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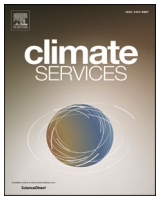

Recognising the social functions of climate services in Bergen, Norway

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ABSTRACT

Climate services' main function has been to provide technical scientific evidence for decision-making in formal institutions. This article makes a case for recognising the diverse functions and meanings of climate services across the spectrum of institutions constituting climate governance. The article reports on research that identified climate services needs for building resilience in Bergen city (Norway) through a collaborative back-casting workshop with actors variously engaged in climate governance. Participants' discussions raised four key observations on climate services. First, they saw the potential for using climate information in a diverse set of formal and informal institutions. Second, they considered how to adapt information to these diverse settings. Third, they looked at how information could enhance existing initiatives, rather than demanding 'new' products. And fourth, participants' proposed climate services highlighted their diverse functions, and led the authors to suggest classifying services according to their principal functions. The article finishes by proposing a field of *'social climate services'* that configures relationships between scientists and social actors, built on technologies of humility, for enriching the ongoing culturally and politically charged debates and practices around climatic change in informal institutional settings. Social climate services function can include enabling people to voice their concerns, learn, critically reflect on changes to culture and identity, build social networks, and try out new practices.

Practical implications

- In this article we contribute to the debate on what constitutes a 'climate service' by asking a group of practitioners to map out a landscape of potential services that they see a demand for. Recent studies show practitioners to be quite critical of climate services as a field, noting that services are mainly pushed by scientists according to their supply of new technical products and assumptions of demand, with little attempt to assess actual demand or evaluate their impact. To address this, our work fostered discussion among scientists and decision-makers, to align the supply and demand for climate information, and arrive at a shared understanding of information needs.
- Our study mapped the climate services demanded for building resilience to climatic and other changes in the city of Bergen, Norway. We convened a one-day workshop with a mixed group of 18 practitioners variously active in the city's climate governance, including scientists developing climate services, local government planners and policy-makers, people from key services like the public library, architects from local consultancies, local volunteer groups, academics from the university, and leaders of non-governmental organisations. Some participants – e.g., climate scientists and municipal planners – had long discussed climate information needs of the city, while for others this was the first time they participated in such discussions; thus they brought their own, 'fresh' perspectives. We structured discussions around a 'back-casting' exercise, where participants came up with visions of a resilient Bergen in 2050, and then thought about everything needed to facilitate the transition to that scenario; this could be anything from political will to financial resources, infrastructure and planning, or indeed climate (and related) information, for example. From these needs we narrowed down a list of 20 potential (and current) climate services.

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- The workshop raised four important and quite surprising findings about how some practitioners interpret the need for climate services in Bergen. First, workshop participants discussed the potential for using climate information for decision-making in a very diverse set of institutions and situations. Services were discussed in the more conventional sense, as providing scientific information for quite formal and technical decisions, such as using projected flood return periods to design stormwater systems in the municipality. But participants also talked about using climate information in classrooms, rain festivals, repair cafés, citizens conferences or library discussion groups. These are not the kind of settings where climate services are usually envisaged as being of use.
- Second, participants talked about ways that climate information (and services) need to be adapted to fit decisions in these different institutions or settings. While a technical report might be appropriate for decisions in a stormwater engineers office, very different types of information and ways of presenting that information are required in a library discussion group; e.g., stories of current climatic change, or even imagined stories of future impacts. A good climate service is one that is fitted to peoples' expectations, fore-knowledge, culture and experience in a certain setting.
- Third, participants talked about how climate services could build on or enhance existing initiatives in Bergen, rather than a need for 'new' products or services. For example, some participants discussed how climate information could be introduced to 'repair cafés' or 'maker spaces', where groups of people interested in sustainability, and working on small projects – from repairing toasters to designing a park bench from recycled materials – converse about climate, and could integrate information into their work. Others talked about reviving traditional and local knowledge of Bergen's climate, which could be displayed around the city in different ways. The emphasis was less on new data or analyses, and more on how existing climate information could be tailored for integrating it into ongoing work.
- A fourth important finding, which follows from the other three, is that practitioners developing climate services that highlighted their different *functions*. There is an assumption that climate services first and foremost provide scientific input on technical matters (e.g., stormwater sizing), but that this information can also bring about certain other side benefits, such as helping people learn about climate change, strengthening working networks, or changing institutions' cultures. What the workshop revealed is that sometimes these side benefits need to be put front and centre, as the primary intended purpose and design-focus of certain specialised climate services. Participants particularly emphasised the social functions of climate information, and recommended services that raise the quality of informal discussions about what climate change could mean for Bergen. That is, not only technical information targeted to a specific decision, but a type of information, communicated so that can be absorbed into everyday conversations in different settings where people are socialising and making sense of climate change; in the library, in the repair café.
- The workshop revealed the need to look at climate services in a broader context. Indeed, the role of municipalities is changing with the social, economic and environmental changes they are facing. To address these complex and multifaceted changes, municipalities are, in some instances, inviting local stakeholders across sectors to discuss and co-create visions and actions for the future, as forms of collaborative, inclusive governance. To support this, there is a greater need for meeting places where citizens, NGOs, business actors, academia and the wider public sector can co-create and critically discuss future scenarios, and develop services and information that take into account the nuances of a broad and complex context. Social aspects of climate adaptation and climate services need to be an important part of that context.

Introduction

Under the umbrella of science for climate adaptation and risk management, the past 15 years has seen increasing attention to developing climate services. What climate services are is contested, but Bruno Soares and Buontempo (2019, p.4) argue that at their core they constitute "*the provision of climate information in ways that supports decision-making through engagement with the users of that information*". In this way, some climate service scholars have come to see climate services as emerging from, and travelling[1] through, complex 'knowledge systems' (Bruno Soares and Dessai, 2015; Buizer et al., 2016; Kirchhoff et al., 2013); with Vogel et al., (2019: p. 5) discussing this as, "complex and, usually, messy and interactive 'spider webs' of daily, real-world engagements [through informal and formal institutions and networks] […] including various shadow networks". We think of knowledge systems (in terms borrowed from Star and Griesemer, 1989) as ecologies of intersecting institutions, or social worlds, wherein actors attribute different meanings and uses to climate information. So seen, a challenge for climate services scholars and practitioners is to make climate information meaningful in diverse 'social worlds'. We argue that taking this challenge seriously requires critically rethinking what constitutes a climate service, recognising their technical but also their *social* and other functions. This paper presents research on climate information needs in Bergen, Norway, which emphasised climate services' social functions in interpreting what climate change means for city inhabitants.

There is a growing body of work on making climate services meaningful and functional for user groups in different social worlds (i.e., institutions, organisations or communities), mainly along two lines. One line works to map the information needs and functions of groups, in order to target, repackage and tailor scientific outputs (Carr et al., 2020; Porter et al., 2015). A second, related line engages user groups in collaborating with scientists toward co-creating climate services (Vincent et al., 2018; Bremer et al., 2019a,b). Ostensibly, this means taking scientific work 'out of the lab' and relocating it to other institutional settings, where the research process and products come to be influenced by the epistemologies and values, cultures, norms and rules of that social world. By taking on a role in designing, conducting and utilising scientific research, user groups – whether farmers or urban planners – are assumed to invest climate services with various qualities, functions and meanings (Bremer et al., 2021). This is one reason why it is difficult to define climate services, because information morphs when it travels through knowledge systems, and takes unique forms when translated to different social worlds. Such co-creation also situates climate services in wider moves toward collaborative governance, recognising the complexity, uncertainties and mutual dependencies associated with climate risks. Collaborative governance emphasises the creative approaches to climate adaptation emerging at the interface of governmental, non-governmental, private and scientific organisations (see e.g., Kooiman, 2003).

Notwithstanding the diversity of institutions in knowledge systems, and thus the numerous possible types and uses of climate information, the climate services field has arguably been biased towards developing new, technical climate science products with the function of supporting official decision-making processes in formal organisations like municipalities or utility companies (Findlater et al., 2021; Vaughan and Dessai, 2014). This amounts to products like probabilistic seasonal forecasts, flood return periods, or hydrological maps to support climate risk management for example. The focus on formal science-for-policy relations reflects the power of global climate science and policy networks

[1] Scholars of science and technology studies have looked at how information travels or is translated within networks; see for instance Latour's (1990) 'immutable mobiles', Fujimura's (1992) 'standardised package' or Star and Griesemer's (1989) 'boundary objects'. Work on boundary objects features prominently in climate services literature.

(like the 'Intergovernmental Panel on Climate Change' or 'World Climate Research Programme'), in defining climate services (Haines, 2019; Krauß, 2020), the logics and cultures steering the formal institutions responsible for managing climate risks (Daly 2021; Harjanne, 2017), and the neo-liberal imaginary (of the European Commission for example) of establishing a climate services market of commercial products (Bruno Soares and Buontempo, 2019; Webber and Donner, 2017).

