Quality assurance in context:

A review of standards, best practices, and guidelines for quality assurance of climate services

Deliverable 5.3

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About Climateurope2

Timely delivery and effective use of climate information is fundamental for a green recovery and a resilient, climate neutral Europe, in response to climate change and variability. Climate services address this through the provision of climate information for use in decision-making to manage risks and realize opportunities.

The market and needs for climate information has seen impressive progress in recent years and is expected to grow in the foreseeable future. However, the communities involved in the development and provision of climate services are often unaware of each other and lack interdisciplinary and transdisciplinary knowledge. In addition, quality assurance, relevant standards, and other forms of assurance (such as guidelines, and good practices) for climate services are lagging behind. These are needed to ensure the saliency, credibility, legitimacy, and authoritativeness of climate services, and build two-way trust between supply and demand.

Climateurope2 aims to develop future equitable and quality-assured climate services to all sectors of society by:

- Developing standardization procedures for climate services
- Supporting an equitable European climate services community
- Enhancing the uptake of quality-assured climate services to support adaptation and mitigation to climate change and variability

The project will identify the support and standardization needs of climate services, including criteria for certification and labeling, as well as the user-driven criteria needed to support climate action. This information will be used to propose a taxonomy of climate services, suggest community-based good practices and guidelines, and propose standards where possible. A large variety of activities to support the communities involved in European climate services will also be organized.

Executive Summary

This deliverable presents a meta-review of standards, best practices and guidelines for quality assurance (for providing the credibility, salience and legitimacy of climate services). It focuses on the public sector as a particular form of science-policy interaction. In particular, this deliverable is based on concepts and insights from the interdisciplinary field of science and technology studies (STS) to understand how forms of quality assurance work in practice. We find that there is no one-size-fits- all form for quality assurance.

Our preliminary findings indicate that the concept of climate services, co-production, and standards are used and interpreted differently across different communities. It is worth noting that different groups of actors use climate services for different ends, and it makes a huge difference in which decision-making context information is used – e.g. on urban planning or by economic actors for creating markets for climate services. The decision-making context/ 'ecology' and its logic shapes what form of knowledge is needed and what form of quality assurance is seen as salient and legitimate. STS concepts help us to understand how climate services and forms of quality control are embedded into and resonate with their political context and reflect well-established decision-making structures and local values. The salience and legitimacy of climate services cannot be taken for granted. Instead, they can get lost and have to be actively maintained. They relate to the trust and persuasive power of the institutions who provide climate services. As a result, climate services need to be translated into local contexts and fit to local practices and values. Processes of providing legitimacy and credibility become difficult to formalise without diluting local specificities and contextual nuance. Instead, climate services should be both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites and offer a means of translation.

Drawing on the STS literature, we define standardization as a process of constructing uniformities across time and space, through the generation of agreed-upon rules and a script. Instead of linking standardisation to any overarching historical trajectory (such as a tendency toward global social convergence and homogeneity), we argue for a differentiated and symmetrical approach that investigates the full spectrum of choices of standardisation for providing the quality of climate services. We emphasise the variety of ways in which standards and standardisation undergird diverse social, cultural, political, and economic logics and values, as well as the equally varied implications for the well-being and suffering of individuals and social groups.

In this lens, the deliverable analyses existing standards as well best practices and guidelines for providing quality assurance of climate services. These include standards from the International Organization for Standardization (ISO), the World Meteorological Organization (WMO), and a number of European funded projects in the context of the Horizon 2020 and Horizon Europe programmes. Following the seminal work in STS, we seek to reconstruct the script that brings people and things together in a world already full of competing conventions and standards. CE2 offers a great window of opportunity to reconstruct the processes of the creation of standards for climate services in an empirically sound way. We seek to identify the variety of choices available for designing standards for climate services, reflect their specific logic and set of priorities as well as their outcomes. Based on such a comparison of design choices, we explore the space for possible intervention to shape standardisation in a more responsible and sustainable way.

Keywords

Best practices, climate services, climate governance, co-production of knowledge and social order, quality assurance public sector, science and technology studies

1 Introduction

Climate services are at the crossroads. On the one hand, regulatory and governmental organizations such as the European Union have called for the development of climate service standards to ensure their good quality (CEN-CENELEC, 2016; Doblas-Reyes et al., 2024). On the other hand, the World Meteorological Association (WMO) and multiple academic specialists suggest that climate services should be 'co-produced' through the collaboration between multiple stakeholders to address real users' needs (Bremer et al., 2019; Porter & Dessai, 2017; WMO, 2018). How do these concepts, standardisation and co-production fit together? If co-production's value rests on identifying unique, context-specific needs of climate information according to specific users, and standards aim at reducing differences across places (Barry, 2001; Timmermans & Epstein, 2010), aren't these terms contradicting each other? The argument that we present in this deliverable is that ensuring the quality of knowledge for climate services depends on easing the tension between standardisation and co-production, and on the reflexive combination of formal and informal processes to translate and embed climate information in particular decision-making contexts.

As the Climateurope2 (CE2) grant proposal states, one of the objectives of Work Package 5 (WP5) is to 'support the robust co-production between climate service providers and users by developing coherent, policy-relevant good practices and guidelines for the use of climate services and their certification' (Climateurope2, 2022, p. 30). Thus, Task 5.3 provides policy support by deriving policy relevant recommendations for climate service development, paying special attention to the production of good quality knowledge for climate variability response. Our work complements WP3's focus on Business models and WP4's focus on Market development.

This deliverable has two main aims. First, to present a literature review examining how perspectives on co-production, standards, and quality criteria from the interdisciplinary field of science and technology studies (STS) can inform climate services development and their standardisation. Second, to present a meta-review of best practices, guidelines, and quality criteria for science policy interactions to support the standardisation of climate service (Climateurope2, 2022). Science-policy interactions for climate adaptation are extremely vast. Vertically, they extend to all levels of governance (UN, EU, national, regional, local); and horizontally, to a broad range of organizations dedicated to the development and implementation of climate adaptation policies and dedicated scientific organizations across sectors such as flood management, urban planning, land use and infrastructure. These levels have been explored and presented in D4.5 and D5.2. To make an original contribution to the climate services debate and to make the focus of this deliverable more precise, we examine advice for knowledge quality assurance addressed to the production of climate services with and for the public sector. Contrary to standards, guidelines, and best practices are less formal mechanisms of 'soft law', non-legally binding, that do not involve certification (Tallacchini, 2015). Guidelines have however a more general orientation, while best practices are more specific.

The literature has emphasised in particular three principles that define the quality of knowledge for climate services (Bremer et al., 2022): *Credibility*, that information meets standards of scientific plausibility; *salience*, that information addresses topics of greater political relevance; and *legitimacy*, that the information influences decision-makers on assessment results (Cash et al., 2003; Clark et al., 2001; R. B. Mitchell et al., 2006). Legitimacy is also defined as 'the fairness of the process from a "political and procedural perspective" – that is, that all relevant stakeholders were consulted and that the knowledge is perceived as unbiased' (André et al., 2021, p. 32). Legitimacy is also more than bringing stakeholders to the table. It also involves discussions about who should be consulted with and for what overall objectives (Miller & Wyborn, 2020).

It is important to note that there are potential trade-offs between these criteria, even when they all are tried to be addressed simultaneously. For example, by engaging with policy actors, scientists might fear losing their impartiality and credibility; conversely, attempts to increase the scientific credibility might limit the chances

of making knowledge more salient or legitimate. According to Cash and collaborators (2002), part of the challenge is that actors on each side of the science-policy boundary understand these dimensions differently. However, it is also possible that in particular occasions the criteria can complement and strengthen each other (Cash et al., 2002). Our literature review, and the reflexive turn in STS in particular, suggests that we should pay more attention to how these criteria are framed and defined in particular contexts and by particular actors, more so on the case of those who provide recommendations for quality assurance. Put differently, we explore how understandings of quality, credibility, salience, legitimacy, and their interrelations, are co-produced together with particular institutional contexts.

Drawing on STS, we take co-production not only as a matter of bringing more actors to the table, but as a reflexive and analytical exercise that helps us to identify how is co-production conducted, who is included and excluded to participate, and for what outcomes. From an STS point of view, co-production refers to the multiple ways in which the production of knowledge is shaped and simultaneously shape wider socio-political orders (Honeybun-Arnolda et al., 2024; Jasanoff, 2004; Laurent, 2024). Fig. 1 helps to contrast how we see co-production and how it is usually understood in the context of CE2 and climate services more broadly, often taken as a synonym of co-creation or co-design.

