EVOKED

Enhancing the value of climate data

Deliverable 3.3

Reports on execution of field trails at each case study site

Work Package 3 – Co-Validate

Deliverable Work Package Leader: [partner]

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EVOKED

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Project information

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1 Introduction

1.1 Background of the document

The main objective of the field trials was to bring into practice the key aspects of EVOKED: the focus on climate services, the Living Labs approach, and the information design of the selected climate services for each of the EVOKED case study sites (Deltares, 2019). To support comparing the outcomes of these case studies, Deliverable 3.2 (Deltares, 2020) was developed to create a framework to structure the data that has been collected in the case studies as well as to draw lessons and conclusions based on a case comparison. The final objective as presented in the present report is "a systematic evaluation of the climate information designs and thus of the communicative qualities of currently used climate services; insight into the different information needs, perceptions of risk and uncertainty, and the responsibilities and roles of different stakeholder groups; a set of visualization principles and visualization strategies for stakeholder specific climate services." (Deltares, 2019, p.17).

To get to this point, the research results from the different Living Labs will need to be evaluated as part of the EVOKED project. As mentioned before, the case study sites will be different, but the methodology is similar to compare the results. In general, the evaluation could be a cross-comparative analysis consisting of three steps:

1. Establish an inventory of common practice: What type of information design is currently applied in climate services used at each case? This means having insight into visualization strategies and knowledge products that are currently used for communicating climate data, and their communicative qualities.
2. Establish an inventory of perception: What are for each case the risks and uncertainties commonly associated with climate data by end-users, how do the end-users see their responsibilities and the urgency to act, and to what extent do the current interpretations lead to actions of climate adaptation?
3. Evaluate the visualization of climate data: What climate information design, for the successful development of knowledge products/climate services, leads to the appropriate action by end-users? (Deltares, 2019, p.17).

In the end this information is used to answer the following six hypotheses:

1a) Usability gap(s) is/are present in the original climate services that are used in the case study sites.
1b) – This/these usability gap(s) is/are caused by a limited feedback loop from the end-users to the producers of the climate service.
2a) - Living labs have contributed towards the development of a feedback loop between the user and the developer
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.
3a) - Information designs help to convey information to the end-user
3b) - Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.

1.2 Background information about the hypotheses from D3.1

1.2.1 Information about the usability gap hypotheses

Table 1: *Overview of existing climate adaptation support tools. Adapted from available tools via the European climate adaptation platform (Climate-ADAPT, 2020). The table gives an overview and some tools can address multiple subjects.*

Subject	Subdivision of subject	Number of tools
Challenge	Water management	32
	Disaster risk reduction	21
	Coastal management	26
Goal of the tool	Prepare/inform	41
	Predict	24
	Design to decide	14
	Dialogue	10
Techniques used	Mapping	27
	3D visualisation	2
	Tables/metrics	32
	Photos/visuals	6
At which stage	Plan	48
	Do	20
	Check	14
	Act	7
Scale	National	30
	Regional	24
	Local	29
Used elements of solutions	Participatory planning support tools on decision making	6
	User centred design of model	16
	Collaborative/Interactive modelling	5
	Visualisation	19

Currently, we observe that there is not a wide variety of climate services available. A review of climate services available via the European climate adaptation platform presented in Table 1 indicates that most climate services are providing information with regard to the planning phase and only a marginal number of tools focus on the acting phase. The current use of scientific knowledge within climate services is focused on providing, rather than communicating, climate information. Thus, the problem facing end-users is not a "lack of knowledge", but rather (i) knowing which knowledge to use and when, as well as (ii) knowing how to deal with risks and uncertainties related to different kinds of climate knowledge.

The observations in the table imply that there potentially exists a usability gap to which Lemos et al. (2012) are referring, as there is a chance that these tools do not cover all information needs for climate impacts (e.g. lack of tools about heat stress or drought, etc.). This gap is also addressed by Weaver et al. (2013) who argue that the gap results from a mismatch between the delivered climate services, which are often projected on a large spatial scale and require technical expertise to understand, and the required information for the local end-users to develop policies, allocate budgets, or implement measures (Harrison & Williams, 2007; Lemos et al., 2012; Weaver et al., 2013).

As a result, planners and policy makers perceive the information provided by these climate services as uncertain, too geographically and temporally distant, and to be solved elsewhere rather than at the municipal level. This perception is reinforced by a lack of knowledge of the precise impacts of climate effects at the local scale (Wilson, 2006; Goosen et al., 2014, p.1036). Weaver et al. (2013) point out that these problems with climate services' usability gaps can lead to a delay in decision making by end-users, which can consequently lead to a delay of taking climate adaptation and mitigation measures.

In EVOKED we are investigating the existence and characteristics of these usability gaps regarding climate services. Our first two hypotheses are:

1a) A usability gap is present in the climate services that are used in the case study sites.
1b) This usability gap is caused by a missing feedback loop from the end-users to the producers of the climate service.

Our hypothesis is presented in Figure 1. The usability gap is located between the climate services and the climate change action. The arrows represent the missing feedback loops between the end-users and the producers of the climate services.

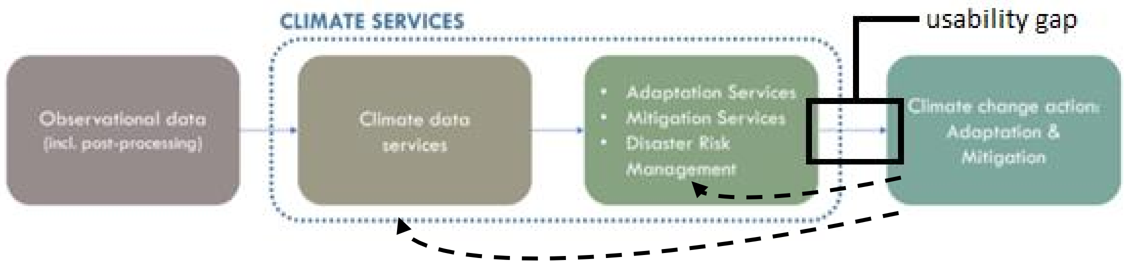

Figure 1: *Climate services by Hamaker et al. (2017, p. 11) with the location of the usability gap (Lemos et al., 2012) and the necessary feedback loops.*

In order to investigate how we can establish this feedback, EVOKED will be initiating Living Labs. In some of these Living Labs, existing climate services will be taken as point of departure while, in others, completely new climate services may need to be developed.

When we look at the research paper of Raaphorst et al. (2020), which was written based on the data collected for the EVOKED project, 12 different usability gaps can be identified (Table 2).

Table 2: *Analytical framework that describes twelve usability gaps for climate services (CS) (Raaphorst et al., 2020, p.11).*

	Validity	**Readability**	**Interactivity**
Stakeholder	Is the desired action the responsibility of the targeted audience?	Does the visual language and its possible connotations, match the interpretive frames of the audience?	Is the visual literacy required for interpreting the CS suitable for the target audience?
Purpose	Is the purpose (understand, feel, act) suitable for the phase in the policy cycle?	Is the purpose of the CS clear? (otherwise people act before understanding)	Can the CS be repurposed by the user?
Information	Is the information shown correct/trustworthy?	Is it clear what information is presented in a CS?	Can the information be modified?
Visual format	Does the visual mode enable an accurate representation of the climate phenomenon?	Is the type of mode, and its way of reading, clear? (A story map requires a different viewing than a standard GIS map)	Can aspects of the mode (zoom level, colour scheme, etc.) be modified?

This table can be used to answer hypothesis 1a as it provides a framework to identify any potential usability gaps that may have been encountered in the EVOKED cases.

1.2.2 Information about the living labs hypotheses

A second theoretical concept within EVOKED is the Living Lab. The Living Lab approach is thought to be a useful approach to establish a firm feedback loop between the end-users and the producers of the climate service. Hence, the Living Labs might help to bridge the usability gap. In the EVOKED project we test whether this approach is indeed useful.

Living Labs have been emerging as a form of collective governance and experimentation to address societal challenges and opportunities on many subjects, e.g. urbanization, climate change, and health. A Living Lab is an ongoing, iterative process. It is much more than just a workshop or observation of activities; it involves active participation of various stakeholders in a number of events and forums for testing and producing a climate service (SGI, 2018). Each Living Lab within the EVOKED project will look slightly different depending on the climate service that will be produced, the climate issue at hand, the people involved and the context (geographical, social, and institutional). Each Living Lab will be composed of a collection of activities such as workshops, interviews, focus group activities, surveys, as well as policy studies (see Figure 2).

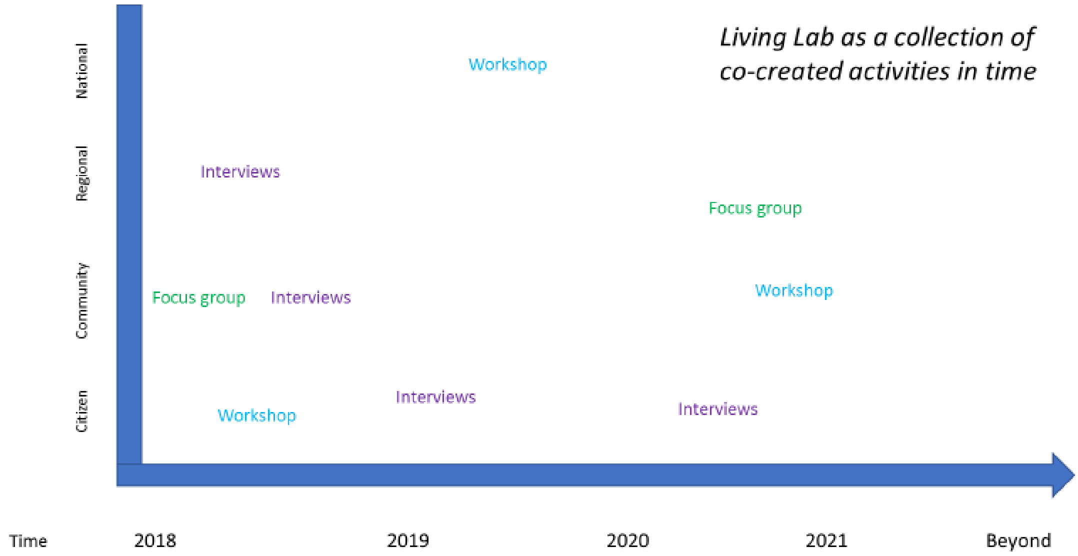

Figure 2: *Example of Living Lab as a collection of co-crated activities in time (SGI, 2018)*

The principles of the EVOKED Living Labs approach are described in Deliverable 1.1 (SGI, 2018, p.13-14). The key principles of Living Labs (LL) that are incorporated within EVOKED are:

Continuity: An EVOKED LL should:

- build on existing networks and actions for climate services
- focus on long-term learning and trust as an output of the LL
- be willing to work in small steps, but realize the urgency that some end-users may have
- as far as possible, plan for the "institutionalization" or continuation of the climate service after the end of the project
- as far as possible, strive for resulting products and processes that can be transferrable to other cases and settings
- motivate stakeholders to continually share their knowledge

Openness: An EVOKED LL should:

- create atmosphere of transparency
- involve all relevant stakeholder groups and strive for a balance among ages, gender, culture, socio-economic positions
- share information and insights with partners within the LL, among the partners, and outside of EVOKED
- help make sense of the uncertainty and risk associated with climate adaptation actions
- provide platforms for knowledge co-production and learning about the role of climate services

Realism: An EVOKED LL should:

- be sensitive and link to the relevant policy, governance, environmental, and social-economic contexts of the LL area
- base climate service work on actual identified needs
- coordinate timing of LL actions with other relevant milestones in the area (elections, planning documents, etc.)
- take into consideration the available financial, human, and environmental resources (limitations and opportunities)
- facilitate sustainable innovations and test climate services in real settings
- strive for optimism, while maintaining realistic expectations

Influence: An EVOKED LL should:

- encourage ownership of the process and climate service produced
- connect stakeholders from various sectors and competences to work towards societal resilience
- set up clear communication channels
- find ways to make the LL and climate services attractive to politicians and citizens
- ensure that actions and learning are two-way, and that stakeholders can contribute to the development of climate services

Value: An EVOKED LL should:

- clarify the added value of the climate service for the prospected end-user and stakeholders – provide incentives to participate
- make involvement of stakeholders cost-effective, attractive and fun
- avoid the need for stakeholders to commit long hours and travel for workshops
- provide concrete and measurable outcomes
- ensure outcomes are framed simply and in non-academic language to be usable for stakeholders
- find innovative communication channels other than reports (videos, other media, arts, etc.)
- raise awareness of climate services for politicians and citizens

Sustainability: An EVOKED LL should:

- build on existing local and epistemic knowledge of risk and uncertainty
- ensure that climate services produced are ecologically, socially, and environmentally sustainable
- strive for sustainability in project operations (avoid unnecessary travels, choose sustainable alternatives)

Finally, to better identify the living labs that have been used within the EVOKED cases, the typology developed by Schuurmans et al. (2013) (see table 3) will be used.

Table 3: *Different types of Living Labs (Schuurman et al., 2013, p.5)*

Living Labs for collaboration and knowledge support activities	**Original 'American' Living Labs**	**Living Labs as extension to testbeds**	**Living Labs supporting context research and co-creation**
Multi-stakeholder collaboration, focus on collaborative platforms, knowledge sharing and community development	Laboratory made to resemble the real-world, smaller scale, data capturing, can also be in-home research on a small scale focusing on ethnographic methods	Environments within which users and stakeholders can collaborate in the creation and validation of ICT services	Environments aimed to support innovation processes focusing on the early development phases of needs analysis and early design
Enabler-driven	Provider-driven	Provider-driven infrastructure with Utilizer-driven projects	Utilizer-driven

1.2.3 Information about information design hypotheses

During the process of translating raw data into useful information, choices are made about the processing, organizing, structuring, and presenting of the data. Furthermore, choices are also made about the message that these data are intended to convey to a particular audience. These choices are often made implicitly.

In the EVOKED field trials, we want to experiment with climate information by involving the end-users in the information design (i.e. the way in which information is presented, Horn, 1999). Information design focuses on the communication of information to receivers. This process of visual communication consists of three stages: the i) production, ii) image, and iii) audience stage (see Figure 3). Information design can potentially serve as a bridge between science and policy since the form of (raw) research data is often inadequate for the communication of findings to policy-makers (Wurman, 1989). In other words: "*to make data valuable, it has to be structured, transformed and presented in a meaningful way*" (Kazmierczak, 2003; Goosen et al., 2014). This may be, for example, in the form of a report or a map, as well as many other ways of communicating information depending entirely on the message and the intended audience for this information.

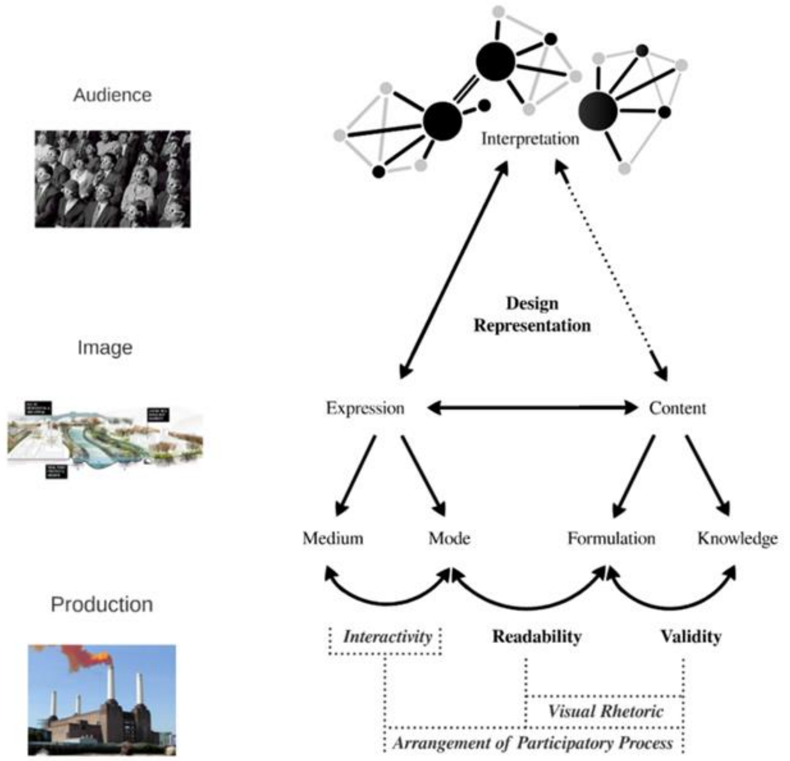

Figure 3: *Critical visual research framework (Raaphorst et al., 2018)*

This notion of visual communication in information design is important to guide the development of alternative climate information designs in the EVOKED field trials. For example, an extensive technical report may be of value for someone working in the government having an extensive background in his or her field, but it could also appear as a report full of difficult, technical language to citizens. On the other hand, showing photographs to citizens that illustrate the impact of urban flooding or property damage may communicate the same information much better.

Climate services with information design for different groups of personnel can be developed by using a methodology adapted from Raaphorst et al. (2018), Figure 4. This methodology assumes that climate service visualizations have an implicit or explicit goal, and that the quality of visualization depends on the extent to which that goal is achieved. Climate data visualizations that do not lead to the appropriate action by its targeted audience are therefore considered unsuccessful. Such miscommunication occurs due to inconsistency in any of the visual communication components: (1) the appropriate knowledge, (2) framed for a specific audience, (3) readable in its choice of visual expression, and (4) presented on an appropriate medium, leads to (5) the desired interpretation (and resulting action).

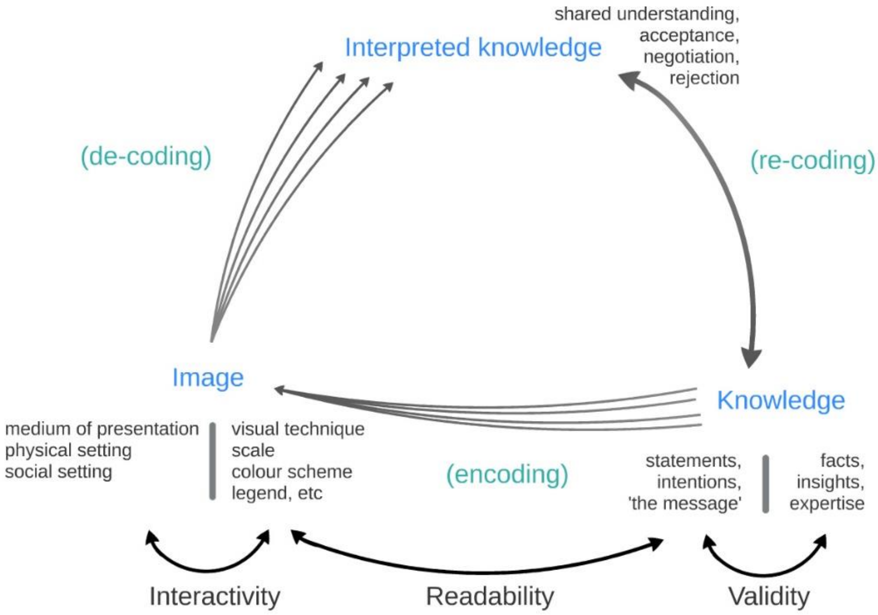

Figure 4: *The methodology of climate information design. Adapted from Raaphorst et al. (2018)*

Three important communicative qualities are distinguished within this methodology of climate information design: validity, readability, and interactivity. Validity entails whether the type of climate information presented is appropriate, and whether the message (or in the case of a climate service: implied levels of risk, responsibilities to act) is perceived as accurate or credible. Readability constitutes whether the climate information and the intended message of the content is visualized in a way that the targeted audience understands. In this case, successful communication is not primarily dependent on the type of information, or credibility of risk calculations, but rather the visual language used. Finally, interactivity depends on both the physical medium on which the climate service is presented (printed poster, projector screen, web interface), and the social setting (desired level of participation) where the climate service is used.

In the field trials, the goal is to find ways in which climate information meets the needs of the end-users and to bridge the usability gap between the producers and users of information. Experimenting with various components of information designs (e.g. type of climate information, framing, visual expression, medium, and type of audience) will help to identify the type of usability gap (i.e. validity, readability, and/or interactivity) and to improve the design of the climate service with each iteration. These field trials may result in climate services that are better attuned to the end-users' needs.

Therefore, the following hypotheses can be used to this end:

3a): Information designs help to convey information to the end-user
3b): Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.

1.3 Reading guide for the document

The rest of the document is structured in the following way:

In Chapter two, a description of each of the case study locations/regions is given. At the end of each case study, the hypotheses mentioned above are answered for the specific case. Finally, at the end of the chapter a summarizing table of the answers to these hypotheses for all cases is presented.

In Chapter three, the outcomes of the hypotheses for each case are compared and discussed in further detail.

In Chapter four, concluding remarks are given. This includes a contribution to the main research question of EVOKED, implications for practice and a look forward in the form of recommendations for future research.

2 Description of the cases

The EVOKED project works with several case study locations. These are in Norway, Sweden, Germany, and the Netherlands and are carried out by the different project partners involved in EVOKED. This can be summarized as (Table 4):

Table 4: *Overview of the different project partners and associated case study partners and locations.*

Project partner	Case study partner	Case study location
NGI	Larvik Kommune	City of Larvik, Norway
SGI	Värmland County Administrative Board	City of Arvika, Sweden
		Region of Värmland, Sweden
Christian-Albrechts-Universität Kiel	Municipality of Flensburg	City of Flensburg, Germany
Deltares	Waterschap Drents Overijsselse Delta	Fluvius region, The Netherlands
	Provincie Noord-Brabant	Northeast Brabant, The Netherlands

Additionally, in Figure 5 a map is included to portray the scale and locations of the different case study locations.

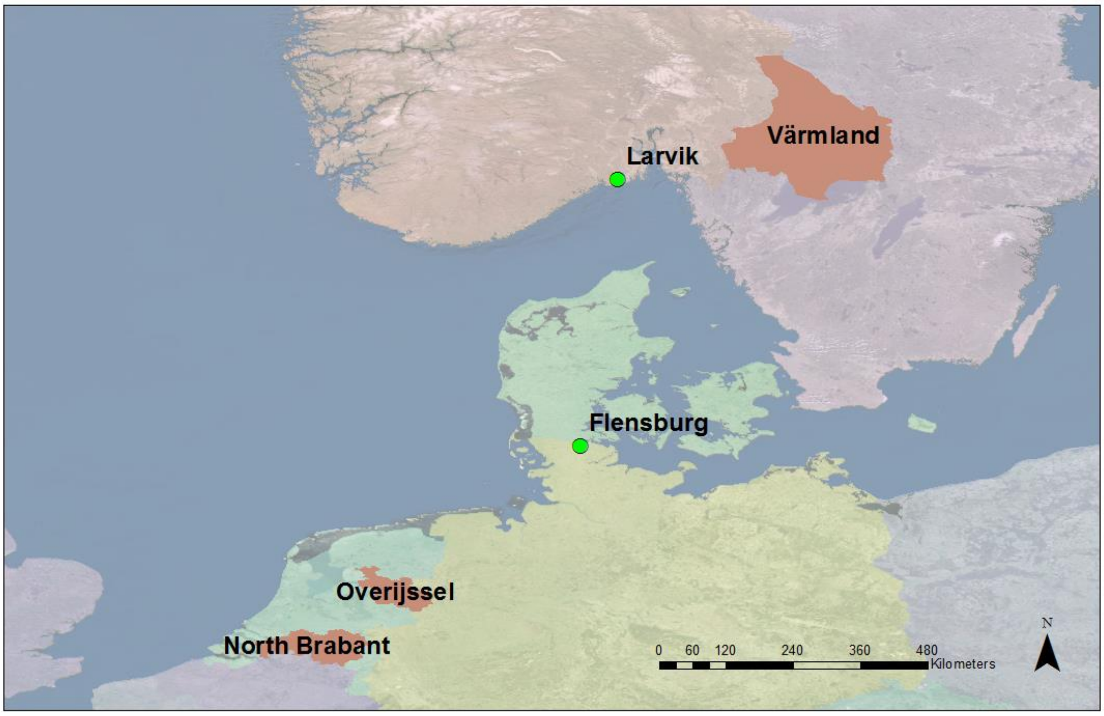

Figure 5: Overview of the case study locations within the EVOKED project

The rest of this chapter will zoom in to each of the case study locations and provide a brief overview and context. This is of value for understanding the answers to the hypotheses as well as the context in which these can be placed.

2.1 Larvik, Norway

2.1.1 Case description

2.1.1.1 General information about case study location

Larvik municipality is located in southern Norway (Figure 5) with a population of about 47,000 inhabitants. Larvik is a coastal municipality with a 110 km long coastaline. Furthermore, the 3rd longest river in Norway (Numedalslågen, 352 km), runs through the municipality from north to south. The city of Larvik is the administrative center of the municiplaity and is located by the coast. As a coastal city located in southern Norway, Larvik is exposed to weather and has always experienced floods, strong winds, storms, and storm surges. However, these events are now becoming more frequent, more intense, and the costs of damages are increasing. Hence, there is a present awareness on the effects of climate change and during interviews, respondents easily identified climate adaptation needs for Larvik. This includes the need to increase the awareness of climate change and adaptation in Larvik's strategic planning documents as well as a need to build up knowledge and competence.

2.1.1.2 Climate adaptation needs and visions in Larvik municipality and the development of Martineåsen

Improving the knowledge base is essential for meeting the visions of Larvik as the city has ambitious goals of urban development, including construction projects to build homes for a 1.5% annual growth of residents. To support meeting this goal, the city of Larvik is conducting a feasibility study to assess the development of Martineåsen, an area of 200 hectares situated about 1 km from the city center. The aim is to create a new neighborhood at Martineåsen with an urban intensity and environmental qualities that attract resourceful people of all ages including families (Larvik kommune, 2013; 2015).

Key objectives to achieve this vision include a focus on building residential areas and homes that are innovative and green as well as being designed for climate changes. One challenge in building these homes is the scenery of Martineåsen which is hilly and quite varied with tall deciduous trees as well as pine forest and heath. A small lake, Kleivertjønn, as well as several bogs in the area. These physical qualities represent important blue-green infrastructure that provide both opportunities and challenges to be considered in the comprehensive development of the area. Furthermore, infrastructure and outdoor spaces must be designed to ensure public safety.

2.1.1.3 Governance structure, challenges and potentials

In Norway, Risk and Vulnerability Analysis (RVA) are conducted for all development plans as specified in the Plan and Building Act (Plan- og bygningsloven, 2008). Additionally, the Civil Protection Act stipulates that municipalities must regularly conduct Comprehensive RVAs as the basis for contingency and emergency response planning (Sivilbeskyttelsesloven, 2010). Recently, the local impacts of climate change due to a range of natural hazards including extreme rainfall, flooding, erosion, landslides, and storm surges were explored as an input to the most recent update of Larvik municipality's Comprehensive RVA (NGI 2016). These studies provided a prognosis of potential natural hazards in a 50-year perspective as a result of climate change with the results also available for future RVAs needed in development plans.