But some scholars (see Bremer et al., 2021; Baztan et al., 2020; Cook and Overpeck, 2019; Daly 2021; Haines 2019; Krauß, 2020; Porter and Dessai 2017) have called for more attention to how we can better realise the wider, more informal social benefits of climate information, for communities concerned about a changing climate. This implies broadening the spectrum of institutions targeted for climate information to include more informal social worlds, from gardening collectives to city missions, networks of school strikers or neighbourhood groups. It implies foregrounding the social, cultural and ethical functions of climate information, such as how it can affect groups' sense of vulnerability and agency (Daly and Dilling, 2019; Turnhout et al., 2020), build relationships (Haines, 2019) and learning (Vanderlinden et al., 2020), link up with histories and identities (Bremer et al., 2020; Marschütz et al., 2020) and appreciate climate alongside communities' other pressing challenges (Baztan et al., 2020; Vogel et al., 2019). It implies entertaining creative new forms of climate services that are tailored to these social functions; could climate discussion groups, or repair cafés[2], be considered climate services? What about strengthening governance networks (Kolstad et al., 2019)?

Against this background, this paper presents a study in Bergen, which sought to collaboratively identify the actual climate service needs of actors in different institutions, towards governing a transition to a resilient Bergen in 2050. Our first aim is to present the different types of climate information that emerged as meaningful for governance actors in Bergen's various social worlds. This work uncovered some surprising findings, notably that participants in this study put less emphasis on new technical products, and more on how climate science can bolster ongoing social initiatives and knowledge sharing arenas; from discussion groups at the library to conferences about the city's public spaces. Based on a critical discussion of these research results, our second aim is to join our voice to others in arguing for more concerted work on climate services' social functions. That is, to nurture a field of practice – 'social climate services' – that configures relationships between scientists and social actors, built on technologies of humility, for enriching the ongoing culturally and politically charged debates and practices around climatic change in informal institutional settings. Much of this type of work is already underway – including in Bergen (Kolstad, 2019) – but it is often relegated to being a fortuitous corollary benefit of the more technical work. Climate services' social functions need to be lifted up as a focus in their own right.

Section 2 begins by introducing the Bergen study concept and method, before Section 3 briefly presents the findings of this study relative to the types of climate services sought, and which of these are already implemented in Bergen. Section 4 discusses these findings and makes the argument for social climate services. Section 5 concludes.

Context and methods: identifying climate services to support a resilient Bergen in 2050

The CoCliServ project in Bergen, Norway

This study was undertaken as part of the ERA4CS-funded CoCliServ research project ("*Co-development of place-based climate services for action*": http://cocliserv.cearc.fr), run from 2017 to 2021. CoCliServ sought to integrate climate information with community debate and action in specific European places, by: (a) mobilising available climate information and identifying information needs; (b) developing participatory approaches and creative tools for representing local climates; and (c) creating a knowledge quality assessment protocol. The project was implemented in five sites: Bergen in Norway, Jade Bay in Germany, Dordrecht in the Netherlands, the gulf of Morbihan and the Kerourien neighbourhood in Brest, France. These sites followed a shared methodological design, starting with narratives (Krauß, 2020) and extending to normative scenario design (Vanderlinden, 2015). This paper reports on a workshop designing scenarios for a resilient Bergen in 2050 to elicit climate services needs, and subsequent follow-up meetings.

Bergen city sits encircled by seven mountains on the west coast of Norway, described as the 'Gateway to the Fjords.' It is Norway's second largest city and has a long history (950 years-old in 2020) influenced by international trade (notably as part of the Hanseatic League from 1360 to 1775). Today Bergen is the country's busiest freight and passenger port and a marine industry hub, a centre for higher education and research, and in 2000 it became a European City of Culture. Bergen also has a long-standing identity as a 'city of weather' (Bergen Kommune, 2018) and is often portrayed as Europe's rainiest city (Meze-Hausken, 2007).

In 2020, Bremer et al. (2020) mapped how global climate change is emerging and stabilising as a matter of concern across various public spheres of Bergen, arguably re-moulding the city's identity and culture from a city of *weather* into a *climate* city. Climate science and ideas are today ubiquitous in discussions about Bergen's future across institutions. This concern is mutually generated at the convergence of various influences, including from climate science institutions, municipal policy, political leadership, social movements and activism, media attention, cultural performances, and direct experience with nature. This sets the scene for the CoCliServ workshop, where the public discussion of a resilient Bergen in 2050 links up to ongoing discourses on climatic change, and the city's perceived vulnerabilities to sea-level rise, flash-floods and landslides.

Conceptual framework: co-producing a list of climate information needs across institutions

This work was conceptually conceived as co-producing a list of climate information needs (including identifying uncertainties and information gaps) that is meaningful in different institutions, or social worlds (Daly, 2021). In this paper, institutions refer to '*regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life*' (Scott, 1995; p. 56) whether in formal local government or informal community gardens for instance. Institutions have a culture – a framework of understandings and practices – that influences how actors attribute meaning to information and mediates how they relate to the rules and decision-making processes (Ostrom, 2005; Scott, 1995). For climate information to be meaningful within an institution, it can be seen as translated to fit an institution's culture and logic for implementing their rules and activities (Bremer et al., 2021). This process of adapting climate information to an institution was conceived by Lemos and Morehouse (2005) as 'co-production'; deliberate (normative) collaboration between people working across institutional boundaries, including through intermediaries or boundary organisations.

Specifically, our workshop set out to create a setting for people active across a diversity of institutions in Bergen – including outside established science and policy networks – to collaboratively identify common and differentiated climate information needs relative to envisioning a resilient city. Acknowledging the range of perspectives on co-production processes, our work was particularly conceived as fostering *iterative interaction* among key governance actors variously active in producing

[2] Repair cafés are settings where people skilled in repairing certain items, from clothing to toasters, meet up and volunteer their services for others who 'drop in' with items in need of repair. Usually such settings double as important spaces for socialising.

and using climate information, via a workshop and subsequent meetings. We aimed to trigger ongoing conversations for reconciling the supply and demand of climate information (Sarewitz and Pielke Jnr, 2007) through scenario back-casting. This process was also designed to *empower* actors normally excluded from formal governance debates, and stimulated discussions that gave rise to *social learning* about the information Bergen city has, and the information the city needs (Bremer and Meisch, 2017).

It is not straight forward for people to recognise and communicate institutions' information needs, and these workshops drew on scenario design and back-casting as a process for creatively eliciting these needs. Back-casting is a future-oriented, transformative scenario technique for addressing long-term complex problems (Dreborg, 1996). We developed 'policy' or 'normative' scenarios for Bergen in 2050, with a focus on developing a city that is resilient[3] to climatic and other changes, and back-cast desired pathways for arriving at these scenarios (Vervoort et al., 2014; Wardekker et al., 2020). In particular, the workshop built on concepts of 'participatory' and 'incremental' scenario planning (Vanderlinden, 2015). Van de Kerkhof et al. (2002) argue that participatory back-casting allows participants to shape the transitions between a possible future and the problematic present and helps them to identify opportunities for radical change. In a similar vein, Bibri (2018) stresses that participatory back-casting is key in developing shared visionary images of a long-term future. Back-casting is transformative in that it stimulates an accelerated movement towards achieving the goals and aspirations of local communities.

Our approach shared similarities with the three-step transition scenario method proposed by Hines et al. (2019): 1 Select a vision of the future used as end-point to be reached; 2. Indicate obstacles and opportunities to getting there from the present situation; 3. Define milestones and interim objectives. While some back-casting work draws quite simplistic and linear paths toward scenarios, 'incremental' design highlights a set of (the near infinite) possible pathways, and how they intersect and branch off each other at critical junctures. These 'hinge points' have been discussed as 'transition' points between adaptation pathways when certain paths become untenable (Haasnoot et al., 2019), moments of surprise or 'wildcards' (Wardekker et al., 2010) or 'tipping points' in stable systems (Scheffer et al., 2012). It is at these points that we assumed information needs become apparent.

A workshop to elicit climate service needs

Researchers at the University of Bergen held a one-day workshop with 18 participants in November 2018, articulated around three working sessions: (i) developing scenarios for a resilient Bergen in 2050; (ii) assessing the situation in Bergen today, to back-cast ways to the desired future scenarios; and (iii) identifying resource needs, particularly for climate services, to arrive at this desired future. We sought to build visions for Bergen's future that were anchored in an appreciation for Bergen's past; the processes, features, culture and identity that make Bergen particular. We designed the scenario development exercise to build on previous ethnographic research of public narratives of climate in Bergen as a place (Bremer et al., 2020), as studied in scientific literature, text analysis, participant observation of public events and as elicited through narrative interviews.

The ethnographic work on Bergen's public narratives influenced the recruitment of the 18 participants. Six interviewees from this ethnographic study were invited to the workshop to establish continuity, with 12 identified either by workshop facilitators or by the narrative interviewees, as having earlier collaborated in climate research or policy in Bergen, from participation in climate-related public events or membership to organisations with a climate focus. Participants were selected for their active engagement with climate discussions, but with a deliberate strategy to also invite participants from outside the scientific and policy institutions that are usually engaged in the city's climate governance. By inviting participants like librarians, members of migrant communities, amateur writing group organisers and NGO members, we sought to introduce a broader set of voices and visions for the future, based on diverse lived experience and knowledges. Participants were also selected for having lived in Bergen for more than five years, in order to have accumulated experience of the weather and climate, and feelings for what it means to live in Bergen. In total, we had nine women and nine men participate, across a broad age range (from students to retirees), who were divided into three heterogeneous groups of six. Groups were designed to ensure that each had a climate science expert and an actor working in local government, but also included participants with other backgrounds. Each group was facilitated by a social scientist, with two groups working in Norwegian and one in English (Table 1).