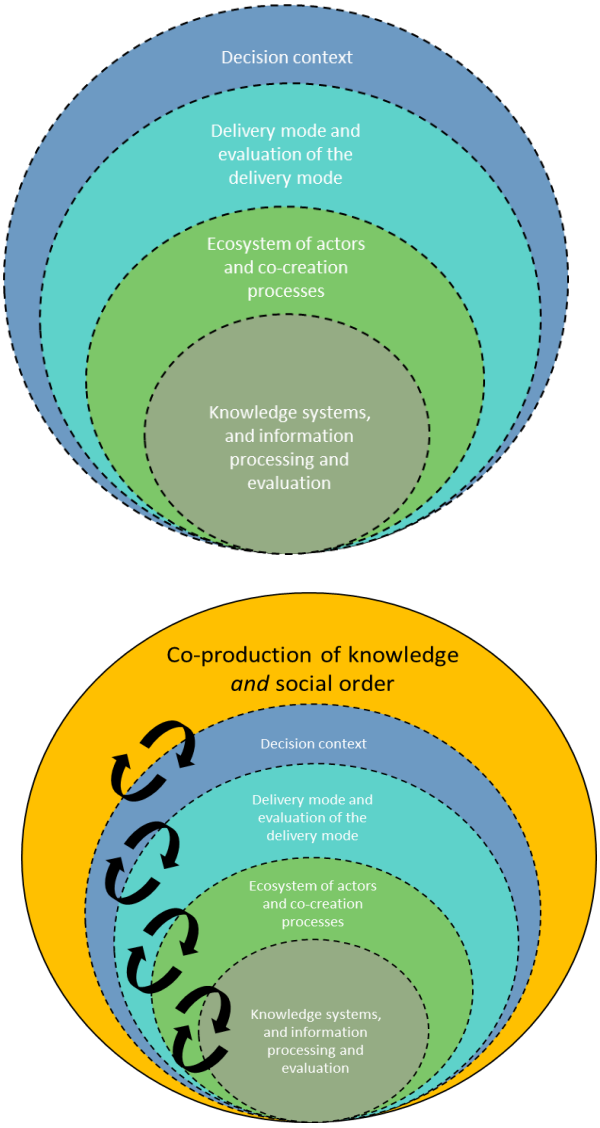

Fig. 1 CE2 climate service components (up) and our STS-inspired proposal (down).

The research questions that this deliverable aims to address are:

MAIN RESEARCH QUESTIONS
1. What forms of quality assurance (standards, best-practices and guidelines) are used or recommended by agencies (e.g. WMO) and other institutions/ projects?
2. What processes of quality assurance can be formalised, upscaled and standardized (e.g. peer review) and what processes are place or context-based and need to be embedded in local practices, cultures and traditions?

Table 1. Our main research questions.

To address these questions, and informed by our literature review, we conduct a 'meta-review' of documents dedicated to provide best practices and guidelines for quality assurance. Others have defined 'meta-review' as 'a process by which articles on a specific topic are collected and analysed to reveal trends and gaps in the literature over time', and as summaries of 'existing literature based on theoretical descriptors, concepts, and subcomponents' (Bishu & Kennedy, 2020, p. 596). Drawing on STS, we explore what understandings of credibility, salience, and legitimacy are brought forward by those documents, and how the documents suggest that these quality criteria can be maintained. Our review will help to identify recommendations that can be upscaled and standardised, and those that are more embedded in their local and institutional context.

The deliverable contains four main parts. Following this introductory Part 1, Part 2 provides a literature review that explores how co-productionist sensibilities of STS can help improve understandings, production, and uses of climate services. We examine, for example, standardisation and debates on quality assurance in the case of the Intergovernmental Panel on Climate Change (IPCC) and the traveling and transformation of scalable semi-standardised innovation models across diverse socio-cultural contexts. Part 3 examines established standards and best practices and guidelines developed within the context of Horizon 2020 and Horizon Europe projects that have included public sector organizations among their consortia. In Part 4, we conclude by providing a set of recommendations suitable for uptake by policy makers at various levels.

2 Literature review: co-production in STS and climate services

In science and technology studies (STS), the view that science, society and politics are separate domains is associated with modernist thinking that has eroded over the last 50 years (Jasanoff, 2004; Mahony, 2013; Miller & Wyborn, 2020). Now, the sustainability and climate sciences are beginning to catch up with this line of thinking (Cash et al., 2003; Clifford & Travis, 2018; Devine-Wright et al., 2022; Hölscher et al., 2021). The recognition that science, society and politics are intertwined and mutually constitutive is an important view that others have suggested across many important fields of interest. On the one hand, we have seen a rise in processes and proposals seeking to diversify the set of actors involved in socially and politically relevant knowledge production, agenda-setting and/or decision-making in environmental and climate-focused fields (Lemos et al., 2018; Norström et al., 2020; Schneider et al., 2019). On the other hand, we have a diverse set

of theoretical approaches analysing the mutual constitution of knowledge and social order (Jasanoff, 2004; Latour, 1991).

Research in the former tends to focus on intentionally bringing together 'relevant' actors in diverse spaces for diverse purposes to produce more relevant, practical, socially robust and credible knowledge or action. The focus on 'doing' co-production has emphasised how siloed, disciplinary thinking is no longer sufficient to meet the challenges of today. Research in the latter tends to observe and analyse the broader implications of the mutual construction of science and society. To be clear, this is not a set of practices or processes one can follow, but a worldview and framing that researchers in STS (and other fields) can follow. This approach helps us to better understand the particular qualities we take for granted in science, expertise and scientific advice. Principles like replicability, credibility, trustworthiness, and authority are not pre-given qualities innate within the production of scientific knowledge but instead are shaped and reshaped by many socio-cultural contexts they are embedded within, the processes and practices surrounding knowledge-making and the structures that frame how we come to know and understand the world (see Beck et al., 2016). Both approaches are known as 'co-production' but have different modes of study and intentions behind the approach (**normative-procedural** – to do knowledge co-production for a particular purpose, and **philosophical-analytical** – to study and analyse moments or spaces of the mutual construction of knowledge and society). These different approaches produce different outcomes (expected or otherwise).

The use of co-production has proliferated in climate policy and climate services (Bojovic et al., 2021; Bremer et al., 2019; Vincent et al., 2018). However, there is an uneven geography associated with the production, circulation and use of climate services across the world, ranging from international organisations (e.g., the World Meteorological Organisation) through to more local municipalities in specific countries (e.g. Greece or Spain). As such, the communities involved producing and providing climate sciences may often be unaware that each other exists and lack the inter-/transdisciplinary knowledge needed to work together effectively and collaboratively (Cuevas-Garcia, 2018; Lipp et al., 2023). It is also argued that quality assurance, standards, and guidance for climate services are behind what is available for traditional forms of science and knowledge provision (Doblas-Reyes et al., 2024). This gap is thought to have negative implications for climate services' salience, credibility, and legitimacy (Bremer et al., 2022; Cash et al., 2002).

In this short literature review, we draw from the literature in STS to explore how co-productionist sensibilities can help improve understandings, production, and uses of climate services. We first unpack recent moves toward reflexive understandings of co-production and explore *why this matters* for climate services. Next, we use reflexive understandings of co-production and draw from lessons learned from expert climate organizations, like the IPCC and it's boundary-work, to explore how the processes of quality assurance, relevant standards, and other forms of assurance (such as guidelines and good practices) needed to ensure the saliency, credibility, legitimacy, and authoritativeness of climate services are reconciled. We then explore how STS has engaged with standards and quality assurance and highlight the challenges in traditional approaches to quality assurance in climate services. Lastly, we provide key recommendations for how we might move forward by understanding what can and cannot be formalised, upscaled and standardised for wider processes of quality assurance of climate services and how legitimacy, credibility, and saliency may still be achieved in the process.

2.1 Co-production: towards a reflexive understanding

The recognition of two dominant strands of co-production research is not new. Indeed, in climate change research more broadly, Bremer and Meisch (2017) suggest a broad framework – and an eight-sided prism – for understanding diverse forms of co-production that can:

> guide co-production inquiry so that it does not need to be limited to any one facet but can be opened up to integrated study along different dimensions… The prism offers eight complementary perspectives for understanding the role of climate science in a context and designing a co-production process and practices to better integrate climate information with decision making in that context (p.13).

