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# The EU needs a demand-driven innovation policy for climate services

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ABSTRACT

Climate services have climbed high on the agenda of EU research policy, yet few contributions have reflected on the actual usability of climate services from the perspectives of the intended users, let alone the implications for future EU research and innovation policy. This commentary reflects on four key lessons learnt from engagement in climate services research projects and discusses implications for future EU research policy: i) all end-users have pre-established decision-making processes and tools for their purposes, hence all new information needs to be adapted ii) one size fits none – and tailoring takes time iii) building trust between different actors, processes and confidence in new information is key in the tailoring process – and resource-demanding iv) purveyors and intermediaries can facilitate tailoring processes but need to finance their activities until end-users demonstrate willingness to pay and/or the climate service is readily implemented. The main argument is that more attention needs to be paid to the demand-side of climate services to help viable climate services make it through the innovation "valley of death" – that is, the twilight zone between technical invention and (commercially) successful innovation. EU Research and Innovation (R&I) funding streams and policies for establishing truly transdisciplinary learning loops driven by (actual) user needs can function as vehicles through the valley of death.

## Introduction: The need for a redrawn roadmap for climate services

The EU roadmap for climate services (European Commission, 2015) was launched in 2015 and has been influential in the design of EU research policy, including calls for proposals and the design and execution of Horizon 2020 projects (Street, 2016; Jacobs and Street, 2020). Although the roadmap builds on stakeholder input and emphasizes the importance of co-creation, co-production and iteration between different actors, processes and competences, recent research has concluded that "in theory and in practice, a supply-driven approach remains commonplace" (Daniels et al., 2020, p. 4). This supply-driven thinking is also reflected in a central figure in the EU roadmap (Fig. 1), describing the essence of the thinking behind climate services. The climate science community (notably, primarily the natural sciences) is portrayed as suppliers of information to the user community (note the main direction of the arrows between the main elements in the figure), while social sciences and and humanities are portrayed to provide drivers of "service demand". Moreover, the figure seems to rest on the presumption that there actually is a demand in the user community and does not specify the user community to any large degree. It is also worth noticing that the EU's Horizon 2020 Research and Innovation (H2020 R&I) funding scheme (signified by the upper long, green bar at the bottom) focuses on the supply side.

Although it has been argued in the climate service debate that more attention must be given to the demand-side and users (Lourenço et al., 2016; Jacobs and Street, 2020), literature taking the perspective of actual users and extracting key lessons for policy and practice remains scarce.

## Four lessons learnt for the road ahead

Drawing on empirical social science evidence and experience from several H2020-funded R&I projects, as well as general engagement with climate services processes over many years, we have extracted four general lessons which are relevant for future programming in EU R&I funds. Hereafter, we will present these lessons, followed by a discussion of their implications.

First, practically all end-users have pre-established decision-making processes and tools for their purposes. This means that all new climate

