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How much unnoticed merit is there in climate services?

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ABSTRACT

The European Union and a growing number of its Member States have become active in promoting and funding the development and to some extent deployment of climate services. Despite significant progress in the creation of large high-quality open access repositories of basic climate data and despite the growing number of pilot projects with more tailored co-designed climate services for various sectors, no real breakthrough in the uptake of climate services has been witnessed. Two projects EU-MACS and MARCO, funded from the EU H2020 programme, assessed what the obstacles to uptake were and how these could be alleviated. This article discusses main outcomes from these projects, with special attention for the need to better underpin the concept of climate services and the justification to promote their use, e.g. by means of the merit good concept. The projects also identified the need for a climate services market observatory. Other articles in the same special issue provide more in-depth insights regarding several subjects.

Practical implications

Climate services comprise a broad collection of information service products. This diversity implies plenty of opportunity for innovations and business development. Yet, the diversity in products is plagued by lack of standardization in terms, product categorisation, and quality assurance, etc., which seriously hampers uptake of these services. At a more fundamental level this diversity is also a signal of a lack of unifying views regarding the concept of climate services, the role of public and private actors in the development and delivery of these services, and the amount of (public) effort needed to decisively improve the uptake of climate services. The current definitions of climate services and of the entire domain of activities ('market') are rather ad-hoc. We make a plea for the use of the **merit good** concept as point of departure for coherent strategies and policies, and a sound basis for valuation of climate services and for justifying public support and promotion efforts.

The projects EU-MACS and MARCO identified a collection of obstacles regarding the uptake of climate services. To resolve these and thereby promote use and further development a set of policies and measures was identified. Obstacles were identified in three domains, demand related obstacles, supply related obstacles and obstacles regarding matching of demands and offers. The main obstacles at the demand side have to do with lack of incentives to use climate services, typical short-term orientation in a sector, lack of awareness (of climate risks or of climate services), lack of risk management into which climate service can feed, and so far available impact projections suggest minor risks for that user. At the supply side the major obstacles include the lack of packaging climate information as a service, insufficient resourcing of product development and delivery, lack of understanding of user needs and characteristics, and lack of business model development among public providers. Obstacles affecting matching are among others unclarity regarding the fitness of the service for the user's decision process, mismatches in temporal and/or spatial resolution offered and desired, lack of guidance or consultancy, mismatches in culture and language of user and provider, lack of overview of climate services on offer and users seeking.

These and other obstacles can be overcome or at least significantly alleviated by means of packages of policies and measures, including the following items:

- establish regulation on mandatory climate risk reporting, transparency, and accountability:
- enable, incite and support collaboration between different types of actors, notably also across the public – private divide; recognize the supportive role of brokerage and market place facilities for climate services in this respect;

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- especially public actors and public-private collaborations should adequately and timely assess realistic and viable resourcing/business models for the stage of regular climate service provision;
- monitoring and ex-post evaluation of climate services use and its effects, of which the results are public, with the aim to inform policy makers as well as providers and users, while inter alia also enabling to demonstrate the benefit generation capacity of different types of climate services for different types of users – this set of tasks would be handled by a so-called market observatory;
- standardization, such as of terms, product categories, and product ratings, and quality assurance which is also relevant to current and prospective users, should be pursued by the entire climate services sector;
- open and affordable data policies, in line with EU directives, should be rigorously pursued by all Member States; open data does not need to be always equated with free of charge, but data should be affordable for all relevant users; recognize the supportive role of brokerage and market place facilities for climate services in this respect;
- foster innovation in climate services along the entire value chain, including – inter alia – sufficient emphasis on climate knowledge and innovation across different academic curricula (natural science, technology, economics, social sciences, medicine, law).

1. Introduction

Throughout society, in practically all countries around the world, climate change has gotten attention in the public and private sector, often leading to specific new public policies addressing the mitigation and adaptation sides of climate change, which in turn need informational underpinning from 'climate information and services' (Jones et al., 2014) The private sector has gotten active too, showing an increasing understanding that it should better shed against risks as well as better prepare for new opportunities (CDP, 2018). Despite this notable increase in attention for climate change and willingness to act over the past years, the transition from overarching strategies to concrete implementation plans, regulations and measures is still quite slow (EEA, 2018). Hence there is a need to step up action. This is where climate services come into the picture. Climate services can inform the decision-making processes in the public and private sector in order to enable better outcomes.

Climate services are in the first place thought to be relevant for adaptation, but they can also serve a part of the mitigation plans and actions, such as for renewable energy planning and operation. Furthermore, quite some users of climate services may have other or additional motivations for using climate services than preparing for climate change (Tart et al., 2019; Perrels, 2018). Apparently, quite different conceptions of what a climate service embodies, can be found among providers and users of climate services, as well as policy makers. This diversity may create a lot of opportunities, but it is suspected to be also one of the reasons why the uptake of climate services is proceeding slower than expected (Lourenço et al., 2016; Vaughan et al., 2018).

Two H2020 projects EU-MACS[1] and MARCO aimed to clarify the workings and remedies regarding these obstacles as well as provide insights in how the market for climate services could develop assuming more and less optimistic assumptions regarding the alleviation of the obstacles and enablement of the drivers for uptake. This article synthesizes some of the main findings and messages.

In the MARCO project the emphasis was on (1) getting overviews per user segment (often but not entirely related to economic sector definitions) in terms of current levels of engagement, user needs, supplier diversity, and experienced shortcomings, and (2) assessing what the current market volume of climate services might be and how it may expand, notably for selected user segments. The overviews were generated by means of conducting on-line surveys to which relevant target groups were invited to participate, as well as by conducting interviews among both users and providers of climate services (Tart et al., 2019; Cortekar et al., 2019; Bater, 2018). These assessments provide a mapping of current market structure ('who is using what, provided by whom'). As regards market volume assessment, on the one hand an approach applying market intelligence algorithms was explored (Howard et al., 2019) and on the other hand for selected user segments the evolution of drivers of demand for climate services were assessed and tentative demand growth scenarios generated for these segments (Bay and Halsnaes, 2018; Bay and Domgaard, 2018). Both lines of investigations were steered by the hypothesis that expansion in the use of climate services comes from resolving gaps at the provider and user side in the current market as well as from turning opportunities into climate services.

The EU-MACS project aimed to assess what obstacles are encountered by users and providers in the climate services market and how these relate to various drivers (or absence thereof). Complementary to MARCO the prime ambition was to better understand the mechanisms behind enabling, disabling and boosting obstacles, the relations across obstacles, as well as between obstacles and drivers. The higher degree of interaction with stakeholders meant a focus on just three user segments (finance, tourism, urban planning), plus the provider side. EU-MACS applied surveys and, in particular, interviews and workshops. Even though some interviews had a more generic overview character, most interviews and notably the workshops were aimed to get deeper insight in why obstacles existed and in what way these could be relieved (e.g. Damm et al., 2019; Giordano et al., 2019; Hamaker-Taylor et al., 2018). The investigations were inspired by transaction cost theory, modern public choice theory and constructive technology assessment (Perrels, 2018; Stegmaier and Visscher, 2017), while applying the PESTEL categorization[2] (Cortekar et al., 2017) and customized interactive formats (Stegmaier and Visscher, 2017; Hamaker-Taylor et al., 2018), next to living labs (EU-MACS webpages; Giordano et al., 2019).

In EU-MACS these methods were applied to tease out more in-depth insights on obstacles and their root causes, as well as to explore attractiveness of certain solutions. A multi-stage synthesizing analysis was carried out, which is further discussed in Section 3. Subsequently, building on an internal workshop, policy scenarios were designed which aimed at enhancing the use of CS under different types of governance regimes (Stegmaier and Perrels, 2019). The policies were composed from the earlier identified policies and measures, and the governance regime specific effectiveness was rated. Owing to space limitations the policy scenarios are not further discussed here. A separate, yet to be published, article will be dedicated to this topic.