The first working session randomly allocated to each group one of three prepared scenarios for 'Bergen in 2050' (see Fig. 1), inspired by public narratives in Bergen that emerged in the ethnographic research on narratives of change, and chosen by researchers because they represent contrasting (if complementary) strategies and were anticipated to open up for alternative ways of exploring resilience in Bergen. Scenario A was titled **'A 1.5 degree city'**, and related to the municipalities Green Strategy, which has a mitigation focus on reducing Bergen's emissions to control average global warming to no more than 1.5 degrees Celsius. Scenario B was titled **'Let it rain'** and embodied an attitude of living with climatic change, which is anticipated to bring increased rainfall to already rainy Bergen. Scenario C was titled **'High-tech haven'** and emphasised the need to make the most of climatic change, by exploring economic, technological and other opportunities, in renewable energy for example. Scenarios were left very broad – including just a title, a photo and a short statement – with the intention that groups would add their own details and dimensions to the scenario and make it their own.

Groups were asked to complete their scenario by choosing five 'dimension cards' from among a set of 16 pre-written cards, including a blank one (see Fig. 2), inspired by the public narratives from the ethnographic study. The cards reflected morals and meanings imparted in public narratives about climate in Bergen, such as Bergen being close to nature and its people naturally resilient, or aspirations for resilient physical infrastructure with public transport and climate-proof buildings. Participants chose cards that fitted their allocated scenario or that they, as a group, found most relevant and important to the Bergen context; stimulating lively group discussions about what they liked, disliked, and felt was missing in their scenario. This exercise highlighted

Table 1
Groups of participants in the workshop.

Group 1: (Norwegian)	Group 2: (Norwegian)	Group 3: (English)
Climate researcher at a research institute	Climate researcher at a research institute	Climate researcher at a research institute
Planner at Vestland County	Planner at Bergen Municipality	Planner at County Governors Office
Planner at Bergen Municipality	Social scientist at the University of Bergen	Social scientist at the University of Bergen
Member of NGO 'Grandparents for climate action'	Member of NGO 'Friends of the Earth'	Engineer at the department of clinical medicine, Bergen Hospital
Advisor at the Norwegian Climate Foundation	Architect at a consultancy	Retiree running writing groups with retirees
Librarian in a Bergen public library	Member of NGO 'Climate = Health'	Member of NGO 'Climate = Health'

[3] Defined in the IPCC's 6th Assessment Report Glossary as "The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation".

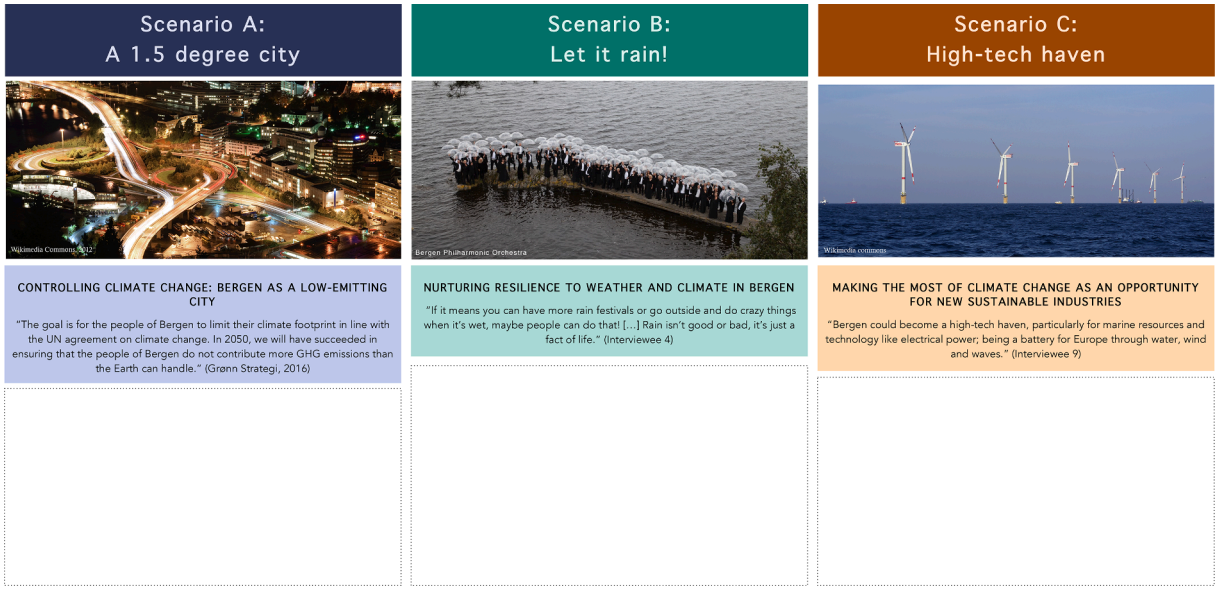

Fig. 1. The three prepared scenarios for 'Bergen in 2050'.

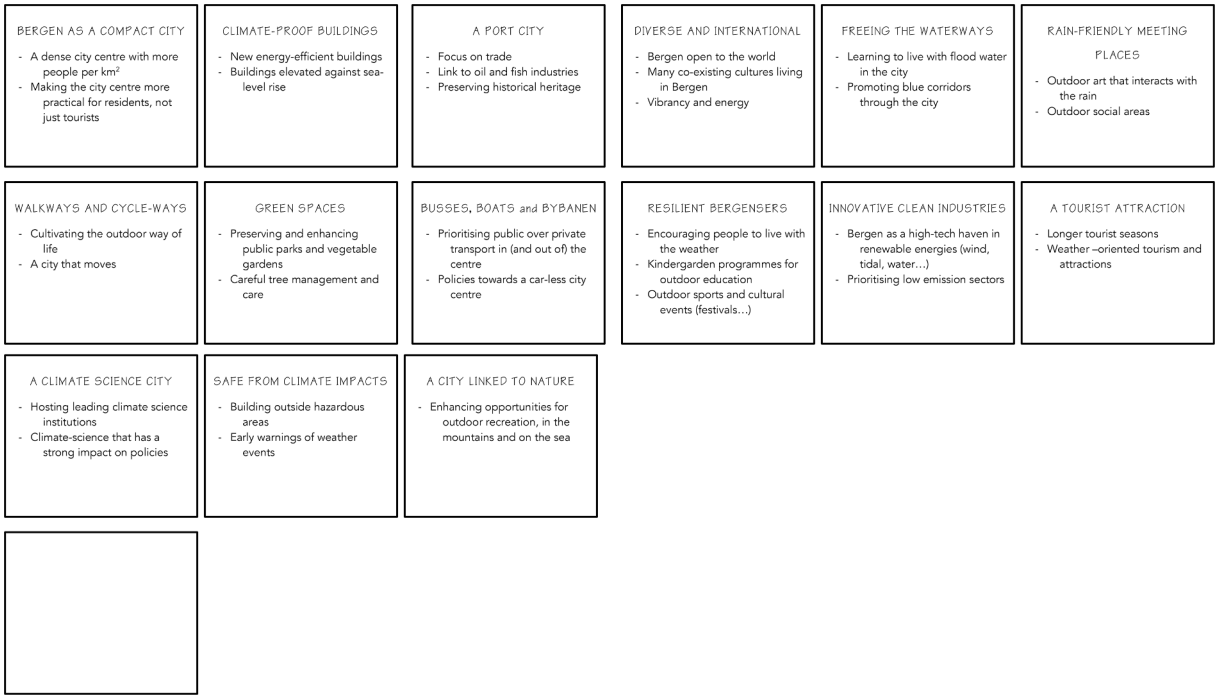

Fig. 2. The 16 pre-written 'dimension cards', to flesh out the scenarios.

the dimensions of Bergens past and present that are considered important for its future (for instance the card 'Bergen as a climate science city' was chosen by all groups).

After developing a detailed future scenario, groups completed an assessment of the situation in Bergen today, relative to their scenario and the five chosen dimensions. In their assessment participants asked, along what trajectory is Bergen developing now, and to what extent is that trajectory likely to see Bergen land on our scenario? They went dimension by dimension and asked for example: 'to what extent is Bergen becoming a climate science city, as of today?'

Groups then moved to the 'back-casting' exercise, and identified steps that Bergen needs to take to move towards a trajectory that achieves their detailed scenario by 2050. Participants wrote and drew a sequence of steps that they ordered chronologically, with attention to the short, medium and long term. All groups noted a large number of steps, which were a mix of actions, decisions, processes and resources (in Fig. 3, the group distilled these as steps and the barriers to these steps). The final part was to assess what was needed to achieve each step. These needs could be anything from climate science and information to material resources and finance, political will, or laws for example (see e.g., the blue 'needs' in Fig. 3). Groups finished by assembling their needs as a prioritised 'wish list'. They went need by need on their back-casting exercise, and ranked them in order of importance for them as a group, for advancing Bergen's resilience.