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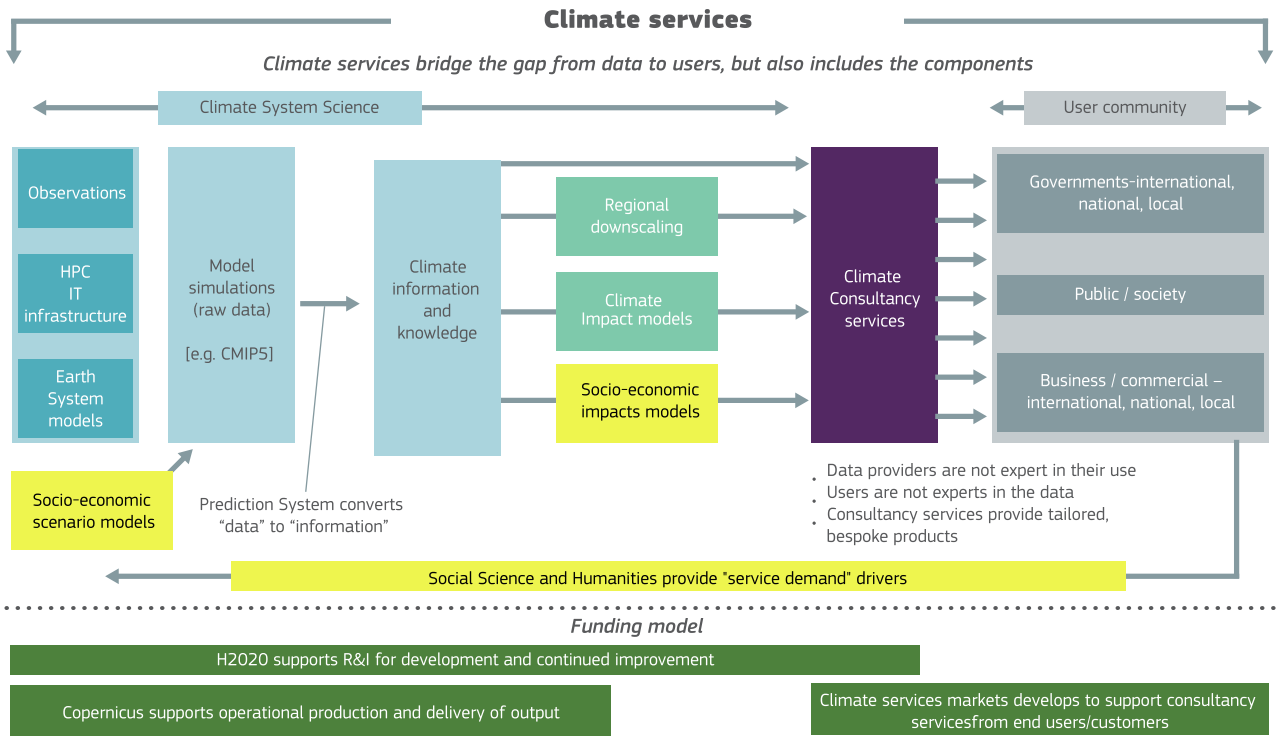


**Fig. 1.** The essence of climate services as illustrated in the European research and innovation Roadmap for Climate Services. Figure: The European Commission.

service information needs to be adapted to what end-users already have in place. Moreover, sometimes end-users are not aware of their needs for climate services, at least not at a very detailed level. Engagement with developers of climate services may contribute to end-users becoming more aware of their own demands, and to establishing new processes where climate services are relevant. These activities are however time-consuming, and end-users do not necessarily have the capacity or willingness to invest in such processes unless they acquire and/or allocate dedicated resources for this purpose. Recognizing these basic points is crucial to enable the development of usable climate services.

Second, since all end-users have unique decision-making contexts, – chains and tools, it is clear that – in terms of climate services – one size fits none. Instead, for climate services to become usable, they need to be domesticated and adapted. The value of climate services is critically dependent on the end-user's tasks, risk-preferences and risk-management goals. While some climate services may be relevant for larger groups of end-users, many climate services need to be adapted to existing practices among end-users. Moreover, climate is only one of the numerous variables affecting decisions and it has different weights in each of them (cf. Bruno Soares and Dessai, 2016). In practice, end-users typically combine information from various decision-making tools. Thus, acknowledging and nurturing processes of *domestication*, that is, how use of information and technology is context-dependent and shaped by specific practices, is key in building usability (Sutcliffe and Ortega Alvarado, 2021; cf. Sørensen, 2006). End-users already know the strengths and weaknesses of their existing tools and information well. New information is therefore often used qualitatively, to compare and benchmark what they already use. Many end-users have ambitions to integrate new climate information in their decision-making chains, and to use it in quantitative terms. However, they test and validate new information rigorously before (if at all) incorporating the new information into their decision-making processes and -chains.

Third, a key issue in domesticating new information is trust among actors in the process, and trust in the very process itself. Building mutual bonds of trust, both between developers and end-users of climate services but also between people and departments in the end-user organization domesticating the new information, are key in building usability of new information. Similarly, building confidence in the new information is key to usability. Many users are typically most familiar with weather forecasts that offer deterministic (and daily) forecasts, or perhaps statistical models based on historical averages. Shifting mind-sets and operations towards probablistic forecasts over longer time horizons is a major challenge, and limits users' ability to trust climate info. Thus, clearly expressing forecast reliability (probability and skill) is a key element to this issue of end-user trust. In this process, end-users appreciate iteration with the developers of the climate service, who can provide technical support and customer service. Many end-users also have crucial ideas on how to improve climate services which are relevant for the developers of climate services. Thus, iterations between different actors and steps in the process is key.