To the extent possible, the projects have been mutually using outcomes from earlier Tasks and Deliverables in each of the projects. An example of this is the comparable categorisation of providers in both projects. This was initially developed in EU-MACS, but with a clear view to the work in MARCO. This enabled the combining of results regarding the positioning of the various providers along a simplified value chain for climate services (see Annex 1). A far more substantial effort was the joint synthesis report of the projects (Perrels et al., 2019) built around three themes, being (1) linking the analysis of obstacles (EU-MACS) to the analysis of market prospects (MARCO), (2) underpinning the idea of a market observatory (MARCO) with assessment of the business model – market organisation combinations and of climate policy alternatives (EU-

[1] EU-MACS: EUropean MArket for Climate Services; MARCO: Market Research for a Climate services Observatory.

[2] PESTEL: referring to Policies (governance), Economics, Science, Technology, Ethics, and Legislation (regulation).

MACS), and (3) identifying additional recommendations, on top of each project's recommendations, following from the synthesis. The second topic will be discussed in Section 3 of this article, whereas the third will be integrated into a presentation of key messages and recommendations. The first topic requires too much space to be discussed here, while aspects of it are dealt with in other contributions of this special issue (Howard et al., 2019; Perrels in this issue).

A frequently occurring, pervasive, issue is the broad diversity of interpretations of what a climate service constitutes (Vaughan and Dessai, 2014; Bessembinder et al., 2019). The mere unclarity of the term appears to put off quite some potentially interested users (Bater, 2018; Perrels, 2018), whereas at the same time it causes misunderstanding and some degree of distrust within the climate service expert community. Whereas Bessembinder et al. (2019) discuss the case for a clearer and generally accepted taxonomy, Section 2 of this article discusses the problem and consequences of the broad inclusiveness of the term, and it suggests some ways to deal with this diversity.

Several other contributions to this special issue deal with key prerequisites for significant growth of the CS market. Therefore, this article deals with a few clusters of critical issues not so much discussed in the other articles, in particular the linking of encountered shortcomings to underlying causes, and the diverse understanding of what constitutes a climate service.

The rest of the article is organized as follows. In Section 2 the alternative understandings of the concept of climate services and the consequences thereof are discussed. Also a few suggestions how to deal with it in practice are put forward. This section also indicates what the consequences are for what is understood as 'the market for climate services', which by itself has also consequences for how promotion of climate services is framed. In Section 3 the main obstacles and (disabled) drivers and remedies and their interrelations are discussed. Section 4 reflects on the likely benefits for policy making of underpinning the concepts of climate services and markets for climate services with the theoretically founded notion of a merit good. It also reflects on the concordance of the findings of the two projects, and concludes with presenting the key recommendations regarding enhancement of the use of climate services. Concise conclusions are presented in Section 5.

2. The varied understanding of the concept of climate services

2.1. Observing the differences

Providers, developers, users, potential users, and other stakeholders turn out to have different understandings or expectation of the notions of 'climate service' and 'market for climate services' (e.g. Georgeson et al., 2016; Cortekar et al., 2017; Stegmaier and Visscher, 2017; Larosa and Perrels, 2017; Howard and Howard, 2018; Bay and Halsnaes, 2018; Bruno Soares et al., 2018). Vaughan et al. (2018) also discuss inconsistencies for WMO/GFCS when comparing the use of term – through case examples – and the definition by the same organisation. Skelton et al. (2019) discuss the related confusion regarding conceptualization of 'users' in the emerging climate services complex in Switzerland.

Even when discussing the concepts with a more narrowly defined group of (potential) users, the perceived scope of a climate service can vary significantly (e.g. Damm et al., 2019; Tart et al., 2019; Hamaker-Taylor et al., 2018).

Differences in interpretations will continue to hinder researchers and policy makers in making comparisons and inferring conclusions, such as regarding the understanding of the market size and growth potential of climate services, as well as the appreciation of relevance and severity of obstacles to uptake of climate services. This is illustrated in various project reports (Cortekar et al., 2017; Larosa and Perrels, 2017) and articles (Cortekar et al., 2019; Tart et al., 2019; Howard et al., 2019). These publications show that categorization of different actors in users, providers or otherwise is not straightforward, and associates with how wide scoped one wishes to define a climate service, while it also depends on the moment (year) of studies owing to the evolving nature of the climate services market (new products, new players).

By and large one can observe that actors of which the core activities concern production and first line reprocessing of basic climate data tend regard climate services mainly as a data provision-oriented service. Yet, the overall value chain of climate service portfolios is much longer (see Annex 1 for more detail). Equally important is the interpretation of the service nature in the case of climate services. A significant share of the efforts in the emerging climate services market concern product development efforts rather than regular service provision activities (Larosa and Perrels, 2017), although the distinction between these can get blurred (see also Larosa and Mysiak, 2019). Lack of recognition of the differences between service development and service provision as well as pertinent, and effectively limiting, conceptions of what is a climate service will often lead to inadequate service delivery models (business models) of climate services. In turn this makes it appreciably more difficult to better match supply to demand for climate services in certain use contexts.

In the interactive stages in EU-MACS the understanding of climate services came up both in interviews as well as workshops targeting the three focus user segments and the providers of climate services. Both the surveys and the semi-structured interviews did include questions aimed at understanding the degree of affinity with climate services and the scope of use (Hamaker-Taylor et al., 2018; Cortekar et al., 2017; Gregow and Harjanne, 2019).

2.2. Different concepts of climate service and consequences of the diversity

The probably most frequently adopted definition of climate services, at least in Europe, is the one presented in the European Roadmap: "The transformation of climate related data – often together with other relevant information – into customized information products, offered as such or embedded in consultancy and/or education [condensed version of the definition]" (European Commission, 2015). The Global Framework for Climate Service (GFCS), initiated by the WMO, uses a mixture of text and infographics to introduce the concept, but the message boils down to the EU definition. In the Fifth Assessment Report of the IPCC (WG2), 'climate information and services' are very broadly defined as "institutions that bridge generation and application of climate knowledge" (Jones et al., 2014). In EU-MACS the definition of climate service used the Roadmap description as guidance while building on definitions and categorisations of earlier studies (Cortekar et al., 2017), (see Annex 1).

Important concerns regarding the broadening of the scope of what can be regarded as climate service are (1) that 'all-inclusiveness' threatens to make the term 'climate service' meaningless as it can mean almost anything, and (2) that – in the absence of common transparent standards and quality assurance – the broad scope and high diversity makes it hard to judge the relevance, quality, and skill levels of offered expertise and experts. The latter concern is the theme of the article by Bessembinder et al. (2019). In the EU-MACS study, the former concern was tackled by introducing the notion that, regardless the importance

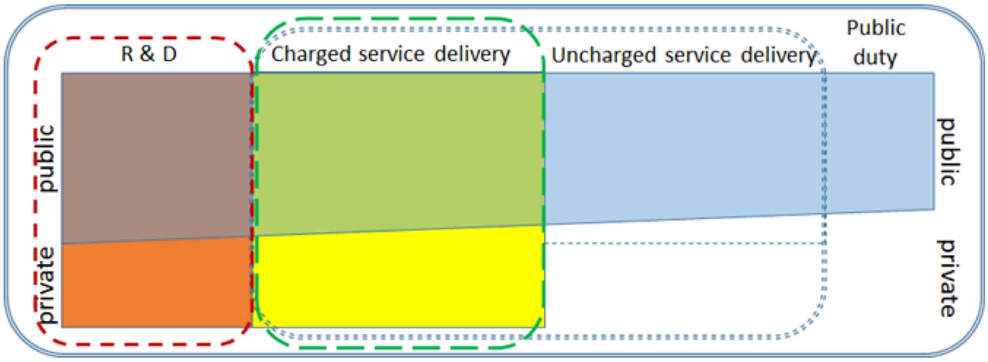


Fig. 1. Different delineations of what is captured by 'market' for climate services.

of the added non-climate information, the role of climate information should remain sufficiently crucial in order to qualify as a climate service (Larosa and Perrels, 2017). It was also emphasized that different development layers of climate services exist, beginning with historical – observation based – statistics. Next to provision of historical statistics and related indicators, seasonal climate projections, with a range of about 2–12 months, are climate services. Most prominently, at least in terms of attention value, are the emerging climate services for long term, climate change adaptation support, often extended to impacts. There is also emerging a forecast capability regarding multi-year events, such as for El Niño (ENSO) (Barnston et al., 2017; Trenary et al., 2018).