Putting this into practice, Bremer et al., (2019) applied the prism to read the context of co-production in climate services. This advancement in co-production thinking in climate services is useful to help information providers and knowledge producers recognise that the context in which they co-produce knowledge matters, as does widening participation in co-design events and being transparent about their intentions and aims from the outset. As a result, it is widely assumed that more 'co-production' can lead to 'better' outcomes and that increasingly recognising the need for relevant actors to be more involved in the process which can lead to better uptake of climate services and more reflexive and collaborative design (Krauß, 2023; Krauß et al., 2024; Vincent et al., 2018). However, this framing ignores critical insights on the more **philosophical-analytical** tenets of co-production. These insights are associated with deeper understandings of how uptake of climate services actually emerges, how co-production processes might become durable and legitimate fixtures of climate-information provision, and how institutions learn and respond. Further, these insights can help us explore how climate services are shared, and in what contexts across diverse spaces of knowing and doing, and help us as researchers to better understand place-based specificities and local context when thinking about considering standardising quality assurance processes for climate services (Beck, 2019; Honeybun-Arnolda et al., 2024).

Further work has been outlining how local contexts and specific framings matter in co-production processes and the role this plays in wider analytical framings of the co-production of science and society – or in other words – *making co-production more reflexive*.

Reflexivity and learning are seen as core tenets in STS research (Chilvers, 2013; Chilvers & Kearnes, 2016; Wynne, 1992). Reflexivity is a process of continuous reflection, scrutinising assumptions and values, interrogating the role of framings and approaches within themselves and through the institutions that are being studied and open to change (Beck & Siebenhüner, 2022; Pallett & Chilvers, 2013; Wynne, 1992). Being reflexive is a choice that requires intent and commitment throughout the research process and the capacity and processes to enact changes where needed, which some institutions often lack (Honeybun-Arnolda, 2023). Making co-production more reflexive is not only about conducting more participatory co-design or co-creation events with an extended set of participants. Instead, doing co-production reflexively is to anticipate un-/intended consequences and put measures in place for mitigation; reflect on framings, choices, approaches and methods, and the role they play in shaping the outcomes. It means attending more explicitly to diversities and exclusions; recognising the diverse ways in which people make sense of and understand information and thinking about co-production in more relational and systemic terms (Chilvers & Stephanides, 2023; Honeybun-Arnolda et al., 2024). What this means for thinking about climate services, scientific credibility, relevance, and legitimacy is drawn out in more detail in the section below as we explore learnings from the IPCC.

2.2 Reconciling scientific credibility, political relevance, and legitimacy

The IPCC is an important case to draw insights for learning about how processes of quality assurance vis-à-vis scientific credibility, political relevance, authority and legitimacy are navigated and reconciled (Beck & Siebenhüner, 2022). Lessons here can be applied to thinking about quality assurance and climate services. As

the leading international expert organisation, the IPCC has faced demands in the past for greater political relevance, geopolitical representation, scientific integrity, transparency and accountability. Situated at the interface between international science and politics, the IPCC has to maintain political relevance and scientific integrity amid intense political pressures (internal and external), tight deadlines and a continually evolving, multidisciplinary scientific landscape. It has to reconcile political demands – salience, legitimacy, geopolitical representation – with the need for expert decision-making, such as integrity and the relative autonomy of scientific self-organisation. The hybrid nature of the IPCC suggests that there is neither a single, exclusive criterion, such as political relevance, nor a single, linear path to evaluate its performance and learning capacity. Different forms of learning serve different functions/purposes and may have trade-offs and unintended consequences. As discussed in the previous section, reflexive learning can be considered a means to enact the organisation's responsiveness, openness, innovation, transparency and accountability.

2.3 Proxy debates in co-productionist perspectives

First, when scientists, politicians, and publics agree on the basic principles and most robust findings of climate science, there is still plenty of room for disagreement about what the implications of that science are for action. Second, disagreement expressed in disputes about scientific evidence is often rooted in more fundamental differences over epistemology, values, and the sources of well-being, or about the role of science in policy making. This can include choices about rules of membership for an expert organisation, its lines of accountability to scientific and political communities, the standards by which it defines evidence, and its procedures for review and approval (Beck et al., 2016; Jasanoff, 2011).

2.4 IPCC's Experience with Standards

After enduring much external critique, in 1999 the IPCC began to revise and formalise its scientific quality-control procedures. These revisions indicated a constitutional moment because the IPCC turned itself from a scientific to a legal mode of governance, standardising its rules and procedures (Edwards & Schneider, 2001). Henceforth, the IPCC faced the challenge of reconciling forms of scientific self-organisation with these newly formalised legal modes of coordination. IPCC science had to be moulded into political and legal modes of operation to ward off critique about legitimacy, quality assurance, and credibility.

While formalising rules of procedure, the IPCC faced additional problems. Chiefly, reconciling informal, decentralised, and flexible modes of scientific self-organisation with formalised, centralised, and hierarchical modes of coordination and governance. The strategy of formalising (Sundqvist et al., 2015) and standardising procedures and matching them to consensus processes is double-edged. For one, this process is designed to contribute toward a greater coherence of governance structures and so increase the political robustness of the organisation. Conversely, it risks of restricting the space available for independent self-organisation within the climate science community as well as the functionality of scientific procedures (Skodvin, 2000) and the ability to be reflexive and transformative when needed.

Additionally, different audiences have different criteria by which they judge the salience, legitimacy, and credibility of the IPCC, like other international and global bodies. There is a real sense in which the more monolithic the IPCC becomes, the more fragile its public edifice becomes—the very opposite of the robustness which formalisation is meant to achieve (Hajer, 2012). Furthermore, the efforts at formalisation are unevenly distributed. Indeed, an earlier suggestion that 'informal rules based on the everyday practices of scientific communities guide the bulk of the work' carried out by the IPCC arguably still holds (Edwards & Schneider,

2001, p. 227). Two other scientists with considerable personal experience have also suggested that one of the unwritten rules observed within the organisation is that the 'IPCC shall depend uniquely on informal interactions among groups of scientists (authors) to develop its findings and avoid using formalised approaches' (Mach et al., 2017; Yohe & Oppenheimer, 2011, p. 633).

Although the formalising of procedures has contributed towards greater coherence of governance structures – and therefore increased the political robustness of the organisation – these efforts constrained the flexibility of scientific processes, which initially formed the backbone of the IPCC (Edwards & Schneider, 2001). Even further, the processes of formalising procedures have subjected the IPCC to greater procedural bureaucracy and complexity and brought with it a loss of transparency, public accountability and trust (Beck & Mahony, 2018; Hulme & Mahony, 2010). This has been the subject of much scrutiny and analysis in recent years.

In sum, the IPCC was constructed to bring together forms of expertise to produce global scientific assessments on the state of climate change in various channels. The IPCC aimed to be policy-neutral, not policy-relevant. As the organisation matured, the freedom and authority of scientific knowledge-making and information provision came into stark contrast with the political authority, credibility and trustworthiness of international bodies and two different modes of operation – legibility and assurance – came into play in the public domain. How the IPCC then attempted to reconcile these challenges has led to much critique and questioning over the role and authority of scientific knowledge in complex political arenas and capacities for reflexive institutional learning (Beck, 2012; Borie et al., 2020; Pallett & Chilvers, 2013). This line of thinking is not unique to STS scholars, but in this case, it demonstrates the challenges of formalising procedures and how it is not a one-size-fits-all approach. Moving forward with climate services and being reflexive in our thinking requires us to learn from historical antecedents like the IPCC and build more applicable, robust, and impactful forms of quality assurance for climate services.

2.5 Standards and quality assurance

It is a common agreement in STS that standardisation is 'a process of constructing uniformities across time and space, through the generation of agreed-upon rules' (Barry, 2001; Bowker & Star, 1999; Busch, 2011; Timmermans & Epstein, 2010, p. 71). Moreover, 'every standard implies a "script" that specifies the various roles of users, as well as their skills, motivations, requirements, tools, and final outcomes' (Timmermans & Epstein, 2010, p. 79). In this way, 'once created, [they] can help fix in place the relations of heterogeneous actors' (Winickoff & Mondou, 2017, p. 11). STS scholars have observed that there is no guarantee that these scripts will be followed exactly as the developers expected. Thus standards must 'find a balance between flexibility and rigidity and to trust users with the right amount of agency to keep a standard sufficiently uniform for the task at hand' (Timmermans & Epstein, 2010, p. 81). In order to function, standards have to be tinkered with to be incorporated into existing routines, 'interests, associations, and practices' (Timmermans & Berg, 1997, p. 274). Moreover, standards must be translated from the abstract to local specific situations. Timmermans and Berg (1997) emphasise this situation by stating that '*universality is always local universality*' (p.297, emphasis in the original). This paradoxical term refers to:

> the alignment of protocols which is collectively achieved through the convergence of different trajectories… Local universality… is about being in several locales at the same time, yet being always also *located* as a product of contingent negotiations and pre-existing institutional and material relations (Timmermans & Berg, 1997, p. 297).