The workshop finished with participants completing feedback forms, and a commitment from us as conveners to continue the discussions.

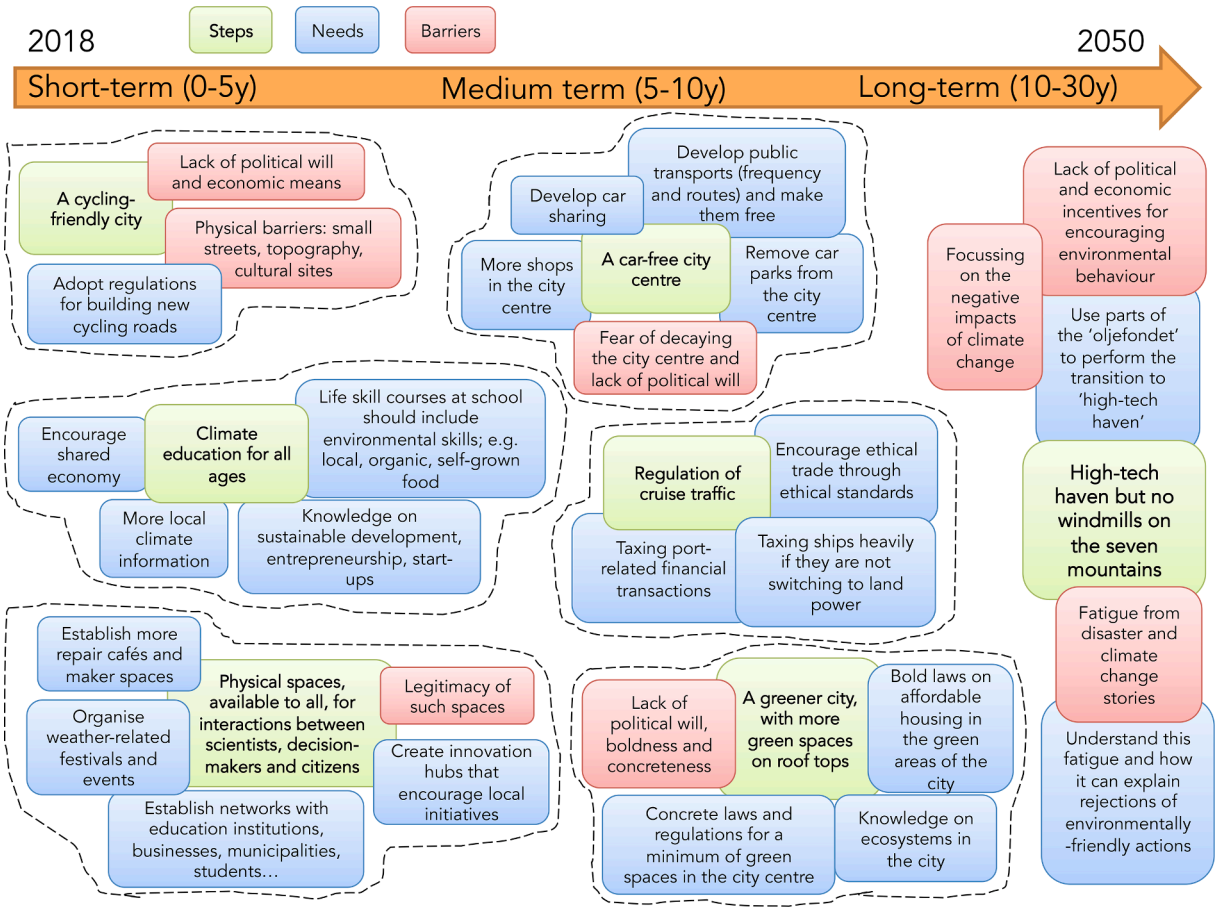

Fig. 3. The back-casting of Group 3 to their vision of Bergen as a 'High-tech Haven'.

Four months later we circulated a report from the workshop and invited participants to an afternoon meeting to discuss the findings over coffee. We also had follow-up meetings with participants from the municipality to ask for their input into enriching and validating our findings. This iterative interaction strengthened the working relationship underpinning the co-creation of our research, adding technical and social robustness.

Climate services in support of a resilient Bergen in 2050

Six dimensions of resilience in Bergen

We interpreted and analysed all content of the workshops together – scenarios, back-casting, wish lists and feedback forms – as qualitative data (Silverman, 2014; Denzin and Lincoln, 2017). Similar to grounded theory (Glaser and Strauss, 2017), we did not overlay any strict *a priori* conceptual frame, and rather sought to see what themes around resilience emerged from the data itself. We conducted two runs of coding the data for emergent themes, and relations between themes as portrayed by participants, e.g. in back-casting. Coding was conducted by grouping printed paper copies of the data on large sheets of paper. The first coding run distilled how workshop participants discussed resilience, as the overarching focus for climate-related information and initiatives. Our analysis revealed six dimensions of resilience – as recurrently referenced and linked concepts – prominent across all groups' work. These six dimensions were recognisable to participants in follow up discussions. The second coding run went back over the data and re-coded it according to these six resilience dimensions, with a particular focus on the 'climate services' discussed relative to each dimension. In a third step of analysis, we interpreted the primary 'function' of each suggested climate service relative to the corresponding resilience dimension. We coined four broad categories of functions according to our reading of some fundamental differences in the purposes of services noted by participants.

The six dimensions of resilience that we distilled included:

i. *Bergen as a climate science city*: climate science and related disciplines are essential to how we plan for a resilient city, demanding both 'new research' and work to better integrate science with decision-making and practice in different institutions.
ii. *Engaged citizens in a healthy democracy*: citizens need opportunities to discuss what climate and other changes mean for Bergen, and what kind of city they want to live in. This includes creating socially active spaces, having a regard for vulnerable groups in decisions, and making changes to the formal decision-making frameworks in local government.
iii. *Resilient Bergensere*: Bergenseres' (residents of Bergen) attitudes to living with the climate affect their resilience, and can be shaped through public climate fora, nurturing extant cultures of living in the rain, but also promoting a greener local economy.
iv. *A city linked to nature*: One of Bergen's resilient features is its link to nature, surrounded by seven mountains and the fjord, and this link can be strengthened through creating new public green spaces, and urban food gardens for example.
v. *Transport in and around the city*: transport is a focus for reducing emissions while improving the quality of life and the environment, and demands urban planning, public transport, challenging a 'car culture', and extending walk/cycle ways.
vi. *Safe and smart buildings*: Buildings' safety and 'weather-proofness' affects their resilience to climate-related impacts like storms,

floods or heat waves; while smarter buildings are more energy efficient and have a regard for emissions over their lifetime.

Eliciting possible climate services according to resilience dimensions

Working within this framework of six resilience dimensions, we summed together a meta-list of all information, initiatives and actions that participants discussed for supporting these dimensions, before refining this list to retain only 'climate services', as defined by Bruno Soares and Buontempo (2019)[4]. This focused on the mobilisation of climate information, and removed other needs such as political will, financial resources or built works. For instance, seawalls and covered walkways are not classed as climate services, because (while linked to climate) they do not relate to climate information provision. This noted, we deliberately employed an inclusive interpretation of what constitutes 'information' and 'decision-making' and arrived at a list of 20 climate services (see Table 2, and a comprehensive list in Appendix A). These services introduced a diversity of creative ways for integrating climate information into existing city governance across a spectrum of institutions. Rather than go through each, we make some overarching observations from participants' discussions during the workshop.

First, participants discussed climate services in a tangle of different decision-making settings, across a broad spectrum of institutions, which together contribute to the city's governance. They conceived of a broad array of possible uses for climate information for very different kinds of decision-making relative to institutions' various rules, norms and cultures. They did discuss climate services as technical evidence for official and explicit decision-making process in formal institutions, for urban planning for example. But they also saw an educational role for climate services – in the classroom or public campaigns – in shaping individuals' everyday personal decisions. And they talked at length about decision-making process in informal institutions like community gardens or repair workshops. This echoes the Urban@UW initiative in Washington, for example; a cross-disciplinary and experimental living lab for engagement and change, employing landscape architecture as a way of thinking (Way, 2020). In short, participants looked beyond formal public decision-making institutions and processes.

Second, we found that participants differentiated between different types of climate services according to the various institutions or social worlds where decisions are taken. Their discussions reflected an understanding that information needs to be translated and tailored to be meaningful to institutions' cultures, so that the same information might be deployed, interpreted, and acted on in quite different ways in different institutions. For example, where resilience is discussed as greater technical understanding of climate and flooding, then services amount to robust scientific studies targeted to policy makers or technicians, like the engineers in stormwater management. But where resilience is about engaged citizens, then services take the form of social spaces for discussing what climate change might mean for Bergen, and particularly its most vulnerable inhabitants. In recognition of these translatory challenges, the Norwegian Organisation of Municipalities has been developing a handbook, for co-creating social innovation in different institutional settings, for example. Participants discussed the creative potential, and diverse forms, of climate services.