In the MARCO project, the definition of climate services was guided by the need to operationalize a transaction-based service identification approach, i.e. based on registered delivery of such services identifiable from statistics and other sources of information on realized transactions (Georgeson et al., 2016; Howard and Howard, 2018; Howard et al., 2019). Supporting transactions, e.g. in relation to observation capacity (also) used for climate services, are in that approach identified as climate services. Eventually, transactions are identified as climate service when various specifically defined sub-sectors conduct transactions of which auxiliary information indicates that it concerns climate services. This approach includes only certain segments of the climate services 'market' in a broader sense as represented in Fig. 1, but at the same time seems to overattribute activities as climate service as understood in the EU-MACS project and in the EU Roadmap (Perrels et al., 2019). This also means that diversity in the understanding of what is a climate service ties in with the views regarding appropriate organisational structures for climate services. This article has been – so far – using the term 'market' in a rather flexible way, meaning that also public, uncharged, service provisions are included. Text Box no.1 discusses this in more detail and thereby illustrates that there can be quite different appreciations of the size of the climate services market. In situations where we wish to avoid the term 'climate services market' 'climate services complex' is used.

The distinction in climate services so far presented is largely supply side driven and mainly based on temporal categorisation of observations and projections of climate phenomena which, in turn, can be loosely associated with user need theme areas. From a user perspective and hence at least partly from a service-product profiling and clustering perspective, climate services can also be categorised by main and subthemes based on the main motivating themes (drivers), such as Disaster Risk Reduction (DRR) and Sustainable Development Goals (SDG). These two thematic examples also underline that the (initial) motivation for using climate services can be rooted outside the realm of climate change and variability proper.

Climate services can also be regarded as part of the servitization trend (Harjanne, 2017), of which the concept of 'energy services' (e.g. Fell, 2017) can be regarded an early and somewhat related example. Elaborating on this notion is the view that 'service' – as in the case of climate or energy service – is a knowledge-intensive activity (Schricke et al., 2011) that entails growing volumes of communication and interaction between – an often growing number of – involved actors. Many contemporary climate services may be expected to depend on co-creation and co-operation (Vaughan et al., 2018; Oudshoorn et al., 2008, 2003; Hyysalo et al., 2016). From this follows that the distinction between service provider and service user becomes blurred or layered, i.e. participating organisations will often become both providers and users, albeit with more emphasis on one of the two roles.

The above discussion on servitization and complex cooperation already referred to both co-creation and co-operation (i.e. joint provision). Yet, development of a climate service means that there is not yet a climate service-product available that can be provided regularly. The various surveys and interviews in MARCO (Bater, 2018) and EU-MACS (Cortekar et al., 2017; Larosa and Perrels, 2017) projects provided indications that for various product-market segments the distinction between development and regular delivery is not clear cut, e.g. when each service delivery occasion entails significant tailoring and use of advanced expertise. In the context of the value chain, the development of new tools or methods can be understood as important investment in the entire climate service delivery infrastructure, and therefore as a climate service of sorts, even though it should be regarded as separate from the climate services market proper.

Some experts consider the basic observation system and its immediate output, often largely owned by public meteorological and hydrological agencies, not as a climate service (e.g. Hamaker et al., 2017). However, others, such as many meteorologists, hydrologists, and climatologists would regard the separation as problematic, if only because some monitoring services can feed directly into climate services (Gregow et al., 2016) or constitute climate services themselves. The above co-creation argument about user inclusion could just as well be used also for these public agencies from which the raw data come. In other words, even though a part of the observation system is outside the realm of climate services, significant parts (incl. e.g. many satellite systems) do intentionally serve (also) climate services (Hamaker et al., 2017).

Box 1
Delineating the market(s) for climate services.

Essential for a market is that there are transactions, and by extension prices. Climate services are delivered as a (charged) market product, as uncharged – yet transaction like –public service, and as part of a public duty without the notion of a transaction. The latter happens when a public agency is supporting – as a public duty – other public bodies. Public bodies often deliver services to citizens free of charge. At least a part of these deliveries has transaction features (e.g. as data downloads), and thereby such an activity could be considered an extended concept of a market, i.e. public sector deliveries that emulate transactions. Despite the absence of a market price, they may still have an implicit price for the user, if somehow a cost can be attributed to the search and acquisition effort (Perrels, 2018). This practice is similar to the concept of 'generalized transport cost' in transport economics (e.g. de Jong, 2015) and stems from transaction cost theory (e.g. Williamson and Cheng, 2017).

Delivery of climate services can be based on sequenced and/or collaborative processes. As a consequence, the number of transactions and involved turnover increase much faster than the value of the climate service. Furthermore, subsidies and in-kind elements can further obscure proper representation of prices and market volume. Also a large share of the R&D work for developing climate services should be separated, if one wishes to know the volume of regular service provision (market volume). Fig. 1 summarizes how different actors and experts may understand what activities are covered by a climate services market. There is public and private provision of climate services. When 'market' is used as a catchword, all the activities shown in Fig. 1 are included. If product development is seen as distinct from service delivery, the climate services market proper gets reduced to delivered climate services, of which public duty could be taken out as being unattainable for market provision. Finally, in the narrowest sense, the climate services market only concerns charged services.

2.3. Conclusion on key terms

All in all, we conclude that the understanding of what constitutes a 'climate service' and what a 'market' for climate services is, is very hard to unify into one sweeping definition. Instead of imposing one view, it seems wiser to make explicit what one's choices are (in given contexts), and what the grounds for these choices are. Over time, and in relation to policies which have to define boundaries, a further harmonisation will probably arise. This harmonisation can be promoted through standardization initiatives (Bessembinder et al., 2019). For comparison, one could be referred to the term 'energy services', which experienced a similar plight, but nevertheless became a more or less accepted term, which however still highly benefits from being clarified when used in a certain context (Fell, 2017; Kindström and Thollander, 2017).

3. Obstacles and remedies

Over the years a collection of studies has been reporting on shortcomings in the emerging complex of national and international climate services (Hewitt et al., 2017; Brasseur and Gallardo, 2016; Lourenço et al., 2016; Vaughan and Dessai, 2014; Máñez et al., 2014). The analysis in EU-MACS, supplemented with the wider scoped market scanning information from MARCO, has the ambition to systemize the overview of obstacles and understand the underlying causes. We present here the summary results of the synthesizing assessment of obstacles based on two internal workshops, one joint workshop with MARCO, and a two-stage internal survey aimed at rating different obstacles. The first internal workshop included group work to come to an agreement regarding an initial list of shortcomings and underlying causes and an initial clustering of these. Transaction cost theory was used to underpin this approach (see also Annex 2).