In order to better illustrate the co-productionist understanding of standards, we will now examine the difficult cases of developing standards for green biofuels, and the case of diverse semi-standardised innovation models

– i.e. tools to guide innovation processes. While the first is a case of technical and performance standards, the latter is closer to a procedural standard, so the latter, although alien to climate services, deserves attention.

Winickoff and Mondou (2017) examine how three different standardising organisations – the European Union's Renewable Energy Directive (RED), the International Organization for Standardization (ISO), and the Roundtable on Sustainable Biomaterials (RSB) intended to establish standards for green biofuels. They observe that each organisation has different ways of producing standards. Each organization gets different sets of participants involved, have different scientific capacities, and faces different political issues. Winickoff and Mondou observe that intending to avoid political controversy, RED delegated the responsibility of creating standards for biofuels to a private consultancy. However, this delegation was not too effective at avoiding controversy. Civil organisations questioned the decision and demanded the inclusion of social and environmental impact considerations in the standard. ISO took about six years to develop a standard, but had to exclude several topics that it could not agree upon – for instance, the socio-economic impacts of green biofuels –, and the members did not know what would be acceptable for the World Trade Organisation (WTO). In turn, RSB succeeded in developing novel sustainability metrics; however it had little industrial buy-in. This cross-case comparative study also illustrates that different standards offer different benefits. For example, ISO standards are accepted worldwide, but RSB are taken to be more scientifically rigorous since they are developed together with a more diverse group of stakeholders.

Moving on to the last examples, innovation models are relevant for climate service co-production because they propose 'scripts' about collaborating and structuring knowledge and technological development processes. Two very illustrative examples include the case of the implementation of the 'MIT model' in different countries, and the case of the deployment of 'pre-commercial procurement' for robotics. In the first case, Pfotenhauer and Jasanoff (2017) examine how political and academic actors from Cambridge, UK, Portugal, and Singapore hired consultants from the Massachusetts Institute of Technology (MIT) to strengthen their innovation practices. Interestingly, each location interpreted the MIT model differently, depending on what they considered their 'deficits', what they considered the causes, and how better innovation practices could help to overcome them. Pfotenhauer and Jasanoff (2017) argue that it is not helpful to think about how well a place is able to implement the model. Instead, they suggest that success or failure has more to do with how well places can articulate what they expect from innovation and what counts as success or failure.

As they observe, the diagnosed problems were 'a loss of leadership in the UK, a self-inflicted lag in Portugal, and a size disadvantage in Singapore'. The corresponding 'cures' were 'a minimally invasive injection in the UK, an external aid to overcome broken structures in Portugal, and enhancement of extant strengths in Singapore' (p.802). Translated to climate services, these cases underscore the need to encourage places hiring climate services to have well defined expectations from the acquired services and what will count as success, failure, or good quality. For service providers, it means learning to help the users articulate their needs without imposing on them a pre-determined solution. The case of the MIT model also demonstrates that procedural standards can be interpreted and implemented very differently in different locations.

Cuevas-Garcia and collaborators (2024) have also explored a peculiar project in which a co-productive innovation model known as pre-commercial procurement was used to address challenges from the water authority of Barcelona. Since the project implementing the pre-commercial procurement exercise was guided by the section on robotics innovation of the European Commission, the only possible solution to Barcelona's problems had to be a robotic one. This limitation determined what challenges could be provided by public sector organisations interested in participating in the project. In contrast to the MIT model, which was open to local interpretation, the pre-commercial procurement model implemented in the Barcelona project was so rigid that it did not officially allow modifications to be better adapted to the context of implementation. The roles that the pre-commercial procurement model included were not enough to represent the multiple

relevant stakeholders. The result was that the model interpreted the user needs in a very limited way. In the end, the water authority was not interested in what the robot could do.

The lesson is that co-production models (in the normative-procedural sense) and proposed solutions should not be too rigidly defined from the outset. In the philosophical-analytical sense, the pre-commercial procurement model was co-produced with the coordinators' assumption that the European Commission aimed at bringing forward specific technologies through standardised ways of orchestrating collaborations that could be used regardless of context-specificities.

Going forward, co-production and (procedural) standardisation are processes that interact and interrelate in different ways. First, a strict normative-procedural understanding of co-production suggests that standards are developed and agreed upon by a broad set of actors (Brunsson et al., 2012). Second, in the opposite direction, co-production processes can be guided by standards, formal or informal, mandatory or voluntary, etc. (Cuevas-Garcia et al., 2024; Laurent, 2022; Pfotenhauer & Jasanoff, 2017). Third, and shifting to a philosophical-analytical understanding of co-production, standards are produced in unique and specific ways by different organisations according to different institutionalised norms and values (Winickoff & Mondou, 2017). Each organisation articulates in different ways the scientific/technical and political dimensions. Fourth, the actual implementation and use of standards are co-produced together with the specific localities in which they are deployed (Timmermans & Berg, 1997).

The arguments above present a unique and complex challenge for climate services. Standardising quality assurance processes is a difficult challenge. Many important and interrelated factors are at play, shaping un-/intended outcomes. There is a difficult task at hand to navigate the boundary between applicability, use and relevance of climate services that make sense and are productive at all scales, and gaining political authority, credibility, salience and trust across the board. In the following sections, we provide some recommendations to conclude this review on how we CE2 can implement and standardize quality assurance processes. These should take into account the diverse and important local specificities of context, framing and intentionality and to offer a guide on how be more reflexive and aware of this that could be implemented into a standardized quality assurance programme.

2.6 Standardising quality assurance for climate services

Here we provide a number of recommendations as identified in the literature. Later sections of this deliverable will make connections between these and our meta-review of best practices for climate service co-production. Miller and Wyborn (2020, p. 92) provide the following recommendations for orchestrating normative-procedural co-production which we find particularly salient for climate service quality assurance:

> *Be more inclusive and accommodating of diverse participants and their knowledges within science processes,*
>
> *Be more attentive to the power accorded to diverse participants (and how the less powerful can be afforded the power to insist on their rights to participation and the significance of their ways of knowing),*
>
> *Be more attentive to the processes and objectives of co-production and how they work to include and exclude both participants and knowledges* [plural intended]*, and*

Be more reflexive about the forms and arrangements of credibility, legitimacy, and accountability present and their implications for what knowledges [plural intended] *and arrangements hold sway.*

Applying this to quality assurance of climate services, then, might look like exploring in whose interests are the climate services being developed and utilised, how might processes of formalised quality assurance exclude and dilute cultural and local context, value and diminish their effects and how might taking more systemic and relational approaches to information-provision improve usability. What this means specifically for the quality assurance of climate services is:

1. There can be no formalised best-practice and guidelines that truly account for the spatial and temporal diversity in the use and circulation of climate services.

2. However, processes of expert validation like peer-review, means of conflict resolution, conflicts of interest; and circulation of knowledge in climate services can be standardised using formalised processes of quality assurance. Reflexivity and learning can become embedded into these processes by asking questions of diversity, exclusions, critiquing assumptions and anticipating wider effects.

3. Informal processes of reflexivity, like the above, can be suggested as a guide to follow for each climate service case.

4. Climate services developers and users should be aware of how *definitions of risks emerging from climate variability and change, and their remedies, are defined both by science and socio-political dimensions*, and must consider this.

Reflexive co-production in this vein challenges dominant assumptions that processes of quality assurance for climate services can indeed be standardised. Against its very ethos, quality assurances vis-à-vis best practices and guidelines obscure and obfuscate any local specificity, cultural contexts, and values or particular modes of knowing and using climate services. By virtue of being standardised, formalised approaches to quality assurance will either be too broad or vague to be productive and meaningful across multiple scales and/or it will proliferate climate service practices that may be seen as credible and legitimate through the lens of global scientific standards but are falling short of meaningful use and impact.

We are at a crossroads. We must reconcile both the need to demonstrate credibility, trust, and salience through quality assurance of diverse climate standards and enable meaningful, reflexive learning and inclusion of local context and place-based nuance to go beyond traditional thinking associated with the authority, credibility and trust in climate information provision.