2.1.1.4 Main stakeholders (see Table 5)

Table 5: *Main stakeholders in the case of Larvik*

Stakeholder	Public/ private/ civic	Relevant climate impacts	Relevance to climate impact adaptation / case
Local authorities in Larvik	Public	Flooding and storm surges, erosion, landslides	These stakeholders have a keen interest in understanding the risk of flooding and storm surges with regard to planning processes and subsequent city development
Regional authorities	Public	Flooding and storm surges	
National road authorities	Public	Flooding and storm surges	
National food safety authority	Public	Flooding and storm surges	
Landowners	Private	Flooding and storm surges, erosion	For the development of Martineåsen, landowners are important to ensure comprehensive development of the area. Furthermore, this group of landowners has been involved in the feasibility study for the development of Martineåsen and will provide a point of departure for further Living Labs in collaboration with EVOKED.
Local businesses	Private	Flooding and storm surges, erosion	
Building developers & contractors	Private	Flooding and storm surges	Contractors and consultants who are often engaged in the construction activities were identified as also having high interest and influence as they both need the best available knowledge possible to also implement adaptation measures.

2.1.1.5 Climate impacts

For Martineåsen, climate risks that were identified as most important were related to flooding and the area's current capacity to hold and infiltrate large volumes of water in the event of extreme rainfall. An illustration of this buffering capacity is shown in Figure 6 for the city of Larvik. This figure is based on digitally mapping the terrain and calculating the volume of water that can potentially be stored within natural depressions. Although an estimate, it provides an indication of flood potential as water will most likely follow drainage pathways along the terrain under extreme precipitation (NGI 2016). Thus, development of this area will result in changes in the scenery and all changes that influence the runoff of surface water must be thoroughly examined in order to not increase risks to areas downhill of Martineåsen (NGI 2016).

2.1.2 Local climate service(s) description and selection

2.1.2.1 Available climate services

Climate services that are used to help address the consequences of climate changes are related to the climate profiles that are published by the Norwegian Climate Service Center for each county (Norsk Klimaservicesenter, 2019). These profiles summarize current conditions as well as expected changes in hydrological conditions and natural hazards as a result of climate change (precipitation, flooding, landslides, snow, avalanches, storm surges, extreme weather events, drought, and wind). The likelihood for these different events in the Vestfold County can be found in the Climate Services that are summarized in Table 6.

Many municipalities use this information as a point of departure for creating more detailed and local maps of areas exposed to various kinds of natural hazards. This was essentially work that NGI started for the municipality of Larvik in 2015 and 2016 (NGI, 2016) where different hazards (landslides, flooding (both snow melt and pluvial flooding), as well as combined effects of storm surges and sea level rise) and example scenarios that could occur for selected locations were assessed. The municipality has developed this work further and created urban flood maps as well as storm surge and sea level rise maps for the coastline within the municipality. An example of such a map is presented in Figure 7.

Table 6: *Information provided by the original CS used within Larvik*

Flooding from the regional system			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
Norwegian Climate Service Center (KSS)	Regional profile with expected climate change predictions	Text, data	https://klimaservicesenter.no/faces/mobile/article.xhtml?uri=klimaservicesenteret/klimaprofiler/klimaprofil-vestfold
Larvik municipality	Assessment of climate change impacts to include local flooding (50- and 200-year return period)	Report text, maps	https://www.larvik.kommune.no/media/4850/lardal-og-larvik-kommuner-tilpasning-til-klimaendringer-15042016.pdf
Kartverket	Web tool visualize present-day storm surge levels and future sea level rise	map	https://www.kartverket.no/sehavniva/se-havniva-i-kart/
Extreme precipitation			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
Norwegian Climate Service Center (KSS)	Climate change and changes in precipitation (as well as temperature and flooding) for Norway	Text, maps, data	https://klimaservicesenter.no/faces/desktop/scenarios.xhtml?climateIndex=precipitation_amount&period=Annual&scenario=RCP85&region=NO&mapInterval=2085

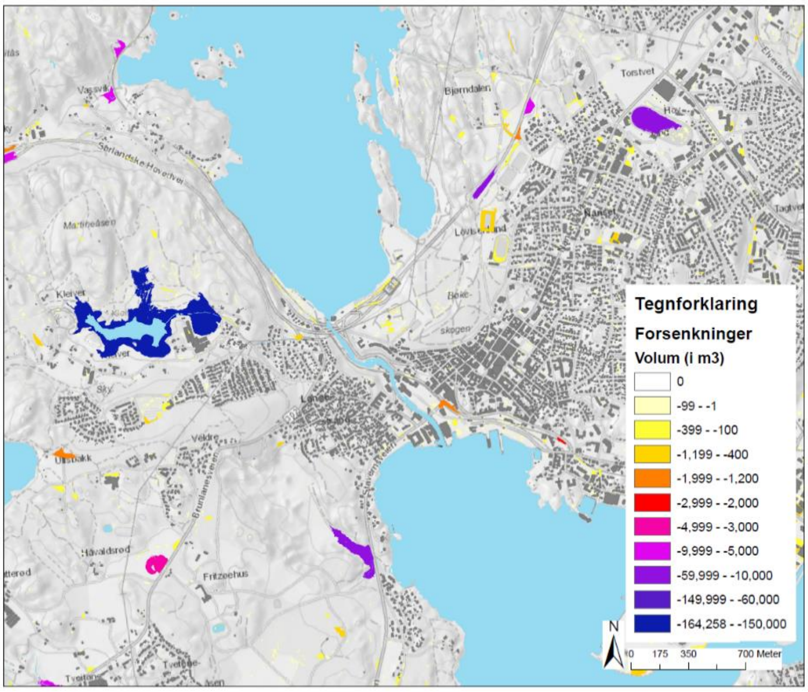

Figure 5: *Estimated water volume that can accumulate in natural terrain depressions in Larvik, including Martineåsen (NGI 2016)*

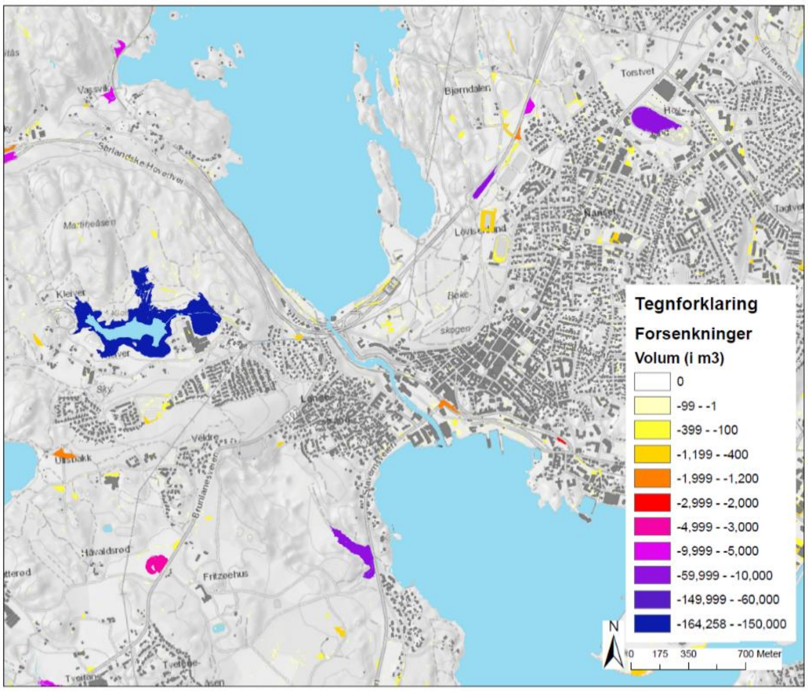

Figure 6: *Estimated water volume that can accumulate in natural terrain depressions in Larvik, including Martineåsen (NGI 2016).*

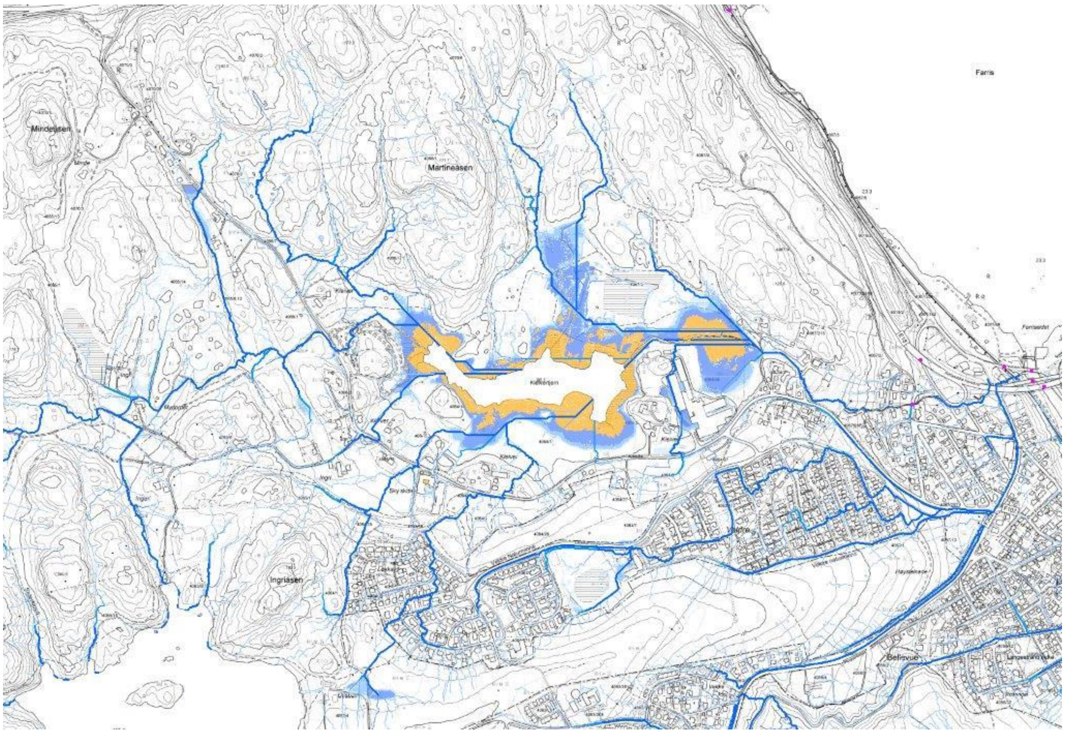

Figure 7: *Potential water ways and water accumulation in natural landscape depressions in Larvik, including Martineåsen (Larvik municipality)*

2.1.2.2 Selection of climate service(s) to work with

The climate services listed above are perceived as useful. However, since the study focuses on the development of a new area, the municipality was interested in exploring a climate service that could serve as a planning tool to select measures and specify requirements prior to building. Therefore, during the March 2019 EVOKED partner meeting in Den Bosch, Larvik municipality and NGI applied the climate information design tool to different groups of relevant stakeholders for the development of Martineåsen (landowners, building developers, contractors as well as politicians).

After this meeting, it was relatively quickly decided that the target stakeholders for conducting the Field Trials and the further development of the climate service would be building developers and contractors and there were two types of climate services that were considered relevant for this group: i) Blue Green Factor tool and ii) selected indicators from the BREEAM Communities framework. Reasons for selecting these two were based on the following needs:

- Serve as a tool for communication of climate related topics between planners in the municipality and developers.
- Address measures that are climate-wise favorable. Create flexible conditions for the possible projects with their different ambitions and challenges (physical/economic).

- Show costs and benefits (both concerning effects of climate change, needs for maintenance, and future risk events).
- Develop and/or combine already existing climate services for assessing climate impact.

The Blue Green Factor (BGF) tool provides a list of different blue-green infrastructure for building development projects (urban hydrology, flooding and biodiversity). It is based on a point system for the different measures and an equation that calculates a total BGF. The tool serves as an additional guarantee for blue-green infrastructure and Oslo municipality has developed a standard.

In this Oslo standard, the objective of the BGF is to ensure local floodrisk management as well as to improve and preserve vegetation. Different surface areas have an assigned value on a scale from 0.1 (impermeable surface such as asphalt or concrete) to 1 (open water or vegetation in contact with soil more than 80 cm thick). Each score is multiplied with the sub-area and a final score is obtained by adding all of the sub-area scores and dividing by the total area. These scores reflect a qualitative assessment of infiltration. The BGF also incorporates additional urban green qualities with extra points for wet ponds, rain gardens, trees, bushes, as well as green walls. Although a minimum value for BGF can be stipulated in a municipality master plan or regulation plan, the BGF tool was intended to be used at the building plan phase (Ardila & De Caprona 2014).

BREEAM Communities is a trademark assessment method for integrating sustainable design in the planning of new communities (or transformation projects). The method includes several assessment categories to ensure that environmental, social, and economic aspects are included in the design. In this capacity, the method includes much more than blue-green infrastructure for managing flooding. BREEAM Communities is both a framework and classification system and can be applied in planning processes, for promoting dialogue or as a certification system. It is intended to support planners, authorities, developers, and investors throughout the master planning process and thus prior to the more detailed building plan phase.

There are five main categories (Figure 8); governance, transport and movement, resources and energy, land use and ecology, as well as social and economic wellbeing. For the purposes of the development of a climate service to help address the consequences of climate change, the following sub-categories were identified as important:

- LE01 Ecology strategy
- LE05 Landscape
- SE08 Microclimate
- SE11 Green infrastructure
- SE10 Adapting to climate change

BREEAM®

Step 1	Step 2	Step 3
Governance		
GO 01 – Consultation plan	GO 02 – Consultation and engagement GO 03 – Design review	GO 04 – Community management of facilities
Social and economic wellbeing		
SE 01 – Economic impact SE 02 – Demographic needs and priorities SE 03 – Flood Risk Assessment SE 04 – Noise pollution	SE 05 – Housing provision SE 06 – Delivery of services, facilities and amenities SE 07 – Public realm SE 08 – Microclimate SE 09 – Utilities SE 10 – Adapting to climate change SE 11 – Green infrastructure SE 12 – Local parking SE 13 – Flood risk management	SE 14 – Local vernacular SE 15 – Inclusive design SE 16 – Light pollution SE 17 – Training and skills
Resources and energy		
RE 01 – Energy strategy RE 02 – Existing buildings and infrastructure RE 03 - Water strategy		RE 04 – Sustainable buildings RE 05 – Low impact materials RE 06 – Resource efficiency RE 07 – Transport carbon emissions
Land use and ecology		
LE 01 – Ecology strategy LE 02 – Land use	LE 03 – Water pollution LE 04 – Enhancement of ecological value LE 05 – Landscape	LE 06 – Rainwater harvesting
Transport and movement		
TM 01 – Transport assessment	TM 02 – Safe and appealing streets TM 03 – Cycling network TM 04 – Access to public transport	TM 05 – Cycling facilities TM 06 – Public transport facilities

Figure 8: *Illustration of the categories and steps in the BREEAM Communities assessment method (https://www.breeam.com/discover/technical-standards/communities/).*

2.1.3 (Re)development process for a (new) climate service

The first version of the climate service for building developers and contractors with a potential interest in the development of Martineåsen in Larvik municipality was presented as either the BGF tool or a checklist table of selected sub-categories from the BREEAM Communities assessment method. Based on these available examples, the format of the climate service is a table with the objective to be used as a communication tool on climate related topics between planners in the municipality and developers. Infiltration and Green infrastructure were identified as important aspects to include in the climate service for information on physical measures. The first version of the climate service is displayed in Figure 9.

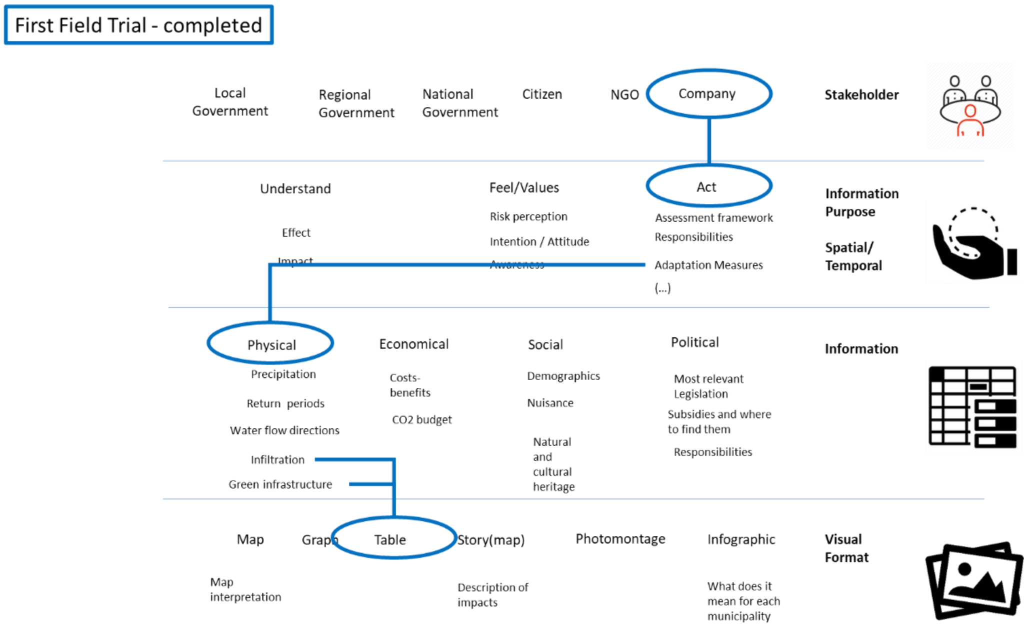

Figure 9: *Information design of version 1 of the climate service to be developed for Martineåsen.*

2.1.3.1 Identification of information needs and the usability gap(s) present

The first Field Trial was held 28-08-2019 with builders/contractors, real estate developers and consultants (engineers, architects) as well as representatives from Larvik municipality (Figure 10). The intention was to receive feedback on the feasibility study for Martineåsen and use of Blue Green Factor or something similar in line with a simplified BREEAM communities' checklist for climate service for climate adaptation.

The Field Trial included general presentations to build a background knowledge on the development of Martineåsen, the effect of climate change on the area, as well as the two checklist tools intended as the first version of the climate service. Everyone was divided into two break-out groups to discuss and afterwards there was a plenary discussion. Interestingly, none of the participants had experience working with Blue Green Factor. Some of the builders/ real estate developers have experience with BREEAM-NOR for buildings, but not BREEAM communities. One person has had good experience with a criteria checklist developed by Trondheim municipality to highlight different qualities in similar development projects. He shared that initially he thought this was not useful, but in retrospect, the tool provided builders with assurances about the municipalities' priorities (i.e. infrastructure) in relation to building development.

The feedback was that the group of present stakeholders preferred a tailored version of BREEAM communities rather than BGF as it provides greater flexibility and has more focus on improved landscape qualities. The group also indicated that it was important that the climate service can be used by the municipality to specify expectations regarding the development of the area. Furthermore, there was a lot of discussion on the economic aspects of the development project and the challenges of having a long-time perspective (50 years) on generating commercial interest.

Figure 10: *Photo during the break-out group discussion during the first Larvik Field Trial for co-design of a climate service for climate adaptation in development projects.*

2.1.3.2 Creation of an improved information design

Based on the first Field Trial, the climate service is being revised with the second version that is inspired by the BREEAM Communities sub-categories incorporating additional aspects for climate adaptation and climate mitigation (Figure 11). This climate service is named "Klimameny" (Climate menu) (Figure 12) and was presented to the same group of stakeholders in a workshop carried out virtually in September 2020.

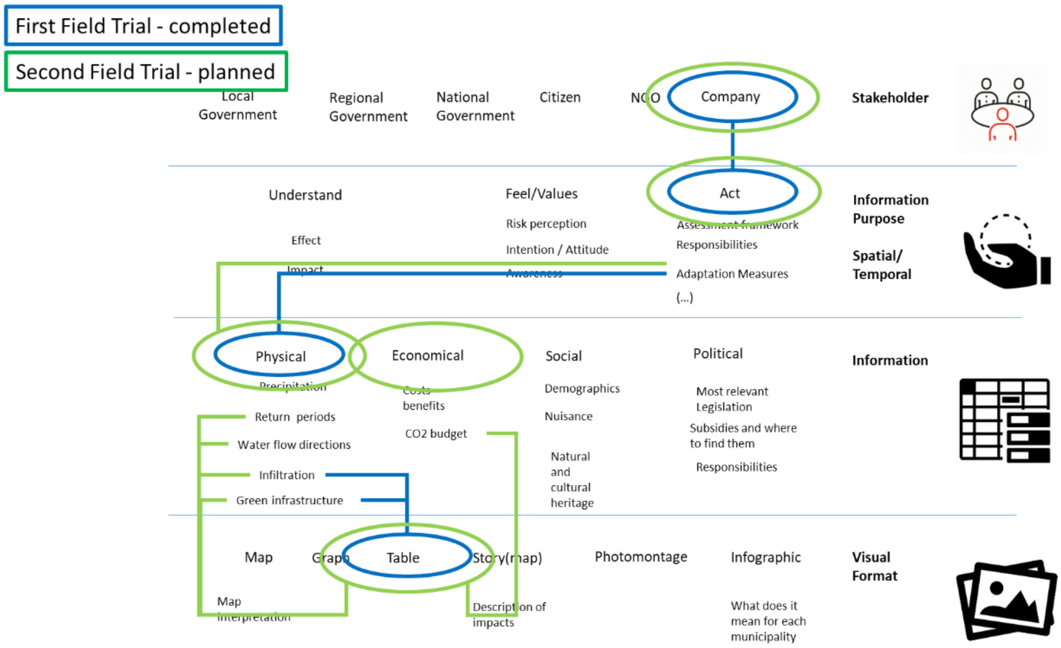

***Figure 11:** Information design of version 2 of the climate service to be developed for Martineåsen.*

The "Climate menu" is intended to function as a discussion tool between planners in the municipality and developers for addressing climate adaptation measures. It is not meant to provide solutions but rather a starting point for discussions between the municipality and builders with the goal being to identify potential measures early in the process when conditions are more flexible. The response from the stakeholders (builders and developers) was positive and there is an agreed understanding that climate adaptation is an important and relevant theme. The municipality will continue to refine the "Climate menu" to include an additional column for following up topics not only during the planning phase but also during the construction and building phase. Furthermore, they would like to test its application using a specific case in Larvik together with one of the stakeholders that have participated in the Field Trial.

TEMA	Eksempler på problem-stilling	Skala	Krav/veiledere	Eksisterende kunnskapsgrunnlag	Manglende analyser/ kunnskap	Eksempler på tiltak	Klima-verdi (1-5 der 5 er gunstigst)	Kostnad investering (1-5 der 5 er billigst)	Kostnad drift (1-5 der 5 er billigst)	Vekt (1-5 der 5 er viktigst)
Nedbør	Flom/ Overvann Styrtregn Snøfall Stormflo/springflo Havnivåstigning	Regional/ lokal	Plan- og bygningsloven Blå-grønn faktor Overvannsplan – Godkjenning KMT Ingen økt avrenning Lindholm m.fl. (2008): Veiledning i klimatilpasset overvannshåndtering. Norsk Vann Rapport nr. 162.	Fare/ aktsomhetskart. Lardal og Larvik kommuner – tilpasning til klimaendringer (NGI) Mulighetsstudiet vann og vannsystemer (Rambøll)	Detaljerte flomanalyser	Grønne tak Fordrøyningsbasseng – åpent eller lukket Etablering eller gjenetablering av utflommingsområder ut fra bekker og elver Bekkeåpning. Åpne bekker som er lagt i rør for å øke fordrøyningskapasiteten. Erstating av tette overflater med porøse eller vanngjennom -trenglige flater Regnbed eller våtmarks anlegg Tradisjonelle løsninger: Etablering av kummer og lukkede overvannsløsninger Flomsikringtiltak/Landhevning				
	Skred Snøskred Steinskred Kvikkleire	Regional/ lokal	Plan- og bygningsloven	Fare/ aktsomhetskart. Lardal og Larvik kommuner – tilpasning til klimaendringer (NGI)	Detaljerte skredanalyser	NBS tiltak (vegetasjon) – bevaring eller nyplanting Drenering Skredvoller Skredsikring – tradisjonelle løsninger? Nett				
Vind og temperatur	Generelle vindforhold	Regional	Vindstandard (NS-EN 1991-1-4:2005+NA:2009)	Værstasjoner www.selarvik.no www.vindsiden.no		Overordnet arealplanlegging				
	Lokalklimatiske vindforhold	Lokal		Analyse av lokale vindforhold ved utbygging på Martineåsen (Outdoor Environment Technology as)		Bevaring av eksisterende vegetasjon Plassering og orientering/volum bygg Etablering av skjermingstiltak (vind, nedbør, snø, sol) Utforming av detaljer (spesielt takkonstruksjoner).				
	Tørke	Regional/ lokal		Nedbør registreringer Temperaturmålinger www.selarvik.no		The main summertime requirements of a space are likely to be provision of shade, cooling, air movement and prevention of glare. In winter conditions the focus will be on protection from wind and rain. (BREEAM comm.)				
Økologi og biologisk mangfold	Tap av biologisk mangfold	Regional/ Lokal	Plan- og bygningsloven M100 (2014): Planlegging av grønnstruktur	Grøntstruktur kartlegging Landskapsanalyse	Detaljerte analyser	Reetablering av kvaliteter Bruk av landskapsøkologiske arealprinsipper (liten avstand mellom grøntarealer, større arealer med diverse form, korridorer som ivaretar sammenhenger mellom grøntområder, buffersoner)				

Figure 12 *Excerpt from the "Climate menu" climate service developed for Larvik municipality, a tool for communication of climate related topics between planners in the municipality and developers.*

2.1.4 Answering the hypotheses for Larvik

Table 7: *Hypotheses answers for the case Larvik*

Hypothesis	**Answer for case**
1a) – Usability gap(s) is/are present in the original climate services that are used in the case study sites.	There were usability gaps present in the Larvik case as the local authorities were looking for a CS that could serve as a planning tool to select measures and specify requirements prior to building the Martineåsen neighbourhood. As current CS do not provide information on this aspect, a usability gap has occurred in which these CS do not provide the necessary information for the current stage of the planning cycle.
1b) – This/these usability gap(s) is/are caused by a limited feedback loop from the end-users to the producers of the climate service.	The usability gap has occurred because of a need identified by the municipality of Larvik. Building developers are not involved in regional scale planning as this is carried out by the municipality. However, the municipality identified CS as an opportunity to involve the developers in anticipation of meeting future expectations related to regulation plans. Thus, the CS to be developed is expected to minimize the usability gap.
2a) - Living labs have contributed towards the development of a feedback loop between	The case of Larvik can be categorized as 'a living lab for collaboration and knowledge support activities' (Schuurman et al., 2013). This is so since the case setting was focused around the idea of re-developing the BGF tool and the BREEAM Communities assessment-method to provide local authorities

the user and the developer	with an analysis framework to choose certain climate adaptation measures. After feedback from the user group (builders/contractors, real estate developers and consultants (engineers, architects), as well as representatives from Larvik municipality) the CS was further tailored to the needs of the users.
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.	For the case of Larvik, the following can be said for the applicability of each of the organizational principles of an EVOKED Living Lab: • *Continuity* – The CS was developed with an already existing network of stakeholders including NGI. This made it easier to establish feedback loops as the stakeholders already know each other, making it easier to interact. • *Openness* – As most sessions were done in a plenary session (with some break-out sessions), it allowed stakeholders to understand the position of others. As both the authorities and the developing partners were on the same side, it allowed for a more open discussion and co-designing the CS. This in turn helped develop the feedback loop between user and CS developer. • *Realism* – The aspect of realism is reflected by the fact that the users wanted a more tailored version of the CS and greater flexibility with the use of it. Therefore it can be concluded that realism helped reduce the usability gap. However, at the same time it can be concluded that *realism* does not help to establish the feedback loop between users and developers itself. • *Influence* – The Living Lab approach in Larvik allowed stakeholders to contribute to the development of CS through providing feedback. Additionally, as it allowed the inclusion of different stakeholder groups it also provided these groups with a sense of shared ownership which in turn leads to an atmosphere of openness. Consequently, the aspect of influence helped to establish the feedback loop needed to reduce potential usability gaps as the extra added value motivated end-users to engage. • *Value* - The Living Lab environment helped to add extra value to the development of the CS and why they should use it. Therefore, it can be stated that this helps to establish feedback loops as it provides incentives for end-users to participate in the co-design process which in turn helps to establish the feedback loop. • *Sustainability* – The concept of sustainability does not contribute to establishing feedback loops between users and designers as it focusses on the sustainability of the development process itself.
3a) - Information designs help to convey	The information designs helped in the development of a climate service that improve the usability of the information conveyed to the user. This is so as it allowed the developer to better

produced information to the end-user	understand how to address the usability gaps that were present as well as to address the information needs of the end-users.
3b) - Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.	Climate information designs have helped in the case of Larvik as it allowed for a structured dialogue between the developer and the end-users about what needed to be included and changed over the course of the development process. Therefore it can be stated that information designs are a useful tool to establish feedback loops between the producer and the end users.