Fourth, there is room and need for dedicated intermediaries (also called purveyors, boundary workers/spanners/organizations, knowledge brokers etc.) to engage in the development and customization/tailoring of climate services. Such intermediaries often prove to be crucial in building usable climate services. They have key roles in: Adapting information to local practice, determining the best method to deliver information (choice of media, visualization, choice of variables etc.), ensuring the scientific information is comprehensible, establishing the timing of delivery, clarifying the limits of forecasts and so on. No (potential) customers have the exact same needs, and there are resource constraints (both in terms of time and money) regarding how far researchers and technical developers of climate services can engage with potential end-users of the climate service. However, intermediaries also depend on having stable financing to carry out their activities. In general, all the processes described in these four lessons are time-consuming, and time is a scarce resource in most organizations.

## Concluding discussion: How can climate services make it through the valley of death?

Against this backdrop, we suggest that future EU R&I research policy and – funds, such as provided through the Horizon Europe Framework

Programme, should focus more on the end-user's actual needs. The European Innovation Area currently being developed should encompass climate services, and policies for fulfilling the targets of the EU Green Deal should support the development and uptake of climate services. In short, the EU needs a demand-driven innovation policy for climate services.

Specifically, more funds need to be allocated for chartering the "last mile" of climate services, that is, the gap between useful technical inventions on the one hand, and usable, (commercially) viable innovations on the other (Lemos et al., 2012; Brasseur and Gallardo, 2016). It is also important to note that not all climate services are meant to be commercialized. Climate services as a public good, supported by public funds, are pivotal for achieving adaptation and mitigation goals and ensuring the well-being of all. In other words, there is a need to take a broader view on climate services and see their development and deployment as part of broader societal processes towards sustainability, far beyond climate adaptation and mitigation only. This raises an important question if a private market for climate services could ever (or should) emerge without public funds if it does not also serve more overarching societal benefits (e.g., through open access data and tools).

Ultimately, the eventual success of building a market (both commercial and non-commercial) for climate services will be determined by the demand-side, both in the private and public sector, and the degree to which the supply side will be able to respond to user needs and demands. Our evidence and experience suggest that climate information provided through standardized climate services is often not necessarily seen as directly *usable* (i.e., applicable and fit for specific problem solving) by end-users. Instead, end-users see the new information as *useful* in qualitative terms, along with already existing tools and information. *Scalability* is an important issue in this regard. For some end-users, general and standardized climate services may be a useful compliment to existing information and decision support. Other end-users may have more specific needs. For highly specialized end-users to be willing to pay for and/or put the new climate service and information into use, including in more quantitative terms (which is a goal for many end-users), the information must be transformed from useful to usable (Lemos and Rood, 2010; cf. Dilling and Lemos, 2011), which often requires further support and tailoring of the information.

The idiom of co-production (Jasanoff, 2004) is often invoked as a strategy for producing usable climate services, but co-production is not a silver bullet for resolving all the challenges associated with developing usable climate services. Our experience is that even co-designed, co-produced scientific state-of-the-art climate services and related products are not enough to put the services into direct use. This observation is supported by the literature (Briley et al., 2015), also by recent contributions: "Information and products are generally presumed or incentivized to be a singular end product (Harvey et al., 2019), an outcome often delivered and tailored by scientists who do not always fully appreciate the potential needs, context, goals or capacities of the people they seek to help" (Daniels et al., 2020, p. 4). There is a rich and burgeoning literature on co-production, including practical advice based on empirical research (Bremer and Meisch, 2017; Bremer et al., 2019; Miller and Wyborn, 2020; Turnhout et al., 2020; Norström et al., 2020; Chambers et al., 2021). However, although co-production has become common terminology to describe the development of climate services, the literature on co-production seems to only have had limited impact on the very practices of co-producing climate services (Vincent et al. 2018; Soares and Buontempo 2019).