3 Meta-review of existing best practices guidelines and standards

3.1 Methodology

Our meta-review consisted of a series of iterative steps. These included revision of diverse mapping efforts from CE2 partners, definition of analytical dimensions and guides for interviews and document analysis, in-depth collection of data, filtering data sources, analysis, and write up. Our starting point was to identify

documents produced with the participation of the public sector or directed towards the public sector in order to help "assess the fit between the supply and demand" of climate services (Climateurope2, 2022, p. 31).

First, we built on previous efforts from different WP's of the CE2 project to identify standards, best practices, and guidelines on quality assurance that could potentially be helpful for analysis. From *D1.1 Current landscape of initiatives and standardisation norms and approaches* and *D1.2 Framework to support the equitable standardisation of climate services* we collected relevant ISO and CEN-CENELEC documentation. We selected for analysis documents that were likely to include considerations for collaborations between climate information providers and public sector organizations.

From *D4.2 Initial state of the market: actors, sectors, terminologies* we gathered that 'very limited information is available on the commercial part of the CS market in particular for the private sector' (p.11). To overcome this limitation, D4.2 screened climate service applications from EU funded projects. The advantage is that the CORDIS database includes a large amount of information that is publicly available. WP4 collected descriptive information from 75 EU funded projects that included the terms 'Climate service' and 'Europe'. Intending to understand the public sector demand for climate services, we requested to WP4 partners their database to be able to identify projects that included public sector organizations among their consortia partners. However, we decided to exclude public meteorological organizations in order to focus only on reported views of public sector organizations with limited understanding of climate services – in other words, users rather than producers of climate knowledge. Meteorological organizations are represented in WMO guidelines we included in our analysis.

In order to get a better grasp of how to conduct research on the involvement of public sector organizations in these projects, one project in which there were existing contacts was selected for initial study and for the development of interview guides and analysis criteria. Preliminary project analysis included the analysis of one deliverable and interviews and email conversations with four RESCCUE project participants from the public sector, from the municipalities of Barcelona, Bristol, and Lisbon.

Next, from the 75 projects that WP4 identified, 22 included public sector organizations that were not meteorological organizations. We collected deliverables that provided policy recommendations, best practices, guidelines, or reports where the public sector consortia partners were involved as co-authors or reviewers. A first round of pre-selection collected 67 potentially relevant project deliverables. These were submitted to a more careful relevance assessment conducted by one postdoctoral researcher and three research assistants at the TUM. A number between one and four was given to each deliverable according to the following criteria:

Score	Description
1	Clear potential to identify information about quality assurance, science-policy interactions and co-production; clear involvement of public sector.
2	Dedicated to general best practices, limited focus on quality assurance, and limited or no clear involvement from – nor focus – on the public sector.
3	Provokes a gut feeling of usefulness mixed with ambivalence.
4	Most likely not useful.

Table 2. Usefulness assessment criteria for document selection and analysis

14 deliverables were considered for in-depth analysis. However, we decided not to include more than two deliverables per project to pay more attention to the analysis of each document. Once filtering the list once more, we considered six Horizon 2020/Europe deliverables for analysis. The list of analysed documents included 4 documents produced by ISO, CEN-CENELEC and WMO, thus the total number of in-depth examined

documents was 10. The table includes only documents that were thoroughly analysed and discussed before this deliverable's submission's date.

Organization/ project	Document title	Year of publication	No. of pages
ISO	ISO/TS 14092 Adaptation to climate change — Requirements and guidance on adaptation planning for local governments and communities	2020	50 p.
CEN-CELENEC	Guide 32. Guide for addressing climate change adaptation in standards	2016	38 p.
WMO	Step-by-step guide for establishing national frameworks on climate services	2018	58 p.
WMO	Guidelines for user engagement in climate services	2018	44 p.
Climate.fit.City (Horizon project)	D2.2 Description of co-designed services	2018	118 p.
e-shape (Horizon project)	D4.4 Capacity Building Best Practice Guide	2020	86 p.
RESCCUE (Horizon project)	D5.4 Enhanced communication system for stakeholder participation	2020	91 p.
ERA4CS (Horizon project)	Co-production of climate services: A diversity of approaches and good practice from the ERA4CS projects	2021	57 p.
B-WaterSmart (Horizon project)	D5.1 Manual of stakeholder mapping and engagement	2021	49 p.
B-WaterSmart (Horizon project)	D5.6 Guidelines and recommendations for regulation and policy instruments	2024	101 p.

Table 3. Documents included for in-depth analysis.

The interview and analysis guides were developed by the T.3 leads from the TUM and were shared with the rest of WP5 in order to obtain feedback and clarification questions. The documents were analysed by two postdoctoral researchers and a research assistant at the TUM. The qualitative analysis software package Atlas.ti and MS Excel were used to code the materials and collect relevant citations. The analytical strategy was mostly a top-down thematic analysis (Braun & Clarke, 2022).

The revised interview and analysed guides have been used to gather further qualitative data on four projects funded by the EU LiFE Project. The analysis of those projects will serve to test findings from this deliverable and to provide input to the next deliverable 'D5.4. Policy brief: pathways from standardisation of climate services to climate action'. The interview and analysis guides are included as Appendix 1. All the gathered information was compiled for the elaboration of this deliverable and submitted to internal review. Consecutively, all the sections of the deliverable were refined and polished further.

3.1.1 A note on document interpretation

The first observation to make is that this meta-review depended on a generous interpretation of the examined documents' content. A generous interpretation was needed because documents that are simultaneously about (1) climate services, (2) best practices, guidelines, standards, (policy) recommendations for quality assurance; and (3) co-production (4) with and for the public sector are scant. If these four conditions were followed, almost no document would qualify for analysis. Instead, the data collection and analysis for this deliverable was guided by the assumption that multiple sources can provide helpful insights. For instance,

even though the ISO/TS 14092 standard is not about climate services, its relevance is clear: Since it provides detailed advice and requirements on how local governments should produce climate adaptation strategies, ISO/TS 14092 is very helpful for the development of good quality-climate services with local public sector actors. Our meta-review thus included documents that were predominantly about climate adaptation even if they did not explicitly use the term climate services. We included documents that were specifically addressed to local governments and municipalities, but also those that intended to address public sector entities of a higher scale.

The following sections highlight our findings. The analysis is structured according to our quality criteria. We start with (scientific) credibility, continue with salience, and finish with legitimacy. Comparative highlights are left to the conclusion section.

3.2 Meta-review findings: maintaining credibility, salience, legitimacy

This section examines what the revised documents suggest about the maintenance of (scientific) credibility, salience, and legitimacy of climate services for the public sector. The purpose of the analysis is to identify differences between the recommendations that different documents provide, paying particular attention to the quality criteria they emphasise and how they understand and operationalise each criterion. In conducting the analysis, we aimed at identifying operationalisations of the quality criteria that could either have the potential to be standardised or that are context specific. The analysis helps us to validate and illustrate insights from our literature review.

Not all the documents approached all or even some of these criteria too explicitly. Thus, here we should again refer to our generous way of interpreting the documents. We extracted information that touched upon or evoked the quality dimensions (i.e. credibility, salience, legitimacy) at least tangentially, even if the precise terms were not used. Yet, we tried to keep a balance between our generous interpretation and a firm conviction that the dimensions were not referred to at all in the documents, if this was the case. We do not suggest that the producers of the documents do not care about credibility, salience, and legitimacy as important criteria of quality. It is possible that those dimensions are emphasised in documents that were not included in our sample. We begin by describing general differences in the scope of the guidelines and then dedicate specific sections to each of the quality criteria. Each quality criteria section is in turn divided according to the different forms that the documents deal with the criteria.

3.2.1 Scope of the guidelines

The documents we analysed contrast significantly in who produced them, the breadth of the advice they provide, the targeted audience(s), and the detail they provide for diverse themes of relevance for climate change and variability response. Importantly, they differ on how much they focus on specific quality criteria. Some emphasise legitimacy, others salience, and others credibility.

It is important to take into account who the producers of the analysed documents are. There are three main groups of producers in our document sample:

1. Standardization bodies such as ISO and CEN-CENELEC;
2. A (global) meteorological organization, WMO; and

3. Multi-disciplinary and multi-sectoral participants in European projects, including the public sector.

Some producers included narrower or broader forms of expertise. For instance, possibly the narrower group was the producers of the WMO Guidance on good practices for climate services user engagement: the Expert Team on User Interface for Climate Services, Commission for Climatology. By contrast, Horizon project participants included, as in the case of B-WaterSmart, climate science experts, social scientists specialised in environmental studies, consultants, and public sector representatives.