2.1.5 Reflection on the case together with the case owners

Together with the case owners we discussed the case with the case owners by both looking back and looking forward. This was done with questions provided by Deltares.

Looking back

The most valuable aspect of EVOKED has been the development of the "Climate menu" as a climate service has been valuable as a tool to increase understanding of climate change with the advantage of providing a tangible method to address climate change impacts. This tool would most likely not have been developed if not for the EVOKED project.

The interactions with the other case study site partners, learning about their challenges and following the production of their selected climate services has also been valuable.

The municipality has the advantage that they are quite aware of which challenges are most pressing; however, they are uncertain as to how to solve these issues. The "Climate menu" provides a framework for discussion and they would like to further test this.

Climate change and climate change impacts are difficult to discuss and in plan processes the first instinct is for builders and developers to become defensive. In the last years there has been a gradual increase in understanding climate change after the municipality's project "Vær Smart" as well as the pilot project carried out by NGI for Larvik municipality (report reference). Being able to use the "Climate menu" to guide the discussion with builders and developers is expected to increase this understanding on the need to consider climate change even more, especially by being able to give the builders and developers options that they can select rather than having to implement a top-down dictated climate adaptation measure. Furthermore, the "Climate menu" as a tool for dialogue is viewed as advantageous and forward thinking compared to the alternative, which is to include specific provisions within the approved planning documents.

Engaging the builders and developers has been a challenging aspect of the project. Furthermore, understanding the role of the municipality and what the municipality was expected to accomplish as a partner in a research project has also been a challenge. For example, some of the long emails in English with a long list of tasks required time to understand and translate into something more practical.

In retrospect, the decision to target the builders and developers as the EVOKED stakeholder group for Larvik was a good decision as they are a more permanent group of stakeholders compared with for example politicians that circulate in and out depending on the voting cycle.

Looking forward

Larvik municipality would like to test out the "Climate menu" using an ongoing zoning plan process within the municipality with one of the builders/developers that have also participated in the development of this tool.

An important aspect for the future use of the "Climate menu" is to also use it as a tool to communicate between departments within the municipality. This helps ensure that planers handle zoning applications and planning documents in the same manner.

An additional and future activity to support the "Climate menu" would be preparing fact sheets for alternative climate adaptation measures to also include costs. This information would be useful for planners, builders and developers.

2.2 Värmland and Arvika, Sweden

2.2.1 Case description

2.2.1.1 General information about case study location

Värmland County Administrative Board (VCAB) is a governmental authority as a link between the people and municipal authorities in Värmland county on one side and the central government and authorities (Länsstyrelsen Värmland, n.d.) on the other. It has a central role in climate adaption and crisis management in the county and coordinates the regional and municipal efforts to adapt society to a changing climate. Värmland county in western Sweden has a population of 280 000 and consists of 16 municipalities. The third largest municipality in Värmland, Arvika (population 26082 in 2018 – Arvika Kommune, 2020), lies northeacst of Glafsfjorden and is situatied on its bay - Kyrkviken (Figures 13-15).

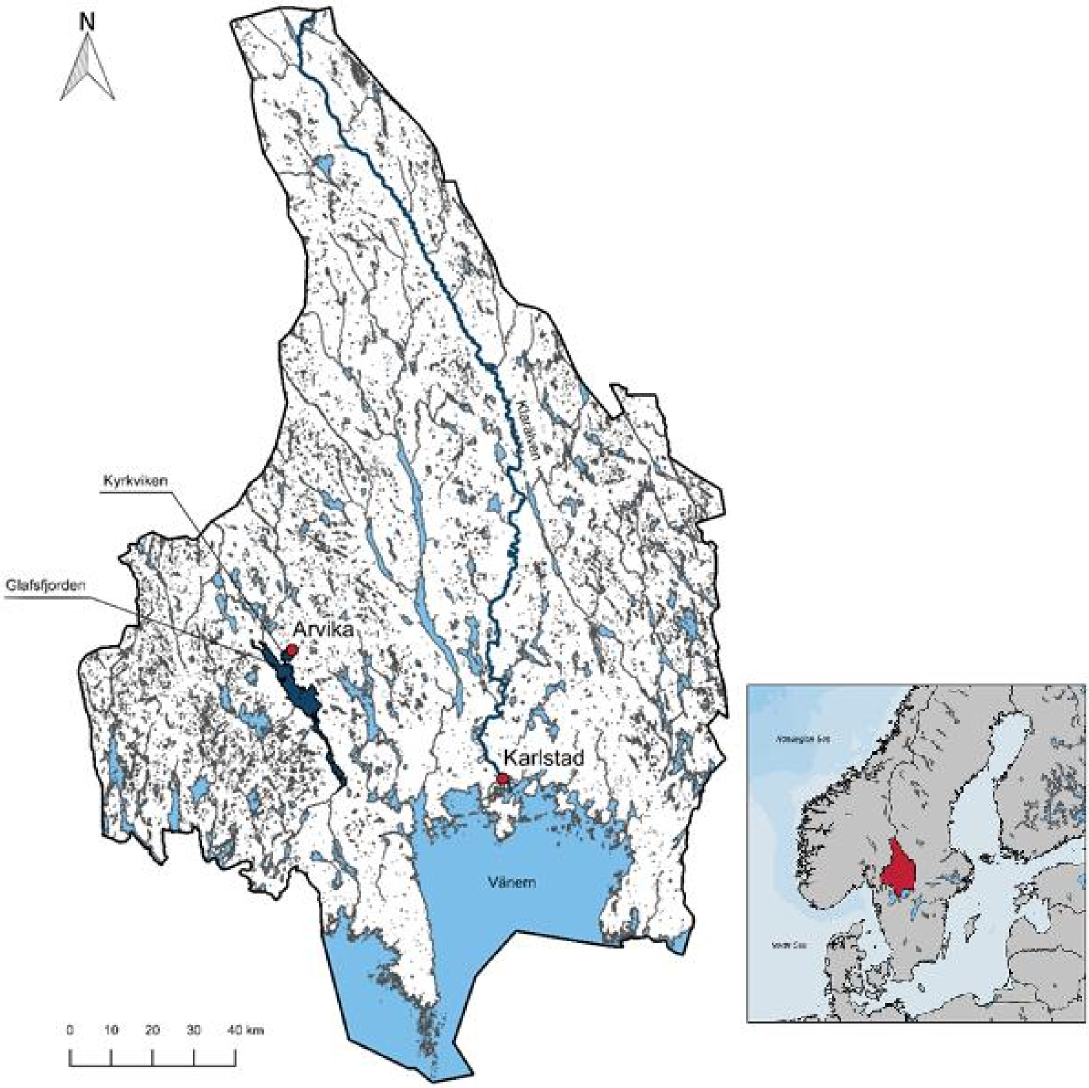

***Figure 13**: Map of the case study location Värmland and Arvika within the context of Swede*

2.2.1.2 Climate adaptation needs and visions in Värmland county and Arvika

Balancing the need to build more housing in the city centers in attractive areas at risk for flooding and protecting housing and infrastructure from extreme weather events is one of the main challenges of urbanization for VCAB and Arvika. This is linked to the regional vision of being an attractive and sustainable growth region. Within EVOKED, the goal of VCAB and Arvika municipality is to find ways to communicate the integrated risks associated with a changing climate and bring together relevant stakeholders to improve the awareness and knowledge capacity of various target groups to enable urban and rural development with sustainable water quality and quantity.

2.2.1.3 Governance structure, challenges and potentials

In 2018 Sweden formally adopted a climate adaptation strategy (Löfven & Skog, 2018). But the concrete measures to adapt to a changing climate are a responsibility for physical planning and development at the local level. National authorities also have an important role to initiate, support, and evaluate climate adaptation work. The County Administrative Boards have the responsibility to coordinate climate adaptation work, to assist municipalities, and to report yearly on progress. The Swedish municipalities play the central role in climate adaptation work as they are responsible for technical provision such as water and sewage and physical planning, as well as to provide preventive measures for natural hazards as well as risk and vulnerability assessments.

2.2.1.4 Main stakeholders (see Table 8)

Table 8: *Main stakeholders in the cases of Värmland and Arvika*

Stakeholder	Public/ private/ civic	Relevant climate impacts	Relevance to climate impact adaptation / case
Värmland County Administrative board	Public	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	VCAB is tasked with coordinating and providing guidance to the municipalities with their climate adaptation work and developing climate adaptation plans for various sectors
Municipality of Arvika	Public	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	Interest in understanding the risk and uncertainty associated with measures to improve water quality and measures for flood protection
Local politicians	Public	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	
National water management authorities	Public	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	Influence on climate adaptation measures.
Regional water management authorities	Public	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	
Local citizens	Private	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	Interest in understanding the risk and uncertainty associated with measures to improve water quality and measures for flood protection
Local businesses	Private	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	
Interest groups	Civic	Pluvial and fluvial flooding; Drought; Worsening of water quality; Forest fires	

2.2.1.5 Climate impacts

In Värmland the most important climate related impacts affecting the municipalities in the county are fluvial and pluvial flooding, landslides, worsened water quality, drought and threats to drinking water supply, as well as forest fires. Within EVOKED, the focus is on flooding and poor water quality. In Karlstad, the county seat in Värmland, there is a growing need for more green infrastructure to take care of water overflow and groundwater. In some places, there is a need to pump out water. But still Karlstad is committed to build close to the water, because of the limited space suitable for building (River Klarälven and Lake Vänern) and have adopted the principles to protect and adapt housing and infrastructure.

In the past century Arvika has experienced flooding of Glafsfjorden and Kyrkviken as a major risk to society. More recently, major flooding occurred in 2000, 2014 and 2019. Impacts include drainage system overload and poor quality of surface waters.

2.2.2 Local climate service(s) description and selection

2.2.2.1 Available climate services

Within the county, the existing climate services that can be considered a basis for planning of climate adaptation are (see table 9):

- The Swedish Meteorological and Hydrological Institute's (SMHI) Regional Climate Analyses (SMHI, 2015)
- The Swedish Civil Contingency Agency's (MSB) flood maps of watercourses (MSB, 2020a - see also Figures 12 and 13) and coastal areas, MSB's slope stability maps (MSB, 2020b)
- SGI's landslide risk assessments (SGI, 2017)

The regional Planning Catalogues and the inter-agency cooperation – Geodata Portal (Lantmäteriet, 2020).

All current available climate services as well as reports and web-based maps are presented in either a wms- or shp-format.

For most of the municipalities in Värmland county, including Arvika, the available climate services comprise maximal water level maps at local level (Urban Rain Depth Models), flood risk maps, a building level inventory (available online), a guidance paper for managing extreme precipitation, Risk and Vulnerability Analyses (as reports and maps), and water quality measurements.

In Arvika, risk assessments in the municipality are done with the help of geological, geotechnical, and topographical knowledge, together with mapping of flooding and landslide risk that the national authorities provide, as well as services provided by consultancies. The Swedish Meteorological and Hydrological Institute (SMHI) provides regional climate scenarios seen as a useful modelling tool in risk management.

Table 9: *Information provided by the original CS used within Värmland and Arvika*

Flooding from the regional system			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
Percentage change in local seasonal flows	Winter months compared with summer months, periods 1961-1990 with scenario 2069-2098 under RCP8,5	Static map, text	https://www.lansstyrelsen.se/download/18.98e386016343936f5420f/1526068516533/Framtidsklimat-Varmland-RCP.pdf
Extreme precipitation			
Name	**Keywords about focus**	**Information format**	**Internet link or reference**
Yearly maximum precipitation (24-hour period)	Comparing periods 1961-1990 with scenario 2069-2098 under RCP8,5	Static map, text	https://www.lansstyrelsen.se/download/18.98e386016343936f5420f/1526068516533/Framtidsklimat-Varmland-RCP.pdf
Drought			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
Number of days per year with low soil moisture	Comparing periods 1961-1990 with scenario 2069-2098 under RCP8,5	Static map, text	https://www.lansstyrelsen.se/download/18.98e386016343936f5420f/1526068516533/Framtidsklimat-Varmland-RCP.pdf
Heat stress			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
The year's longest heatwave (# of days with average temp over 20 degrees C over 24h period)	Comparing periods 1961-1990 with scenario 2069-2098 under RCP8,5	Static map, text	https://www.lansstyrelsen.se/download/18.98e386016343936f5420f/1526068516533/Framtidsklimat-Varmland-RCP.pdf

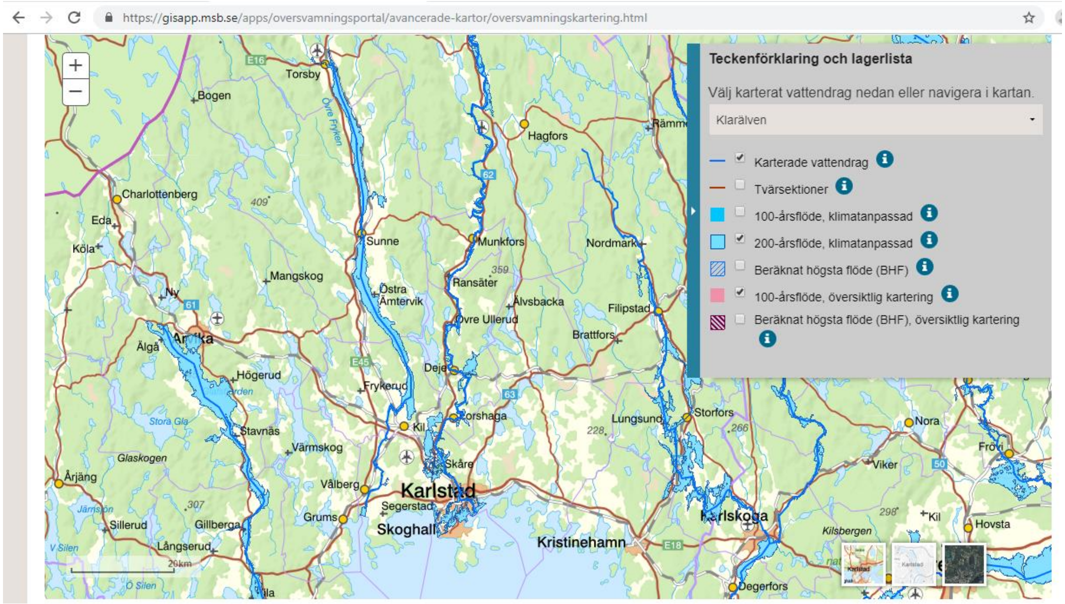

Figure 14: *Screenshot from MSB's flood mapping website. The 200-year return period is shown.*

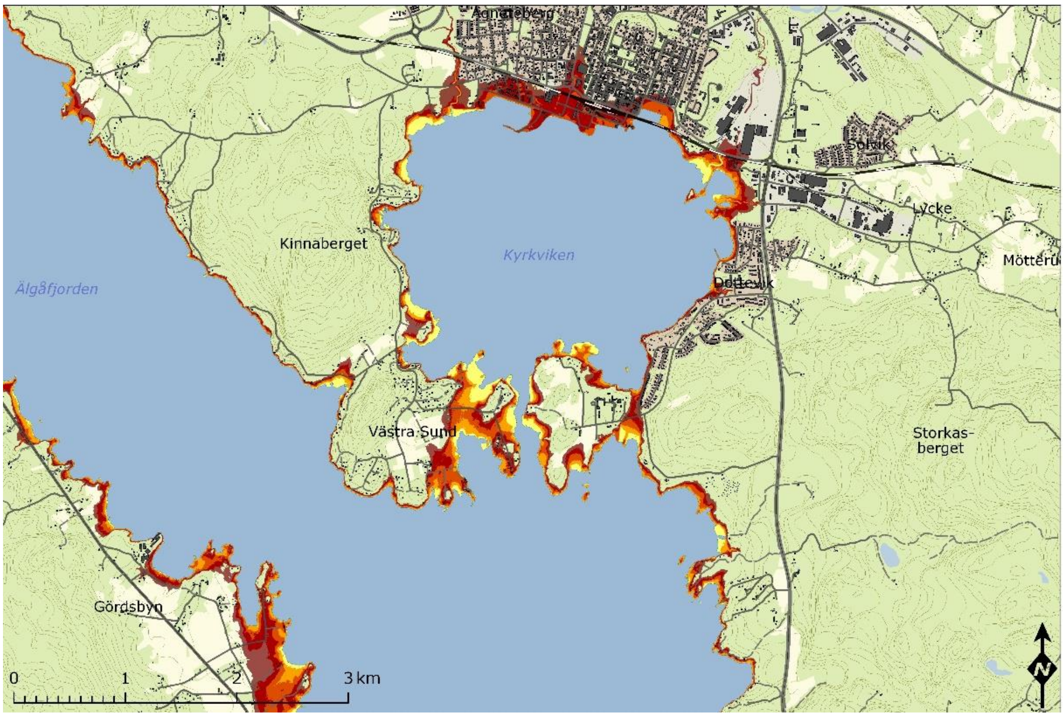

Figure 15: Arvika Flood risk map

2.2.2.2 Selection of climate service(s) to work with

Prior to, during, and after the March 2019 EVOKED partner meeting in Den Bosch, representatives of VCAB, Arvika, and SGI discussed how the information design format could be used to understand the nature of the usability gaps and to point out ways to address this. It was decided to use SMHI's data on regional scenarios as a basis but improve and change presentation and focus on flooding and risk impacts. Story maps were chosen as the appropriate means to present the information to municipal authorities (in Värmland) and citizens (in Arvika), since they could present climate data in a manner that was easy to understand and contextualize to the local conditions.

The information design exercise for VCAB focused on local and regional stakeholders. Its purpose was to move from only understanding effects of climate change from existing climate services, to promoting understanding of how climate change affects society. And finally, how to raise awareness and promote action for making adaptation assessments and frameworks. The developed information design should also make responsibilities more transparent and facilitate acting on climate adaptation measures. The existing information on precipitation, return periods, and water flow directions should be complemented by cost-benefit analysis, more impacts on social and nature aspects and the political/governance aspects of measures to deal with climate adaptation. Story maps, including maps and info graphics, focused on what the data means to municipalities, were understood as the way forward and a way to make the existing climate service reports and maps more useful and understandable. Story maps were chosen as the best option for dissemination after VCAB and Arvika learnt how the story map for the EVOKED case in Flensburg was being developed.

Arvika is now also developing a story map. The stakeholders are mainly the Municipality itself (specifically the municipal-owned company Teknik i väst), as well as citizens who need to see what the local government does within climate adaptation. The climate services (story map and climate adaptation plan) are to be addressed to a wide range of sectors in the municipality, including power, fiber, district heating, sanitation, water supply and sewage, to coordinate actions. The purpose is to understand the shortcomings in existing systems and sectors, and to make citizens aware of their responsibilities and obligations. It would support action to map climate adaptation measures and demand accountability. Information would show the climate change impacts on sectors and their social consequences, as well as how responsibilities are delineated among relevant regional and national authorities and frameworks. Climate data, regional climate scenarios, climate change impacts, flood risk mapping, and cloudburst data return times should be as short and useful as possible and presented as interactive story maps, including videos, 3-D models, and infographics. To see the additions to the CS see figure 16.

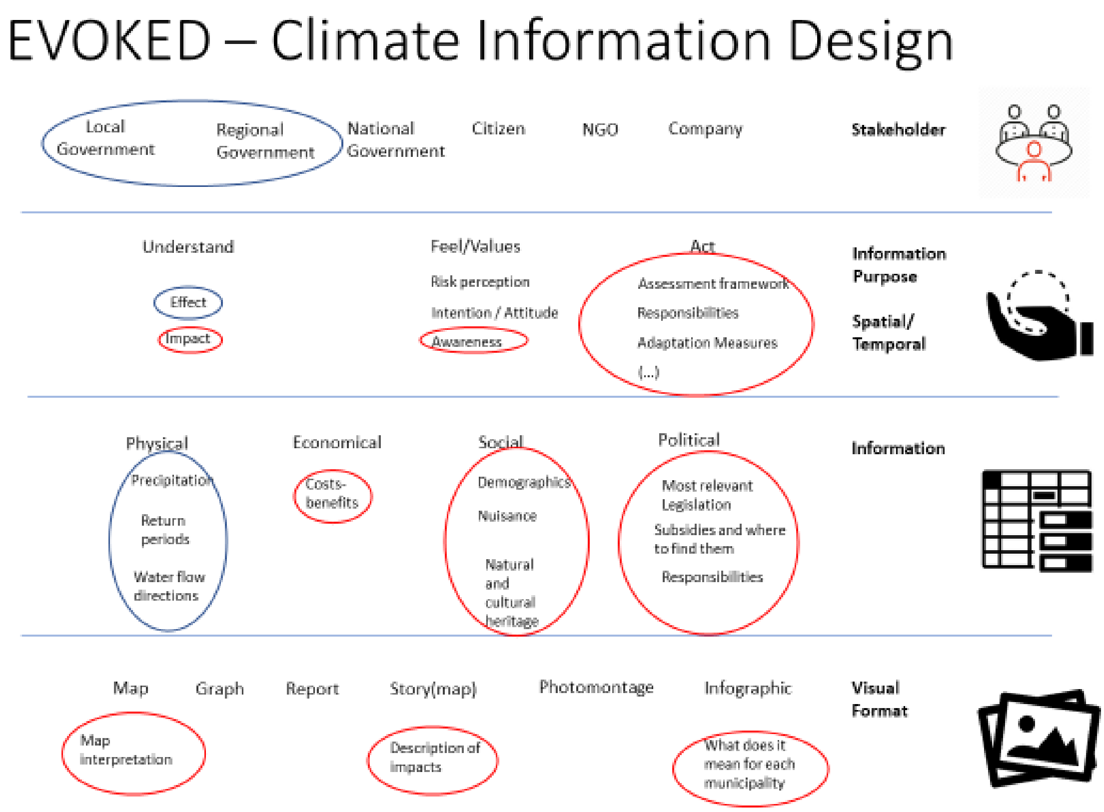

***Figure 16:** VCAB information design template. The blue circles represent current climate services available for the county and the red circles represent the desired further development of the climate services*

2.2.3 (Re)development process for a (new) climate service

2.2.3.1 Identification of information needs and the usability gap(s) present

The main needs for further information are focused on the way that the climate data are presented. The problem is rather too much data rather than two little. In Sweden in general, stakeholders mention that local capacity is hindered as the knowledge provided by national authorities is sometimes unclear and difficult to use or insufficiently harmonized. This is echoed in the Arvika case; as an Emergency Coordinator mentioned in an interview "There is a lot of knowledge, but we need to know how to use the knowledge. We don't know all the details and need help with this".

Unclear guidelines about responsibility for climate adaptation measures is also an apparent information gap. In Värmland county many citizens are aware that the individual (property owner) bears the responsibility for protecting their own property against flooding and are responsible if damage does occur. But they still sometimes ask the municipality for help. The SMHI regional climate analyses are useful, but too extensive and long to be easily understood, with too many basic facts at a low resolution. It is also difficult for municipalities to choose what RCP scenario to plan for.

Municipalities in Värmland county, in a workshop/field trial in February 2019, cited the need for more dialogue and meetings with VCAB in their climate adaptation work and the possibility to ask direct questions to authorities and other experts, training and education, as well as more discussion on the interpretation and developing of risk and vulnerability analyses. They also wanted more specific help on planning scenarios, mapping cloudbursts in non-urban areas and more analysis on consequences of flooding, cloudburst, etc. and good adaptation examples.

Arvika specifically illuminated the need to have a strategic adaptation plan to coordinate projects and measures, and communicate these measures, as well as to utilize the knowledge available and help to reach more vulnerable groups with risk data. Too much data to process and how to choose from these data were a big challenge.

2.2.3.2 Creation of an improved information design

The Field Trials were initiated, with a more extensive workshop on 7th February 2019 to discern what needs the municipalities in Värmland had, and in what way VCAB could help the municipalities with their climate adaptation work through the formulation of the Värmland Climate Adaptation Strategy. The meeting was attended by 46 participants – 36 from the 16 municipalities (including Arvika) in Värmland county, 8 from VCAB and 2 from SGI.

Furthermore, also a stakeholder dialog meeting was organized by VCAB (with input from SGI/EVOKED) in Karlstad on how VCAB can support municipalities in the county with their information needs for climate adaptation. The dialogue was not set up exclusively for the purpose of EVOKEDs field trials, but many of the questions were important input into the development of the information design and the field trials. Additionally, SGI also briefly presented EVOKED and the ideas of climate services and Living Labs at this meeting. The focus of the discussion was on the needs of the municipalities, with no real discussion about the climate service to be produced. But the results were relevant when we later discussed the input into the information design of WP3 and developing the climate service.

In general, the municipalities expressed a need for better coordination among municipalities and had ideas about how VCAB can help with this. Discussion was also on financing adaptation measures and how to deal with conflicting objectives within the municipalities. As Värmland has several smaller municipalities, there were feelings that many climate adaptation measures were too costly for small municipalities to deal with on their own. The climate change impacts, challenges, and measures presented at the meeting by VCAB and individual municipalities were presented with planners and other practitioners in mind, the latter in turn need to make the information more understandable for politicians and citizens. Results of the discussion also included what types of information were needed and how they should be presented.