Third, we saw that, while participants did discuss *new* technical products, they spent more time discussing ways in which climate information could bolster and extend ongoing initiatives within each of the six dimensions. For this reason, in assembling the list of climate services in Appendix A, we included a right-hand column listing, for each service, existing corresponding initiatives in Bergen (as of 2020) which participants mentioned at the workshop or in subsequent meetings (Bergen municipality submitted several rounds of comments). The workshop discussions invite us to look beyond climate services as 'new products' – state-of-the-art scientific data and analysis and visualisations – to also consider the jumble of ways in which communities and groups are already trying to make sense of climate information and connect it to action. The 'With a Heart for Arendal' network, in Arendal municipality in Norway, is illustrative in that it developed from a national pilot project, via local initiatives, to become a permanent network and meeting place, open to the public to participate in co-creation of local governance ideas (Guribye, 2016). Workshop participants also argued

Table 2
Key dimensions identified by workshop participants of a resilient Bergen and desired climate information (or services) necessary for supporting these dimensions.

Dimensions of resilience	Desired climate services	Primary function (s)
Bergen as a climate science city	A city that hosts leading (international) climate science institutions that provide climate information	Organisational
	An interdisciplinary, cross-sectorial climate science sharing platform, both virtual and physical	Organisational
	Climate-related school courses	Educational
	Public climate awareness campaigns	Educational
	Public conferences for how to plan for Bergen's public spaces under climate change	Social and educational
	Lessons from earlier life in the city – sharing traditional and local knowledge, technologies, and practices	Educational
	Climate-related scientific reports made available for formal public decision-making	Technical evidence
Engaged citizens in a healthy democracy	Physical and virtual social spaces to discuss visions for Bergen's future, under climate change	Social
	Workshops for working on small sustainability-related projects, informed by climate information	Social
	Assessment of different social groups' vulnerabilities in city decision-making	Social
Resilient Bergensers	Rain festivals and events as ways of learning about Bergen's climate and how to live in it	Social and educational
	Art, design and architecture in the city, developed in cooperation with climate science	Social and educational
	Learning about how Bergensers relate to nature, climate and weather	Educational
A city linked to nature	An overall plan for water and wastewater systems integrating climate projections	Technical evidence
	Climate-informed planning of green urban spaces and blue corridors	Technical evidence
	Climate-informed urban food gardening	Social and educational
	Public institutions adopt, learn about and manage green spaces and waterways, under climate change	Educational
Safe and smart buildings	Climate informed processes for making buildings and monuments more weather-proof	Technical evidence
	Structural planning to prohibit building in flood-prone areas	Technical evidence
Transport in the city	Strategic and structural planning for transport, based on climate information and the municipalities' targets for emission cuts	Technical evidence

[4] Note: we will use 'climate services' as shorthand in this section, though participants very rarely used this term.

for mobilising local and traditional knowledge for contemporary decisions.

The diverse functions of climate services

A fourth finding was that the participants' 20 potential climate services foregrounded or prioritised various primary *functions* depending on the functions, rules, norms and cultures of institutions (see Table 2). Table 2 is a summary of the range of primary functions identified, and a more detailed list can be found in Appendix A. Here we make a distinction between emergent *benefits* and purposeful *functions*. Numerous studies assess the beneficial outcomes – as intended and unintended (or corollary) emergent properties – of climate services use within knowledge systems (Bremer et al., 2019a,b; Bremer et al., 2021; Bruno Soares et al., 2018). For example, a probabilistic seasonal forecast for farmers can affect agricultural practices and yields, and in addition have resultant benefits for environmental quality, scientific literacy, social networks, farming cultures and so on (Suckall and Bruno Soares, forthcoming). Benefits then are all the good things we see to happen as a result of actors deploying climate services, many of which are unforeseen and only become apparent with time. But benefits should not only be thought of as serendipitous. Often they result from actors own agency in activating surprising outcomes through, for instance, using a climate service in new or unintended ways.

Functions on the other hand are the planned, intended purposes of a climate service, for which it is primarily designed and against which its quality and 'delivery' is first and foremost appraised. The function predefines the explicit aim and role of the service, as a purposeful commitment to fulfilling some anticipated desirable outcome(s). A product designed for educating school children is fundamentally different in aim and nature to a technical product for sizing stormwater systems, or for organising a network of local experts. For us then, the function of a climate service is the predefined targeted role or outcome it is to fulfil, while its benefits are the array of actual beneficial outcomes that result (including the functional benefits). Notwithstanding this distinction, some services have more than one function, and the boundary between benefits and functions can be fuzzy.

Participants discussed six potential services that could be described as typical *technical evidence*, in that they provide scientific information in a technical format to support formal, highly specialised decision-making process, often characterised by quantitative risk management calculations. This ranged from studies on hydrology and extreme weather probabilities, to risk calculations for designing water systems, projections of climate impacts for urban zoning, transport planning and designing green spaces, or technical information for weather-proofing buildings for example.

Two potential services foregrounded *organisational* functions, in that they sought to establish new organisational structures and actor networks for generating and disseminating climate information, or nurture existing platforms for information sharing. With reference to our sociological framing of institutions and organisations (Scott, 1995), these services seek to formalise relations between groups of actors – e.g. linking scientists and planners in plan-making processes or workshops – in rules and decision-making platforms, towards nurturing alternative logics for appropriate ways to think about and enact resilience in organisations' activities (March and Olsen, 1989).

Participants raised nine potential climate services with a more formal *educational* or pedagogic function, emphasising learning usually through the transfer of knowledge. This could be through setting up school courses on climate, public awareness campaigns, arenas for learning about the local environment and culture, or initiatives where groups can 'adopt' and learn about managing a waterway or green space in a changing climate. Importantly, learning was not limited to the scientific state-of-the-art, with some participants suggesting that a resilient city should re-learn from the lessons offered by traditional or local knowledge.

Interestingly, participants identified seven potential climate services where the *social* function of climate information was emphasised. Participants saw climate science, climate scientists, and climate information as having an important role in enriching the ongoing culturally and politically charged debates around climatic and other changes to the city in both informal and formal institutional settings. They discussed these 'social spaces' as meeting places for a diverse field of actors, where climate information can be put forward as one of many types of knowledge related to matters of concern under discussion. Here participants discussed climate information less as a 'solution' or a 'lesson', and more as providing for well-founded conversations on climate in arenas where people are talking about how they tend their gardens, strive to live sustainably, or portray nature in art and stories. These spaces were likened to ongoing discussion groups in the public libraries or organised by local NGOs, but also raised larger public spheres, like 'rain festivals'. Participants also envisaged workspaces where individuals and groups can work on projects related to improving the quality of life and the environment, through art-science collaborations, makerspaces, or urban gardens. Indeed, climate information increasingly features in these activities.

Foregrounding the social functions of climate services

Rethinking 'information' and 'decision-making' in climate services

This workshop generated some surprising findings for us. We convened governance actors for collaboratively identifying information needs in Bergen, as a first step to reconciling the 'demand and supply' for (scientific) climate information (Sarewitz and Pielke Jnr, 2007). And though we employed a novel approach, we had 'standard' expectations that we would arrive at a list of opportunities for new data, scientific analyses and interpretation, interfaces and visualisations to support formal decision-making, similar to the tools we might see on the European Environment Agency's '*Climate-ADAPT*' platform. What surprised us was that participants raised diverse types of decision-making, and accordingly, different accounts of what constitutes information.

The workshop thus confronted us first-hand with what some other commentators have asserted; that technical climate information (and services) is only the tip of the iceberg (see e.g., Baztan et al., 2020; Daly, 2021; Findlater et al., 2021; Haines, 2019; Turnhout et al., 2020; Vanderlinden et al., 2020). Technical information addresses a narrow spectrum of decision-making, based on a technical rationale and (arguably) a deficit model of information transfer where 'more science means better decisions' (Sarewitz, 2004). But it ignores a broad swathe of other social and individual decision-making processes that draw on information in other ways, according to other logics and rationalities (Dryzek, 1990; Thornton and Ocasio, 2008). Rationalities associated with culture and identity, power and politics, or indeed vulnerability and survival for example. Vandermolen et al., (2020), for instance, identified three broad typologies for how information is linked to decisions, ranging from the conceptual use of information (where information can help enhance knowledge); instrumental use (information is used to inform decision-making e.g., management and operational decisions); and justification (where information is used to further support a decision already taken e.g., investment plan). The point is that to be meaningful for decisions in a wider spectrum of institutions or social worlds, climate services must reconsider what counts as information and how it is availed for 'rational' decisions, considering institutions' different rules, norms and cultures (Scott, 1995).

One illustrative opportunity raised at the workshop was to engage with local and traditional knowledges. Some traditional approaches to anticipating, reading and living by climate and phenological rhythms in Bergen's everyday life – from interpreting winds and lunar cycles to dates on traditional calendars – could offer cues for adapting to climate variability and change (Norgaard, 2011). Such knowledges and practices appeal to more place-based sets of rationalities, founded in

generations of lived experience and culture, which can make them more legitimate for decision-making in certain institutions, for gardening or farming for example (Strauss, 2003). But Klenk et al. (2017) recommend caution in the 'extractive' ways in which local knowledge is currently used in climate adaptation research (e.g. to corroborate scientific knowledge and standards) and the need for a more reflexive attitude regarding the purpose of engaging local communities, how such knowledge is used, how to identify local priorities, and the potential impacts of such co-production processes across "knowledge systems and visions of the future" (Klenk et al., 2017; p. 12). In this context, a key challenge for climate services is to appraise local and traditional knowledges carefully and critically for how well they perform in a changing climate, and integrate them in contemporary ongoing practices (Vogel et al., 2019).