Professional climate services intermediaries may facilitate iteration between different actors, reconcile supply and demand and build usability through tailoring, but adequate initial investment is needed. End-users are not necessarily willing to pay or invest in terms of time spent before they get to try, test and validate the service. Because of this catch 22-like situation, readily developed climate services risk stranding in the innovation "valley of death" (Auerswald and Branscomb, 2003), that is, the twilight zone between technical *invention* and (commercially) viable *innovation* (cf. Brasseur and Gallardo, 2016). Future EU R&I funds should therefore be programmed to make sure that potentially (commercially) viable innovations make it through the innovation "valley of death". This can for instance be done by developing calls for innovation funds where climate service intermediaries in partnership with user partners can seek funds to tailor climate services to specific end-user needs, thereby potentially increasing their usability. This may positively affect the willingness to pay and/or make investments in terms of time spent, and thus pave the way for a potentially (commercially) viable market or demand for climate services in the medium to long term.

A solid exploitation plan for the legacy of R&I projects on climate services is only a necessary but insufficient condition for climate services to become truly usable for end-users. The ultimate test for climate services is the end-users' eventual willingness to make use of (and in relevant cases pay for) the services. We argue that EU R&I funds for climate services have so far not focused sufficiently on the "last mile" of climate services, i.e., how to put the services into operational use. A useful thought experiment could be to flip the thinking around: To establish usable climate services and a potential viable market for them, we need to walk the *first mile* as seen from the perspective of the end-users, that is developing products and services that they are actually willing to put into use (and in relevant cases pay for).

This needs to be complemented by policy incentives that underpin the need for climate services. A prominent example are the activities of the Task Force for Climate-related Financial Disclosure (TCFD) that created a demand in the financial sector for information on the physical impacts of climate change on their assets and resulted in a legal mandate for climate-risk disclosure from financial institutions via Article 173 of the Energy Transition Law of France (Clapp and Sillmann, 2019; de Bruin et al., 2020). Another example of policies driving the demand for climate services the EU's Risk Preparedness Regulation, requiring the European Network of Transmission System Operators for Electricity (ENTSO-E) to conduct seasonal assessments of expected power demand and associated security of supply, driving a demand for use of weather data. A third example is the EU taxonomy for sustainable finance currently being developed, putting pressure on funders and investors to proof their decisions in terms of sustainability, including climate change. Such policies can foster the development and deployment of climate services.

Consequently, future EU research policy generally needs to focus and direct more funds to the demand-side of climate services, starting with more focused efforts on transdisciplinary scoping and co-design of research programs and calls. Seed funds need to be made available for co-exploration and development of transdisciplinary research proposals, as the groundwork for usability is often laid in the proposal development phase of R&I projects. Currently, proposal developers lack sufficient time and resources to enable "true" co-design of R&I projects on climate services, which is where the use potential as seen from the perspective of end-users is sown. Drafters of EU calls for R&I funding should pay special attention to the critical phase after R&I projects have ended and must further acknowledge and accommodate for the fact that climate services need to be maintained, further developed, and customized to user's needs. More funds for the exploitation phase are therefore key, in particular tailoring services provided by intermediaries, together with easily accessible open-access data and knowledge. Importantly, intermediaries are also users of climate information. Arrangements for sharing risks and costs between developers, intermediaries and potentially interested customers of climate services need to be developed accordingly. As the "last mile" is focused on the exploitation of the research and innovation done in R&I projects and requires a particular expertise and end-user interaction, it should receive additional attention by the funding agencies, for instance in terms of complementary exploitation grants awarded to most promising R&I outcomes. End-users should have a say in which exploitation projects receive funding.

