong tourism and freshwater use (D1.1, D1.2 and D1.3), and dry spells could amplify the pressure on the water resource (D1.1). In winter, heavy rainfall events and strong winds might increase the risk of flooding and storms (D1.2). Extreme weather and climate events are a natural part of the climate system but climate change might lead to new extreme weather events (e.g. unprecedented heatwaves).

Deliverable 3.2, p. 121 shows the results of the **evaluation of climate services** regarding seasonal changes for primary activities and tourism.

Deliverable 3.3, p. 56-59 provides the related **feasibility discussion for improved local climate services.**

We found many sources of information in the scientific literature and climate services regarding extreme events, up to regional scale (about 10 km). The evaluation activity found that the scale of the information (Climat HD, DRIAS) could be insufficiently precise to support local action, for example regarding the timing and location of extremes. However, we do not know whether this really constitutes a knowledge gap

for local stakeholders regarding decision-making. There is the possibility to access more local information about future extremes but this requires doing data analysis (using free online data platforms).

The main scientific limitations that we found concerning extreme weather events are: the lack of consistent definitions, the limitations in the tools used to analyse them, the lack of high quality and long-term data to detect them and to attribute the influence of climate change, their large variability, and the limited understanding of their diverse underlying processes. Moreover, the limited observational record for rare events impedes future projections since the skill of the models used to simulate future extremes is judged based on this record.

We see possibilities for improvement in the determination of future extremes at local scale including the derivation of the local impacts, maybe in the form of a service showing the aggregated variability (spatial and temporal), accounting for uncertainty (models and scenarios), and involving the local stakeholders (to identify the necessary information for adaptation).

Seasonal changes for primary activities and tourism

Inhabitants of the Gulf are reporting changes within the seasons, such as rainfall more frequent in winter or summers that are getting drier (D1.1), but also changes of the phenological seasons themselves. Indeed, hay and wheat harvests in the Gulf are perceived to happen typically 1 month earlier now than 50 years ago (D1.1). Therefore, seasonal changes of the weather as well as changes in the weather seasonality (i.e. structure of seasons) are both perceived and questioned by inhabitants of the Gulf. These are important questions since seasons play a large role in agriculture and tourism in the Gulf (D1.1, D1.2 and D1.3).

Many climate services cover climatological changes (e.g. temperature, rainfall) within the meteorological seasons (e.g. winter) but we found very few considering changes in the structure of the seasons. Many changes in the seasonality of climatological variables (temperature, precipitation) and in phenology (crops) in relation to climate change have been identified in the scientific literature, including studies or reports for Brittany or Morbihan. However, it is difficult to attribute the evolution of the crops between the effects of climate change, changing agricultural practices due to climate change and those not due to climate change. We found many elements of scientific

evidence suggesting that seasons are changing, but most climate services addressing seasonality focus on phenology, while the others have static meteorological seasons.

Deliverable 3.2, p. 122 shows the results of the **evaluation of climate services** regarding seasonal changes for primary activities and tourism.

Deliverable 3.3, p. 59-62 provides the related **feasibility discussion for improved local climate services.**

A climate service investigating how the seasonality of different indicators or climate variables might be changing in the year, in relation to climate change, could be interesting for the local stakeholders (agriculture, tourism). In this regard, we recommend selecting the indicators and variables in collaboration with the local stakeholders, as well as the scale of the information, in order to improve the relevance for local adaptation.

Warming (air and water) for primary activities, tourism, and territorial planning

Agriculture in the Gulf is perceived to be impacted by climate change both inland through the effect on the timing of crop harvest (D1.1), and in seawater through the effect of warming that is damaging the production of oysters (D1.2). Since tourism benefits from the local production of oysters (D1.2), climate change may also indirectly affect tourism in this way, as well as directly with rising air temperatures.

Deliverable 3.2, p. 122 shows the results of the **evaluation of climate services** regarding warming (air and water) for primary activities, tourism, and territorial planning.