A broader conception of decision-making and information is important because climate adaptation is often recognised as a challenge of governance. This reflects a changing role of municipalities and the public sector more generally, including in Norway, moving from regulatory management via new public management to governance approaches in collaboration with scientific institutions, the private sector and civil society (Kooiman, 2003; Pierre 2000; Rhodes, 1997). The Municipality 3.0 approach, for instance can be seen in many Nordic countries, often linked to the term co-creation (Guribye, 2016; Torfing et al., 2016; Ulrich, 2016). If we recognise the mutual dependence of formal and informal institutions for addressing complex and uncertain climate risks, then we also recognise that it is insufficient to limit climate information to a narrow bracket of formal decision-making bodies.

This whole discussion hinges on how we define climate services, rather inclusively, in this paper. There are networks of climate service scholars and practitioners who espouse a narrower and more technical framing, that begins and ends with climate science (Daly, 2021). For them, local knowledge – for example – is outside the definition of climate services, it is something else. But given the prominence of climate services in science for adaptation, we have to ask what becomes of these marginalised institutions, knowledges and rationalities if they are excluded by definition?

Putting climate services' functions first

One way of broadening conceptions of climate services is to focus on their diverse functions. Our workshop raised four broad functions of climate services – technical evidence, organisational, educational and social – which were associated by participants with how information was deployed, for which decisions, in which institutions. For us, looking at the many possible purposes for providing climate information quickly enabled an appreciation for the potential richness of the climate services landscape. Given the limited scope of our workshop it is likely there are more functions, and possibilities for unpacking these four broad categories.

There has been some work on the potential functions of climate services beyond the technical provision of climate information. Goosen et al. (2014) for example, advance the notion of climate adaptation services "(…) as being an information service supporting the assessment of vulnerability in a wider perspective and includes the design and appraisal of adaptation strategies" (Goosen et al., 2014, p. 1036). In their conception, this type of service is better aligned to spatial planning at the local level. Similarly, Daron et al. (submitted) propose the idea of climate impact services to help inform decisions related to the impacts of specific climate-related hazards. But we argue that these notions still start from the technical (and to a degree the organisational) functions of climate services, unsurprisingly given the genesis and context within which climate services emerged as a field.

Another tendency has been to unpack the diverse benefits derivable from technical climate services. Regional Climate Outlook Forums (RCOFs) for example, are climate services whose primary functions are technical i.e., the production and provision of consensus-based seasonal forecasts to inform decisions but also organisational i.e., through their networking processes and building capacity activities amongst those involved (Gerlak et al., 2020). In some instances, RCOFs can also enact an educational (and even social) function "[…] through processes of knowledge sharing, debate, and dialogue [that] can help stimulate social learning around key topics" (Gerlak et al., 2020, p.778). This is important work that highlights the different aspects of climate information and its impacts in a knowledge system. But it reinforces a bias toward technical evidence functions insofar as social, educational or other outcomes are usually classed as by-products or incidental to a more technical effort (see e.g., Findlater et al., 2021).

A focus on functions forces us to *re-categorise* social, educational or other outcomes from being corollary benefits to being the primary intended purpose of a service, integral to its design, development and quality. This opens up for divergent branches of climate services work, given the social functions of climate information often demand a different *type* of service than technical decisions for example. And as the participants showed, unpacking these functions fundamentally starts from better understanding the potential for climate services to be applied in a range of institutional configurations as well as the context within which climate information can support decision-making and be meaningful to end-users (Bruno Soares et al., 2018; Vogel et al., 2019). The functions that can be enacted through climate services also depend on how the information is expected to be used. The social functions of climate services are particularly important but have escaped notice due to the emphasis put on technical development of new products.

Social climate services

Our findings combine with a growing number of scholars and practitioners (e.g., Baztan et al., 2020; Daly, 2021; Marschütz et al., 2020) arguing for a category of climate services work that foregrounds services' social functions; what we discuss as 'social climate services' (SCS). We foresee a dedicated branch of study and practice devoted to creative ways of transforming climate information in the explicit service of diverse social (and cultural) functions or aims. But what could this category of social climate services contain and what type of benefits could be realised? Workshop participants put forward pragmatic content and we offer a first conceptual sketch of this category.

One aspect of SCS is to empower social groups to voice their climate change concerns (Bremer et al., 2020). People are differently affected by climate change, so it is important to create spaces where they can share their legitimate concerns about what changes will mean for them, and for communities to address matters of concern with care (de la Bellacasa, 2017). Collective processes that enable the voicing of key concerns and vulnerabilities and identifying needs and priorities within communities and user groups should be at the heart of SCS development, provision and access to such services. This is particularly relevant when considering wider issues of equity and justice and the protection of the most vulnerable groups to a changing climate (Webber and Donner, 2017; Bruno Soares and Buontempo, 2019). Climate Assemblies and Juries[5] for example, have been on the rise as a way to help tackle the climate emergency through public deliberation and more democratic forms of policy-making (Shared Futures, 2020; Wells et al., Submitted). Others have written about distress at the prospect of change, including in Bergen (Fløttum et al., 2016), and the workshop saw opportunities for people to 'come to grips' with changes through meetings held at the public library. A related aspect is to understand climate change as part of a bundle of factors that is affecting the vulnerability of groups.

A second aspect of SCS is to nurture learning, less through (educational) lessons or information dissemination, but rather through

[5] Citizens' assemblies or juries (also referred to as 'mini public') are a type of deliberative method for involving and engaging citizens in democratic processes (Shared Future, 2020).

informed social interaction and peoples' practical interaction with the world. Here, notions of social learning are relevant – learning from observing, listening, and debating with others – and so are pragmatic approaches to learning through practice (Reed et al., 2010). One example is a citizen science initiative, where people built and set up sensors to measure temperature and humidity around Bergen and discuss their measurements to make sense of local climatic change. Rain festivals could serve as another example.

Thirdly, SCS can support critical reflection on climate change's reshaping of local cultures, identities, sense-making, and the narratives communities tell about themselves and the places they live. Scholars have analysed how climate narratives are affecting communities' representations of place, appraisal of risks, and self-perceived vulnerability to these risks (Bremer et al., 2020; Marschütz et al., 2020). Workshop participants discussed opportunities for art-science collaboration, exhibitions of art and architecture symbolising local climate, and installations or sculptures around the city.

Fourth, SCS serve a networking function, where groups of people together come to learn about the network of institutions, initiatives and groups that constitute adaptation governance in the city, and forge active and trusting working relationships (Gerlak et al., 2020). Public city planning conferences are a good example here, as are the recurrent 'klimathons', assembling policy-makers and scientists to discuss climate governance challenges in Bergen (Kolstad et al., 2019).

A fifth aspect of SCS is to support groups of people trying out new practices. Some scholars see the key to adaptation is to invest individuals and institutions with sets of adaptive everyday practices and routines (Shove, 2010). Workshop participants highlighted different groups striving to change their practices, in gardening collectives or repair cafés for example. In these settings, climate knowledge is largely tacit and seen in the practical gestures and bricolage of gardeners adjusting to changing conditions through trial and error, for instance.

Taken together, we see social climate services as having a performative impact on social groups, where 'performativity' refers to how language can be a form of social action (Butler, 1997; Bourdieu, 1991) in climate services: the ways knowledge and concepts shape actors' understandings of themselves in their city, facing climate and other changes. For instance, Taddei (2013) argues that climate forecasting is a performative social action. It directly affects the way individuals and groups perceive time. Scholars such as Wynne (2007) further point to the deeper forces shaping scientific understandings and normative representational performances of the 'democratic' publics in public participation in science and technology.

Common to these different applications of SCS is the deployment of climate services as 'technologies of humility'; a term coined by Sheila Jasanoff (2007). These are services that seek to incorporate climate information into groups' ongoing activities – in the garden or at the rain festival – in a way that recognises, "the limits of scientific knowledge and […] when to stop turning to science to solve problems" (Ibid, p. 33). Climate science does provide us with important information and tools for thinking with, but in many informal social arenas, science reaches limits to what it can say, about our fears, our identities, our values or our practical know-how for instance. In these settings, "science offers only part of the picture" (Ibid, p. 33). 'Humble' SCS – whether repair workshops, rain festivals or art installations – means augmenting informed spaces that compel groups to consider the ambiguities and complexities around climate change in thinking about societies' differentiated vulnerability and what is an equitable and just way to act. Humble services enable continuous learning in the face of changing conditions. In this way, we discuss SCS as services that *configure relationships between scientists and social actors, built on technologies of humility, for enriching the ongoing culturally and politically charged debates and practices around climatic change in informal institutional settings*.