During the March 2019 EVOKED partner meeting in Den Bosch the idea of developing story maps crystalized for the SGI/VCAB team, and we gained a lot of inspiration from presentation from the Christian-Albrechts-Universität (CAU) on story maps and the information design work led by Deltares.

On the 4th April 2019 SGI and VCAB presented EVOKED and the Information Design template at the CATCH – Water Sensitive Cities (Interreg North Sea Region) meeting and workshop in Vejle, DK on the needs for information design to develop climate adaptation strategies in mid-sized cities (including Arvika). Participants included 26 local and regional CATCH partners from Germany, the Netherlands, the UK, Denmark, Sweden and Belgium. There was a strong interest in the EVOKED project among CATCH participants and interest in using the EVOKED information design exercise in forming the CATCH partners climate adaptation strategies. The workshop participants found it helpful to consider the parts of information design dealing with "why" they were developing a climate adaptation strategy and for whom. Greater understanding of the importance of presenting climate "services" in an understandable way was also seen. We discussed not only what we want the target groups to know about climate adaptation, but also how we would like to make them feel in relation to climate impacts. This was an eye-opener for some participants and helped SGI and VCAB refining their own ideas for story maps for VCAB and especially Arvika within EVOKED.

Between May and the beginning of September 2019 a series of skype meetings was held between SGI, VCAB and Arvika on co-developing the story maps as the main climate services to be produced within EVOKED. These meetings focused on how to present and make risk analyses more understandable, how to develop visions and goals for the story maps, and how they could also be used in the VCAB climate adaptation strategy. We also specified further the needs of VCAB and Arvika based on the SMHI regional climate scenarios and discussed involving GIS competencies. VCAB presented the climate adaptation goals that could be used in the story maps, based on the information design and the scenarios developed in EVOKED WP2. We also planned the first "pre-field trial" (or first "field trial") and discussed how to present the EVOKED Information design and visions and needs for work (WP1) at the CATCH partner meeting in Arvika in September 2019.

On the 9th September 2019, we had a first "Pre-field trial" workshop in Karlstad with GIS teams from VCAB, Arvika and SGI to discuss the target groups for the story maps in both VCAB (regional level) and Arvika (local level) and the potential structure of the story maps. While this meeting was still at the co-development phase, it was also a way of validating how the information design could be implemented. Discussions during the workshop focused on the following questions (one group for Arvika and the other for VCAB): Who are the target groups? What do they know today? What do they want to know? What do they want to feel? What do they want to do? What is the message we want to give them? How do we best reach the target groups with the story maps?

The results told that VCAB would make a story map for decision-makers (politicians and administrative managers) with the objective to make decision-makers in Värmland municipalities aware of how climate change affects society, how they see their own role in climate adaptation, and how they can make decisions based on knowledge. This was necessary since decision-makers in the municipalities lack knowledge of why they should work with climate adaptation and since practitioners in the municipalities have expressed a need for climate adaptation education for decision-makers. For Arvika story map discussions, the results were that Arvika's target group would be citizens in Arvika city, with a secondary group the potential future citizens of the city. The objective is to raise awareness among Arvika citizens of the problems and measures regarding Kyrkviken's water quality. This would be to make information easily assessible, to illuminate needs that citizens might not know exist, to show citizens what their local tax is used for and why. To show how citizens of Arvika are affected by water quality and how citizens of Arvika influence water quality.

The workshop also included planning for the next field trials in Arvika and Karlstad (VCAB) on the 25th and 26th of November, respectively. On 26 November 2019, the first co-validation field trial was run at VCAB in Karlstad with environmental engineers, GIS personal, planners and strategists from six municipalities in Värmland county (including Arvika), VCAB and SGI representatives. The goal of the meeting was to present the first prototype and structure for the VCAB story map that VCAB will use to inform relevant decision-makers in the municipalities about climate change impacts, what they can do to manage this and how VCAB can help. We gathered their ideas about structure and content and ways to make it more relevant for the municipalities' own needs.

SGI first presented general ideas about what a story map is and how it can be used, as some of the participants had not heard about this specific tool previously. Then VCAB presented the prototype first version. The group then had a structured discussion regarding:

1) Structure – what is useful and what is missing?
2) Content – What needs explaining, which maps are useful and should be presented? Which time aspects should be shown? Is a drastic approach needed? How should the SMHI regional scenarios be explained?
3) Municipal roles and responsibilities,
4) Which good examples of climate adaptation should be shown?
5) Should they be local, regional, national or international examples?
6) How to communicate and disseminate the story maps.

These categories were chosen, after discussions between VCAB and SGI, to gain practical input into the story maps. They address the questions in the Information Design Template that were not discussed in the first field trial, designing the story map objectives and target groups (Annexes A and B)

All comments were documented and used to help develop the second version of the VCAB story map. The broad categories for the discussion were developed in working meetings between VCAB and SGI. As such they reflect the stakeholder needs as determined in the workshop with all municipal representatives in February 2010. Main conclusions of this field trial are below:

Structure

- Good tab structure to go first to where you are most interested.
- Story maps can be used as educational material for authorities and politicians
- The film embedded in the story map shows a mainly urban environment, but many municipalities in Värmland are villages and rural communities.
- Show the consequences of a changing climate and what they mean for different areas of municipal responsibility

Content

- Use the SMHI current regional scenarios and then explain that to understand the societal consequences of climate change, we need to know what the situation is today.
- Show upstream, downstream dynamics in flooding situations
- Explain what the different flooding scenarios mean – i.e. a 100-year flood or a 200-year flood.
- The idea with the storymaps is not that they are a planning tool, but rather an awareness and interest raising tool
- Long discussions about what time perspective to show and what RCP scenario to plan for. There is still a lot of uncertainty around using the different scenarios. The story maps cannot recommend one scenario rather than the other but can explain what they mean. It is important to present this information in a trustworthy manner.

Municipal roles and responsibilities”

- Should be discussed in the story map

Good examples

- The point of departure is Värmland county and good examples should be taken from here, but even from other EVOKED countries, like the Netherlands. Värmland has several small municipalities and it is good to take examples from other small municipalities, rather than urban areas.
- Examples should show a holistic picture of climate work, and even be related to energy use, regional development or biological diversity
- Discussions on ways to make the story maps more interactive – such as promoting a competition for municipalities to show their good practice or have a function where questions could be posed.

Communication

- Discussions included a ”road trip” to promote the story map in the municipalities in Värmland, organising a webinar to provide capacity building on using the story maps, presenting the story maps at the annual Swedish ”Climate Adaptation Conference” and in the Swedish Climate Adaptation Portal. More specifically the story map could be presented at one of the monthly meetings of the municipal directors and politicians in Värmland county.

Figure 17 shows a screenshot from a first draft of VCAB's story map.

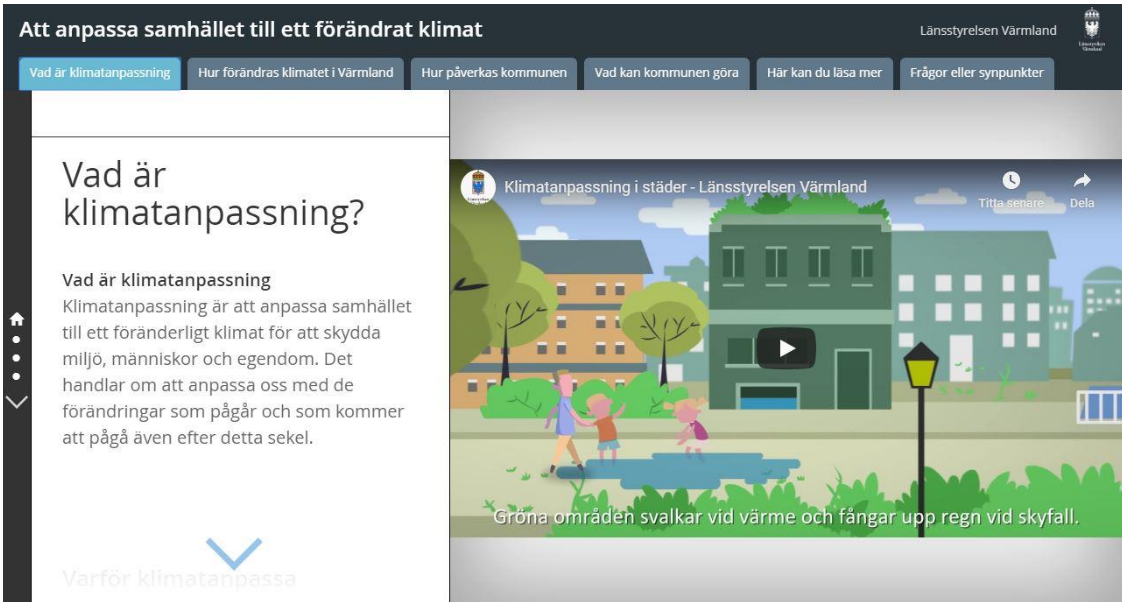

Figure 17: *Screenshot of a first draft of VCAB's story map.*

2.2.4 Answering the hypotheses

Table 10: *Hypotheses answers for the cases of Värmland and Arvika*

Hypothesis	Answer for case
1a) – Usability gap(s) is/are present in the original climate services that are used in the case study sites.	There were usability gaps present in the original climate services used in Värmland and Arvika. The knowledge provided by national authorities is sometimes unclear and difficult to use or insufficiently harmonized. Additionally, unclear guidelines about responsibility for climate adaptation measures are also an apparent information gap in these climate services. Finally, the SMHI regional climate analyses are useful according to the end users, but too extensive and long to be easily understood, with too many basic facts at too low a resolution . It is also difficult for municipalities to choose what RCP scenario to plan for.
1b) – This/these usability gap(s) is/are caused by a limited feedback loop from the end-users to the producers of the climate service.	It can be stated that the usability gap is the result of a missing feedback loop between the developers of the climate services that are operating on a more national level and the more regional/local oriented information needs by the VCAB, municipality of Arvika, and other involved stakeholders.
2a) - Living labs have contributed towards the	The EVOKED Living Lab that was used in Värmland and Arvika can be categorized as 'Living Labs for collaboration and

development of a feedback loop between the user and the developer	knowledge support activities' (Schuurman et al., 2013). This is so because collaboration and knowledge sharing between the different participating stakeholders have been an important aspect during the field trials. Furthermore, the environment that the Living Labs have provided for the EVOKED cases of Värmland and Arvika have contributed to the development of a feedback loop between the users and the developer through the co-design of a new story map CS for the end-users.
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.	For the case of Värmland and Arvika the following can be said for the applicability of each of the organizational principles of an EVOKED Living Lab: • *Continuity* – The CS was developed with an already existing network of stakeholders (where SGI as EVOKED partner was part of the reference group). This made it easier to establish feedback loops as stakeholders already know each other, making it easier to interact. • *Openness* – The Living Lab environment allowed for an open and transparent discussions between the different stakeholders. This helped a feedback to loop to be established. • *Realism* – The aspect of realism can also be found in that the story maps are also used by VCAB for their work in assisting municipalities with their climate adaptation plans. However, as was the case in Larvik, here also the aspect of realism does not help to establish the feedback loop but rather is useful for closing/reducing the usability gap(s) that may exist. • *Influence* – The Living Lab approach in Värmland and Arvika allowed for stakeholders to contribute to the development of CS through providing feedback. Additionally, as it allowed the inclusion of different stakeholder groups, it also provided these groups with a sense of shared ownership which in turn leads to an atmosphere of openness. Thus, the aspect of influence helped to establish the feedback loop necessary to reduce potential usability gaps. • *Value* - The Living Lab environment helped to add extra value to the development of the CS and why they should use it. Therefore, it can be stated that this helps to establish feedback loops as it provides incentives for end-users to participate in the co-design process which in turn helps to establish the feedback loop. • *Sustainability* – The concept of sustainability does not contribute to establishing feedback loops as it focusses on the sustainability of the development process itself.
3a) - Information designs help to convey information to the end-user	For the case of Värmland and Arvika, the information designs helped to better connect the produced information to the end user as it allowed to better visualize potential usability gaps as well as to communicate these.
3b) - Information designs are useful tools	The information designs in the case of Värmland and Arvika were useful for communicating and visualizing usability gaps.

to establish the feedback loops between the end-users and the producers of climate services.	Therefore, they are helpful to start a dialogue on the visualized form of a climate service.

2.2.5 Reflection on the case together with the case owners

The SGI and VCAB partners in EVOKED worked as a team to co-develop and co-validate the climate services (story maps), thus somewhat blurring the line between knowledge providers, translators and users. Even the Arvika representative, while not a formal project partner, contributed greatly to the design and validation processes, even though they were initially seen as a knowledge user.

Because the goals and philosophy of the EVOKED project were closely related to an Interreg North Sea Region project where VCAB and Arvika were partners (CATCH), there was a great cross-fertilization between the projects and the methodologies developed within EVOKED about Living Labs, climate services and story maps were presented at CATCH-'water sensitive Cities: the answer to challenges of extreme weather events has the overall objective to demonstrate and accelerate the redesign of urban water management of midsize cities in the North Sea Region in order to become climate resilient cities that are sustainable, livable and profitable on the long term. Interaction between the projects took the form of both VCAB's and SGI's participation in a CATCH workshop in April 2019 where EVOKED was presented and the Information Design template used in EVOKED was modified and used as part of a workshop to start the process of designing climate adaptations strategies for mid-sized cities in the North Sea region (including Arvika). Cross-fertilization was further developed at a CATCH partner meeting in Arvika in August 2019 where SGI and VCAB presented EVOKED's Information Design template again , but included how visions could be incorporated into climate adaptation strategies and tools, based on the EVOKED Needs and Visions exercise in EVOKED WP1.

Throughout the process of co-developing the story maps, both VCAB and Arvika municipality were considered the story map owners and developed first prototypes after the first field trials. The SGI and VCAB partners also assisted, especially the GIS experts from SGI.

Story maps is a concept/method that is taking off rapidly in Sweden as a form for communication and addressing the usability gap in climate services. However, the concept of climate services is rarely used in climate adaptation in Swedish municipalities and it is sometimes difficult to express what we mean by the services. Yet despite some confusion around the terminology, after discussions and explanations about what climate services are and stakeholders involved in the field trials thought that story maps are a good way make knowledge more useful. This was because story maps were a practical way to package and visualize information and climate data. This is perhaps a start to a paradigm shift in how stakeholders understand and use climate data.

2.3 Flensburg, Germany

2.3.1 Case description

2.3.1.1 General information about case study location

The city of Flensburg is located in the north of Germany at the Baltic Sea coast (Figure 5) and has 96,204 inhabitants (Stadt Flensburg, 2019). The city is situated at Flensburg Fjord and low-lying parts experience regular flooding under strong north-easterly winds (Jensen & Müeller-Navarre, 2008). Current research shows that due to sea level rise (SLR) the intensity and frequency of coastal flooding will increase in the Baltic Sea until 2100 (Sterr, 2008; Wong et al., 2014; Weiße & Meinke, 2017; The BACC II Author Team 2015). Large-scale coastal protections measures such as dikes are partly implemented at the German Baltic coast (Hofstede, 2008; Landesbetrieb für Küstenschutz, Nationalpark und Meeresschutz Schleswig-Holstein, 2015) but not implemented in the city of Flensburg.

2.3.1.2 Climate adaptation needs and visions in Flensburg

A preliminary climate change screening was developed for Flensburg in 2017 and since 2018 the department of climate mitigation is responsible for climate adaptation in the city of Flensburg (Norddeutscher Rundfunk 2017). Climate adaptation is currently implemented by diverse departments of the city administration such as the civil engineering (e.g. the installation and maintenance of pumps) and the city planning (e.g. regional planning activities) departments. However, a division managing such activities consolidated under climate adaptation and an adaptation strategy does not yet exist (Norddeutscher Rundfunk 2017). .

2.3.1.3 Governance structure, challenges and potentials

Municipalities in the state of Schleswig-Holstein are responsible to protect public land and values, such as infrastructure, in terms of both flood protection and climate adaptation (Ministerium für Energiewende, Landwirtschaft, Umwelt, Natur und Digitalisierung 2017). Further, private homeowners are in charge of taking precautionary measures in order to prevent potential damage from extreme weather events to private values (Landesregierung Schleswig-Holstein 2019).

The risk from flooding due to storm surges and extreme precipitation events constitute significant challenges for the city of Flensburg, which need to be addressed now and in the future. The cooperation and exchange with other municipalities (such as the county Schleswig-Flensburg), which are nearby, and other Baltic Sea cities (such as Schleswig, Eckernförde, Kiel, and Lübeck), which are similarly vulnerable to climate change effects, can been seen as potentials.

2.3.1.4 Main stakeholders (Table 11)

Table 11: *Main stakeholders in the case of Flensburg*

Stakeholder	Public/ private/ civic	Relevant climate impacts	Relevance to climate impact adaptation / case
City of Flensburg (administration and local authorities)	public	Coastal flooding due to sea level rise	Understanding the risk of flooding and future impacts for planning; and initiation of the adaptation process.
Local politics	public	Coastal flooding due to sea level rise	
Regional authorities	public	Coastal flooding due to sea level rise	General interest in activities on local level. Provide information about regulations on regional level.
Local business	private	Coastal flooding due to sea level rise	Interested in receiving information on coastal flooding and future impacts and potential adaptation measures. Potentially affected by SLR.
NGOs	public	Coastal flooding due to sea level rise	
Citizens	civic	Coastal flooding due to sea level rise	
Media	public	Coastal flooding due to sea level rise	Reporting of project activities via local newspaper.

2.3.1.5 Climate impacts

Increase of coastal flooding due to sea-level-rise
Sea levels at the Baltic Sea coast have risen in recent years following the global mean (Norddeutsches Klimabüro, 2011) and a mean change of 14 cm has been observed along the Baltic coast (DWD, 2017). Due to SLR coastal flooding will increase in intensity in the Baltic Sea until 2100 (Sterr, 2008; Wong et al., 2014; Weiße & Meinke 2017; The BACC II Author Team 2015).

Increase of extreme precipitation events
Heavy rainfall events are likely to occur more often under future climate change in Flensburg (Madsen et al., 2014). Flensburg experiences already such events where basements, garages, and main traffic roads are flooded (Soerensen and Nolte, 2014; NDR 1 Welle Nord, 2019).

Drought during summer
Dry summers with long periods without precipitation such as the 2018 summer are likely to occur more often (Samaniego et al., 2018).

2.3.2 Local climate service(s) description and selection

2.3.2.1 Available climate services

The template "Current available climate services Flensburg" includes available climate services for the federal state Schleswig-Holstein in general and for Flensburg specifically. As flooding and precipitation are the most interesting climate change impacts to explore, those services which are relevant to those impacts are presented in Table 12. Some climate services include information on both aspects and are named in both categories.

Table 12: *Information provided by the original CS used within Flensburg*

Flooding from regional water system			
Name	**Keywords about focus (e.g. flood risk; consequences; etc.)**	**Information format**	**Internet link or reference**
ZeBis Schleswig-Holstein Flood Hazard Maps	Floods with a high probability (1-in-a-20-years; HW20)	Map	http://zebis.landsh.de/webauswertung/index.xhtml
	Floods with a medium probability (1-i-a-100-years; HW100)	Map	
	Floods with a low probability (1-in-a-200-years; HW200)	Map	
ZeBis Schleswig-Holstein Flood Risk Maps	Floods with a high probability (1-in-a-20-years; HW20)	Map	http://zebis.landsh.de/webauswertung/index.xhtml
	Floods with a medium probability (1-i-a-100-years; HW100)	Map	
	Floods with a low probability (1-in-a-200-years; HW200)	Map	
Norddeutsches Küsten- und Klimabüro – tool to visualize coastal protection needs	Coastal protection needs at the Baltic Sea Coast – today and until 2100	Map	https://kuestenschutzbedarf.de/ostsee.html
Climate Adaptation Roadmap of Schleswig-Holstein	-Regional projections (state level) of storm surges and sea-level rise and their impact such as coastal erosion -Affected fields of action such as coastal protection, water management and agriculture	Text	https://www.schleswig-holstein.de/DE/Fachinhalte/K/klimaschutz/Downloads/Fahrplan.pdf?__blob=publicationFile&v=1
Baltic Sea Coast and Climate Change Handbook	-Past and recent changes (sea-level rise, storm surges and erosion) -Predictions of future changes until 2100	Text	https://www.eskp.de/fileadmin/eskp/publikationen/klimawandel/HZG_Booklet_Ostsee_Ansicht.pdf
Climate Service Center Germany (GERICS) - Decision Support Tools as Instruments	Presentation and discussion of adaptation strategies and methods in the German Baltic Sea region	Text	https://www.climate-service-center.de/imperia/md/content/csc/csc_report_19.pdf

to facilitate Climate Change Adaptation			
(Extreme) precipitation			
Name	**Keywords about focus (e.g. water height; accessibility; etc.)**	**Information format**	**Internet link or reference**
Climate Service Center Germany (GERICS)	Climate change and changes in precipitation pattern in Schleswig-Holstein	Table, graphics, text	https://www.gerics.de/imperia/md/content/csc/cordex/bundesland_schleswig_holstein_version1.2.pdf
Baltic Sea Coast and Climate Change Handbook	-Past and recent changes (precipitation) -Predictions of future changes until 2100	Text	https://www.eskp.de/fileadmin/eskp/publikationen/klimawandel/HZG_Booklet_Ostsee_Ansicht.pdf
Climate Adaptation Roadmap of Schleswig-Holstein	Information on change of precipitation patterns and heavy rainfall	Text	https://www.schleswig-holstein.de/DE/Fachinhalte/K/klimaschutz/Downloads/Fahrplan.pdf?__blob=publicationFile&v=1
North German Climate Atlas (Norddeutscher Klimaatlas)	-Information on possible future changes of precipitation and heavy rainfall -Ranges: Possible ranges of minimum and maximum changes	Maps, text	https://www.norddeutscher-klimaatlas.de/klimaatlas/2071-2100/jahr/niederschlag/norddeutschland/mittlereanderung.html

2.3.2.2 Selection of climate service(s) to work with

In the case study of Flensburg, we focused on future flooding and sea-level rise. As no CS with this specific focus were in place, CAU identified together with the case study partner (city of Flensburg) the need for local CS to support adaptation initiatives. Based on the identification of needs, a flood impact analysis (including flood maps) was conducted. As the city is in its initial stage to adapt to SLR in the community, a story map was developed (http://meeresspiegelanstieg-in-flensburg.info/) to inform citizens about SLR in Flensburg and raise awareness among the general public (Figure 16). This story map CS will be further assessed and developed in the field trial.

Figure 18: Front page of the story map (http://meeresspiegelanstieg-in-fo/)

2.3.3 (Re)development process for a (new) climate service

2.3.3.1 Identification of information needs and the usability gap(s) present

No specific local climate services were in place. The case study partner asked for local information on future coastal flooding, also considering sea-level rise. The story map was produced following different steps:

Firstly, a first version of the SLR story map was designed. The first part of the story map contains general information on global SLR and defines specific terms such as risk or uncertainty. Another component visualizes vulnerable places to future flooding. The first version was sent for feedback to the case-study partner.

The stakeholder analysis applied in the overall project was used as a starting point to make users aware of the climate service via email. Additionally, a distribution list of former project activities was used, and the field trial was advertised in the local German and Danish newspapers, on twitter and on the Facebook account of the city of Flensburg. To identify potential usability gap(s) an online questionnaire was set up (see appendix II) directly connected to the story map asking open and closed questions. The response of the questionnaire was anonymous. Especially the open questions on further information needs and suggestions to improve the technical handling of the story map helped to identify further aspects to be included in an updated version of the climate service.

The first field trial phase ran from June to September 2019. In total, we received 46 returns of the online questionnaire and 36 responses were utilized for further analysis as we received suggestions for further information needs and the technical handling. The feedback of the end users was categorised and used to identify the following information needs: information on past SLR, visualization of SLR, inclusion of information on adaptation measures.

Table 13: *Build categories based on the users' feedback and extraction of comments of users (Vollstedt et al., under review).*

Category	**Comments of participants (extract)**
Past SLR	"How much has the sea-level risen the last 100 years […]?" "How has the sea-level changed in the Flensburg Fjord over the last 70 years? […]"
Visualisation of change of future water levels and SLR scenarios	"Simulation of the different water levels to better visualise the flooded areas." "Visualisation of sea-level rise and flooded areas for the coming decades […]." "Change of water line incorporating different sea-level rise scenarios." "Besides the provided information, also the graphical representation on a city map of flooded areas […]." "Projections should be visualised on a map." "The mean sea-level will rise up to 110 cm. The impacted area should be shown on a map and the flooded area of a one-year statistical flood should be visualised."
Adaptation measures	"Inclusion of in-depth information for the proposed adaptation measures, as not all measures are self-explanatory." "Sample images of the measures would be great." "Greater choice of measures, that can be implemented and are effective." "Name more alternatives for every location."

2.3.3.2 Creation of an improved information design

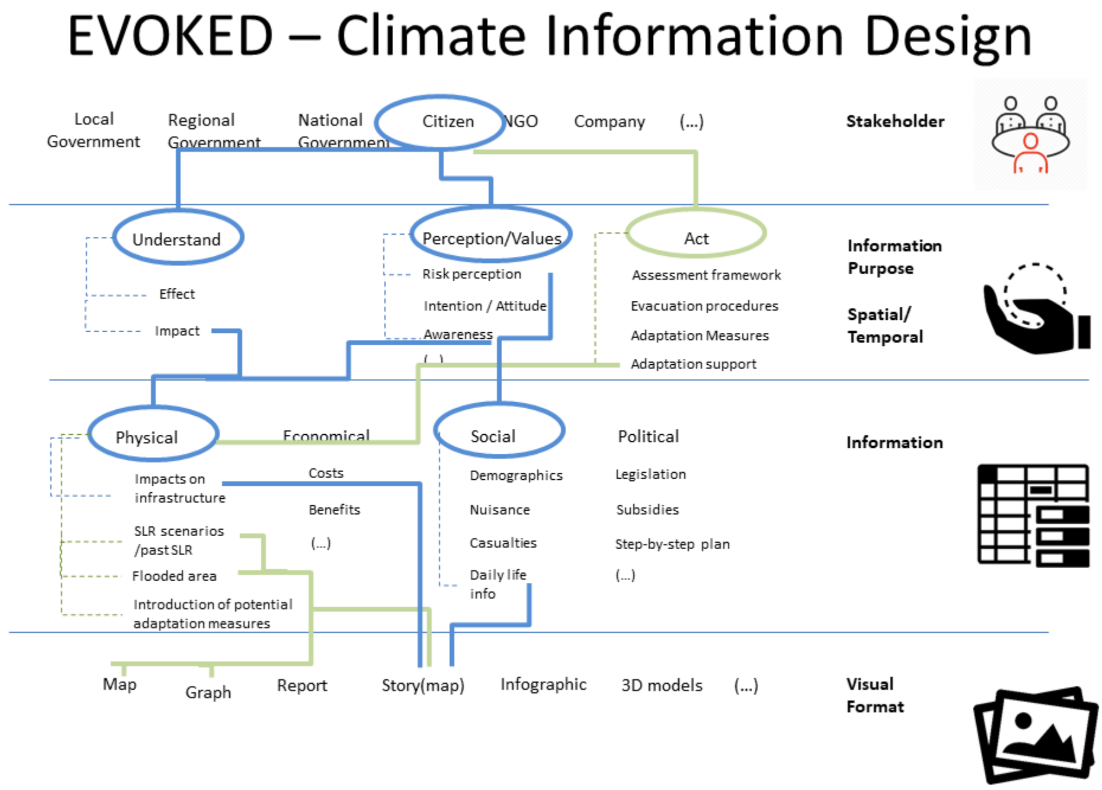

Figure 19: *The Climate Information Design of the climate service before and after the field trial. The blue colour indicates the characteristics of the first version of the climate service. After the field trial and based on the feedback of the stakeholders the information design changed or was rather supplemented by further components (green colour).*

To identify potential usability gap(s) an online questionnaire was set up (see appendix II), directly connected to the story map asking open and closed questions. The response of the questionnaire was anonymous. The open questions on further information needs and suggestions to improve the technical handling of the story map were particularly useful for identifying further aspects to be included in an updated version of the climate service story map CS (see figure 19).