Fig. 2 summarizes the synthesis workflow within EU-MACS. It should be noted that many of the internal EU-MACS experts also took part in MARCO and therefore included the experiences of that project in the feedback provided in EU-MACS synthesis process. The input for the first consultation round was a draft list of shortcomings and underlying causes and an initial clustering of these in shortcomings.

The consultation process, applying series of questions plus a rating exercise of identified shortcomings, aimed to capture the factors behind not realized (latent) demand and latent supply (in terms of content or way of provision). The draft list was edited. Some items were added, a few merged or reformulated. Encountered shortcomings, being obstacles (e.g. lack of budget or lack of user need orientation) or disabled drivers (i.e. absence or even disablement of incentives to account for climate risks, regulation discouraging PPP) are allocated to three

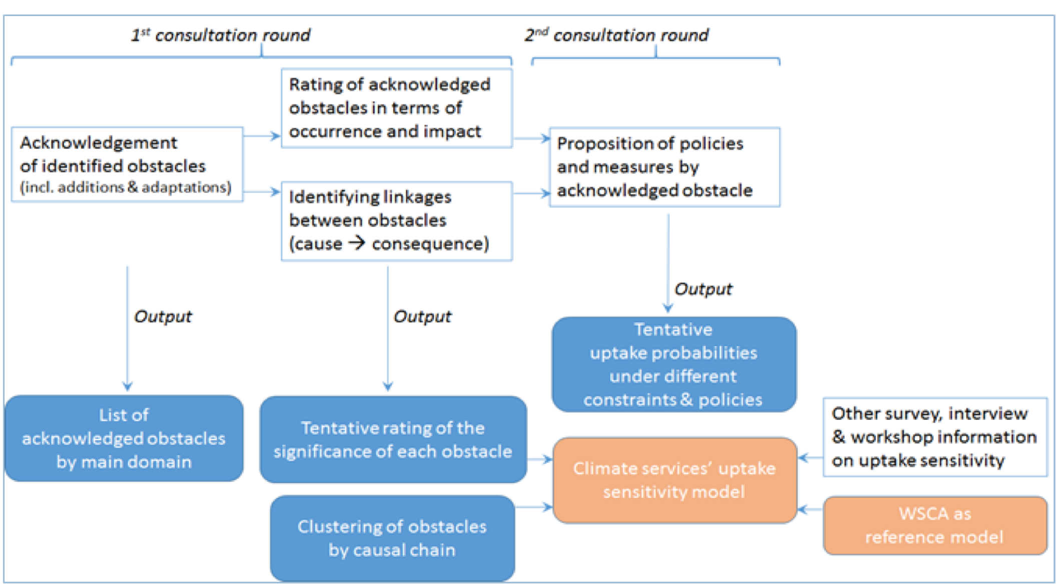


Fig. 2. Synthesizing analysis of obstacles and drivers in EU-MACS.

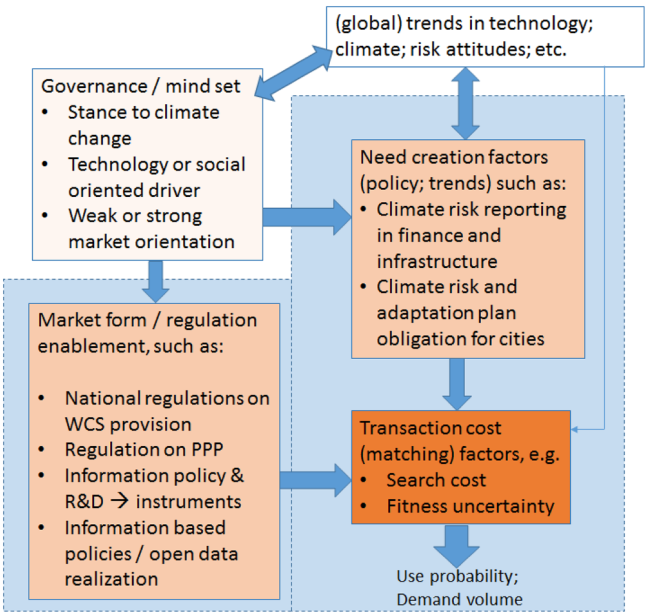


Fig. 3. Main domains driving use probability of climate services.

domains, being (1) those rooted in demand (user) side features, (2) those rooted in supply (provider) side features, and (3) those arising when supply (provider) and demand (user) try to match. Obstacles at the supply and demand side are more fundamental and affect also the way the more operational obstacles of the matching domain occur. The interplay between these domains together with the steering effect of overarching governance approaches and structures leads to a certain probability of uptake of climate services (Fig. 3). By adding the pace of climate change, growth in (exposed) assets, and (protective) technology development the development in use volume can be captured. Yet, this last step is not discussed in this article.

After a final set of obstacles by domain was agreed the project partner experts indicated for each obstacle by focus sector and overall what their rating of the obstacle was in terms of frequency (how often encountered among surveyed/interviewed actors) and in terms of significance (impact on probability of use, if obstacle relevant/occurring). For frequency a four step rating was used, being (1) seldom ($<10\%$ of relevant actors); (2) not so often ($\geq 10\%$ – $<40\%$ of the actors); (3) quite often ($\geq 40\%$ – $<85\%$); (4) most, if not all relevant actors. As regards significance, also four steps were distinguished, being: (1) marginal; (2) moderate; (3) notable; (4) (very) substantial. For illustration purposes the resulting scoring for demand side obstacles is shown in Table 1, for selected user segments. The tables for the supply side and the matching domain are shown in Annex 3.

In a subsequent exercise these obstacles were assessed regarding their relations within and across domains, and eventually their relations to underlying causes, such as missing or wrong regulation. Firstly, for each obstacle clarifications were written. Table 2 illustrates this for a few selected obstacles in the demand domain.

The argumentation used for each of these obstacles, together with prior analysis of the possible underlying causes per domain, can be used to analyse cross-causation (Fig. 4). For example, when just trying to provide up-to-date information in order reassess implications of obstacle 1 in the above table, one should check whether that stance is reinforced by a short term oriented business model (obstacle 2), and whether – even if obstacle 1 would be alleviated – the organisation has the capacity to exploit the information contained in climate services. In turn, it may be that rather than turning around each organisation in the sector individually, it would be much more effective to change regulations such that obstacle 4 (incentives) is turned into a driver. Going through the causal flow diagrams provides clues for the building blocks of a comprehensive policy to promote the uptake of climate services. Packaging of measures is however complex. Therefore, this subject is not discussed in-depth in this article.

Eventually a selection of obstacles by domain was identified, which were regarded as most crucial to be tackled. Furthermore, key public policies as well as organisational measures were identified which are needed to effectively resolve or at least alleviate these obstacles. These selections are presented in Fig. 5. The reasoning for the selected policies and measures is as follows:

- lack of incentives should be tackled by means of legislation on accountability and reporting transparency regarding exposure to climate change risks, this also tackles short term business orientation at least to some extent;
- problems related to lack of awareness, inappropriate data, and to some extent to resource limitation can be alleviated by adequate open data and affordable data policies and related practical tools and portals; standardization in terminology, climate services categorization, and quality assurance also help to resolve this;
- inadequate climate service portfolios, unappealing climate services, lack of tailoring options and consultancy should be typically tackled by diversifying business models, for public, private and cooperating public-private service providers and users;
- the widely felt lack of transparency and overview, which makes strategic decision making on climate services development challenging, would be greatly alleviated by the creation of market observatory (see text box), whereas also the standardization, as mentioned in the 2nd bullet, is helpful for this problem area.