Deliverable 3.3, p. 62-64 provides the related **feasibility discussion for improved local climate services.**

Many climate services give information about surface air warming (annual, seasonal) but very few about the warming of surface water. The evaluation activity (and feasibility discussion) suggested that the topic of surface air warming is covered by sufficient information to facilitate decision-making, and we investigated the scientific literature to find more information about the surface water warming at local scale. We found studies about the warming and its effects on the coastal environment but at a larger scale than that of the natural harbour, and local long-term observations are

lacking, so we do not know if this information sufficient to cover appropriately the local topic. This might constitute a scientific knowledge gap, a missing climate service format (unavailable information), and a challenge for communication climate change at local scale (unavailable knowledge). However, these gaps could be bridged by investigating locally the water warming in collaboration with local stakeholders (such as aquaculture workers) to co-produce the relevant information for adaptation.

Rainfall changes for agriculture

Tourism is a key activity in the Gulf but it can compete with agriculture for the use of water resource in summer such as between drinking and irrigation (D1.3). This increases the importance of rainfall for agriculture in summer to avoid a high risk of freshwater shortage (D1.3). However, too much summer rainfall is detrimental for salt production since it reduces crystallization shortly before the time of harvest (D1.2).

Climate services give information about rainfall (annual, seasonal, monthly), droughts, soil moisture, crop water demand, and river flow. The information suggests that summers in the Gulf will become drier (rainfall, air and soil conditions), although extreme rainfall is expected to increase a little.

Deliverable 3.2, p. 122 shows the results of the **evaluation of climate services** regarding the occurrence of extreme events for agriculture, tourism and territory planning.

Deliverable 3.3, p. 64-65 provides the related **feasibility discussion for improved local climate services.**

Based on the evaluation activity and the feasibility discussion, the current information available from the climate services might be sufficient for the use by local stakeholders in adaptation decision-making. However, we emphasize that the projection of future seasonal precipitation in climate models is associated to large uncertainties, and even contradicting trends sometimes between different projections.

Attribution to climate change

Inhabitants of the Gulf are noticing changes in the weather but in many cases the link to climate change is not clear (D1.1, D1.2, D1.3). This is especially the case with

coastal destruction from storms (D1.1, D1.2), but also for drier summers, more frequent winter rains, and agriculture (D1.1, D1.2, D1.3).

We found several climate services focusing on the attribution of long-term trends and

Deliverable 3.2, p. 123 shows the results of the **evaluation of climate services** regarding the attribution to climate change.

Deliverable 3.3, p. 65-67 provides the related **feasibility discussion for improved local climate services.**

of individual events to climate change. Regarding new individual events (e.g. storms), the findings often become available through research papers (then sometimes disseminated more broadly through the media) published in the months following the event. Regarding long-term trends, we do not see knowledge gaps or missing formats in addition to those discussed previously (drier summers, wetter winter, phenology of crops).

Kerourien in Brest

The analysis of the local narratives of change for Kerourien highlighted that weather and climate only play a minor role in the local topics that are rather related to social matters. The main narratives lines that we found in relation to weather and climate are: housing and urbanization in a changing climate context, building degradation and unhealthy life conditions, physical safety and health troubles related to weather/climate conditions, social justice related with climate change and weather, and planning (climate, water scarcity, energy, urbanization). Many are difficult to inform because they are very local and specific. However, they can be informed (albeit at larger scale i.e. 10 km) by climate services similar to those presented and discussed for the Gulf of Morbihan. Furthermore, climate knowledge could support the planning of climate change adaptation in territory planning (water, energy, urbanization).

Milestone 3.2 presents the **comparison of local narratives with current climate science** for Kerourien on page 30.

Deliverable 3.2, p. 126-127 shows the results of the **evaluation of climate services** regarding the local topics in Kerourien.

Deliverable 3.3, p. 67-71 provides the related **feasibility discussion for improved local climate services.**

The evaluation activity concluded that most services are accessible but unknown to inhabitants so little used (with the exception of extreme events when they are discussed in the local news), and that the main topics of interest are not well treated by the climate services. These topics of interest are: building squalor (in relation to weather and climate change), renewable energies, water management (threat of sea level rise), and air quality (threat of ship traffic pollution). For most topics, as the details of the local issue are very limited, it is often unclear whether the available knowledge from the services and literature are sufficient to address the local issue, which restricts our ability to deduce limitations of the current knowledge and options for improvement.