In the original EU roadmap for climate services there is room for

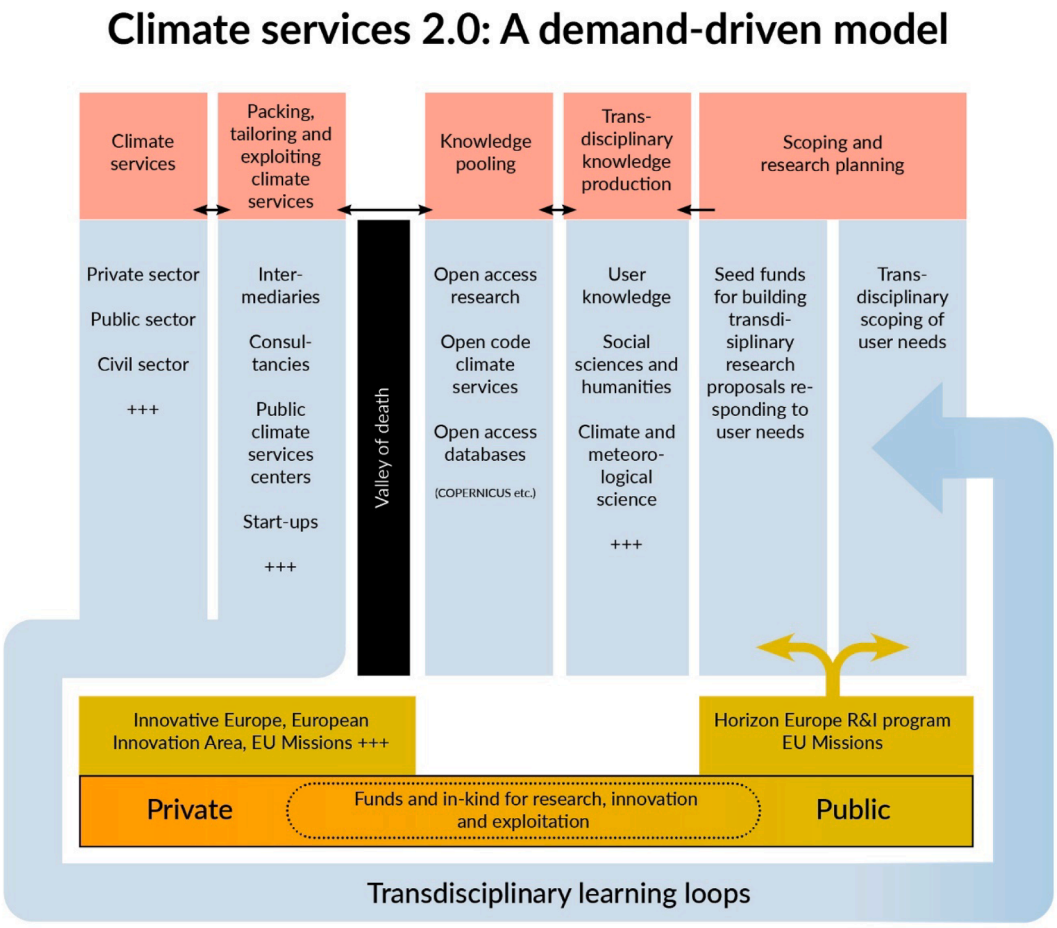


**Fig. 2.** A sketch for a user demand-driven model for climate services, illustrating the importance of innovation policies and R&I funds for viable climate services to survive the innovation valley of death. Figure: Erlend A. T. Hermansen and Eilif U. Reed.

more attention to the demand side, but the timeline stops in 2020. EU R&I programs (e.g., Horizon Europe, particularly EU Missions, Innovative Europe and the European Innovation Area) need to continue the timeline for climate services, and potential funding for more demand-driven innovation and exploitation needs to follow suit.

To return to our starting point and illustrate our main point to develop successful climate services, the figure in the EU roadmap for climate services should rather be flipped around – into a more demand-driven and iterative approach, driven by user needs as illustrated in Fig. 2.

In this scheme, the role of social science and humanities should go beyond being "service sciences" to natural sciences and economics, and instead be integral part of a true transdisciplinary approach, where also the expertise of end end-users is understood as equally valid (cf. Soares and Buontempo, 2019). That also implies that users need to be open to co-exploring new areas for climate services and their potential applications, drawing on lessons from best practice in innovation (Kolarz et al., 2015). Only by establishing truly transdisciplinary learning loops – that is, reconciling demand and supply of climate services through transdisciplinary and iterative co-production – we can ensure that publicly funded climate services survive the valley of death between successful technical invention to successful (commercial) innovation. To meet the goals set out in the EU Green Deal, EU R&I policy should reflect these lessons. The new focus on EU Missions, Innovative Europe and the European Innovation Area (EIA) seems a good start, which needs to be followed up by relevant calls for proposals.

Against this backdrop, we have the following recommendations for future programming of EU R&I policies for climate services:

- When developing Green Deal policies the EU should include a perspective on how climate services can support these policies, and pass regulations supporting the development and uptake of climate services.
- Seed funds for climate services innovation and exploitation should be allocated in implementing the Horizon Europe R&I program, in particular with regard to EU Missions and the Innovative Europe pillar, including the European Innovation Council.
- Climate services should explicitly be encompassed under the European Innovation Area framework currently being developed.

## 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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