The feedback of the end users was categorised and used to identify the following information needs: information on past SLR, visualization of SLR, inclusion of information on adaptation measures. Based on the feedback, further components were added to the story map:

- A graph to visualize past SLR.
- Flood maps showing different SLR scenarios until 2100.
- A series of adaptation measures with a short description to better inform or even support the adaptation process

In November 2019 the second Living Lab workshop took place in Flensburg. As not all workshop participants participated in the first field trial (online questionnaire) a poster showing the implemented changes of the story map was set up instead (appendix IV).

No further comments on information needs were received during this meeting.

Story map components before the field trial

Figures 20-27 show the story map components.

Figure 20: *Component including background information on SLR and definition of specific terms such as risk, uncertainty.*

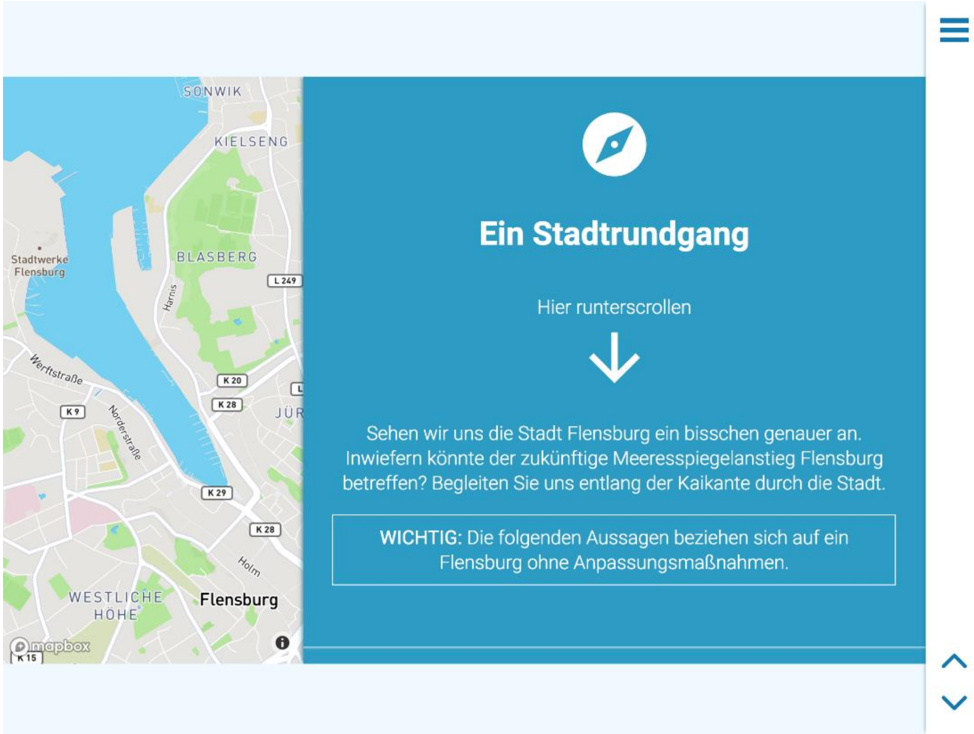

Figure 21: *City walk showing vulnerable places of the city.*

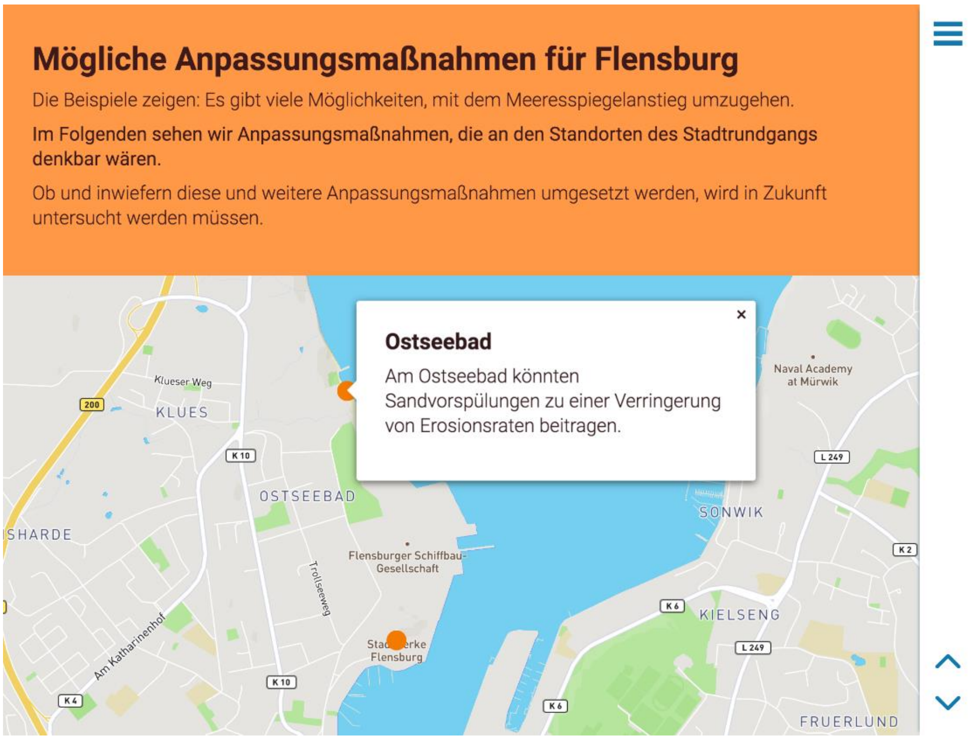

Figure 22: *Map giving ideas on potential adaptation measures at certain locations.*

Story map components added after the field trial based on the stakeholder feedback.

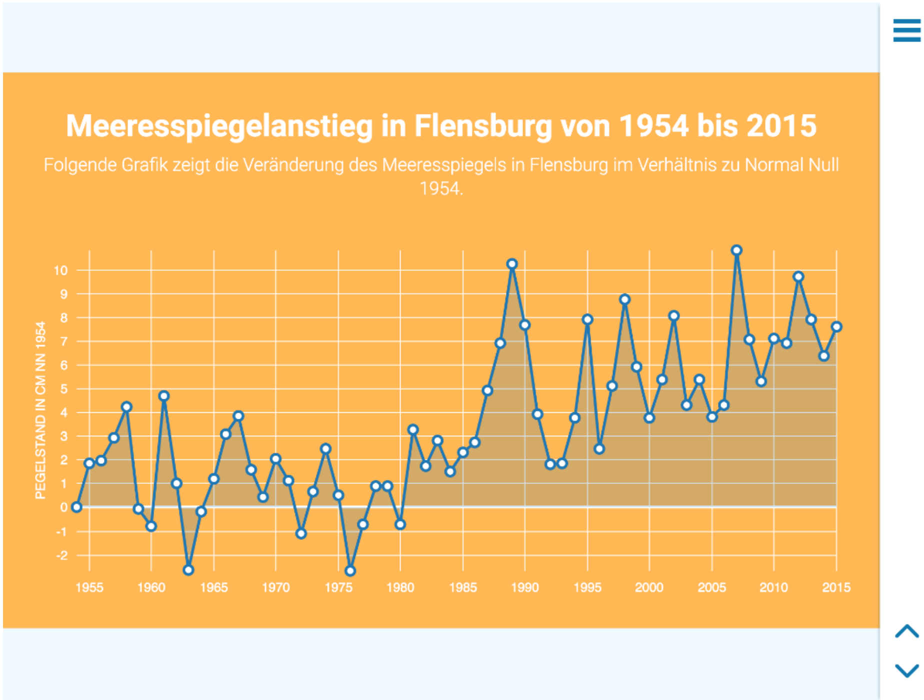

***Figure 23:** Interactive graph visualising past storm surge events from 1954 to 2015*

Figure 24: Picture gallery of past flood events in the city of Flensburg to better visualise the impacts of such floods.

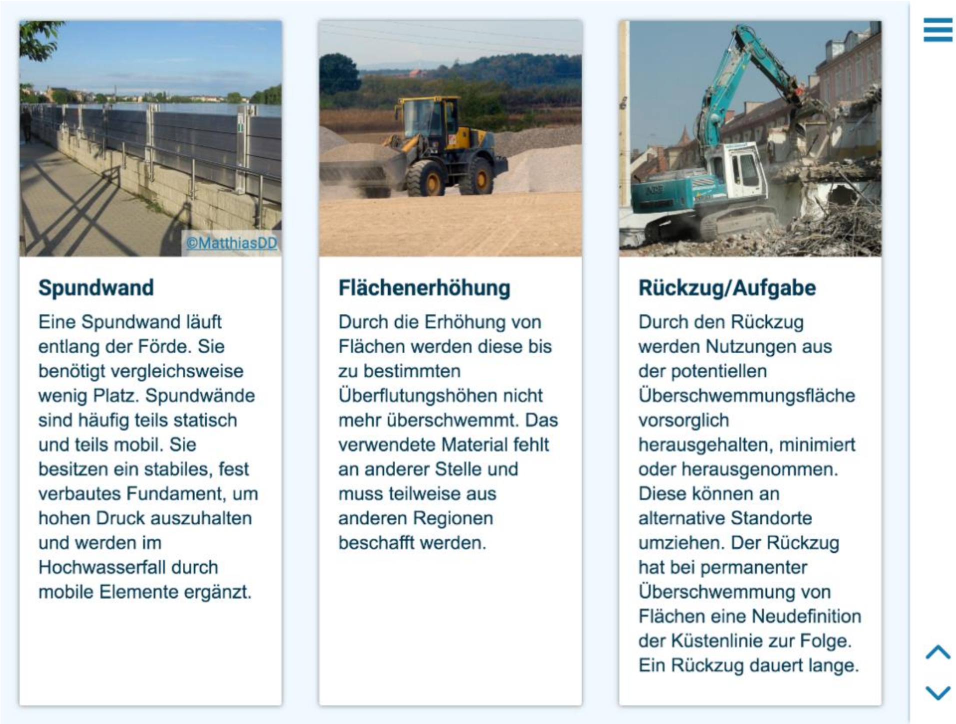

Figure 25: *Extract of adaptation measures introduced in the story map. Besides the picture also a short description is included*

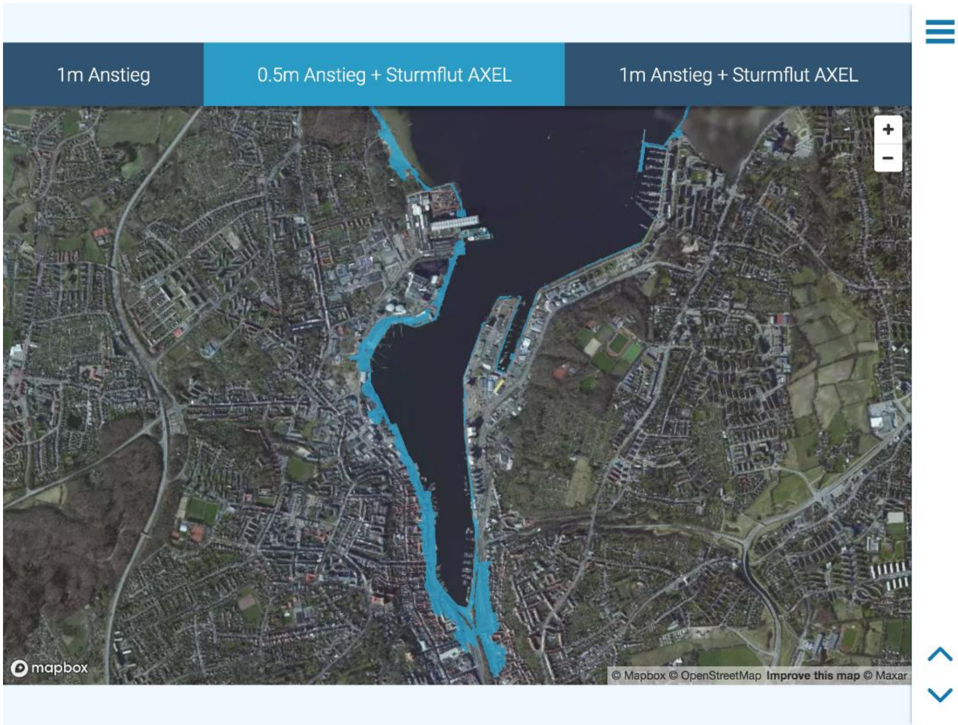

Figure 26: *Story map component showing the flood extent of different SLR scenarios*

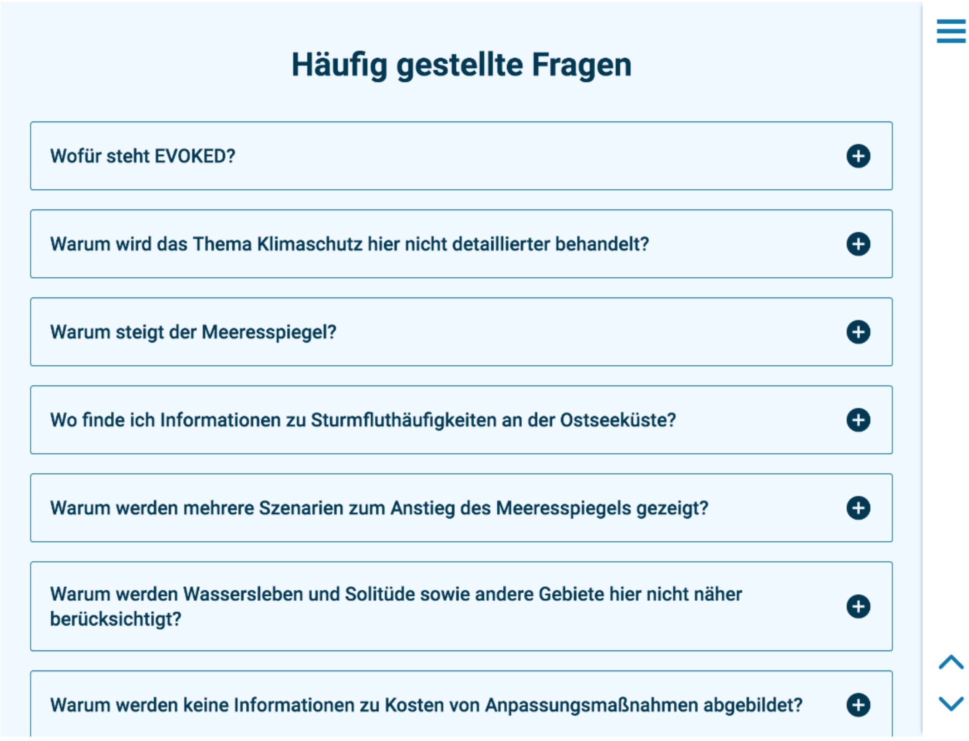

Figure 27: Implementation of a FAQ section to answer the needs which are not in the scope of the project.

2.3.4 2.3.4 Answering the hypotheses

Table 14: *Hypotheses answers for the case of Flensburg*

Hypothesis	**Answer for case**
1a) – Usability gap(s) is/are present in the original climate services that are used in the case study sites.	As the city of Flensburg is in its initial stage of the adaptation process, local climate services considering future coastal flooding and sea-level rise are not yet in place. After the need identification with the case study partner local climate services were needed. As one climate service we set up a story map to raise awareness among the public. In the field trial we identified specific information needs like information on past SLR, flood maps and adaptation measures. By implementing those information needs we intend to increase the usability of the story map CS.
1b) – This/these usability gap(s) is/are caused by a limited feedback loop from the end-users to the producers of the climate service.	The provision of feedback from the end-users helped CAU to further improve the story map CS. Hence, it can be stated that this feedback is necessary to increase the usability of the service.

2a) - Living labs have contributed towards the development of a feedback loop between the user and the developer	The EVOKED Living Lab that was used in Flensburg can be categorized as 'Living Labs supporting context research and co-creation' (Schuurman et al., 2013). This is so because innovation and development has been an important aspect during the field trials. Furthermore, the environment that the Living Labs established in Flensburg has contributed to the development of a feedback loop between the users and the developer through the co-design of a new story map CS for the end-users.
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.	For the case of Flensburg, the following can be said for the applicability of each of the organizational principles of an EVOKED Living Lab: • *Continuity* – The Living Lab was initially based on our key stakeholders but moved away from already existing CS as those CS did not consider sea-level rise. Thus, a new platform was developed. This move opened a feedback loop between the end users in Flensburg and the CAU that acted as the developer in this Living Lab. • *Openness* – There was a consistent feedback process with the case study partner. The feedback process of the story map including a wide range of stakeholders was mainly anonymously, but respondents had the possibility to provide open feedback. Also, a workshop was organised which offered further feedback options. Openness was important in establishing the feedback loop between the end user and the developer. • *Realism* – The aspect of realism is reflected by the fact that the story map tries to address the information needs towards supporting the adaptation process in Flensburg. In this way it tries to connect to actuality and the context of Flensburg. Therefore, it can be concluded that these aspects connect more towards reducing potential usability gaps than to establishing a feedback loop. • *Influence* – This Living Lab principle can contribute less to establishing the feedback loop for the case of Flensburg. This is because the way the Living Lab was set up was more that the users were used to provide feedback but did not have a direct influence over how the feedback was used as CAU implemented the feedback based on relevance and technical feasibility. • *Value* – The workshop was held in Flensburg itself which reduced travel time, the CS itself was made in the form of an online story map and the value for the end users was clarified. Therefore, it can be stated that this helps to establish feedback loops as it provides incentives for end-users to participate in the co-design process which in turn helps to establish the feedback loop.

	• *Sustainability* – The concept of sustainability does not contribute to establishing feedback loops as it focusses on the sustainability of the development process itself.
3a) - Information designs help to convey information to the end-user	The case of Flensburg shows that the information design can help visualize the structure of a CS. This in turn makes it possible to more accurately make useful changes to the story map CS. Thus, it can be concluded that the information designs can help connect the produced information to the end-user.
3b) - Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.	In the case of Flensburg, the information designs were used by CAU to visualize and structure the feedback received on the story map CS that was developed. However, it can therefore be stated this does contribute towards establishing a feedback loop as CAU as developer had information helping them to improve their CS. Therefore, this hypothesis is, in the case of Flensburg, accepted.

2.4 Fluvius region, The Netherlands

2.4.1 Case description

2.4.1.1 General information about case study location

The region is located within the north of the Netherlands (Figure 5). The region has a higher elevation in the northeast (Hoogeveen; Midden Drenthe) and slopes (Westerveld; De Wolden) down to the lower southwestern part (Steenwijkerland; Meppel) (Klimaateffectatlas, n.d.). This is due to the location of the 'Hondsrug' heightening running through the middle of Drenthe. There are no natural water courses running through the region, but rather canalized water courses (such as the Hoogeveensche Vaart and the Oude Vaart). Only the river Vecht can be considered as such, but it runs at the border of the southern part of the region, thus not affecting the region as a whole.

2.4.1.2 Climate adaptation needs and visions in the Fluvius region

For the Fluvius work region, the visions are placed within the national framework 'Deltaprogramma' (I&M, 2017) that gives an overview of via what paths and around what times we aim to create a climate resilient society. The main aim is to be climate resilient around 2050, with this aim being part of everyday policy making and actions taken by stakeholders around 2020. This is the main long-term goal in this region.

The more short-term visions are grounded in the regional-based policy plans. These differ from both the Provincial plans in the 'Omgevingsvisie' and the municipal plans. The short-term visions further differ between stakeholders as not every partner in the work region is going at the same speed or has the same ambitions. A municipality such as Hoogeveen is much more ambitious than a municipality such as Meppel, even while both are in the same region. However, at the same time it can be stated that every municipality will have roughly the same type of challenges that need to be tackled to create a sustainable, resilient society: heat stress and extreme precipitation in the urban areas, and drought in the more rural areas. Additionally, places such as Meppel also have a fluvial challenge due to their location.

However, in general it can be stated that all noses are pointed towards the same goal: creating a society that can withstand and reduce the consequences of climate change for their citizens by 2050. Added to this are also various changes such as the shift towards renewable energy sources.

2.4.1.3 Governance structure, challenges and potentials

In the Fluvius-region, the municipalities, provinces, and water board are responsible for climate adaptation from the policy and analytical side, and for implementing measures in the public space. These operate on either the municipal level or cover multiple regions. Furthermore, they are also influenced at the national level by the Ministry of Infrastructure and Water Management, and the group responsible for the Delta Programme (Especially the Spatial Adaptation part) who dictate the direction in which climate adaptation has to develop, as well as the rate at which it has to be implemented. For water safety, the region also gets help from Rijkswaterstaat for maintanance and improving the main river barriers that protect affected areas from fluvial flooding from the main water system (most notebly the Ijssel river).

The municipalities and the water board are collaborating in the partnership ‘Fluvius’. This was originally a collaboration on the basis of water chain management in the areas but now has been given the assignment to include climate adaptation in this as well. Thus, the challenge is now to incorperate climate adaptation, and the integral character of it into a collaboration that previouluy used to focus only on water management issues. However, the efforts of each municipality are bound to the political bounderies of each municipality. Therefore, within the region the efforts undertaken towards becoming climate resilient by each municipality may differ.

Finally, in the region also civic stakeholders are involved dealing with the interests of the agricultural industry (LTO) as well as nature conservation (NMF). These civic groups also play a role in the decision-making process by advancing their sectoral interests. Additional other groups of importance are for example housing corporations.

2.4.1.4 Main stakeholders (Table 15)

Table 15: *Main stakeholders in the case of the Fluvius region*

Stakeholder	Public/ private/ civic	Relevant climate impacts	Relevance to climate impact adaptation
Municipalities in the Fluvius region	Public	Extreme precipitation; drought; heat stress	Dutch municipalities carry legal responsibility for the spatial planning of public areas. Hence, they have a large impact in the climate adaptiveness of urban areas through the design of these areas (e.g. have enough green spaces and water retention areas). Additionally, they also carry responsibility for proper functioning of the sewer system that affects the impact of precipitation in urban areas.
Water board Drents Overijsselse Delta	Public	Extreme precipitation; drought	Dutch water boards carry a legal responsibility for the management of (urban) surface water bodies. This entails both quality and quantity aspects. Therefore, there needs to be enough water retention capacity for both rainy times and drought. Furthermore, they are responsible for the management of regional flood defenses that may be affected by drought during the summer and need to be strong enough to withstand higher water levels in the winter/spring due to an increase in precipitation.
Province of Drenthe / Overijssel	Public	Extreme precipitation; drought	The Dutch provinces have responsibility for the strategic spatial development of the province. In addition, they are responsible for the management of the provincial water (both quality and quantity). As spatial planning decisions affect the resilience of areas against climate change impacts, this partner is important to see what the strategic needs are for climate services.
LTO (agriculture interest organization)	Civic	Extreme precipitation; drought	The Fluvius-region is also home to agriculture that may be affected by climate change (e.g. overabundance or shortage of rain may lead to reduced crop yields). The LTO is an agriculture interest organization representing the farmers in this aspect. This links to the use of water during drought or drainage of land to reduce water in the ground. Thus, they may have different needs than for example nature organizations.
Housing corporation(s)	Can be public	Extreme precipitation;	It is well known that private properties in urban areas also affect the impact of climate change

	or private	drought; heat stress	(e.g. increased percentage of impermeable surfaces). Within urban areas, a lot of houses are property of housing corporations who rent out these houses. As such, they are primarily responsible for the development of climate adaptive measures on these properties. Therefore, it is good to understand their needs so that they can act accordingly.
NMF (nature interest organization)	Civic	Drought	In rural areas in the Netherlands, besides agriculture nature is also an important function that has its own needs and experiences regarding climate change. As the drought from 2018 showed that nature is especially heavily affected by this climate impact, the needs of this stakeholder are important to consider. Especially, as these may collide with agricultural needs.
WMD (drinking water company)	Public	Drought	The WMD provides drinking water to the Fluvius-region. During drought water shortages can potentially occur that may threaten the delivery of water. Therefore, it is good to understand how the WMD stands towards climate change as they provide a vital function to society.
Safety region Drenthe / IJsseland	Public	Extreme precipitation	The Safety Region Drenthe is a collaboration between different governmental actors and emergency services that focusses on disaster management (e.g. public order or flooding). As regional or pluvial flooding may occur which in turn can affect emergency services, evacuation plans, etc., it is good to understand what information the Safety Region needs in order to prepare adequately.
GGD (health organization)	Public	Heat stress	The GGD is responsible for the public health as well as communication of health risks to the Dutch people. As heat waves negatively affect the health of especially vulnerable groups (elderly, children, sick people) the GGD may need climate information to effectively communicate risks to the right people. Accordingly, this stakeholder is therefore included as well.

2.4.1.5 Climate impacts

The first relevant climate change impact is extreme precipitation. This can lead to both pluvial flooding in mostly urban areas, as well as fluvial flooding from the regional water system. Drought can also occur in the area. Finally, heat waves can cause problems, especially in the urban areas as these can lead to heat stress (PBL, 2013)

Because the upcoming 'stresstest'-analysis will be used as field trial for the EVOKED project by Deltares, the case study will focus on all four topics:

- Pluvial flooding can lead to water in the streets which can disrupt traffic. Additionally, water can also enter buildings and basements which may lead to damage of property. This has happened a few times in Hoogeveen (e.g. Hoogeveensche Krant, 2017).
- Flooding from the regional water system is more severe than pluvial flooding as it involves river floods. This can happen because water overtops a dike, or that the dike breaches. This can lead to societal disruption in the case study area or even casualties. In 1998 this almost happened in Meppel (RTV Drenthe, 2008).
- As the Fluvius case region also has a rural character, climate changes has an impact on agricultural yields. Surface water quality can also be affectedl. Furthermore, this can lead to a decrease of drinking water. Finally, a decrease in groundwater levels during droughts can also lead to soil subsidence (Didde, 2018).
- Heat waves can lead to higher temperatures in urban areas (urban heat island effect). This can lead to overheating of humans which in turn can lead to negative health impacts. Therefore, heat waves can lead to casualties amongst vulnerable societal groups (e.g. elderly, children, sick people) (National Weather Service, n.d.).