Table 1
Averaged ratings of project internal experts, based on surveys, interviews, workshops and prior experience.

Demand	ALL	tourism	Priv. banks
(preliminary) impact projections are of minor importance compared to many other risks	12	12	9
inherently short term oriented business model (ruling out adaptation CS)	12	16	9
no clue about how such information could be used in decision making (i.e. no risk management)	10	9	12
lack of awareness of climate change or (seasonal) climate variability or climate information (as regular input for decision making)	9	9	9
lack of incentives (e.g. if costs are (expected to be) fully compensated)	6	6	10
perception that responsibility rests fully on other actors	6	9	6
denial of climate change	4	4	1
acquisition and/or use of CS is expected to be too expensive, leading to reduced or non-exercised demand	2	4	1
(public) acknowledgement of climate risks is seen as risky for (local) business development (e.g. tourism)	1	6	1
perception that there are no response options (fatalism or gambling)	1	9	1
lack of internal coordination	*		8

*Only reported for the financial sector, but supposedly also relevant in other large organisations.

Table 2
Example of clarification of causes and links by obstacle (Source: Perrels, 2018).

Demand	Clarifications
1. (Preliminary) impact projections are of minor importance compared to many other risks	This could be regarded as a certain stage of awareness where acquisition of rational information led actors to conclude this way (rightly or wrongly). The actors should at least update this assessment regularly. This point may appear active in combination with no. 2
2. Short-term oriented business model (ruling out adaptation CS)	For several sectors commercial product lifetime cycles are short, whereas drivers of demand are mobile and volatile. This is typically the case in tourism and leisure services, while also the downstream parts of food production chains are to some exposed to this. All these examples are easier to sensitize to seasonal CS, but have difficulties to identify benefits of adaptation oriented CS. Also parts of the finance sector have a short-term focus as leading adage
3. Lack of awareness regarding climate change or (seasonal) climate variability or climate information (as regular input for decision making)	Lack of awareness refers to the impression that it is not so relevant for the organization, while this not being based on proper knowledge; somehow in the priorities the topic never gets high enough – which may happen more in SMEs; the existence of climate change and variability is usually not denied, but gets only attention in acute situations; a fortiori awareness about climate services (both adaptation and seasonal) suffers from the same perceived irrelevance frame
4. Lack of incentives (e.g. if costs are (expected to be) fully compensated)	This refers to economic (dis)incentives (e.g. when risks can be transferred), legal (dis) incentives (e.g. when there is no obligation in planning), and social (dis)incentives (e.g. high vs. low reputation risks); the (absent) source can be internal (objectives & norms) and external (inadequate legislation); the latter is more likely for adaptation oriented CS, but also possible for seasonal CS
5. Acknowledgement of climate risks is seen as risky for (local) business development (e.g. tourism)	Actors are well aware of climate change, but there are fears that high awareness among customers may lead to behavioural adaptation to the detriment of the sector (in that region). This is encountered in tourism, but also an issue in climate change exposed yet peaking real estate markets (e.g. Miami). This is less relevant for seasonal CS. This position is often linked to no. 6 and can be maintained by the situation of no. 4
6. Perception that responsibility rests fully on other actors	As consequence of or prelude to no.1, or to support the stance of no. 4, this view can arise, which makes such harder to incentivize unless legally made accountable

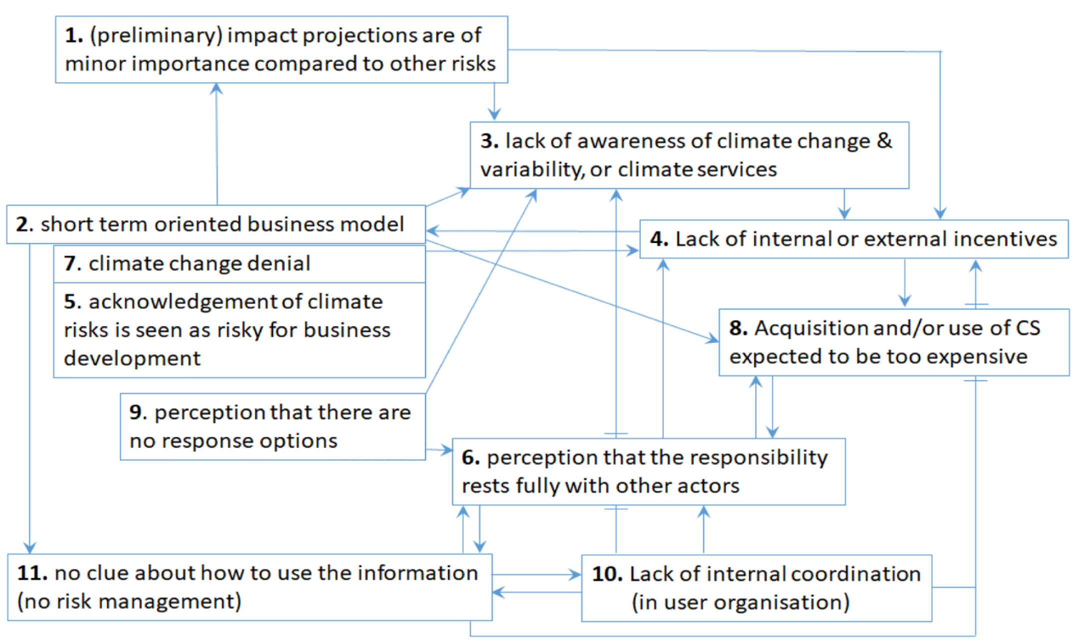


Fig. 4. Causal relations between demand domain obstacles.

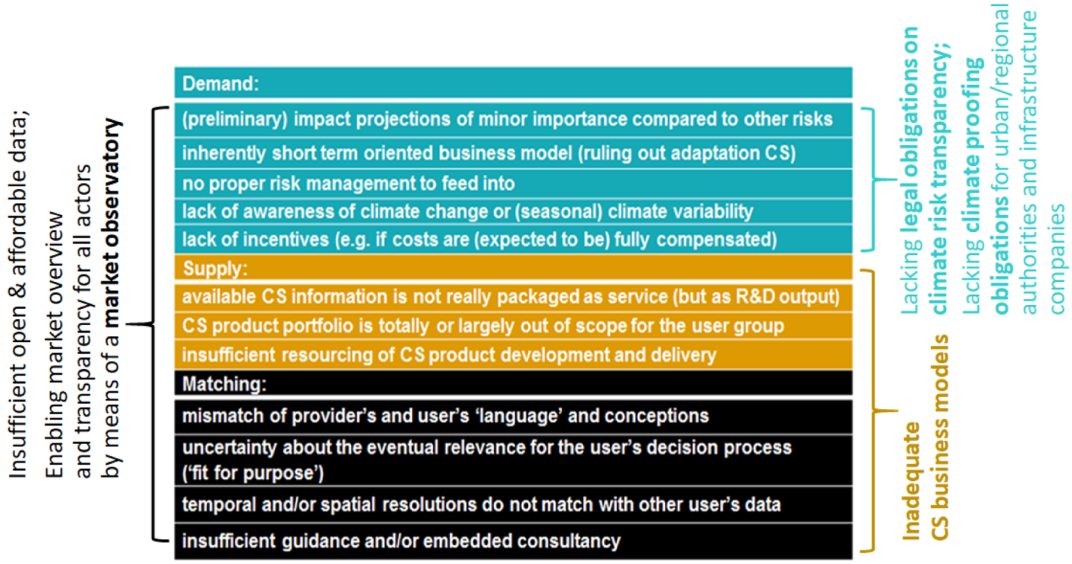


Fig. 5. Summary list of most significant obstacles and related underlying missing or inadequate drivers.