Housing, urbanization, and physical safety in a changing climate context

Climate change was not considered when building the local infrastructure, including homes, and could contribute to squalor in the buildings that are inappropriately insulated (D1.1, D1.2, D1.3). Information about future weather conditions is provided by weather services from the next days to weeks and months, and climate services from the next season to the next decades.

Deliverable 3.3, p. 68-69 provides the related **feasibility discussion for improved local climate services.**

Water management and coastal risks

Sea level rise is a threat to the current coastal infrastructure, including the water management system, and there could be an impact of pollution by seawater on the access to drinkable water. Although the case of Kerourien is specific, we refer here to the discussion about climate services for water management from the case of the Gulf of Morbihan, regarding the similarity of the current limitations and options for local services.

Deliverable 3.3, p. 69 provides the related **feasibility discussion for improved local climate services.**

Planning of renewable energy

Local decision-makers might be interested in the planning of renewable energies in the territory, including the collection of solar energy. We found several weather services and climate services giving information about the future conditions of wind and sunshine, and options for the co-development of a local climate service.

Deliverable 3.3, p. 69-71 provides the related **feasibility discussion for improved local climate services.**

Air quality and ship traffic

The local air quality seems to be impacted by pollution from particles emitted by the traffic of ships nearby. We found two services about present and future local air quality, which might provide sufficient information for local stakeholders.

Deliverable 3.3, p. 71 provides the related **feasibility discussion for improved local climate services.**

Discussion and Conclusion

The local narratives of change (from WP1) were analysed per case study according to potential entry points for the local contextualization of climate information and further co-development of place-based climate services. Building on this analysis, and on the WP3 assessment of the scientific literature and climate services (D3.1), the climate services were then evaluated according to the local entry points (i.e. local issues related to climate change) for each case study. The workshop results of WP2 were included if they were provided until December 2019 (due to the time constraint for the realization of the WP3 deliverable).

The WP1 narratives, which serve as a basis for the evaluation of the climate services, were quite diverse in terms of the given insight on the various interviewees' perception. In some case studies, many quotes from the conducted interviews were provided, whereas others provided only few or none. Since the WP3 analysis of the narratives is limited to the existing reports of WP1, only the aspects that are traceable in the reports can be accounted. In this context, it is important to mention that a perceived link to climate change could only be detected if it was stated in the report. The identification of the climate-related personal concerns of the interviewees was particularly difficult without quotes.

Matters of concerns are understood as individual consequences of the perceived climate issue, such as daily life being affected by climate change, feeling in danger because of climate change, accidents or losses of people related to changes in weather conditions associated to climate change. In combination with a particular local focus, matters of concern may serve as entry points to contextualize climate information locally. In this regard, the quotes of the perception from the interviewees are central for the WP3 analyses. Otherwise, the WP3 analyses of matters of concerns were limited to the interpretation of the perception from the respective WP1 author. In these cases, only general aspects of locally perceived climate change could be analysed from the WP1 reports, and the found issues were limited in terms of personal and local matters. The three general aspects of climate-change-related issues: "seasonal changes", "extreme weather events", and "interaction with water" are probably due to the locations of the case studies that are situated in coastal regions of North-Western and Northern Europe. Due to the described differences in

the provided material among the case studies in the WP1 reports, the evaluation required different methods for each case study site.

As the feasibility study (D3.3) showed, the challenges for communicating climate change on local scale vary between the case studies. This might be due to the different approaches of the evaluation and feasibility studies, resulting from the heterogeneous material available from the WP1 and WP2 basis. Overall, communicating climate change on local scale faces one common challenge in all case study sites: in many instances, local specific information needs could not be specified (detailed) or related to personal matters of concerns. However, the reasons vary among the study sites: for instance, when the local matters of concerns, questions, or information needs from the case studies were not explicit, difficult to derive, or not detailed, the discussion of the feasibility of local climate services was inherently limited. As starting point for the feasibility discussion, this local basis was sometimes lacking of hints regarding additional local specific stakeholder information needs and regarding communication formats beyond the already existing climate service formats. Moreover, a stronger local contextualization of existing formats was only possible when we could gain in depth insight from the stakeholder's demands or interviewees' perceptions (climate-related personal concerns). Therefore, there are instances where it is unknown from the perspective of the feasibility discussion whether local specific information needs could have been localized within a direct stakeholder dialogue or if these needs do not exist.