2.4.2 Local climate service(s) description and selection

2.4.2.1 Available climate services

In the Fluvius region there are two available climate services of interest to the EVOKED project: The Nationale Klimaateffectatlas and the WDOD Klimaatatlas. Within these CS, extreme precipitation, drought, heat stress and flooding from the regional water system are addressed (Table 16). Both CS are web based and present information via interactive maps. A screenshot for both CS are included within this document (Figures 28 and 29).

Table 16: *Information provided by the original CS used within the Fluvius region*

Flooding from regional water system			
Name	**Keywords about focus (e.g. flood risk; consequences; etc.)**	**Information format**	**Internet link or reference**
Nationale Klimaateffectatlas	Flood height when primary flood defenses are breached	Map	www.klimaateffectatlas.nl/nl
	Flood height when regional flood defenses are breached	Map	
	Flood height for areas outside of diked areas	Map	
	Flood risk of areas in 2050 (for experiencing flood heights of >0; >20; >50; >200cm)	Map	
	Dry areas in case of flooding	Map	
(Extreme) precipitation			
Name	**Keywords about focus (e.g. water height; accessibility; etc.)**	**Information format**	**Internet link or reference**
WDOD Klimaateffectatlas	Water height during precipitation event;	Map	https://wdodelta.klimaateffectatlas.net
	Accessibility of roads for normal traffic / emergency services	Map	
	Waterflow directions	Map	
Nationale Klimaateffectatlas	Water height during precipitation event (T=100; T=1000)	Map	www.klimaateffectatlas.nl/nl
	Highest average groundwater level	Map	
	Number of days with an total precipitation level of >15;25 mm.	Map	
	Yearly precipitation amount	Map	
	Percentage of hardened surface in a neighborhood	Map	

	Percentage of surface water in a neighborhood	Map	
	Risk of soil compaction	Map	
Drought			
Name	**Keywords about focus (e.g. water shortage; affected sector etc.)**	**Information format**	**Internet link or reference**
Nationale Klimaateffectatlas	Surface water shortage for a normal / extreme dry year	Map	www.klimaateffectatlas.nl/nl
	Average lowest groundwater level	Map	
	Risk of experiencing drought stress	Map	
	Potential precipitation shortage (T=10; Average)	Map	
	Normal amount of precipitation during summer in mm	Map	
	Soil subsidence 2016-2050	Map	
	Wildfire risk	Map	
Heat stress			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
WDOD klimaateffectatlas	Temperature in relation to surrounding areas	Map	https://wdodelta.klimaateffectatlas.net
Nationale Klimaateffectatlas	Heat stress due to warm nights	Map	www.klimaateffectatlas.nl/nl
	Amount of warm/summer/tropical days a year (>20 °C;>25 °C;>30 °C)	Map	
	Amount of subsequent summer days streak (>25 °C)		
	Urban heat island effect	Map	
	Location of movable bridges	Map	
	Percentage of hardened surface in a neighborhood	Map	
	Percentage of green space in a neighborhood	Map	
	Percentage of elderly people (+65 years) in a neighborhood	Map	

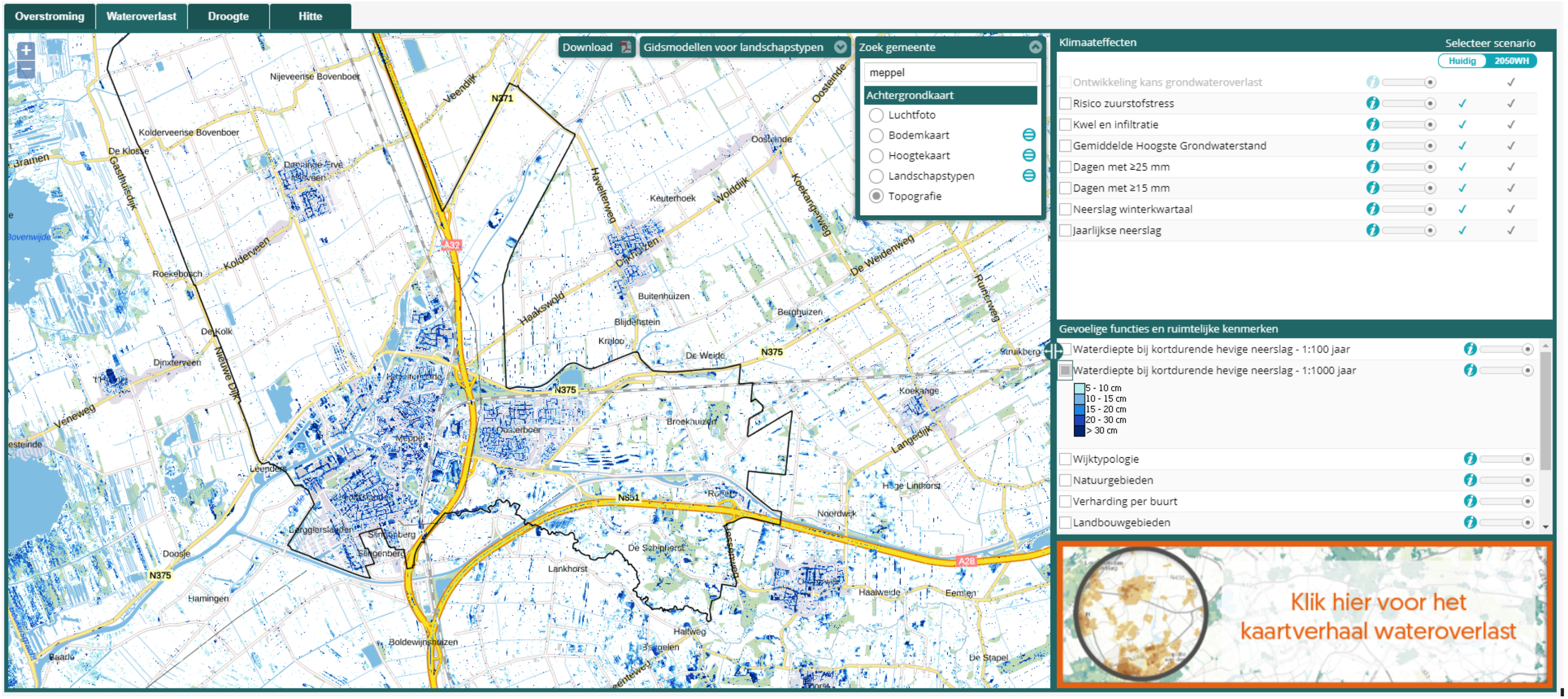

Figure 28: A screenshot of the Klimaateffectatlas (showing water nuisance)

Figure 29: A screenshot of the WDOD-Klimaatatlas (this image is showing the level of water nuisance)

2.4.2.2 Selection of climate service(s) to work with

In the Fluvius case, Deltares has initiated the the Field trial based on the upcoming ‘stresstest’. This will be a continuation of the ‘Nationale Klimaateffectatlas’ and the localized version of this: the ‘WDOD Klimaateffectatlas’. Another reason to focus this climate service is that it will be used in the first place by governmental stakeholders to identify vulnerable areas, and secondly, it will also be used in dialogues with other stakeholders. As such, the climate service has quite a lot of end-users. Therefore, it serves as a good basis for experimenting with ways that may close or reduce the usability-gap between the climate service and its users (Lemos et al., 2012; Weaver et al., 2013). Especially as the ‘stresstest’ is seen as an important upcoming climate service in the Dutch context where a lot of expectations are presented in national governmental policy documents (e.g. I&M, 2017).

Within the Dutch case study, the assumption is made that the new stresstest will be a continuation of the WDOD stresstest in terms of the information that is offered. Therefore, when comparing the information needs of stakeholders (next paragraph) with the climate service, these needs are compared to the information offered in the WDOD stresstest. By doing this, in the development of the new version, additional information could be added that is still missing but seen as relevant.

2.4.3 (Re)development process for a (new) climate service

2.4.3.1 Identification of information needs and the usability gap(s) present

Firstly, for the field trials the information needs for both the governmental stakeholders (municipalities, water board, provinces, and safety region) as well as other relevant regional stakeholders (LTO, NMF, GGD, drinking water company WMD and housing corporations (represented by Woonconcept)) were gathered. For the municipalities, water board, and provinces this was done through a workshop whereas the other regional stakeholders were approached using interviews in which they were asked for their information needs regarding climate change adaptation.

Based on these data the information needs for the most relevant stakeholders were identified as:

- For governmental stakeholders, more information was needed on whether a weather impact at a location had consequences or not (e.g. potential damage, vulnerable houses, etc.).
- In the updated CS version, the climate impact in the rural areas needed to be added as well (e.g. impact on agricultural activities or nature), as now only the impact in urban areas was modelled.
- The need to include potential measures for each stakeholder, who carries responsibility and the costs associated were mentioned as well.
- Another interesting need of information to be mentioned was the unknowns as it allows for discussion about what it means and how potential problems should be tackled.

Other regional stakeholders also had additional information needs that could not be answered with the original CS:

- The GGD required more detailed heat maps on the feel and air temperature in urban areas.
- the LTO would like to know what the impact of extreme weather is on a local level as general impacts are often well known.
- the NMF would like to know what the impact of drought is on the flora and fauna in the region, with a special focus on the 2018 drought. This also since the damage done to nature is often not directly visible (e.g. loss of rare plants is often only seen in the upcoming years).
- Finally, also other stakeholders had more information needs. Hence, it can be concluded that for the region the information needs are diverse, which makes it difficult to include everything into one CS. Moreover, modelling and gathering of additional data will be expensive.

Additionally, also several usability gaps were uncovered:

- What was missing according to governmental stakeholders was information about the effect of weather impacts. This will allow these stakeholders to determine where to act. As such, the information in the original CS was not appropriate for starting the risk dialogue that will come after the performed stress test.
- Not all presented information was correct. According to stakeholders there were inconsistencies in flooding maps which made them inaccurate. Therefore, there was also a need to include other information and experiences to allow for judgement based on the climate impact portrayed by the maps.
- The LTO mentioned the need for more localized and detailed data. The bigger picture is clear as opposed to the local climate change impact on agricultural lands. Thus, the information presented in the original CS was not appropriate for this organization.
- Finally, also the information presented in the CS is focused on informing the user (where can weather impacts happen?) whereas some users are also look for potential measures. Here, the information is not appropriate for the phase of the adaptation cycle they are currently in.

2.4.3.2 Creation of an improved information design

Regarding the development of an improved information design, the Fluvius region work group hired the consultancy firm ‘Nelen & Schuurmans’ to develop a story map as well as a combination of updated and new maps. This makes the new CS a two-fold product:

- End-users may use online maps showing the effect of extreme weather (extreme precipitation, drought, heat stress and flooding from the regional water system) in the region.

- Users can read through a story supported with maps on what the impact of extreme weather means for different activities and sectors (agriculture, health care, nature, etc.).

Additionally, the earlier collected information needs were also shared with the firm to help them better understand what information is required by the end-users. A first prototype of the story map was analyzed by Deltares through the use of the Climate Information Design Framework (Raaphorst et al., 2020) and then compared with the earlier collected information needs. This allowed the Fluvius region work group to give detailed feedback to Nelen & Schuurmans on aspects of the story map that still needed improvement.

During the development, Nelen & Schuurmans also organized a workshop session themselves for civil servants to work with printed maps to see whether the information presented was sufficient and what could still be added. This activity was done separately from the EVOKED project and the work Deltares had done. However, it can still be considered a feedback loop in the development process.

2.4.4 Answering the hypotheses

Table 17: *Hypotheses answers for the case of the Fluvius region*

Hypothesis	Answer for case
1a) – Usability gap(s) is/are present in the original climate services that are used in the case study sites.	In the climate services used within the Fluvius-region (WDOD stresstest, Nationale Klimaateffectatlas) several usability gaps were identified from an interactive session with relevant governmental stakeholders, and from interviews with societal actors. With this empirical evidence it can be stated that for the Fluvius region, the original CS has usability gaps.
1b) – This/these usability gap(s) is/are caused by a limited feedback loop from the end-users to the producers of the climate service.	This is true for the case of the Fluvius region. For in the Netherlands, the task to perform a stresstest is relatively new, which presents a problem for local governmental organizations. This is because they don't have the skills themselves and has to rely on consultancy firms to make the maps. However, one aspect that does need to be taken into consideration is that governmental stakeholders often have a limited budget and therefore may have to limit the information they can 'buy' for a CS with a consultancy firm charging extra for any additional information next to the standard product they deliver.
2a) - Living labs have contributed towards the development of a feedback loop between the user and the developer	The Living Lab environment for the Fluvius region can be categorized as 'Living Labs for collaboration and knowledge support activities' following the distinction made by Schuurman et al. (2013). This is because the end-result has been an end-product of co-designing between the Fluvius

	region work group, Deltares, and other regional stakeholders. Additionally, it can be stated that for the Fluvius region, the Living Lab approach helped establishing a feedback loop between the Fluvius regional work group and the consultancy firm 'Nelen & Schuurmans'.
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.	For the case of the Fluvius Region the following can be said for the applicability of each of the organizational principles of an EVOKED Living Lab: • *Continuity* – The continuity is present in the development process by using the same consultancy as for the original CS, so that the new CS can be considered an update. The stakeholders (minus Deltares) already knew each other, which contributed to the establishment of a feedback loop between the developer and the end-users. • *Openness* – The principle of openness as part of the Living Lab environment also helped with the establishment of feedback loops between the end-users and the CS developer as it allowed for criticism on draft versions of the new CS. • *Realism* – For the development of the CS, identified user needs were utilized to make the information better fitting for the context of the Fluvius region and the relevant stakeholders. However, this aspect therefore more focusses on the usability gap. Therefore, it can be stated that this aspect is not useful for establishing a feedback loop between the end-user(s) and the developer. • *Influence* – The Living Lab environment connects the governmental stakeholders as well as other regional actors with one another. The feedbacks from all stakeholders was taken into consideration, allowing for the establishment of feedback loops. Thus, it can be stated that this aspect contributes to this goal. • *Value* - The aspect of value attends the usability and experiences that end-users achieve in engaging with the CS. As this was the case within the Fluvius-region it can therefore state that this helps to establish feedback loops as it provides incentives for end-users to participate in the co-design process which in turn helps to establish the feedback loop. • *Sustainability* – The concept of sustainability does not contribute to establishing feedback loops as it focusses on the sustainability of the development process itself.
3a) - Information designs help to convey information to the end-user	For the Fluvius-region it can be stated that the use of information designs helped the stakeholders to better understand the development process for the updated version of the CS. Stakeholders explained that it helped them see the process and allowed them to better express potential changes that needed to be made by the

	developer. Thus, the climate information designs supported the co-production process between the Fluvius-stakeholders and the consultancy 'Nelen & Schuurmans' who developed the story maps. Therefore, it can be stated that the hypothesis for the case of the Fluvius-region rings true. However, from the experiences of the project team from Deltares, it can be stated that this was the result from a longer partnership between Deltares and the Fluvius-stakeholders as it took a while for the EVOKED-philosophy to become more embedded within the internal Fluvius processes.
3b) - Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.	As mentioned above, the climate information design proved to be valuable to communicate the usability gaps with the stakeholders. This in turn helped to establish the feedback-loops between the Fluvius-stakeholders and the hired consultancy firm for the development of the new story maps CS. Hence, for this hypothesis it can be stated that it can be accepted for the Fluvius region.

2.4.5 Reflection on the case together with the case owners

Past

In the talk between the regional stakeholder from the Water Board Drents Overijsselse Delta, two examples of the added value of the information design framework were mentioned. These are:

- During the development process for the new version of the climate the design framework helped to answers question such as: Which information needs to stakeholders have and how are these needs fulfilled with the information provided by the climate atlas? In doing so, it gives a direction to the process about the information that needs to be included in the climate atlas. This also provided added value to develop the atlas in a more structured way. Think for example about the type of information provided and the message you want to get across with the climate service.
- During the workshop with local municipality politicians the framework was also a usable discussion tool. During the workshop it helped to guide the discussion about which risks do we see, recognize and which of these do we find (un)acceptable? In the discussion it was brought to the forefront which information is required by local politicians to base their decisions on. Based on these insights you can develop potential new climate services or adjust current ones.

Additionally, the project partner also reflects upon the process of combining both their own project and the EVOKED projects. According to him, the synchronization between the projects went well. Both parties were able other as we both started at a moment that we just started the projects. As such, we were more on the forefront.

Additionally, he also mentioned that collaboration with regional partners is important. What does it bring the Fluvius work region, and how do we present the results in such a way that it matches the Fluvius work approach and involved organizations?

Current

A point of interest is whether, for the Dutch cases, we can also make a version of the results presented in this document for the Dutch municipalities, water boards, provinces, etc. This way a further dissemination of the EVOKED philosophy can be achieved. Added to this, the respondent also mentions that is also important to gain insight in how the framework has been applied in other cases to provide a way on how to use it. By providing examples you make it easier for others to also use the framework as well. Especially if you lower the usability barrier so you can integrate it within a project.Linked to this are also questions such as: How can you create a climate atlas based on the framework? How can you provide the right information for a local politician? What can you learn from other cases?

Future

A potential way to continue the project is by making a connection to STOWA, a knowledge institute for water boards. This group is currently also working on developing climate services for water boards and could benefit from the EVOKED methods and philosophy in making these CS more usable and applicable.*

Additionally, the respondent also mentioned that Deltares could expand upon the framework in regard to local politicians. This could be a follow up from the earlier mentioned workshop in Darp.

Finally, he also addressed the question on how the knowledge developed during the EVOKED project stays accessible for users and interested stakeholders. This aspect is also addressed in paragraph 4.2.1.

2.5 Northeast Brabant, The Netherlands

2.5.1 Case description

2.5.1.1 General information about case study location

The region of Northeast Brabant located in the Dutch province of North Brabant is in the south of the Netherlands (Figure 5). It has both a rural and an urban character (and can thus also be compared with the Fluvius region, although the area itself and the urban centers are larger in Northeast Brabant). It is home to about 550.000 inhabitants, seventeen municipalities, two water boards and the province of North-Brabant. Along the north border of the area flows the river Meuse (figure 30).

Figure 27: *The Region of North-East Brabant Figure 30: The Region of North-East Brabant*

2.5.1.2 Climate adaptation needs and visions in Northeast Brabant

For the province of North Brabant, these visions are described in the integrated spatial plan (Provincie Brabant, 2018a) with the aim being climate proof by 2050. However, a proper definition of 'climate proof' is lacking. Climate proof is described as the effects of climate change being manageable or acceptable. The general ambitions are described in a bit more detail for three major scenery types in the province: the urban areas, the higher grounds, and the low-lying area along the main rivers. Urban areas will grow in a sustainable way, incorporating a renewable energy infrastructure and measures to tackle heat stress and urban flooding. On the higher grounds, the brook and river systems will be turned into a more natural state (using nature-based solutions) to increase the resilience of the landscape for flooding and drought. Along the main rivers, the land will be protected from flooding by strengthening the dikes and providing more room for the river in the floodplain.

Nowadays, adaptation measures are not yet fully integrated in urban planning, renovation, and construction. On the higher grounds, a large part of the water system is still optimized for drainage rather than water conservation and dampening peak discharge. The river area still heavily relies on engineering works, but spatial measures (room for the rivers) have already been implemented in some places. In the spatial plain, risks are addressed in a general way, stating that being climate proof means that risks are either manageable or acceptable. How to assess risk and deal with uncertainties are left open.

On the one hand, there are many small and short-term measures, while the long-term visions are fairly abstract. We are lacking a clear developing path to link these two. In 2018 the province drafted a first implementation programme for climate adaptation that describes the governance structure for cooperation and an overview of planned projects in the period 2018-2021 (Provincie Noord Brabant, 2018b).

The public does not perceive flooding from the main river system as a real risk because the protection works so well. Actual flooding from the main rivers has not happened for more than 5 decades. Flooding and drought along the smaller water systems are becoming more of a problem, as well as urban flooding after heavy rainfall. Awareness is limited to the places where flood or drought occurred in recent years. Heat stress is still a relatively new phenomenon in the cities. It is not much perceived as a problem yet. Some major events (e.g. festivals) have taken measures, but a structural approach is still lacking.

However, as the visions focus on better quality of living rather than solving climate problems, they do appeal to both the public and companies.

The description is still rather abstract, and nobody will object to a better world. However, in the next stage of the spatial plan focus will be on concrete measures. In this stage, conflicts of interest are likely to arise. General criticism on the current plan is the rather positive outlook on how to solve the climate change challenges (positivity bias).

Current practice is that planning of adaptation is relatively easy, but the step towards actual implementation is a big one. Being mainly economy driven, one of the key questions is when to invest (and by whom). To define a clear development path, e.g. using the adaptive pathway approach, information is needed about costs/benefits and timing of measures.

This is the current step in the planning the province is about to start, which will be the risk-dialogue internally, as well as with regional stakeholders.

2.5.1.3 Governance structure, challenges and potentials

In Northeast Brabant, the municipalities, province of North Brabant, and water boards are responsible for climate adaptation issues from the policy and analytical side, and also for implementing measures in the public space. These operate on either the municipal level or cover multiple regions. Furthermore, they are also influenced from the national level by the Ministry of Infrastructure and Water Management, and the group responsible for the Delta Programme (Especially the Spatial Adaptation part) who dictate the direction in which climate adaptation has to develop, as well as the rate at which it has to be implemented. When it comes to floodrisk management, the region also has help from Rijkswaterstaat for maintenance and improving the main river barriers that protect affected areas from fluvial flooding from the main water system (most notebly the Meuse river).

Finally, in the region also civic stakeholders are involved,dealing with the interests of the agricultural industry (ZLTO) as well as nature conservation (BMF). These civic groups also play a role in the decision-making process by advancing their sectoral interests. Additional other organisations of importance are for example (social) housing corporations.

2.5.1.4 Main stakeholders (Table 18)

Table 18: *The main stakeholders in the case of Northeast Brabant*

Stakeholder	Public/ private/ civic	Relevant climate impacts	Relevance to climate impact adaptation
Municipalities in region of Northeast Brabant	Public	Extreme precipitation; drought; heat stress	Dutch municipalities carry legal responsibility for the spatial planning of public areas. Therefore, they have a large impact in the climate adaptiveness of urban areas through the design of these areas (e.g. have enough green spaces and water retention areas). Additionally, they also carry responsibility for proper functioning of the sewer system that affects the impact of precipitation in urban areas.
Water boards	Public	Extreme precipitation; drought	Dutch water boards carry a legal responsibility for the management of (urban) surface water bodies. This entails both quality and quantity aspects. Thus, there needs to be enough water retention capacity for both rainy times and drought. Furthermore, they are responsible for the management of regional flood defenses that may be affected by drought during the summer and need to be strong enough to withstand higher water levels in the winter/spring due to an increase in precipitation.
Province of North Brabant	Public	Extreme precipitation; drought	The Dutch provinces have responsibility for the strategic spatial development of the province. In addition, they are responsible for the management of the provincial water (both quality and quantity). As spatial planning decisions affect the resilience of areas against climate change impacts, this partner is important to see what the strategic needs are for climate services.
ZLTO (agriculture interest organization)	Civic	Extreme precipitation; drought	The region of Northeast Brabant is also home to agriculture that may be affected by climate change (e.g. overabundance or shortage of rain may lead to reduced crop yields). The ZLTO is an agriculture interest organization

			representing the farmers in this aspect. This links to the use of water during drought or drainage of land to reduce water in the ground. Hence, they may have different needs than for example nature organizations.
Housing corporation(s)	Can be public or private	Extreme precipitation; drought; heat stress	It is well known that private properties in urban areas also affect the impact of climate change (e.g. increased percentage of impermeable surfaces). Within urban areas, a lot of houses are property of housing corporations who rent out these houses. As such, they are primarily responsible for the development of climate adaptive measures on these properties. Therefore, it is good to understand their needs so that they can act accordingly.
BMF (nature interest organization)	Civic	Drought	In rural areas in the Netherlands, besides agriculture, nature is also an important function that has its own needs and experiences regarding climate change. As the drought from 2018 showed that nature is especially heavily affected by this climate impact, the needs of this stakeholder are important to consider. Especially, as these may collide with agricultural needs.
Safety region Brabant Zuidoost	Public	Extreme precipitation	The Safety Region Brabant Zuidoost is a collaboration between different governmental actors and emergency services that focusses on disaster management (e.g. public order or flooding). As regional or pluvial flooding may occur which in turn can affect emergency services, evacuation plans, etc., it is good to understand what information the Safety Region needs in order to prepare adequately.
GGD (health organization)	Public	Heat stress	The GGD is responsible for the public health as well as communication of health risks to the Dutch people. As heat waves negatively affect the health of especially vulnerable groups (elderly, children, sick people) the GGD may need climate information to effectively communicate risks to the right people. Accordingly, this stakeholder is therefore included as well.

2.5.1.5 Climate impacts

The first relevant climate change impact is extreme precipitation. This can lead to both pluvial flooding in mostly urban areas, as well as fluvial flooding from the regional water system. Drought can also occur in the area. Finally, heat waves can cause problems, especially in the urban areas as these can lead to heat stress (PBL, 2013)

Because the upcoming 'stresstest'-analysis will be used as field trial for the EVOKED project by Deltares, the case study will focus on all four topics:

- Pluvial flooding can lead to water on the streets which can disrupt traffic. Additionally, water can also enter buildings and basements which may lead to damage of property. This has happened a few times in the past (Elshof & Van den Brink, 2016).
- Flooding from the regional water system is more severe than pluvial flooding as it involves river floods. This can happen because water overtops a dike, or that the dike breaches. This can lead to societal disruption in the case study area or even casualties (Elshof & Van den Brink, 2016).
- As the region also has a rural character, climate changes has an impact on agricultural yields. Surface water quality can also be affected. Furthermore, this can lead to a decrease of drinking water. Finally, a decrease in groundwater levels during droughts can also lead to soil subsidence (Elshof & Van den Brink, 2016).
- Heat waves can lead to higher temperatures in urban areas (urban heat island effect). This can lead to overheating of humans which in turn can lead to negative health impacts. Therefore, heat waves can lead to casualties amongst vulnerable societal groups (e.g. elderly, children, sick people) (Elshof & Van den Brink, 2016; National Weather Service, n.d.).