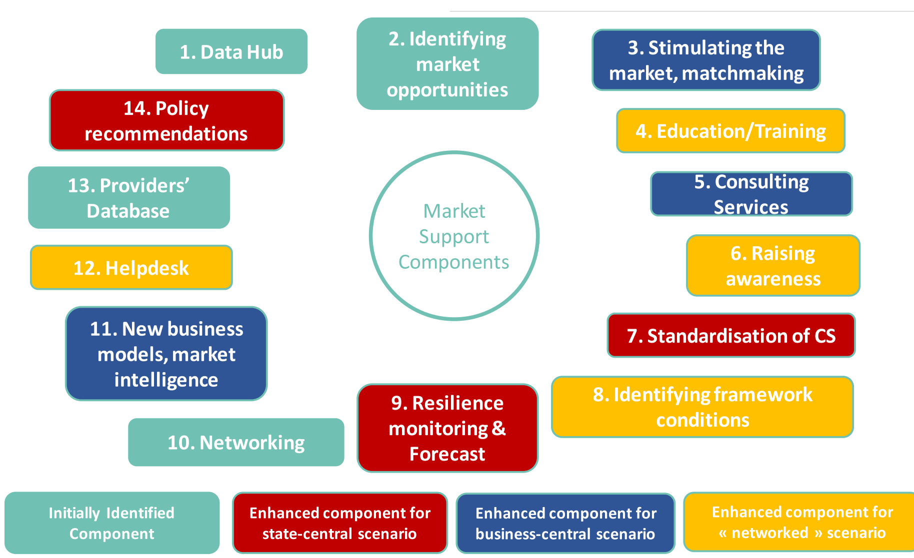
Box 2
Market observatory.

Full development of the climate services market is currently hampered by the lack of insight in, and overview of the market across all types of actors. The understanding of what a climate service constitutes varies widely, as do indications of experts, active in different segments, on what are crucial next developments in terms of products and supporting innovations. While sharing information could improve the insights and overview and better guide product development efforts, it may also result in raising the competitive edge of competing actors. In order to resolve the dilemma, the MARCO project recommended the creation of a 'climate service market observatory' (even though it should combine features of an observatory and a community platform). The possible functions, resourcing, delivery models and governance (supervision) were assessed. A list of 14 market support components was identified, based on preceding work in the project and an internal workshop.

between them in more seamless ways, and more substantially developing by itself parts of the landscape where the current offer is much more fragmentary and incomplete. A wide margin of progression is needed to increase consistency across the market of climate services and understanding of the market for all categories of providers, purveyors, users and decision-makers.

Three alternative governance regimes in which climate service promotion policies can be deployed were developed in EU-MACS (Stegmaier and Perrels, 2019), termed 'state-centred', 'business-centred' and 'network-centred' respectively.

In the 'state-centred' scenario, public authorities are the main driving forces behind the market for climate services. They would contribute to the international standardisation of climate services and the observatory would be in charge of the (sectoral) standards establishment processes. It would also perform resilience monitoring to track and measure the socio-economic and environmental benefits of quality assured climate services; forecasting components would enable better long-term planning and fostering systemic thinking to address climate change in-



Depending on the component, the role of the observatory would vary between clarifying the information landscape, articulating existing mechanisms and facilitating navigation

dependently from particular interests. Policy recommendations and evaluations would be provided to better support decision-makers and ensure progressively stricter regulations towards climate-resilient economies.

In the 'business-centred' scenario, the private sector is leading the innovative developments in climate services. The observatory would stimulate the market and foster matchmaking by offering a creative space where climate service providers, purveyors and users could directly interact. It would ensure that the latest developments feed into comprehensive market intelligence and promote new, innovative business models that could attract new investors. Brokering and other consulting services would be developed to offer advisory and tailored support system to private businesses that are willing to implement climate-proof options.

In the 'network-centred' scenario, the civil society is the key driving force behind climate action. The observatory would contribute to raising awareness, showcasing communication products and highlighting successful case studies. Education and training features of the observatory would play a critical role in building competences. The observatory would have a role of identifying framework conditions, focusing on the enabling conditions required to develop, provide and promote high-quality climate services. Any interested stakeholder in climate action and risk management could benefit from the helpdesk of the observatory, so as to identify appropriate existing services and to link with knowledgeable experts.

Considering both the individual stakeholder feedback and feedback during outreach activities our overall impression is that many agree that some kind of observatory would be definitely welcome. However, opinions differ regarding the exact mission and collection of tasks.

3.1. The benefits of showing the benefits

In the above discussion of obstacles and remedies, one remedy was not mentioned, namely the provision of ex-ante indications of expected benefits of climate services for users. It distinguishes from the other remedies as not being a policy or an organisational measure, but rather a tool, which can be used by climate service providers in conjunction with their service offers. In addition, evaluations of net benefits could be carried out at more aggregate levels as policy monitoring devise, e.g. as part of the market observatory operations. Both in MARCO and EU-MACS feedback from (potential) users clearly indicated that vagueness and/or high uncertainty regarding the size of the benefits is a characteristic of most climate services and has significant impact on the willingness to start using climate services. This should not come as a surprise as for weather services was already found earlier that evidencing the benefits increases interest and promotes development of new or better services (Perrels et al., 2013; Anderson et al., 2015).

Climate services help to engender benefits, but the resulting benefits of adaptation, to which the use of climate services has contributed, should not be entirely attributed to the used climate service(s). The challenge is to identify the *differential effect* of using (better) climate services as compared to using none (or inferior). No use of climate services does not necessarily mean that an actor has no information.

For example, in adaptation cases, climate services can help to better scale and sometimes stagger a preventive investment. The net benefits consist of saving on investment cost minus a slight increase in expected damage in case of prevented overinvestment (i.e. Nurmi et al., 2019) and of avoided expected damage minus extra investment cost in case of prevented underinvestment. Yet, in many cases the size of the expected benefits is quite uncertain or relatively modest compared to the overall use cost. Furthermore, climate services may feed into a wider scoped strategy than just one particular measure. The more concrete the decision context is, the better benefits can be defined and assessed quantitatively. Therefore, it will usually be easier to assess the benefits of seasonal climate services as compared to adaptation-oriented climate services. In this special issue a separate article by Perrels discusses benefit valuation of climate services more in-depth.

4. Discussion

Even though it was argued in the introduction that the rising need for adaptation to climate change implies a rising need for climate services, this does not automatically justify unlimited public resourcing of climate services. As a kind of side information various interviewees, workshop participants, and survey respondents in EU-MACS and MARCO indicated implicitly or explicitly their view or expectation that the provision of climate services was to be mainly a public sector task. On the other several others seemed to lean to the view that the provision of climate services will become mostly a private sector activity, apart from basic climate information provision, such as climate observations and statistics as well as climate model (GCM) projections. To some extent these different views can be related to the type of climate services a stakeholder has primarily in mind, with seasonal climate services associating more with a larger role for market-based services. As these views were less critical for the main purposes of the interactions, and to retain some focus in the interactions, we mostly did not elaborate on this issue in the interactions. Nevertheless, we conjecture that in the background these different visions on the role of the public and private sector further complicate the harmonisation of the concept of climate services, and of related notions ('users', 'market', etc.). We argue that there is a strong case for defining climate services as a **merit good**, which is applicable both in public sector-oriented and in market-oriented governance approaches. A *merit good* (Musgrave, 1959, 2008) is a good or service which can engender more societal and private benefits than (initially) recognized, and hence is easily undersupplied and -consumed, if its provision is entirely left to the private sector. This notion applies for example to education, (preventive) health care, transport safety, etc., and arguably also to many segments of the climate services market.