The main contrast is between the documents that provide a holistic guide and those that have a more specialised focus in a limited set of dimensions. ISO/TS 14092, for instance, focuses on principles, pre-planning, assessing impacts – including impact assessment methods, formulating the adaptation plan, identification of adaptation measures and their assessment, decision-making (including interested parties engagement), implementation, monitoring and evaluation, and reporting and communication. However, as we will show, the subsection of interested parties' engagement is very limited. The EU-funded project deliverables have a more specific focus.

3.2 (Scientific) credibility

(Scientific) credibility refers to 'whether an actor perceives information as meeting the standard of scientific plausibility and technical adequacy' (Cash et al., 2002, p.4). As the examined ERA4CS document observes, 'developing climate services in highly technical and/or highly regulated domains almost mandates a high intensity of involvement. This is necessary to ensure the relevance and credibility of the climate service, which should be as specific and as accurate as the domain they aim to cater for' (p.32).

We identified three main ways in which the documents provide advice on the maintenance of (scientific) credibility: recalling established methods, referring to 'pluralistic credibility' (authors' concept) - evoking multiple disciplines and forms of knowledge, and suggesting 'meta-credibility' and 'meta-expertise' (authors' concept).

One of the main ways in which the documents point to the scientific or other credibility of the knowledge provided to support climate adaptation or climate services is the reference to specific and well-established scientific methods. CEN-CENELEC Guide 32 suggests that standard developers should consider the impact of climate change on the products for which they create standards, drawing on life cycle analysis and life cycle thinking. Regarding what forms of information are valued the most by this organisation, the document suggests that 'probability and expected extent of impacts should be *quantified* as far as possible' (p.12, our emphasis). Similarly, ISO/TS 14092 refers to risk assessment, vulnerability assessment, and threshold analysis – the next section describes how these methods contribute to the dimension of salience.

Another form of evoking credibility we identified can be called pluralistic credibility: When different groups and forms of expertise contribute to gather or produce credible information. ISO/TS 14092 suggests that 'facilitation teams' (cf. 3.3.2, p.23) should establish a network of relevant organisations 'that provide necessary and credible information or evidence that are needed to support the planning process' (p.8). Pluralistic credibility also includes suggestions that information should be multidisciplinary: 'non-climate information, such as demographic, socio-economic and environmental conditions... shall be reviewed as part of the decision-making' (p.8). ISO/TS 19042 suggests that this can be gathered through 'a census, policy-papers and reports; statistical reports' (p.20). Pluralistic credibility is an aspect that can also be considered as a contributor to salience and even to legitimacy. An example included in the WMO Guidance on user engagement suggests:

> The credibility of forecast and monitoring information increases when it is informed by subnational and local experts. These people understand and share their local knowledge of climatic conditions. Therefore, regional institutional cooperation (from subnational authorities) is needed to make climate information understandable and relevant for decision-makers (p.20).

The WMO Step-by-step Guide for establishing a National Framework on Climate Services (henceforth WMO-NF) also provides an example of what we call pluralistic credibility:

> The effective delivery of user-tailored climate services can only be realised through strong partnerships among NMHSs and user groups, including sectoral experts, government agencies, private sector and academia. This will help in the interpreting, tailoring, processing and applying of climate information and advisory services for decision-making, for sustainable development, and also for the improvement of climate information products, predictions and outlooks (p.2).

The third form in which the analysed documents suggest the production and maintenance of credibility is what we call meta-credibility or meta-expertise. This consists of assessing the adaptive capacities and capabilities of local government and community, while also identifying the required levels of expertise. ISO/TS 14092 and WMO-NF include recommendations that emphasise the value of meta-credibility and meta-expertise. For example: 'The first step in establishing an NFCS [National Framework on Climate Services] is to assess existing capacities and have a baseline' (WMO-NF, p.12).

A number of critiques of the ways in which the production and maintenance of credibility are included in the reviewed documents include the following. First, we observe that the methods suggested are limited to the hard sciences. This links to our second critique. As observed, in the case of ISO/TS 14092, the suggested ways in which non-climate information can be collected are quite limited, as the standard only refers to 'a census, policy papers and reports; statistical reports' (p.20). In an area dominated by a limited number of scientific disciplines, advice requires a demonstration of more options, which also contribute to producing robust knowledge. Third, in the case of assessments of meta-credibility and meta-expertise, it is important to note that those assessments are shaped by how relevant expertise is defined in specific local, political, and institutional cultures. For instance, WMO-NF omits social scientists from all the activities required to produce national frameworks on climate services.

3.3 Salience

Most of the documents examined pay detailed attention to the dimension of salience of information regarding climate issues addressed. Salience 'deals with the relevance of the assessment to the needs of decision-makers' (Cash et al, 2003, p. 8086). There are important contrasts between how the documents approach the making of salient knowledge for actions on climate adaptation. Some documents focus predominantly (not to the exclusion of the other) on the salience of climate-related challenges and others on the understanding of the challenge for specific stakeholders. The commonality between these two variants is the need to prioritise what issues should be addressed.

This section is divided in three sub-sections. The first describes advice on the maintenance of temporal and spatial salience. The second and third parts go into more detail on stakeholder mapping and engagement methods.

3.3.1 Temporal and spatial salience

In its section on 'Principles', ISO/TS 19042 provides definitions for 'Prioritization' and 'Relevance':

> **Prioritization:** At the time of identifying the content of adaptation plans including the adaptation measures to implement, it is not necessary or always possible to cover all areas. The local government and community should prioritize the climate change impacts in order to determine where adaptation needs are higher by assessing the relative characteristics of the impacts (magnitude, likelihood and urgency). This should also take into account the capacities of interested parties and the capacities and opportunities of the local government and community to act (p.6).
>
> **Relevance:** Facilitate assessments leading to information for adaptation planning that is meaningful to decision-makers and practitioners, including at appropriate spatial scales and for relevant time durations (p.6).

ISO relies on the well-known methods of risk assessment, vulnerability assessment, and thresholds analysis to determine the relevance of threats that should be addressed by local climate adaptation strategies. In the case of the three methods, ISO/TS 14092 recommends focusing on different temporal parameters (i.e. current or future scenario). Using the same text but only changing the method used, ISO/TS 19042 states repetitively that:

> It is valuable to first perform a risk assessment based upon the current climate, including historical climate and trends, variability and climate events. The focus can then move on to understanding the risks under future climate and non-climate trends, climate events and climate change impacts over the full lifespan of a decision (p. 1415).

Thus, ISO/TS 19042 aims to identify the salience of issues addressed by examining present risks and vulnerabilities, which would be the most obvious and relevant for the stakeholders, and then move to more speculative and future risks.

In addition to a focus on different temporalities, ISO/TS 14092 recommends that the local climate adaptation plan should 'be harmonised with other relevant policies, strategies and plans' (p.17). The adaptation plan should 'identify relevant internal and external policies, strategies and plans that affect and will be affected by their adaptation planning… recognise the dependencies and interdependencies between such policies, strategies and plans' (p.18).

WMO-NF suggests that information provided becomes more salient when it focuses on the local context. The document states that 'the socioeconomic consequences of hydrometeorological hazards are often most severely felt at the local level; consequently, climate risk management requires that decision-making be based on climate information that can be "downscaled" to a local level' (p.7).

Moreover, two of the three general steps for the production of climate services that WMO-NF suggests contribute to salience. The steps are: 'know the user and understand what is needed; make the information service simple, accessible and timely; ensure quality' (p.2-3). However, the examined documents contrast significantly on the amount of detail they provided to the identification and enrolment of stakeholders. We examine these contrasts in the next sub-sections.

3.3.2 Stakeholder roles and stakeholder mapping

WMO-NF emphasises salience, and partly credibility by suggesting that: 'the development and delivery of climate services… require interaction among providers, researchers and users… including governments, civil society, communities, the private sector, technical partners and donors... decision-makers, policymakers, local users, climate scientists and sector experts' (p.1).

For the assessment of climate services and the capacity of stakeholders, WMO-NF recognises that the indigenous knowledge of local communities is relevant. Moreover, WMO-NF Annex 1 describes 'professional communicators, extension agents, research institutes, provincial- and district-level planners and community-based organizations' (p.35) as relevant stakeholders.