2.5.2 Local climate service(s) description and selection

2.5.2.1 Available climate services

In Northeast Brabant there are two available climate services of interest to the EVOKED project: The Nationale Klimaateffectatlas and the Klimaateffectatlas Noord-Brabant. Within these CS, extreme precipitation, drought, heat stress and flooding from the regional water system are addressed (Table 19). Both CS are web based and present information via interactive-maps (for the Nationale Klimaateffectatlas and the Klimaateffectatlas Noord-Brabant) and via stories, photos, graphs, etc. (Klimaateffectatlas Noord-Brabant). A screenshot for the Klimaateffectatlas Noord-Brabant is included (the Nationale Klimaateffectatlas was already shown in the Fluvius region case study description – see page 59, Figure 28).

Table 19: *Information provided by the original CS used within Northeast Brabant*

Flooding from regional water system			
Name	**Keywords about focus (e.g. flood risk; consequences; etc.)**	**Information format**	**Internet link or reference**
Nationale Klimaateffectatlas	Flood height when primary flood defenses are breached	Map	www.klimaateffectatlas.nl/nl
	Flood height when regional flood defenses are breached	Map	
	Flood height for areas outside of diked areas	Map	
	Flood risk of areas in 2050 (for experiencing flood heights of >0; >20; >50; >200cm)	Map	
	Dry areas in case of flooding	Map	
(Extreme) precipitation			
Name	**Keywords about focus (e.g. water height; accessibility; etc.)**	**Information format**	**Internet link or reference**
Klimaateffectatlas Noord-Brabant	Example of an extreme precipitation event on 28-07-2014	Map and internet link to a newspaper article	https://www.klimaatadaptatiebrabant.nl/klimaatopgaven
	Impact of climate change on frequency of extreme precipitation events	Infographic	
	Example of impact of a summer hail storm on 23-06-2016	Youtube-video and map	
	Amount of expected days with more than 25mm of precipitation per day now	Map	
	Amount of expected days with more than 25mm of precipitation per day in 2050	Map	
	Percentage of hardened surface in neighborhoods in urban areas	Map	
	Explanation of why hardened surface may lead to pluvial flooding	Text and internet link	

	Measures citizens can take to reduce pluvial flooding risk in urban areas	Text and helpful internet links	
Nationale Klimaateffectatlas	Water height during precipitation event (T=100; T=1000)	Map	www.klimaateffectatlas.nl/nl
	Highest average groundwater level	Map	
	Number of days with an total precipitation level of >15;25 mm.	Map	
	Yearly precipitation amount	Map	
	Percentage of hardened surface in a neighborhood	Map	
	Percentage of surface water in a neighborhood	Map	
	Risk of soil compaction	Map	
Drought			
Name	**Keywords about focus (e.g. water shortage; affected sector etc.)**	**Information format**	**Internet link or reference**
Klimaateffectatlas Noord-Brabant	Maximum potential precipitation deficit in mm now	Map	https://www.klimaatadaptatiebrabant.nl/klimaatopgaven
	Maximum potential precipitation deficit in mm in 2050	Map	
	Vulnerability of nature and agricultural areas for drought	Map	
	Potential shifts ground water level during a summer drought in 2050 in comparison with now	Map	
	Risk of forest fires	Map	
	Examples of forest fires in the province	Text and photo's	
	Potential for water retention areas	Map and text	
Nationale Klimaateffectatlas	Surface water shortage for a normal / extreme dry year	Map	www.klimaateffectatlas.nl/nl
	Average lowest groundwater level	Map	
	Risk of experiencing drought stress	Map	
	Potential precipitation shortage (T=10; Average)	Map	
	Normal amount of precipitation during summer in mm	Map	
	Soil subsidence 2016-2050	Map	
	Wildfire risk	Map	

Heat stress			
Name	**Keywords about focus (e.g. temperature; affected stakeholders; etc.)**	**Information format**	**Internet link or reference**
Klimaateffectatlas Noord-Brabant	Explanation of why heat stress is a problem in urban areas	Infographic	https://www.klimaatadaptatiebrabant.nl/klimaatopgaven
	Difference between air temperature and feel temperature	Text	
	The amount of days (>30°C) per year now	Map	
	The amount of days (>30°C) per year by 2050	Map	
	The amount of nights (>20°C) per year now	Map	
	The amount of nights (>20°C) per year by 2050	Map	
	Feel temperature in the province of North-Brabant during an extremely hot summer day	Map	
	Amount of lonely elderly (+75 years) per neighbourhood	Map	
	Explanation why lonely elderly people are vulnerable for heat stress	Text	
	Measures municipalities can take to reduce heat stress	Text & internet links to helpful sites	
	Percentage of green infrastructure per neighbourhood for urban areas	Map	
	Measures citizens can take to reduce heat stress	Text & internet links to helpful sites	
Nationale Klimaateffectatlas	Heat stress due to warm nights	Map	www.klimaateffectatlas.nl/nl
	Amount of warm/summer/tropical days a year (>20 °C;>25 °C;>30 °C)	Map	
	Amount of subsequent summer days streak (>25 °C)		
	Urban heat island effect	Map	
	Location of movable bridges	Map	
	Percentage of hardened surface in a neighborhood	Map	
	Percentage of green space in a neighborhood	Map	
	Percentage of elderly people (+65 years) in a neighborhood	Map	

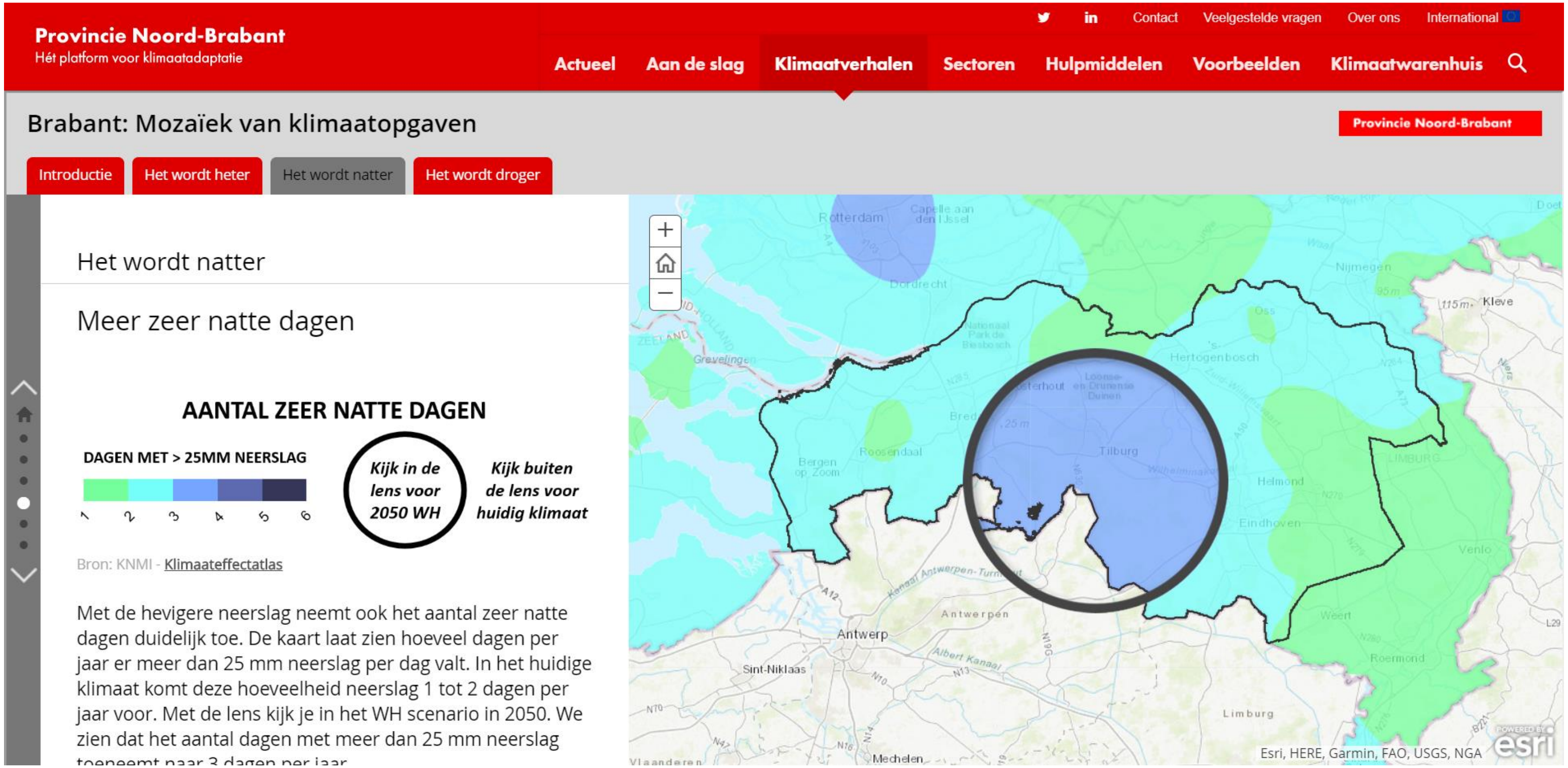

Figure 31: Screenshot of the Klimaateffectatlas Noord-Brabant (the information shown here are the number of days with more than 25mm of rain per day)

2.5.2.2 *Selection of climate service(s) to work with*

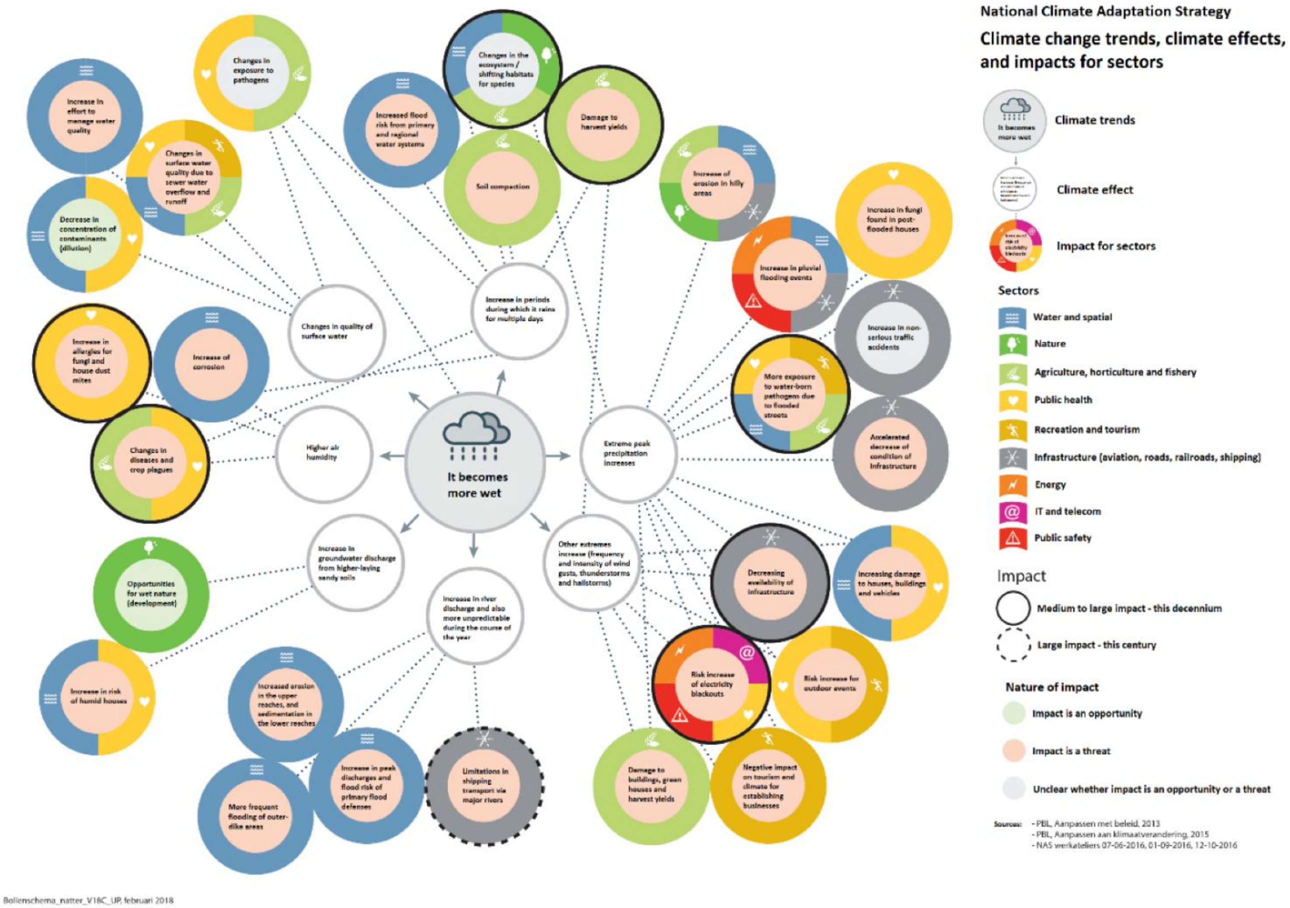

Figure 32: The National Adaptation Strategy infographic (original picture translated to English by Raaphorst et al. (2020, p.11).

For the case of Northeast Brabant, none of the original CS were selected to work with in the EVOKED project. Deltares rather took the stance to be more supportive of the internal processes that were already started by the governmental stakeholders. Hence, for the EVOKED project, Deltares was involved in the development process of making a regionalized version of the National Adaptation Strategy infographic by consultancy firms TAUW and Org-ID (Figure 32), showing the impact and effect of each extreme weather type, as well as on what time scale it plays and what level of government (local, regional, national) carries responsibility. Thus, it can be stated that the new CS will be an addition of the already existing CS rather than an update (as for the Fluvius region).

2.5.3 (Re)development process for a (new) climate service

2.5.3.1 Identification of information needs and the usability gap(s) present

Firstly, for the field trials the information needs for both the governmental stakeholders (municipalities, water board, provinces and safety region) as well as other relevant regional stakeholders (ZLTO, BMF, GGD, and housing corporations (represented by the Housing Cooperation Joost)) were gathered. For the municipalities, water board, and provinces this was done through a workshop whereas the other regional stakeholders were approached using interviews in which they were asked for their information needs and current practice regarding climate change adaptation.

Based on these data the information needs for the relevant governmental stakeholders were identified as:

- The effect of a weather impact is seen as relevant as it shows whether it will lead to problems and actions needed or whether the impact will have no relevant consequences at a location. This also relates to the urgency and damage of impacts, which was missing in the maps from the original CS.
- The effect that climate adaptation measures will have in practice. Potentially via a model in which you can 'sketch' measures to see what would work best at a certain location.
- What is being done by neighbourig municipalities? This allows for knowledge sharing rather than inventing the wheel twice.
- Not only problems, but also opportunities should be mapped. What are the benefits for stakeholders when certain measures are taken?

Other regional stakeholders also had additional information needs, such as:

- For the GGD, heat stress, infectious water or animal borne diseases (e.g. Lyme's disease and cyno-algae) and invading species (e.g. oak procession caterpillar) are important problems. Related information needs are for example the impact of heat stress on day-to-day life or where vulnerable groups are in the neighborhoods.
- For the BMF the impact of drought on nature is seen as an important information need. Furthermore, other subjects are what is already being done regarding climate mitigation by other stakeholders, how you could combine nature with other spatial uses, and how is ground- and surface water used and conserved by other water-using stakeholders.
- For the ZLTO, the most important information need is a translation of what the regional weather impacts mean to the agricultural business, so what does it mean on a local level?

Additionally, also several usability gaps were uncovered:

- What was missing according to governmental stakeholders was information about the effect of weather impacts. This will allow these stakeholders to determine where to act. As such, the information in the original CS was not appropriate for starting the risk dialogue that will come after the performed stress test.

- The ZLTO mentioned the need for more localized and detailed data. The bigger picture is clear as opposed to the local climate change impact on agricultural lands. Therefore, the information presented in the original CS was not appropriate for this organization.

2.5.3.2 Creation of an improved information design

For the creation of the new CS, Deltares was not in the lead. However, based on the information needs and the usability gaps identified, a new version of the regionalized version of the National Adaptation Strategy (NAS) infographic was designed together with the municipalities, waterboards, and province during an interactive session. During this session specific regional characteristics were added to the (generic) NAS infographic. Furthermore, the information on what spatial scale the climate challenges should be addressed (local or regional, or even national level) were specifically addressed. An example when it comes to an increasing heat/temperature is shown in Figure 33.

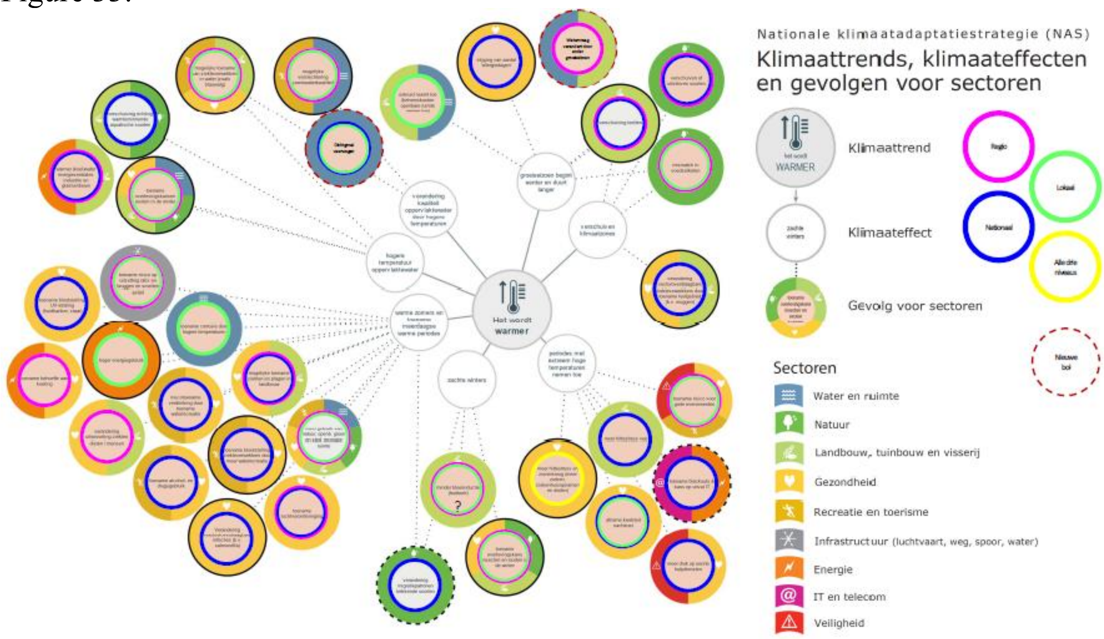

Figure 33: The National Adaptation Strategy infographic adjusted to te level of the regional scale.

This climate service was presented to the region by means of a report. A meeting to discuss the report and its contents further has been postponed due to COVID-19.

2.5.4 Answering the hypotheses

Table 20: *Hypotheses answers for the case of Northeast Brabant*

Hypothesis	**Answer for case**
1a) – Usability gap(s) is/are present in the original climate services that are used in the case study sites.	It can be stated that for the case of Northeast Brabant, there are usability gaps present in the original CS (klimaateffectatlas), as was also identified in the interviews that were conducted in the region.
1b) – This/these usability gap(s) is/are caused by a limited feedback loop from the end-users to the producers of the climate service.	The original climate service was mainly constructed by an interaction of specialists on water management from the municipalities, the waterboards, and the developer (working for the province). There was a limited feedback loop with the other users within the municipality.
2a) - Living labs have contributed towards the development of a feedback loop between the user and the developer	For the case of Northeast Brabant, the Living Lab can be categorized as a 'Living Labs for collaboration and knowledge support activities' (Schuurman et al. 2013). Additionally, it can be stated that for the case of Northeast Brabant, the Living Lab approach helped with establishing a feedback loop between the Province of North Brabant, other regional stakeholders, and the consultancy firms Org-ID and TAUW.
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.	For the case of Northeast Brabant, the following can be said for the applicability of each of the organizational principles of an EVOKED Living Lab: • *Continuity* – the network of users was already in place and is functioning today. The CS developers are hired consultants and are more distanced from the Living Lab, however they have had a long-standing relation and are maintaining the climate atlas for the province of North-Brabant as a whole. • *Openness* – by incorporating the different governmental organisations and the connected stakeholders, the openness will very much help to establish a feedback loop, albeit very often *via* the province. • *Realism* – in this case the EVOKED Living Lab merged with the stakeholder process that was taking place in the region. Realism was therefore a key prerogative in this case and helped to create a feedback loop. • *Influence* – the stakeholders were able to give input to the design of the climate service. Although the process was open for citizens and other societal actors, the practical influence was only by means of interviews. Only governmental organisations were attending the meetings. However, both helped to create a feedback loop. • *Value* - The aspect of value attends the usability and experiences that end-users achieve in engaging with the CS. Therefore, it can be stated that this aspect focuses

	more on reducing/solving potential usability gap(s) present in the CS than to establish a feedback loop between the end-user and the developer. This was also the case in the case of North East Brabant. • *Sustainability* – The concept of sustainability does not contribute to establishing feedback loops as it focusses on the sustainability of the development process itself.
3a) - Information designs help to convey information to the end-user	The information designs were mainly used to reflect on the information needs of the stakeholders and whether these needs were addressed in the first version of the climate service. It did help to connect the information needs to the developer and also to see how they could address the usability gaps that were present as well as to address the information needs of the end-users.
3b) - Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.	The information design did help to develop a feedback loop between the end-users and the CS developers. During an interactive session organized by Deltares, feedback was provided on the new CS and how it should be improved. Thus, it can be stated that the information design is a useful tool as it enables visualizing potential problems that can be used as arguments in discussions between the end-users and developers.

2.5.5 Reflection on the case together with the case owners

Past

The process in Northern-Brabant has been slow and difficult. We made a start during the first workshop in Uden (November 2018). During this workshop, we established a need to look at climate information and services from different perspectives and disciplines. However, following up on this was difficult due to the difficulties to connect the different departments to this process. This was also partly due to the focus on results that stemmed from the commission. As a result, there was little room for flexibility.

Therefore, an important lesson that was learned is that you need to expand your point of view beyond your own department or organization. As now, often involved people in the discussions have a background in water, which causes for a focus on just the important topics and approaches for this discipline. In practice this can lead to an over focus on the portrayal of information using tables and maps. However, other involved disciplines might have problems reading such information formats. An additional point of attention is also that the discussion within the region is focusing on the so-called 'impulsgelden', which is a national subsidy to help increase the adaptation-efforts that are done by lower governments. Thus, there is an increased focus on which projects are still waiting to be implemented and can we use to gain this money? As such, the use of information is less of a concern.

The respondent also hopes to focus on the integration with other disciplines, for there are the potential chances to add value to the overall process. For the water sector often has the stance: this is how we have always done it. This stance makes it new and innovating ideas difficult to land and be used within these organizations.

Another learning point is also that you must connect this project into an already running process. For you are dependent on the project leader and how he or she runs the project. This makes you extra vulnerable for being put on the back burner, especially when more people are also joining the project. Therefore, it is important whether the collaborating partner is the driving force behind the project or just a participant in the overall process.

Frank also mentions that he was trained as a geographer. Thus, he tends to think in maps. However, the consequence of this is that he can sometimes have a blind spot for what the end-users need regarding the information format. This raises the question: to what degree are we willing to divert from our own ways of doing things in favour of adopting other visual formats

Current

One advice given by the respondent is to make an information design tool that is hands on and easy to use for stakeholders. For example, at the moment Kevin Raaphorst, a post-doc researcher from the Radboud University Nijmegen, is making a decision-tree based upon the information design framework. It allows users to answer simple questions in order to provide them with a best fitting visual format for the information that they want to use. Additionally, it also provides them with knowledge about why certain visual choices are made (e.g. you don't use maps for the general public as not every member would be able to successfully read a map).

Additionally, like was also the case with Fluvius, the respondent mentions the question: what can we learn from the other cases? As these may have had to overcome different types of challenges. Both in regard to the complexity of the case as well as the number and type of sectors / partners that were involved in the case. Linked to this is also the wish to share insights within and between the Dutch EVOKED cases. A potential step to do so would be to let the respondent from the Fluvius and North-Brabant cases to join a meeting of the other organization.

Furthermore, another important point would also to make a connection between EVOKED and its knowledge and existing frameworks and work groups. For example, the mentioned link between STOWA and EVOKED could be one of these connections.

Finally, an application is also possible via 'Klimaatportaal'. The Province of North-Brabant can offer the tools and methods developed during the EVOKED project. Additionally, we also have a project going on with HAS (wet agriculture). The question is how we can communicate this in the right way? The EVOKED framework could help with this. The point is that we should do this a few times. Finally, an important question is also who should keep and distribute this knowledge? As mentioned already in the Fluvius reflection, this question is addressed to a degree within paragraph 4.2.1.

Future

For a future continuation of the project (in spirit), the respondent stated that perhaps using interns, the project can be kept going.

In the information design framework can help especially to structure information. Potentially on a meta-level between different climate services?

With EVOKED we have created a foundation for thinking about co-design and making usable climate services. However, the challenge to streamline information is occurring everywhere. This should also gain a place as well as to provide the exchange of knowledge and experiences. Think also about LIFE-IP – a collaboration between partners so you can stimulate learning about topics addressed in EVOKED as well.

2.6 A concise overview of hypothesis answers

Hypothesis	Larvik (p.21-22)	Arvika/Värmland (p.37-38)	Flensburg (p.51-52)	Fluvius-region (p.63-64)	Northeast-Brabant (p.78-79)
1a) - A usability gap is present in the original climate services that are used in the case study sites.	Yes	Yes	Yes	Yes	Yes
1b) - This usability gap is caused by a limited feedback loop from the end-users to the producers of the climate service.	Yes	Yes	Yes	Yes	Yes
2a) - Living labs have contributed towards the development of a feedback loop between the user and the developer	Yes	Yes	Yes	Yes	Yes
2b) - Each of the organizational principles of the Living Lab is useful to establish this feedback loop.	Continuity: Yes Openness: Yes Realism: No Influence: Yes Value: Yes Sustainability: No	Continuity: Yes Openness: Yes Realism: No Influence: Yes Value: Yes Sustainability: No	Continuity: No Openness: Yes Realism: No Influence: Yes Value: Yes Sustainability: No	Continuity: Yes Openness: Yes Realism: No Influence: Yes Value: Yes Sustainability: No	Continuity: Yes Openness: Yes Realism: No Influence: Yes Value: Yes Sustainability: No
3a) - Information designs help to convey information to the end-user	Yes	Yes	Yes	Yes	Yes
3b) - Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.	Yes	Yes	Yes	Yes	Yes

3 Discussion

Regarding the hypotheses answers we can now discuss the nuances that can be distinguished in the answers for the cases forming part of the EVOKED project. This will be done per hypothesis.

3.1 Discussion Hypothesis 1a

"A usability gap is present in the original climate services that are used in the case study sites."

In the concise overview of the hypothesis answers (paragraph 2.6), the answer for all cases has been that a usability gap was present in the case study sites. However, based on the research done by Raaphorst et al. (2020) we can also look at what type of usability gaps might be at play for each case. This in turn allows us to gain an insight in whether some usability gaps might be more prevalent than others, or that each case will contain their own unique arrangement of usability gap(s). This table will be based on the usability gaps that have been reported by each project partner within their respective case descriptions.