By adopting the merit good-principle a clearer set of coherent guidelines can be developed with respect to how much public policy effort seems justifiable and what issues should these policies address. In the climate service policy scenarios of EU-MACS (Stegmaier and Perrels, 2019) we illustrate that a climate services policy, motivated by the merit good principle, can be created in different governance approaches, thereby having a common ground and still allowing for differentiated levels of effort at member state level. Merit good properties offer justifications for public action and support for the promotion of the use of such goods, even though individual scholars may have different stances on the degree of admissible coercion and on the optimal provision of a merit good (Ver Eecke, 1998). In the case of climate services both *public resourcing* to enable at least minimum levels of provision and development of CS as well as *regulation,* to clarify accountability for climate risk management and thereby motivate the use of climate services, seem to be called for. Practical policy making will be greatly helped, if the merit of climate services can be approximately quantified. As noted earlier also for the uptake of climate services at individual level ex-ante benefit indications are helpful.

It appears to be extremely difficult to generate consensus valuations of the volume of the climate service market. One reason for this is the variety in conceptions of what should be included, as was discussed in Section 2. Another reason is the public good status of a significant part of the current climate services deliveries. As a result of the previous two reasons accurate observation of deliveries gets very difficult, and consequently widely varying estimates occur (i.e. Howard et al., 2019; Perrels et al., 2019). However, one could argue that the disagreement on the current size doesn't matter so much, as there seems to be more agreement on the approximate prospects for growth. It is desirable when over time better estimates would arise, and, again, for this purpose the market observatory would be a very helpful facility.

Looking at the key messages of the two studies, it appeared that they accorded quite well. For example, in the MARCO Deliverable 5.1 (Bater, 2018) concerning the synthesis of all 10 case studies a set of observations and recommendations is presented which can also be found in the

EU-MACS Deliverables. In summary the following array of policies and measures is seen as most crucial for ensuring better uptake of climate services across different user segments:

- establish regulation on mandatory climate risk reporting, transparency, and accountability:
  - o especially in the financial sector – both for own so-called macro-prudential reasons, as well as mediator through which other segments (as clients) will be obliged to engage as well;
  - o for urban planning, critical infrastructure companies, and environmentally risky activities, such as mining, through recurrent climate risk assessments and related adaptation plans;
- enable, incite and support collaboration between different types of actors, notably also across the public – private divide; recognize the supportive role of brokerage and market place facilities for climate services in this respect;
- especially public actors and public-private collaborations should adequately and timely assess realistic and viable resourcing/business models for the stage of regular climate service provision;
- monitoring and ex-post evaluation of climate services use and its effects, of which the results are public, with the aim to inform policy makers as well as providers and users, while inter alia also enabling to demonstrate the benefit generation capacity of different types of climate services for different types of users – this set of tasks would be handled by a so-called market observatory;
- standardization, such as of terms, product categories, and product ratings, and quality assurance which is also relevant to current and prospective users, should be pursued by the entire climate services sector;
- open and affordable data policies, in line with EU directives, should be rigorously pursued by all Member States; open data does not need to be always equated with free of charge, but data should be affordable for all relevant users; recognize the supportive role of brokerage and market place facilities for climate services in this respect;
- foster innovation in climate services along the entire value chain, including – inter alia – sufficient emphasis on climate knowledge and innovation across different academic curricula (natural science, technology, economics, social sciences, medicine, law).

5. Conclusions

The title of the article conveys some of the problems encountered, as well as points at the root causes of these problems. Indeed, many types of users are not or barely aware of the potential benefits of better preparing an organisation to climate change and climate variability, and hence cannot recognize the benefits of climate services. On the other hand, many providers of climate services tend to overlook the diversity of merits that a climate service can have for different types of users, owing to lack of understanding of user needs and/or due to relying too much on prefixed ideas regarding possible applications of the climate information. Last but not least, many policy makers lack insight and appreciation of the scope and scale of merits that can be unleashed by the use of climate services, provided these services are of appropriate quality, sufficiently diverse, and affordable.

The merit good principle seems to provide a good basis for formulating a more coherent policy aimed at promoting climate services. It should however be realized that for different kinds of climate services (e.g. adaptation-oriented vs. seasonal climate predictions) the significance and persistence of the merit good character can vary. As a consequence, the case for vigorous support for promotion of seasonal climate services may dwindle fairly soon, whereas for purposes of adaptation and disaster risk reduction it may last much longer.

The projects showed that a significant part of the benefit potential (merit) is not exploited, even though an improvement in the awareness about climate services and a steady rise in the use of climate services can be noted, albeit not quantified exactly. A coherent climate services promoting policy package, consisting of the recommended elements listed in Section 4, should be able to enhance the uptake of climate services as well as the development and tailoring of climate services. Perrels (elsewhere in this special issue) discusses the effectiveness of such packages in more detail.

A market observatory for climate services appears to be generally regarded as a desirable information facility for policy makers, climate service providers and developers, as well as various users. The differences in views on the exact tasking of a market observatory require careful attention. A dedicated effort to quickly get an adequate picture of which task packages and resourcing alternatives are widely supported would be helpful for EU decision makers to agree on what kind of market observatory could be tendered. Yet, we like to emphasize that the collection of tasks, the information service model, and the resourcing model can be expected to evolve over time, whereas it also possible that several organisations, public and/or private, cover each a part of the monitoring tasks.

CRediT authorship contribution statement

Adriaan Perrels: Conceptualization, Funding acquisition, Formal analysis, Methodology, Supervision, Writing - original draft. **Thanh-Tâm Le:** Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing - original draft. **Jörg Cortekar:** Conceptualization, Formal analysis, Methodology, Writing - review & editing. **Eric Hoa:** Project administration, Investigation, Visualization, Writing - original draft. **Peter Stegmaier:** Conceptualization, Formal analysis, Methodology, Writing - review & editing.

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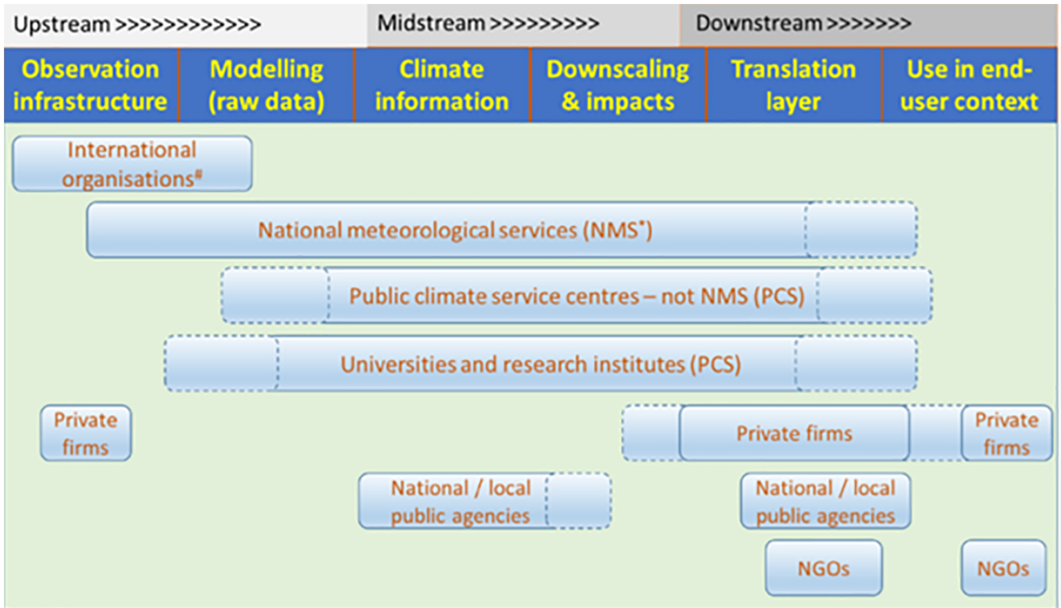
Annex 1. Definition and categorisation of climate services in EU-MACS