Reflecting on the case and the method

The findings from our workshop are undoubtedly a function of the particular case and methodological set-up of our study, and it is worth reflecting on these. Bergen is a quite atypical case, with Bremer et al. (2020) showing the ubiquity of 'climate' in public discourse in the city, reinforced by particularly active climate science and policy spheres. In addition, participants were recognised as well-informed and engaged in climate change-related topics, and many held important roles in the city's governance.

At the same time, our strategy to include voices rarely heard in climate governance fora or public narratives – librarians, volunteers or NGOs – had a bearing on how the workshop unfolded. Including participants active in social and political roles potentially saw more emphasis go to the social functions of climate services than if we had limited participation to scientists, technicians or professionals, who could conceivably have interrogated more technical applications. Our recruitment and scenario exercise also created the conditions for eliciting counter-narratives or dissenting voices to some taken-for-granted worldviews (Turnhout et al., 2020). For example, a public narrative of the hardy Bergen resident, outdoors in all weather (Bremer et al., 2020), often translates into adaptation strategies centred on a close connection to nature and walking. But one migrant participant (Engineer in Group 3) argued that a resilient Bergen should also welcome individuals and groups who do not take pleasure in outdoor clothing and walking in sleet. Interestingly, these dissenting voices were not side-lined in the workshop. Rather, when we had a round of final reflections, it was the climate researcher in Group 3 who first pointed out the predominance of social functions, which she recognised as an important part of her role at the Norwegian Centre for Climate Services.

The workshop approach also opens up for several critical reflections that may have had a bearing on the findings. First, groups were randomly allocated prepared scenario frameworks, but this saw some tension between participants' preferred future scenario and their allocated scenario. Some felt that the scenario was so at odds with their own vision that it was difficult to make it their own. Related to this, the scenarios carry their own assumptions and framings of climatic change and responses, which excluded some responses as beyond the three scenarios scope. Second, the activities were anchored in current climate issues and solutions, rather than unlocking participants' fantasy and opening discussion of possible futures; one participant noted: "It was difficult to keep the focus on the 2050 vision and how to get there. The discussion mostly revolved around the status quo and difficulties with trying to change the course". On one hand, building the scenarios from narratives of Bergen today limited participants' imagination. On the other hand, anchoring the work in lived realities grounded what can otherwise be a fantastical exercise. Third, we adopted a relatively non-interventionist facilitation style that let participants lead their own discussion. One problem with this was that many participants did not endorse their professional role and talked more from a private perspective (which was interesting, but participants were selected for their diverse work lives). Another problem was that discussions often took place at a general level, making it difficult to get to detailed and concrete topics, perhaps because the scenarios were general and the groups heterogeneous. However, it is precisely through those conditions that we got access to discussions on the social (and other) functions of climate services.

Conclusions

This paper reported on research that identified climate services needs for building resilience in Bergen city, through a collaborative back-casting workshop with governance actors. In line with most work on climate services, we expected to elicit a list of (mainly scientific) technical information which could be deployed as evidence for formal city decision-making, for municipal drainage systems for example. But

we were surprised to find that participants held a broader conception of decision-making, as undertaken in diverse institutions or social worlds. Accordingly, they also discussed climate services broadly, encompassing a portfolio of initiatives that foregrounded different functions of climate information and sought to translate it to institutions' different cultures. Importantly, this often meant adapting information to bolster ongoing governance initiatives, in repair cafés or rain festivals, rather than commission new products.

Based on our workshop findings we join our voice to other scholars who look beyond the narrowly conceived functions of climate services as technical evidence, and recognise the other functions and meanings of information in the broad spectrum of institutional settings constituting climate governance. But rather than stretch an already amorphous and ambiguous concept in even more directions, creating further confusion about what constitutes a climate service, we suggested classifying fields of services according to their principal functions. That is, to add precision by distinguishing between functional types of services. From this point, we argued for a field of practice focusing on 'social climate services' (SCS), which foreground the social functions of information in informal institutional settings that facilitate voicing concerns, (social) learning, critically reflecting on culture and identity, building social networks, and trying out new practices relative to climate change.

CRediT authorship contribution statement

Scott Bremer: Conceptualization, Methodology, Investigation, Writing – original draft, Project administration. **Anne Bremer:** Conceptualization, Methodology, Investigation, Writing – original draft. **Lisbeth Iversen:** Conceptualization, Investigation, Validation, Writing – original draft. **Marta Bruno Soares:** Conceptualization, Validation, Writing – review & editing. **Jeroen van der Sluijs:** Conceptualization, Methodology, Investigation, Writing – original draft, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethics statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This project was principally funded by the ERA4CS CoCliServ project (Norwegian Research Council Grant Agreement 274246). The funding body had no influence over the study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

Appendix A. Workshop participants identified potential climate services according to six dimensions of resilience in Bergen, and these were matched to corresponding on-going initiatives already being implemented in Bergen.

Potential climate services identified for supporting resilience in Bergen	Corresponding initiatives currently implemented in Bergen
Bergen as a climate science city	
• A city that hosts leading (international) climate science institutions that provide climate information	• The leading physical climate science institutions in Bergen are NORCE Climate and Bjerknes Centre. • The Research Council of Norway is composed of various research programmes under the broad climate theme. These include KLIMAFORSK, CLIMIT, ENERGIX and TRANSPORT for instance.
• An interdisciplinary, cross-sectorial climate science platform, both virtual and physical, where: o Climate science and other knowledge are brought together to build a comprehensive understanding of Bergen's climate. o Cooperation between science, policy-makers and other social groups is strengthened. This demands incentives for scientists to work in such forum. o Decision-makers have the opportunity to learn about the state-of-the-art climate knowledge and other knowledge sources from different groups.	• Climate research projects that involve Bergen-based municipalities and social groups include SCORE (sustainable urban development in Bergen), BEGIN (creating a resilient and liveable Bergen city), BINGO (sustainable water management in Bergen), ENTRANCE (alternative energy models for Bergen) and CALENDARS (learning to live with climate variability in Bergen). • National competence centres that gather together academic and local governing bodies on climate questions include NORADAPT (Norwegian Research Centre on Sustainable Climate Change Adaptation), CET (Centre for Climate and Energy at the University of Bergen) and NTRANS (Norwegian Centre for Energy Transition Studies) for instance. • The Bergen Energy Lab at the University of Bergen is a forum for networking and sharing knowledge from the business sector and academia, around the topic of renewable energy and energy transition. BEL organises weekly informal lunch meetings and larger half-day seminars. • The think-tank Norsk Klimastiftelse brings together climate researchers, decision-makers and social actors for discussion on topics related to climate change, climate solutions and energy transition around regular climate breakfasts for instance.
• Climate-related school courses o Based on state-of-the-art climate science, by closely involving climate researchers o More practical 'sustainability' courses (e.g., grow your own food, or courses in collaboration with maker spaces, e.g., in coding and other digital skills) o Outdoor education that promotes an outdoor lifestyle, close to nature	• The think-tank Norsk Klimastiftelse provides educational resources for schools, that are based on state-of-the-art climate research. The resources can be found in the magazine $<2^{\circ}$C, on the online school $<2^{\circ}$C skole, or on the klimavakten website which contain infographics of updated climate and energy data. • The Centre for Science Education at the University of Bergen provides online educational resources and tools on sustainable development, on the website Miljølære. These resources are targeted at school teachers and students. • The University of Bergen related kindergarten offer programmes with a focus on the relationship to nature, by creating an environment where nature is a part of the children's everyday lives. • The Bergen Architecture School proposes master's programmes on architecture fitted to the western climate of Bergen, with attention to local material and building traditions.