Table 21: *Overview of the different types of usability gaps suggested by Raaphorst et al. (2020) that are found in each of the EVOKED case studies.*

Visual communication component	Validity	Readability	Interactivity
Stakeholder	**Larvik** A more tailored version of the BREEAM Communities CS was preferred by stakeholders.	**Värmland/Arvika** In the original CS, users sometimes had difficulties with understanding and interpreting the CS.	
	Värmland/Arvika There is a lot of information in the original CS. However, not everything is useful, and this makes it hard for users to use.		
	Flensburg Local CS on future flooding and sea-level rise did not exist for the case of Flensburg.		
	Fluvius region Not all information presented in the original CS is useful for all regional users.		
	Northeast Brabant Not all information presented in the original CS is useful for all regional users.		
Purpose	**Larvik** The old CS was deemed not useful as a planning tool to select interventions and specify requirements prior to developing the area.	**Värmland/Arvika** With the original CS, users sometimes had difficulties with understanding and interpreting the CS as it was too long and extensive. This made them not very usable for its purpose.	**Flensburg** The original identified CS are not owned by CAU which made it not possible to make changes.
	Värmland/Arvika More information was needed on a variety of topics during the different phases of the planning cycle for a new CS.		
	Flensburg Local information on sea-level rise and potential future flooding was needed to raise awareness among inhabitants.		

	Fluvius region Information about potential adaptation measures is missing. This makes the CS inappropriate for users in further stages of the adaptation planning cycle. **Northeast Brabant** Information about adaptation measures is missing. This makes the CS inappropriate for users in further stages of the adaptation planning cycle.		
Information	**Larvik** More information was needed on the infiltration and green infrastructure as potential physical interventions. **Värmland/Arvika** More information was needed on a variety of topics for a variety of stakeholders. **Flensburg** Information on extreme water levels and potential future changes was needed for the city. Further information on adaptation measures that can be employed and are effective for the case study would be required. **Fluvius region** More information is needed on a variety of different subjects and on different scales. Not all information presented in the CS was correct.	**Värmland/Arvika** Information presented in the original climate services was sometimes unclear and difficult to read and understand. There was too much information in the original CS which overwhelmed users. **Fluvius region** According to stakeholders some information provided by the maps was difficult to read.	
Visual format	**Värmland/Arvika** The visual format of the original CS was changed to better present the information. **Flensburg** Improved visualization of potentially flooded areas under different sea-level rise scenarios for users to get a better idea of the potential impacts / consequences.	**Värmland/Arvika** The visual format of the original CS was not understandable, clear and useful enough for users. **Fluvius region** Stakeholders mentioned that the visual presentation of some climate impacts affected the readability of maps.	**Flensburg** Integration of different flood maps under different sea-level rise scenarios to better visualize the flooded area.

***Table 22:** Overview of the identified types of usability gaps for each EVOKED case study. Using colours, a visualization is made to show which usability gaps are more commonly found, and which are more case-specific*

Visual communication component	Validity	Readability	Interactivity
Stakeholder	Larvik Värmland/Arvika Flensburg Fluvius region Northeast Brabant	Värmland/Arvika	
Purpose	Larvik Värmland/Arvika Flensburg Fluvius region Northeast Brabant	Värmland/Arvika	
Information	Larvik Värmland/Arvika Flensburg Fluvius region Northeast Brabant	Värmland/Arvika Flensburg Fluvius region	
Visual format	Värmland/Arvika Flensburg	Värmland/Arvika Fluvius region	Flensburg

Color scheme for table 22	
No cases	
1 case	
2 cases	
3 cases	
4 cases	
All cases	

When we now look at Tables 21 and 22, we can see that while usability gaps are present in each case study area, we can also state that not all types of usability gaps are strongly present. Within the cases we can clearly see that the types that are most prevalent are the ones associated with the usefulness of the information for stakeholders (stakeholder/validity); that the information is not useful for the stage that the adaptation cycle stakeholders are in (often related to a lack of information about what can be done by stakeholders in terms of possible interventions); and that information needs of stakeholders are not covered by the CS. With other words, the necessary information needed by the stakeholders is missing in the CS that needs to be addressed in the form of additional or new data within a new/updated version of the CS.

Another more often occurring type of usability gap was that stakeholders had difficulties with readability of the CS, making it unclear what was meant with the information. For example, in the Swedish case the visual format of reports made it hard for users to grasp what was said in the text. On the other hand, for Flensburg the usability gap was that some information was not self-explanatory. Finally, for the Fluvius region, the readability problem lay in some maps not being not readable enough for some stakeholders.

To answer the hypothesis in a nuanced manner; in all case study sites of the EVOKED project usability gaps were found. However, when looking at the type of usability gaps that were present in the cases (based on Raaphorst et al., 2020), it can be stated that most of these gaps were related to the validity of the information shown, or to be more specific: the information was either not useful or not meeting the needs of the stakeholder. A focus on such types of usability gaps makes sense as the first step towards usable climate services for users will be that the information that they require is provided by the service. When that requirement is fulfilled, other aspects such as the readability and interactivity of such a service will be relevant.

3.2 Discussion Hypothesis 1b

"This usability gap is caused by a limited feedback loop from the end-users to the producers of the climate service."

As for the previous hypothesis, the concise answer for all case study areas is yes. However, nuances need to be made as the limitations in feedback loop between end users and climate services producers are caused by local contextual factors. Therefore, while it might be true that the usability gap is caused by the limited feedback loop, solving the feedback loop itself might require a tailored approach.

For example, in the Fluvius region it needs to be considered that the CS Stresstest is relatively new. This makes it hard for local governmental stakeholders to develop the CS themselves. Hence, they are reliant on consultancy firms to make the maps for them. However, one aspect that needs to be considered is that governmental stakeholders often have a limited budget and therefore may limit the information they can 'buy' for a CS with a consultancy firm charging extra for any additional information beyond the standard product they deliver. This in turn might reduce the feedback loop as there is little to no room for changes to these standard climate services. This contextual factor differs from for example Värmland/Arvika where most available climate services were provided by the Swedish national government through the SHMI and the MSB, which makes developing a feedback loop between local/regional stakeholders and national institutions more difficult. Another contextual factor found in Larvik was that the usability gap occurs because planning of the new neighborhood is normally a responsibility for the municipality. Consequently, there is normally no feedback loop between the municipality and the contractors for the building development as the latter group do not use the CS originally developed for this purpose. However, as this group are now included within the planning process, a new CS needed to be included that also considers these new information needs. Thus, the feedback loop here was put in place to guide the process of co-designing this new CS.

These three cases show that while it is technically correct that the usability gap is the result of a missing or limited feedback loop, it cannot be said that all feedback loops are the same. Hence, the argument can be made that contextual factors causing the feedback loop need to be considered.

3.3 Discussion Hypothesis 2a

Living labs have contributed towards the development of a feedback loop between the user and the developer.

Discussing this hypothesis is a two-parter as the answer is based on the type of Living Lab that was developed in the case study areas (based on Schuurman et al., 2013) and on how this has contributed to the development of a feedback loop between the CS users and developer(s).

When we look at the typology suggested by Schuurmans et al. (2013) we can state that all Living Labs can be characterized as a 'living lab for collaboration and knowledge support activities'. This result is not surprising since the EVOKED Living Labs all stem from the same project, follow the same guidelines (SGI, 2018), and have a similar focus. Additionally, due to the focus on the co-designing aspect when establishing the field trials (Deltares 2019; Deltares, 2020), this will obvioiusly guide the Living Lab towards collaboration and supporting knowledge activities.

When we look at how this setting has helped developing the feedback loop, we do again see similarities between the cases. This is because the Living Lab brings developers and end-users together in a setting that allows for discussion and provides feedback. So, while the participants might differ from one case to the other (e.g. developing companies in Larvik or regional stakeholders in the Fluvius region), the overall process in general does not. As such, we can state as an overall answer that the setting of the Living Lab promotes discussion between end-users and developers. This discussion can be seen as a feedback loop that helps to discuss usability gaps with the developer, which can then be addressed (if the option to do so is there, and the request for changes are within reasonable limits).

3.4 Discussion Hypothesis 2b

Each of the organizational principles of the Living Lab is useful to establish this feedback loop.

As shown in the previous paragraph, the Living Lab contributes to establishing a feedback loop between CS users and developers. However, as was presented in D1.1 (SGI, 2018) a Living Lab is built upon a series of organizational principles. We will now study more closely how each of these principles have(n't) contributed to establishing the earlier discussed feedback loop.

- Continuity

Continuity is explained in D.D1 (SGI, 2018) as a combination of aspects focusing on building upon existing networks, focusing on long-term learning and sharing of knowledge, planning for institutionalizing and continuation of the climate services after a development project is finished.

As shown in paragraph 2.6, for all cases (except for Flensburg where local CS did not exist at the start of the project) this principle contributed to a feedback loop between CS end-users and developers. The main reason was probably that the stakeholders already knew one another, making it easier to discuss potential usability gaps. For Flensburg, where there was no CS yet, the CAU embarked on a process of co-producing such services for different stakeholders.

Therefore, based on the case study sites we can state that the Living Lab principle of continuity is not decisive for establishing a feedback loop between CS end-users and the developer, but can nonetheless contribute to this when already present within the Living Lab environment.

- Openness

Openness is explained in D.D1 (SGI, 2018) as a combination of aspects such as creating transparency between involved partners, involving representative groups, showing a will to share information, realizing potential risks and uncertainties, and providing a platform for the co-production of knowledge and learning.

As shown in paragraph 2.6, it was concluded that for all cases this principle contributed to the development of a feedback loop between CS end-users and developers. It can be stated that this principle is of high importance for the development of a feedback loop. This is because openness allows for an atmosphere in which co-production, learning, and discussion are possible. CAU pursued therefore two feedback loops: one with the case study partner (Municipality of Flensburg) and another dedicated to improving the newly developed CS with comments from citizens. Here the stakeholders had the possibility to provide feedback through the use of an online questionnaire survey and during a workshop in which the improved CS was presented.

Therefore, based on the case study sites we can state that the Living Lab principle of openness is decisive in establishing a feedback loop between CS end-users and should be present within the Living Lab environment if developing this feedback loop is a goal of the Living Lab.

- Realism

Realism is explained in D.D1 (SGI, 2018) as a combination of aspects such as linking to relevant policy, governance, environmental and social-economic contexts of the Living Lab area, building the CS on identified needs, synchronizing the Living Lab with other milestones and opportunities in the area, taking into consideration the limitations and opportunities with regard to available resources (financial, human and environmental), facilitating sustainable innovations and testing climate services in real settings, and finally being optimistic while still keeping realistic expectations.

In paragraph 2.6, it was concluded that this principle did not contribute to the development of a feedback loop between CS end-users and developers. This is because Realism rather focusses on the CS in being linked to the relevant local/regional processes, contexts, and milestones. While Realism is a relevant principle on its own, and certainly one that should be considered, enhancing Realism and thus making the CS more useful is often a result of a well-functioning feedback loop rather than resulting in such a loop.

Therefore, based on the response from the case study sites the Living Lab principle of realism does not contribute to the establishment of a feedback loop between CS developers and end-users.

- Influence

Influence is explained in D.D1 (SGI, 2018) as a combination of aspects such as encouraging ownership of the process and the CS produced, connecting stakeholders from difference sectors to work towards societal resilience, setting up clear communication channels, making the Living Lab and the CS attractive to politicians and citizens, ensuring that actions and learning are two-way, and that stakeholders can contribute to the development of climate services.

As can be read in paragraph 2.6, this principle contributed to the development of a feedback loop between CS end-users and developers. This is because it allows participants of the Living Lab to contribute to the development of CS through a process of co-creation. As this is at the heart of what the establishment of the feedback loop is about it can therefore be stated that this principle lines up this goal. However, it should be noted that influence on the process by stakeholders does not directly translate to changes being made to a CS as these need to be also technically feasible. Moreover, the necessary data must be possible to obtain.

Based on the case study sites, the Living Lab principle of influence is instrumental in establishing a feedback loop between CS end-users and should be present within the Living Lab environment. Without Influence, it will not be possible to have a feedback loop between end-users and developers.

- Value

Value is explained in D.D1 (SGI, 2018) as a combination of aspects such as clarifying the added value of the CS for its users and providing incentives to participate, making involvement of stakeholders cost-effective, attractive and fun, avoiding unnecessary travel and work-hours, providing definite and measurable outcomes, framing these outcomes in a way that is understandable for the participants, utilizing innovative communication channels to disseminate the outcomes, and raising awareness of CS amongst citizens and politicians.

As shown in paragraph 2.6, for all cases this principle contributed to the development of a feedback loop between CS end-users and developers. This is because the process needs to have added value for participants to make them start discussing and subsequently making participation worthwhile. To establish the open atmosphere needed for the feedback loop it is therefore good that participants of the Living Lab understands that the endeavor is worthwhile

Based on the case study sites we can state that the Living Lab principle of value is contributing to establishing a feedback loop between CS end-users and the developer present within the Living Lab environment. As for the principle of continuity, it can be stated that while not being critical the principal of Value supports the establishment in a positive way.

- Sustainability

Sustainability is explained in D.D1 (SGI, 2018) as a combination of aspects such as building on existing local and epistemic knowledge of risk and uncertainty, making sure that the CSs are produced in an ecological, social and environmental manner, and striving for sustainability in the project operations (e.g. avoiding unnecessary travelling).

As shown in paragraph 2.6, this principle did not contribute to the development of a feedback loop between CS end-users and developers. While it is an inspiring principle that should be on the agenda of any Living Lab, it does obviously not contribute to the establishment of the feedback loop between developer and end-users. This is because the principle does not contribute to discussions, nor does it enable criticizing possible usability gaps.

It can be stated that the Living Lab principle of sustainability does not contribute to the establishment of a feedback loop between CS developers and end-users.

- Overall conclusions

Based on the discussions above we can now provide a more nuanced view on the contributions of each Living Lab principle towards the establishment of a feedback loop between CS developers and end-users:

- **Continuity** – This principle contributes to the establishment of a feedback loop. It is not considered a vital aspect of setting up this loop but can rather be seen as a helpful factor when for example participants already know each other, lowering the barrier to discuss and criticize.
- **Openness** – This principle is valuable for the establishment of a feedback loop. Openness within the setting of a Living Lab allows participants to discuss and provide feedback on the CS made by the developer. Hence, it is

a principle that contributes quite heavily to making this feedback loop possible.

- **Realism**- This principle does not contribute to the feedback loop between CS developers and end-users but is rather a spin-off of a well-functioning feedback loop also reducing usability gaps.
- **Influence** – This principle is valuable for the establishment of a feedback loop. This is because this principle touches upon the capacity that participants have to co-produce the CS. Therefore, this principle links directly to the idea of the feedback loop between CS developers and end-users.
- **Value** - This principle contributes to the establishment of a feedback loop. However, it is not considered a vital aspect of setting up this loop but can be seen more as a helpful factor as it provides a feeling that the Living Lab is useful for the participants.
- **Sustainability** - This principle does not contribute to the feedback loop between CS developers and end-users but is more relevant for the entire process.

3.5 Discussion Hypothesis 3a

Information designs help to convey information to the end-user

In the concise overview of the hypothesis answers (paragraph 2.6) the answer for all cases has been that the used information designs have helped to convey produced information to the end-user. This is because these designs allow developers to better understand how to address the usability gaps that were present as well as to address the information needs of the end-users. Therefore the information design framework can in an easy and simple way visualize usability gaps and the (preferred) structure of the CS (regarding the designated audience, goal, information and visual format), making these in turn easier to communicate. For example, in the case of the Fluvius region stakeholders explained that it helped them oversee and better understand the process as that it allowed them to better identify potential changes to be made by the developer. Therefore, the climate information designs supported the co-production process between the Fluvius-stakeholders and the consultancy 'Nelen & Schuurmans' who developed the CS story maps.

It should be noted that this process is not easily picked up. From the experiences of the Deltares project team, it can be stated that this was the result from a longer partnership between Deltares and the Fluvius-stakeholders as it took a while for the EVOKED-philosophy to become more embedded within the internal Fluvius processes. So, while the use of the information design framework looks promising, the adoption within internal organizational processes, alongside with the EVOKED philosophy can make it hard to get over this first initial barrier.

Additionally, from the perspective of the developer, it should also be on their mind to talk with their end-users and to spend time and effort to establish an understanding about what their information needs really are. This may lead to the conclusion that additional information might be required to make a better tailored climate service. Furthermore, not only new data might be necessary, but also smart combinations of different types of data to better show the effect that extreme weather might have on a region (e.g. not only showing a heat-stress map, but also combine this information with the location of vulnerable groups and objects, etc).

It can be stated that this hypothesis is fulfilled, based on the data and experiences gathered within the EVOKED case study areas. However, it does require time and patience for the philosophy and its associated ideas to take root within relevant organizations and partners.

3.6 Discussion Hypothesis 3b

Information designs are useful tools to establish the feedback loops between the end-users and the producers of climate services.

In the concise overview of the hypothesis answers (paragraph 2.6), all cases answers that the information design framework is a useful tool to help establish the feedback loops between the end-users and the producers of climate services. It can be stated that the information design framework can be a helpful tool to both discuss and design (improved) climate services. By being better positioned to pinpoint where potential problems are located within the climate services, it serves as a starting point for a dialogue between end-users and developers. Additionally, for the Climate information design is easy to use by stakeholders, it also allows for a higher engagement of end-users as it does not require extensive analysis of a climate service to develop arguments and talking points.

It can also be stated that the information design-framework is only a support tool and not a definitive answer to the question on how a climate service should be designed. Thus, the design process does still require its participants to think critically about what information is needed, how should the data be visualized in the CS, are the data correct, etc.

4 Conclusion

4.1 Concluding remarks

As discussed in chapter 3, we can state that the ideas developed within the EVOKED project also work with practice. The hypotheses show us that establishing a feedback loop between end-users and developers of the CS, organizing a dialogue with one another and being able to visualize ‘usability gaps’ can help improving the usefulness and legibility of a climate service.

As such, the contribution of the field trials to the overarching main research question of EVOKED *'How to reframe climate data into knowledge products more understandable and useful for end-users concerned with risk mitigation and adaptation?'* (Deltares, 2019) is twofold:

- The proces of designing a climate service: A potential way to reframe climate data into knowledge products that are more understandable and useful for end-users can be done through the process of co-design and dialogues between the end-users and the developer(s) of the climate service. The cases show that this kind of approach works as the improved climate services better address the knowledge needs of stakeholders, and are more understandable.
- The communication qualities of the climate service: The climate information design framework developed during this project helps guiding the reframing process by looking for coherence between four key aspects: intended audience, purpose, information and visual language. The more these aspects are in line with each other, the better the chances for a CS to be used by its intended audience.

However, in doing so, we also need to acknowledge that this main research question does not cover the whole narrative laid out in this document. This is because the question has the assumption that reframing climate data into knowledge products is by itself enough to make them more understandable and useful. In other words, the information and data that stakeholders have access to might not be enough to allow for informed decision-taking about risk mitigation and adaptation due to climate change. Instead, as hypothesis 1a shows us, there is also sometimes a need to include additional or different data for climate services to match. For example, data on the effect of extreme weather in an area might be insightful, but not useful for a municipality as it does not say anything about the impact this will have (e.g. knowing where pluvial flooding due to heavy precipitation may occur does not necessarily tell us something about the impact this flooding will have in an area or whether this situation is undesirable. For when a neighborhood floods it might be bad, but if the flooding occurs in a designated retention area there is no need to act). Therefore, this inclusion of additional information needs to be added to the main research question for it to be more attentive for practice.

Adding this perspective to the research question, we can state that the methodology and philosophy of EVOKED, as it has been developed during the project has provided tools that can be used to improve the usefulness and legibility of climate services to their intended users.

4.2 Implications for practice

4.2.1 Dissemination of the EVOKED philosophy after the project's ending

By stating that the EVOKED methodology and philosophy have been successful needs a nuance regarding its practical implication after the EVOKED project has ended. During the EVOKED project, the project partners were present in the cases to keep track of the process and adjust if needed, but from 2021, this will no longer be the case. As such, an important question is how the ideas of EVOKED will be kept alive in a situation with no active moderation and coordination by a centralized project group?

The dissemination and where to store this knowledge is important. For example, in the Netherlands a lot of helpful information for governmental stakeholders about climate services and climate adaptation are presented at www.ruimtelijkeadaptatie.nl. Adding the EVOKED ideas and information design framework to this site (or an alternative) would help provide a useful approach for both users and developers of climate services to start a dialogue between them in order to improve the usability and in turn contribute to the decision-making of climate adaptation.

Another point of attention is who should use and further disseminate this knowledge within organizations (knowledge brokerage). It is not necessary that all employees have this knowledge, but rather that there are 'knowledge ambassadors' who other employees could go to if they have questions regarding climate services and climate adaptation. But who should be responsible for that and in what way can it be structured? Decisions have to be taken regarding a specific organizational structure.

4.2.2 Potential uses of the EVOKED philosophy and methods

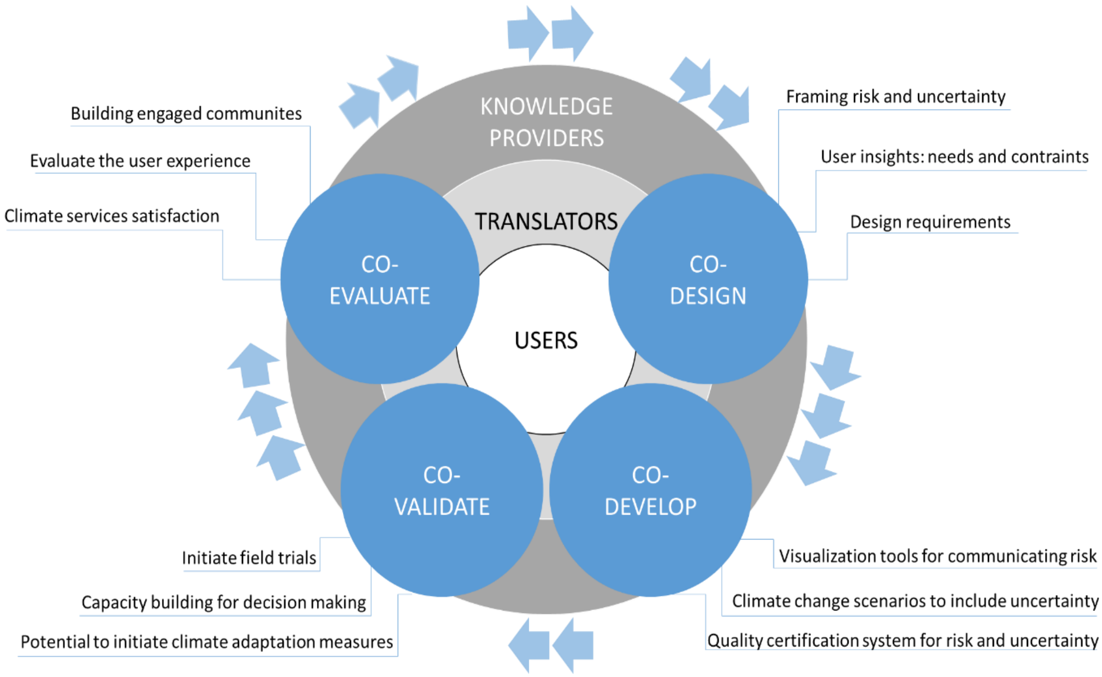

Figure 34: Overview of the co-designing process and the related actions for each phase (NGI, 2020).

If the dissemination is successful, and the ideas and methods are being used, we can also see several ways in which these could have a positive contribution. For this we use Figure 34 as a frame of reference to see where the idea of the information design framework might be applicable.

Based on this figure we can now discuss the potential users for the EVOKED philosophy in each part of the co-designing process.

- Co-design

During the co-design phase, the ideas and methods developed for EVOKED project can be used to gain insight about the users need, to frame the risk and uncertainty involved within the climate services, and to identify the design requirements of these services. In this way the EVOKED method can be used as a design tool in addition to being a discussion tool.

- Co-develop

During the co-develop phase, the ideas can be used as visualization tools to communicate risk. This is because the information design can help to visualize potential usability gaps that may occur during the development process and that may subsequently be discussed among the participants. Hence, climate services can be made more usable by co-development.

- Co-validate

In the co-validate phase, the ideas can be used as visualization tools for decision-making, serving as a basis to initiate climate adaptation measures. This is because you need an informed end-user to select the best climate adaptation measures. The EVOKED method can help to ensure that the end-user will have the right information that he or she needs to make these decisions. Additionally, co-validation can help to engage otherwise passive end-users that might also contribute to the decision-making process in a meaningful way.

- Co-evaluate

Finally, during the co-evaluate phase, the ideas of EVOKED can be used to establish engaged communities, evaluate the user experiences, and measure climate service satisfaction. This can be done by using the information design to evaluate whether the final version of the climate service can fulfill the information needs of the end-users. As the developer and the end-users work together through the process of co-designing and discussing the climate service, it will also help building the engagement of communities in both decision-making processes and climate adaptation.

4.3 Recommendations for further research

Finally, we have three recommendations regarding future research that can be done to make climate services more usable:

Firstly, what is defined by end-users as a ‘good’ climate service depends on if and how the use of such climate knowledge products supports additional climate adaptation solutions that have broad political and public support. Existing studies of usability focus primarily on the various communicative qualities of climate services (e.g. user interface, map symbology, textual explanations, framing of the information) in order to improve the implementation and impact of these services. However, this approach implies that a good product design of a climate service will ensure that a proper implementation of measures or policies will take place. Yet, the increasing diversity of policy contexts and the differentiation within user groups suggest that, without the appropriate contextual embedding of these climate services in practice, a product-oriented approach is not sufficient enough to do so. A study of the combination of contextual factors (e.g. user-friendly product design, user collaboration during production, local policy contexts, commitment of knowledge ambassadors) and their relative influence as necessary conditions for successful use of climate knowledge products could therefore improve our understanding of how future CS could best be designed in order to connect these better to the practice in which these are used.

Secondly, we advise the necessity for more research on the topic of visual language. Within the EVOKED project we have made assumptions regarding what type of visual presentation could be useful for what kind of information and for what type of stakeholder. However, we do acknowledge that we often see dominant ways of portraying information in the form of maps, reports, and infographics. It could therefore be helpful to measure what aspects of a climate service will be used by which types of stakeholders, as well as what type of visualization these will engage with. For example, this could be measured by using an eye-tracking device telling what parts of the screen these users are mainly focusing on.

Finally, a third element that may affect the use of knowledge and data is by connection the EVOKED methodology to the various cultures of planning and institutional settings in which decision-making about climate adaptation takes place. This is because such aspects will determine what stakeholders will be involved in what ways during the decision-making process of climate adaptation and mitigation measures. Therefore, it might be a third direction in which we can advise future research

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