Annex 2 provides a two page-long 'Guide for mapping stakeholders to invite to national consultations'. However, the first page includes only a list of climate-driven problems such as hazards, diseases and epidemics, food security, and water resources. The second page includes a number of useful but limited questions that could help define stakeholders. These include, for example, who are key stakeholders? Who uses climate information services? Who produces information, how the chain of information works? Finally, it suggests placing the NMHSs at the centre of the development of the NFCS. One can argue that this guidance already poses a strong framing on what stakeholders and forms of knowledge are or are not relevant.

ISO/TS 14092 provides a more differentiated way of grouping stakeholders and defining their roles within the creation of local climate adaptation plans. It suggests that the local government and community should establish the following stakeholder groups, who together will develop, implement and evaluate a local climate adaptation plan.

- The **core decision-making team** is the high level governmental actors such as the governor and department leaders. However, it includes the ambiguous terms 'community' within this core decision-making team.

- The **facilitation team** is more heterogeneous, and their tasks are more extensive. It includes 'members from relevant departments… in areas in which climate change impacts are recognized' (p.8), and 'one or more experts whose specialty is in climate science, disaster management, ecosystems, economic and social science, and other areas that are relevant to impact, vulnerability, exposure and adaptation assessments' (p.8).

- **Interested parties** 'enhance… the breadth of knowledge and expertise considered within the adaptation planning process' (p.8). Interested parties include 'citizens and people who live, work, commute or visit' the locality, 'entities under the authority of the local government and community e.g. public service suppliers', 'private sector, regulatory authorities, neighbouring governments and communities, and national government authorities, non-governmental organizations' (p.9).

- A **technical council** has 'knowledge of climate change impacts and of potential adaptation measures in each sector/issue as necessary' (p.15).

Although this differentiation helps to provide order, the participants in the four groups overlap and there is the risk that these could turn vague. RESCCUE D5.4 also uses the term core team or steering group, but interestingly, the values attributed to this group contrasts substantially with the ISO terminology:

> This core team or steering group should be created from the legitimacy over the issue, the capability to lead the action, the ability to establish linkages, the expert knowledge about the case study, the objectivity and equity, considering a wide range perspective and the broad view to lead the correct identification of those who hold a stake in the issue and with the capability to identify and avoid the

potential of marginalising important groups or bias results that could jeopardise long-term viability and support for the process (RESCCUE D5.4, p.14).

Besides the roles and groups above, ISO/TS 14092 suggests that 'there should be an analysis to support the identification of interested parties, including identifying who will be affected by climate change or adaptation measures and who can influence and inform the adaptation planning process' (p.9). However, there are no suggestions about what this analysis consists of. Moreover, ISO/TS 14092 recommends that 'surveys or participatory workshops with interested parties' will help to identify and explore issues'. Potential participants include 'local residents, private organizations and local communities' (p.15). The recommendations are relevant. However, they leave out more detailed advice on how to run participatory workshops or how to differentiate and design roles for interested parties.

The strengths that these ISO and WMO documents provide for the production of salient knowledge, however, is mismatched by its lack of attention to the methods through which understandings of users and stakeholders' needs might be collected. Winickoff and Mondou (2017) observe that this is due to ISO's preference for quantitative evidence rather than qualitative one. ISO's decisions depend on their assumptions about what could be approved by the WTO. By contrast, the Horizon project deliverables examined, and to a lesser extent the WMO Guidance on stakeholder engagement, focus strongly on this dimension.

3.3.3 Methods for stakeholder mapping

Consumers or developers of best practices, guidelines, and standards for climate service co-production find more detailed advice on how to conduct robust stakeholder mapping and analysis in RESCCUE D5.4 and B-WaterSmart D5.1. RESCCUE D5.4 dedicates diverse chapters to mapping stakeholders, analysis of stakeholders' expectations; stakeholders engagement and communication plan; co-design process, and co-production process for implementation. In numbers, it contains about 15 pages on stakeholder mapping and analysis methods and advice.

For the mapping of stakeholders, RESCCUE D5.4 suggests focus groups, semi-structured interviews, and snowball mapping. Further insights are found in the section on identifying stakeholder roles and interests (section 3.2. Jurisdiction matrix). This section observes that 'there are different views and perspectives about a specific issue and the way it can be managed. This complex challenge must be handled carefully to ensure the success of the participatory process and avoid barriers that can hinder the decisions taken or the implementation of actions.' (p.18).

RESCCUE D5.4 also includes helpful figures that, even from the outset, help to think of stakeholders as a highly heterogeneous group because of their knowledge and power capacities and their lack thereof. We do not intend to claim that these are the best figures, but only that there are choices one can make to draw on diverse methods to understand stakeholders in greater detail. For example:

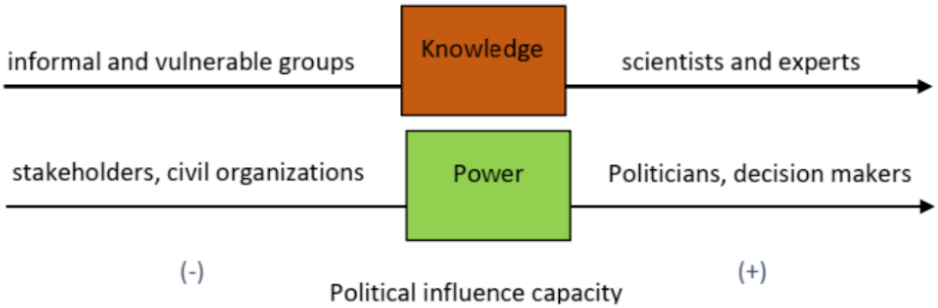

Figure 4. Political influence capacity (RESCCUE D5.4, p.19)

The above figure and analysis can be complemented by stakeholder categorisation methods, yet keeping in mind that positions in the continuum of knowledge and power are not fully stable but may transform across time. RESCCUE D5.4 includes the methods: influence matrices, radical transactiveness, stakeholder led categorisation, Q method, and salience method (see below). Figure 5 gives a sense of influence matrices.

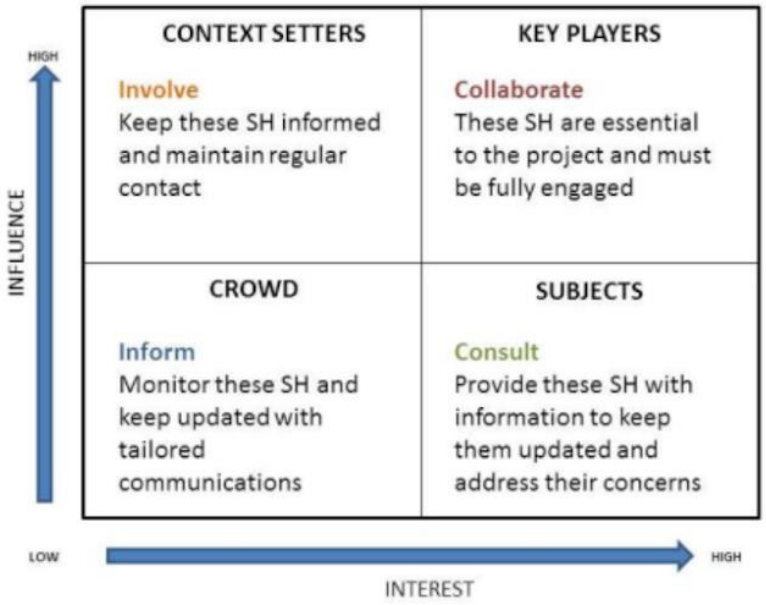

Figure 5. Interest-influence matrix, adapted from Reed et al. (2009) (RESCCUE 5.4, p.20).

RESCCUE D5.4 also makes reference to 'salience method', which is attributed to Mitchell et al. (1997), a highly cited article in a prestigious management journal. The method helps to categorise stakeholders according to their power, their legitimacy to be taken into account, and the urgency to get their challenges addressed.