When the identification of the climate-related personal concerns of the interviewees was possible, cognitive schemes were discussed in the feasibility study, which may enable local climate service providers to further contextualize existing climate information to local conditions. However, evidence on additional local specific information needs was difficult to find based on the social narratives and stakeholder workshops. One reason could be that neither the narratives (WP1) nor the scenario design and development (WP2) were meant to relate their research to stakeholder's expectations and needs with regard to local climate information.

Moreover, better understanding the context of the results in WP1 and WP2 relies on knowing the national language as well as the local knowledge (local familiarity). If this prerequisite of local familiarity is missing, it is very difficult for a climate service provider to contextualize climate information locally, or to initialize a stakeholder

dialogue on local climate change. Beside the reasons discussed above, which may be improved by an adapted design of future projects, another reason that local specific climate information needs could not be specified was that they explicitly do not exist. On one hand because stakeholders did not identify any information need, and on the other hand because missing information was not the reason for missing action.

Several limitations and gaps from the perspective of climate research have been identified which indicate potential fields for local climate services. For instance, the inherent uncertainty of future regional climate scenarios due to the multi-model and multi-scenario approach can be addressed in practice by no-regret adaptation strategies. These no-regret strategies could be co-developed within a science-stakeholder dialogue, initialized or accompanied by a local climate service. In parallel, an ongoing monitoring of the main critical parameters (physical and social) needs to be established. Within a long-term science-stakeholder dialog, the adaptation strategies could be adjusted according to the insights of the monitoring. Next to the general request of increased spatial resolution of future regional climate scenarios, there is a particular demand of regional sea level rise projections, since rising sea levels are a joint threat for all case study sites. Moreover, current and future adaptation strategies need to be considered in order to estimate the local exposure and vulnerability regarding sea level rise and changed storm surges activity. Besides accounting for regional coastal protection measures, there is a research need on future local socio-economic scenarios as this is the major driver of increasing risks to human settlements in the next decades. In order to estimate future vulnerability due to sea level rise on local scales, these physical, technical and socioeconomic aspects have to be available, accounted for and combined within a local climate service in order to provide adequate local climate information formats.

Another joint aspect of relevant climate information is changes within seasons, including extreme events. The approach of using seasons as a cognitive scheme has already been applied for several web-tools, e.g. www.norddeutscher-klimamonitor.de (recent climate change & variability, Meinke, et al. 2014) and www.norddeutscher-klimaatlas.de (possible future climate change, Meinke, et al. 2009). These services localize seasonal climate change as far as possible (from the physical climate

perspective), and could be supplemented by various aspects of seasonal climate change impacts if the related research was available.

We identified the following research gaps: future scenarios on ecosystem service interactions as well as the impact of seasonal changes on health, social, economic, and cultural aspects of society. For the latter, the collection of narratives and scenario workshops as applied in WP1 and WP2 could be a suitable approach if a specific focus is set on changes in seasons and if the relevant stakeholder groups (agriculture, tourism, health, transportation, energy, civil society) are systematically involved. Beside information on long-term changes within seasons, seasonal predictability is subject of discussion among stakeholders, especially within agricultural sectors. Uncertainties within (medium range) seasonal predictions reduce their usability significantly, much more than within long-term scenarios of regional climate change, since no-regret options are rare and explicit mid-term decisions must be taken. Along with reducing the uncertainty regarding future climate (and the associated impacts), one of the main challenges of seasonal forecasting is to communicate its quality and reliability. It is difficult for laypersons to interpret the results, although the forecast system (and the experts) can easily determine how likely its statements are.

In addition to the challenges and limitations described above, some overarching options for the (co-) development and improvement of sustainable local climate service have become evident. The CoCliServ approach clearly showed that the co-development of a local climate service has some prerequisites. These are the knowledge of the respective national language, familiarity with the particular local circumstances and most importantly, the direct stakeholder dialogue with regard to climate change (including the related action and supporting information). For these reasons, integrative work packages (rather than separated) including social and climate research along with art representation formats, focusing on specific case study sites, are a promising approach for co-development and transdisciplinary work.

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