Illustrative value chain – main stages and placement of actors (source: Cortekar et al., 2017)



The value chain of climate services starts in the upstream part with observations and post-processing of these observations. In addition, models can be used for projections, be it seasonal or long-term. In addition, reanalysis datasets can be counted to the upstream part. In the mid-stream part some extension to first order geo-physical responses, e.g. hydrology and soil moisture can get integrated, whereas also downscaling, including local landscape effects are tackled in this segment. Furthermore, specific user segment-oriented tools and dedicated databases, e.g. dispersion of pathogenic vectors and ecosystem responses, typically belong the midstream segment. Generally, it means that at this stage some degree of non-climate information is added, while the portfolio of necessary skills starts to extend beyond those typical found in meteorological research. In the downstream part the role of non-climate information, the embedding of the climate (impact) information in consultancy and/or education, and the portfolio of skills increases much more. As a consequence, the typical providers of climate services are often private consultancy firms and other expert firms, with origins in for example engineering, finance, or risk analysis. In addition, public providers, such as met-offices and national climate service centres, will also play a role in the downstream segment, especially for (open) public climate services. In the midstream part expertise firms will be more and more active, but the role of public providers, universities, and public research institutes will remain very significant. In the upstream part of the market the nature of the activities, being partly natural monopolies, implies that most actors will be public organisations. Yet, there appears to be also space for private observation services, e.g. closely connected with midstream and downstream products.

Evolvement of the categorisation of types of climate service providers and types pf climate services (source: Cortekar et al., 2017)

JPI Climate (2013 / 2014)	ERA-NET for Climate Services (2016)	EU-MACS (2017)
National meteorological and hydro-meteorological service	(Extension of) National weather services	National weather services (or a direct subsidiary)
	Public climate service centre (not from national weather service)	Public climate services centres (not attached to national weather services)
(Federal) State agencies		Public administration / politics (from local to international)
Ministries		
Research institutes	University or research performing organization	University or research institute
Universities		
University networks		
	Non-profit-organization	Non-profit-organization
		Industry or professional body
Private companies	Private business	Private business (from local to international)
Consultancies		
Engineering offices		

Category	Description
Measurement	Instruments and technologies for measurement and calibration, e.g. provision of assistance and advice in the assembly of sensing arrays for ground-based stations.
Operation	Collection and provision of raw data, e.g. provision of raw data to media weather centres.
Modelling	Modelling of data, both certified and non-certified, e.g. modelling of collated data in order to predict the most likely rate of degradation of the polar ice cap.
Data Management	Provision of calibrated data sets, data archiving, data certification and data sales, e.g. provision of validated data sets to consultancies for further analysis.
Processing & Re-Analysis	Provision of data analysis and retrieval services including data mining tools, e.g. provision of essential climate variable models to academia.
Advisory Services	Advisory services, risk assessment and decision support tools provided to public and private sector organizations, e.g. risk assessment for the long-term location of nuclear power stations.
Other Consulting	Consulting services not elsewhere covered, e.g. provision of advice on corporate statements to shareholders on corporate policy towards climate change.
Publication	General publication of analysis findings, e.g. assembly of publications on climate forecasts based on data and analysis for both private and public sector organizations.

Climate services by time frame (Larosa and Perrels Annex 5)

- historic observations and post-processed data (e.g. gridded data)
- reanalysis data
- seasonal and sub-seasonal predictions
- multi-annual/decadal projections
- multi-decadal long term (adaptation oriented) climate change scenarios

Annex 2. Transaction cost theory based identification of obstacles in climate services

Categories of transaction cost and their relevance in the climate service field (source Perrels, 2018)

Production & utilization factors	Phases in CS generation and use > > > > > >				
	Pre-production	Pre-utilization	CS provision	CS use	CS customer relations
Physical assets	Implied achievable quality level	Risk exposure → motivation; Presence of adequate equipment (+ 'make or buy')	Mismatches in physical information delivery outfit; Hesitations on choices for standards halting technical choices		
Knowledge	Capability to link climate & non-climate domains; Sharing/exclusiveness Innovation; choices	Awareness; Risk analysis capability	(risks for) mismatches of delivered information in terms of actual usability owing to non-matching concepts	Apparent fitness for purpose	Continued training and updating options
Human resources	Prevailing work motivators	Availability of skilled employees; 'Make or buy'	Cultural mismatches between provider's and user's staff → miscommunication	User org. internal capacity & capability	
Managerial and coordinative abilities	Extent & quality of internal communication (early signals)	Extent & quality of internal communication (early signals)	Are all relevant departments/experts involved in the process; division of tasks & responsibilities	Information flow (results) management	
Networks/Relations	Public profile; User and competitor relations	Existing contacts with CS providers; User associations; Sector or regional embeddedness			Client feedback; service maintenance
Trust	Preferred CS provider? QA process	Impressions of CS providers; Impressions of products			Client satisfaction monitoring
Regulatory enablement or disablement	Orientation of p-m segments; Innovation & investment priorities				

The table represents a translation towards the production and delivery of climate service of transaction cost types in relation to stages in the production process as formulated by Williamson and Cheng, 2017. It should be realized that this table can be applied to upstream climate service providers (e.g. entailing heavy computing and/or observation capacity), downstream climate services (less heavy but still significant computing and visualization), and purely users of climate services (e.g. cities, farmers, pension funds). The transaction cost in the several phases can cause extra resource use for the providers or for the users or for both. The provider, and maybe also the user, may have sometimes to adapt the business model(s) to enable beneficial use.

Annex 3. Results of the rating exercise and the causal analysis

Supply:	ALL	tourism	Priv. banks
Available CS information is not really packaged as service (but e.g. rather as R&D project output)	12	9	12
CS product portfolio is totally or largely out of scope for the user group	9	6	8
Insufficient resourcing of CS product development and delivery	9	9	6
CS provider faces legislative limits regarding product or user segments it is allowed to service	8	1	–
Lack of understanding of user characteristics	8	6	8
CS provider does not employ clear product profile or client type profile	7,5	4	8
No interest or capability to develop CS beyond mere data provision	6	9	8

Matching:	ALL	tourism	Priv. banks
Mismatch of provider's and user's 'language' and conceptions	12	9	16
Uncertainty about the eventual relevance of the CS for the user's decision process ('fit for purpose')	12	16	9
Temporal and/or spatial resolutions do not match with other user's data	12	6	12
Insufficient guidance and/or embedded consultancy	10	9	12
User demands too sophisticated for no-charge or low-charge CS provision	8	8	1
Hard to specify CS needs	7,5	9	9
Unclear where to look for CS services (if NMS cannot deliver)	6	9	12
User organisation cannot develop unified vision on CS needs	6	1	3
Uncertainty ranges incompatible with user's decision process	3	12	3
Hard to make choices between alternatives (within and across providers)	1,5	1	1
Lack of climate service data processing skills (no GIS capacity)	**		16

*Other partners did not explicitly mention this obstacle, but from the exercises with city representatives (urban planning) and from anecdotal evidence can be inferred that this is a rather wide spread problem, especially in large organisations, across user sectors.

**Lack of climate service data processing skills, notably for spatially explicit data (GIS), appears to be an issue in the financial sector for the time being. Once climate service data start to be used more, recruitment of GIS experts and of expertise will probably alleviate the problem. Can also be an issue in other (not studied) sectors.

The orange cells indicate significant deviations from the overall impression of a particular obstacle.

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