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Potential climate services identified for supporting resilience in Bergen	Corresponding initiatives currently implemented in Bergen
• Public climate awareness campaigns o To share Bergen-specific climate science; and what climate change means for Bergen o To suggest measures individuals can take to mitigate their climate impact and adapt o That are linked to climate science platforms and social meeting places	• The yearly Climate Festival 112, initiated by the municipality of Bergen and now hosted by the Bergen International Film Festival, looks into Norwegian's commitment to climate change mitigation, and encourages collective action. • NORCE organises academic lunches: open lunch-lectures at the Bergen Public Library to discuss global and local climate change with researchers from the Geophysical Institute, NORCE or the Bjerknes Centre. • The water use calculation tool from the municipality of Bergen helps people understand their private consumption of water and energy. • The green flag is an environmental certification scheme for kindergartens and schools. • Every year for a few days, researchers present their current research to school students during Forskningsdagene (ung). The event is open to all on the following weekend. • WWF associates Bergen Municipality in their national awareness campaigns on waste management and plastic in the oceans. • The Bergen Chamber of Commerce and Industry has launched the #Plastsmart awareness campaign, to raise awareness about plastic pollution. This campaign is a collaboration between business, academia, decision-makers and administration in the Bergen region. • The oljiefri.no initiative started as a collaboration between the municipality of Bergen Municipality and the environmental NGO Naturvernforbundet. It is now a national initiative to help people transition to greener energy and reduce energy consumption.
• Public conferences for how to plan for Bergen's public spaces under climate change	• The City Architect Office and BIFF have started a collaborative, knowledge-sharing platform about sustainable city designs.
• Lessons from earlier life in the city – sharing traditional knowledge, technologies and practices	• The grassroot organisation Norwegian Grandparents Climate Campaign organises climate breakfasts and other events to discuss climate and energy questions, and share experience from older generations.
• Climate-related science to be made available for public decision-making: o Science to inform surface water management – Waterways and run-off – Rainfall – Sea level rise – Flooding – Extreme weather events o Science to inform planning the city's green spaces – Bergen's ecosystems and biodiversity – Food plants able to be planted in Bergen o Science on natural hazard risks – Extreme weather events – Ways of protecting humans, animals and buildings o Science for mitigation – Demography – Transport needs – Consumption patterns – Resource supply – Emissions o Research on science communication o Science on establishing social spaces for dialogue o Knowledge in economics, in particular on how taxes are used for future sustainable projects (and who pays what)	• Science to inform surface water management o The Norwegian Water Resources and Energy Directorate provides resources and knowledge for managing flooding and landslides, in particular through their online flood, landslide and weather risk indicator. o The Norwegian Meteorological Institute provides weather forecasts and warnings for private individuals, emergency planning authorities and government agencies • Science on natural hazard risks o Yr and Storm provide weather forecasts and warnings for extreme events, as well as news and facts related to weather and climate. • Science for mitigation o Transport needs: The National Transport Plan and Regional Transport Plan for the region of Bergen, as well as the national transport habit survey give an overview on the transport measures in place, individual commuting habits, and visions for the future. o Emissions: the think-tank Norsk Klimastiftelse provides knowledge on CO_2 emissions. In addition, the municipality of Bergen's AirQuality in Norway provides warnings and updates on air quality and pollution. • Research on science communication o The LINGCLIM research group at the University of Bergen looks at language and communication around the issues of climate change, energy transition and lifestyle. • Science on establishing social spaces for dialogue o The CALENDARS project at the university of Bergen looks at different institutions' ideas of seasons and whether these ideas are implemented successfully in practice. • Knowledge in economics o The city council for climate, environment and urban development gather knowledge on climate adaptation, vulnerability to climate change and models of circular economy.
Engaged citizens in a healthy democracy	
• More physical and virtual 'social spaces' to discuss the visions for Bergen's future, including under climate change: o Network-building o Making sense of climate change in Bergen o Visions, practical steps and making value conflicts explicit o From neighbourhood to city scale; strong neighbourhood groups o Linked to local decision-making processes	• The Impact Hub Bergen is part of a global network of collaborative spaces where entrepreneurs and social innovators come together to discuss and implement their ideas for a sustainable society. • The organisation Barekraftige liv coordinates networks of citizens in the same neighbourhood around activities that promote sustainability (discussions on climate, repair workshops, urban gardens, etc).
• Work spaces to work on small sustainability-related projects, informed by climate information o Maker-spaces o Repair cafés	• The Marineholmen makerspace in Bergen has hosted CoCliServ workshops on building weather sensors and discussing Bergen under future climate conditions. • Bærekraftige liv organises repair workshops, in particular for clothes, bikes, computers, phones, umbrellas and small objects.
• Assessment of different social groups' vulnerabilities in city decision-making: o based on climate information o involving vulnerable groups to discuss how climate justice concretely materialises in Bergen	• The municipality of Bergen's plan for the city and the community proposes a vision for the city of Bergen in 2030 (green, engaged, compact, diverse, safe and distinctive), as well as presents statistics relative to the demographics of the city.
Resilient Bergensers	
• Rain festivals and events as ways of learning about Bergen's climate and how to live in it	• **Regnfest**, a rain festival that was organised in October 2007, to explore the joys of a rainy weather. It was the only occurrence of such event. o **A 2018 local newspaper article** said that the music festival Bergenfest lost 3.5 million NOK because of bad weather. One of the organisers of Bergenfest said: "It is unreasonable to continue to have such festivals in Bergen".
• Art, design and architecture in the city, developed in cooperation with climate science	• **Rain sculptures** in Skostredet and on Torgallmeningen in Bergen centre, that interact with the rain and make the water visible

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Potential climate services identified for supporting resilience in Bergen	Corresponding initiatives currently implemented in Bergen
o School competitions about art and design related to Bergen's weather	
• Learn about Bergen's culture relative to nature, climate and the weather; how Bergensers relate to their surroundings	• **Kindergartens and schools' programmes for learning about the local environment** (Miljølære, Norwegian Directorate for Education and Training). The programmes have a focus on the relationship to nature, by creating an environment where nature is a part of the children's everyday lives. • **Books and theatre pieces** on Bergen's rainy weather (for instance Regnbyen Bergen and Regn by Stig Holmås) • Ideas2evidence.com is an **interdisciplinary institute** based in Bergen that gives an overview of climate-related data collection, activities and initiatives.
A city linked to nature	
• An overall plan for water and wastewater systems integrating climate projections	• The Municipal overall plan for precipitation takes care of the **management of surface water as a result of precipitation**; this includes the management of areas prone to **flooding**. • The 2019-2028 Plans for water systems in Bergen look at how to **sustainably manage water resources**.
• Climate-informed planning of green urban spaces and blue corridors, to maximise ecosystem services and improve recreational and meeting place values of green spaces o Reopen natural waterways in the city, with consideration for climate, infrastructure, recreation and ecosystems o Climate-informed management of the forest on the seven mountains	• 2018-2030 Bergen municipality strategy document aims to **preserve meeting and recreational green spaces in the city**. • The policy document 'Green strategy for Bergen' and the Municipal Society and Area Plan organise the **zoning and planning for land use; which include considerations for maintaining green and blue areas**. • The Strategy document for **Bergen as a 'walking city'** • 2018-2030 Bergen municipality strategy document aims to ensure a **continuity between 'blue' and green' zones, via corridors**. • **Opening the waterways**: the river in the park of Fyllingsdalen in Bergen will be reopened and trout reintroduced, and the area around redesigned to include a nature playground, an apple orchard. • 2018-2030 Bergen municipality strategy document includes **management plans that have been adopted for the seven mountains around the ci**ty. In addition, the Foundation for Forests and Trees in Bergen relies on volunteers to maintain the nature on the seven mountains.
• Climate-informed planning of urban food gardens (e.g., on roofs, parcel gardens…), and urban gardening practices	• Takhagen på Landås, part of the Bærekraftige Liv Landås neighbourhood initiative, has established **roof gardens** where both retirees and nearby kindergarten children are in charge of growing the food. • Management Plan for Urban Trees in Bergen: this strategy document recommends that both the management and planting of new trees in Bergen should be a priority, and it **explores the feasibility of adding fruit trees in public parks**.
• A scheme where public institutions can adopt, learn about and manage green spaces and waterways, with a regard for climate change	• Management plans for watercourses and adoption schemes for rivers and watercourses by kindergartens and schools
Safe and smart buildings	
• Climate informed processes for making buildings and monuments more weather-proof o Review of architecture of new buildings (e.g., flat roofed houses are more prone to leaking, Bergens housing poorly designed for heatwaves) o Extended risk assessment before building	• Bergen Architecture School includes programmes on designing buildings for the local West Coast climate, and also programmes on reducing emissions from buildings, in their design, choice of materials, building process and use. • The University of Bergen's EnTek building is planned as an innovation hub for work on climate, energy and tchnology.
• Structural planning to prohibit building in flood-prone areas.	• The Bergen Municipality plan for surface water addresses climate risks associated with surface flooding, and how the municipality aims to respond.
Transport in the city	
• Strategic and structural planning for transport based on climate information and the municipalities' concrete targets for emission cuts o Stop work on the E39 highway o A road that bypasses the city centre (especially Danmarksplass) o Build housing near workplaces o Car-free areas in the city centre, with a simpler decision-making process for establishing those areas o Reduce parking spaces in the city centre o Design the city around public transport routes o Improving and extending the network of cycle friendly cycle and walkways in the city, and making them rain-proof and user-friendly (flexible adherence to guidelines: good enough is better than perfect!) o Moving industries outside the city o A denser city centre – A city centre designed for residents, not only tourists (e.g., more grocery shops) – Policies to contain housing prices and make the city centre more affordable for families	• **Stopping roadwork on the E39**: work on the E39 continues, with improvements on the stretch between Os and Bergen. • **Car-free areas and reduced parking spaces in the city centre**: the strategy document for **Bergen as a 'walking city'** encourages planning for the city centre and suburbs as better adapted for pedestrians, to encourage accessibility, well-being, road safety, public health and the environment. • **Design the city around public transport routes**: The city already has a **densification strategy along the light rail**, and now **densification will further be considered along all existing and new public transport routes** through the Plan BERGEN 2030. • **Improving walking and cycling ways**: The cycle ways strategy for Bergen 2020-2030 want to ensure that Bergen has coherent and safe cycling ways, that are maintained all year round, and with good access to bicycle parking places. • **A denser city centre**: Bergen Municipality's Plan BERGEN 2030 includes a project called Sustainable and attractive densification for Bergen, which looks into **densification strategies for Bergen**. o The project Sustainable and attractive densification for Bergen looks at where and how Bergen city-centre can be densified in a sustainable way that attracts residents.

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