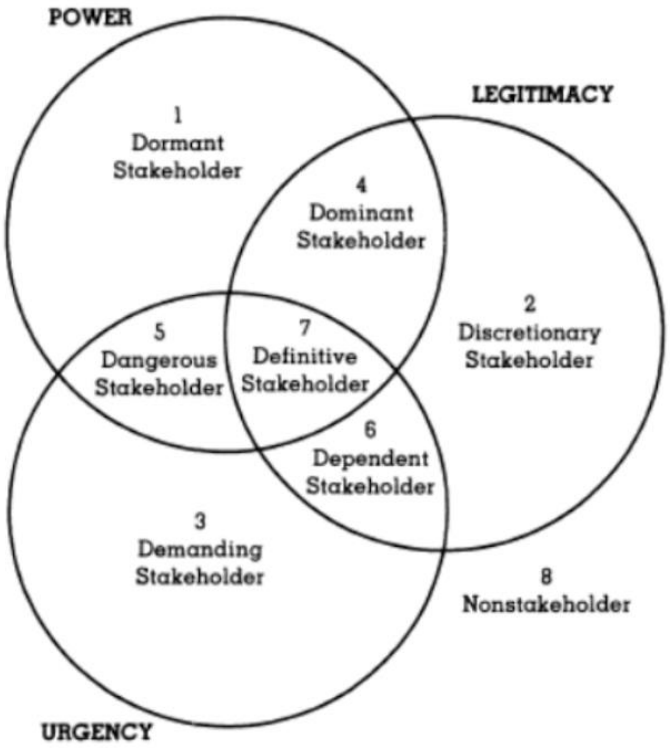

Figure 6. Mitchell et al.'s (1997) classification of stakeholders for salience method

The method above can help to distinguish for whom the information provided by climate services should be the more salient and who should be involved in the definition of problems and solutions. The differentiation of stakeholders based on these dimensions thus can complement other best practices, guidelines, and standards.

Moreover, RESCCUE D5.4 includes steps and methods for identifying stakeholder expectations before they are involved in a co-design process. This deliverable also suggests a series of methods to prioritize the solutions that come out of the co-design process involving residents (e.g. PEST [political, economic, socio-cultural and technology] analysis, SWOT [strengths, weaknesses, opportunities and threats] analysis, Nominal Group Technique (NGP), Constructive Controversy, Analytical Hierarchy Process (AHP), and several multi-criteria methods developed in the social sciences). These suggestions have the potential to ensure the salience, credibility, and legitimacy of knowledge and solutions that climate services could provide.

Despite the potential value of the methods suggested in these documents, one should consider that deciding who is what type of stakeholder, and even the production of stakeholder categories, is open to local interpretation and can be affected by pre-existing and place-specific power relations.

3.3.4 Methods for stakeholder engagement

Besides stakeholder mapping, the documents we analysed provide advice on how to engage with the stakeholders once they have been identified. Some documents provide detailed descriptions and lists of existing (normative-procedural) co-production methods. Examining different methods helps to identify, first, that there are different ways of co-producing climate services; second, that different processes offer different opportunities and limitations. But the way that the analysed documents present co-production methods

contrasts dramatically. Many documents provide long lists of possible methods, with the risk of making the readers confuse co-production with specific formats to run single engagement events rather than a whole long-term process.

Such is the case of the ERA4CS co-production of climate services document. It provides a long list of engagement facilitation methods including

> scoping and co-design workshops, questionnaires, face-to-face and telephone/online interviews, user surveys, one-on-one, focus group, online and/or open discussions, participatory mapping, living lab approaches, serious gaming, field trials and trips, demonstration service testing, field and usability testing, use of dedicated 'engagement points', attendance to stakeholder forums conferences and seminars, engagement with or co-creation of user boards, training and capacity building, and on-line feedback loops (ERA4CS, p.23-24).

The above includes engagement tools of highly contrasting capacities. For instance, a living lab requires months or even years for developing the most basic infrastructure, but a one-on-one conversation or a survey are much easier to set up. The model that the WMO Guidance document provides overcomes this issue by distinguishing between forms of passive engagement (e.g. websites and web tools), and of active engagement (e.g. 'interactive group activities' and 'focused relationships'). Pertinent recommendations that this WMO document provides include (1) that 'the amount of time and expense needed to improve the uptake of climate information in decision- and policy-making potentially increases along the spectrum, as participation becomes more active' (p.7). (2) It also observes that face-to-face interaction is crucial. (3) The recommended next steps section suggests 'build capacity with user groups to understand, interpret and apply climate information within contextually relevant decision-making frameworks... and possible climate impacts and adaptation responses' (p.13).

However, the ERA4CS document is helpful at providing descriptions of challenges and dilemmas faced by partners of the diverse projects they examined. One of their informants reported that long-lasting relations with non-scientific partners are limited by project durations. A dilemma that emerges is that it is more productive to involve in the project partners who are already known to take advantage of previously existing trust and understanding. However, the limitation is that consequently no new relationships are established.

The more detailed guidance on how to conduct stakeholder engagement can be found in the RESCCUE D5.4 and B-WaterSmart D5.1 documents. Both of these deliverables emphasise that stakeholder engagement possibilities and therefore strategies have to be tailored to the specific context. RESCCUE D5.4 states that 'every process has its own peculiarities and specific issues that make it unique and different, so it is not possible to give a standard solution' (p.9). In turn, B-WaterSmart D5.1 posits that:

> Stakeholder engagement is individual to each context, dynamic, and one of the most challenging components of any management program, hence it is critical to prioritize in terms of financial and human resources (Conallin et al., 2017). This requires the integration of different sources of knowledge – including local or traditional knowledge - consideration of different local realities, and building trust amongst the stakeholders and institutions involved, in order to empower citizens and social groups, while ensuring equity in access to environmental benefits and natural resources (Reed, 2008). (p.16).

Other useful pieces of advice that both RESCCUE D5.4 and the ERA4CS documents provide are that the timing and duration of co-productive engagement provides advantages for the relevance of the process. RESCCUE D5.4 resonates with this claim and further expands it, noting that:

> The stakeholder engagement process requires indicator-based monitoring, based on systematic interaction among stakeholders (e.g., number of contacts, number of workshops, presences, organizations and sectors involved, etc.), discussion of applied methodologies, mutual oversight about the information quality and credibility of the of new data produced (ERA4CS, p.38).

This section demonstrated that the examined documents contrasted substantially in the ways they suggest that salient information can be produced. There is a broad range of advice on the methods that can be used to conduct stakeholder mapping and engagement. The lesson to learn is that rigorous methods can help to identify local specificities that should be taken into account to produce salient climate services. Yet, all methods and the categories they provide even for classifying stakeholders have to be used reflexively, since the urgency of stakeholder challenges, their power and their legitimacy can always be subject to debate, and be affected by those with power to decide.

3.4 Legitimacy

This analytical section aims at responding to the question how do the revised documents suggest that the legitimacy of climate services can be maintained? Following Cash et al. (2002, p. 5), legitimacy 'refers to whether an actor perceives the process in a system as unbiased and meeting standards of political and procedural fairness'.

In our analysis, we examined what the revised documents said about how epistemic and political authority is formally allocated between key actors, and who is entitled to speak for science, the state, and the public in unison (mandate). We also paid attention to the rules of political and cultural accountability through which those taking part of co-production operate. Moreover, we also examined whether the documents paid attention to an overarching legal and regulatory context that guide either climate adaptation, climate services, and (normative-procedural) co-production. These are relevant for an analytical-philosophical co-productionist study because they throw light on how knowledge production and use shape and are shaped by a broader social order.

Three main ways of bringing the broader legal and regulatory context were identified in the documents. The following sub-sections examines each of them.

3.4.1 Remembering legal contexts

First, some documents only mention that paying attention to the legal and regulatory context is important. This is the case of ISO/TS 14092. The ISO standard observes that climate adaptation plans should identify relevant policies and regulations and make reference to relations between the local government and UNFCCC Paris Agreement, the UN Sustainable Development Goals, the Sendai Framework for Disaster Risk Reduction, and the New Urban Agenda (Habitat III). These are, however, very general regulations. Mentioning legal frameworks in this form does not necessarily imply that their prescriptions are linked to the content of the standard or the local adaptation plans that it provides guidance to.

3.4.2 Self-positioning as the legal framework/legitimate actor

Second, guideline documents position themselves as the legal framework, rather than describing general or more specific frameworks in place in particular places. In the case of WMO-NF, the document does not show

much explicit awareness of existing policies and regulations. Instead, it proposes that the NFCS [National Framework for Climate Services] will serve as 'a legal framework for collaboration at the national level to generate and share user-oriented climate services for use by the relevant social and economic sectors' (p.11-12). To do so, the document evokes the formal intergovernmental agreement that back up the guidance it provides, established by 'Heads of State and governments, ministers and heads of delegations' (p.4) during the World Climate Conference-3, Geneva, in September 2009.

Such a self-positioning as the legal framework is possible because of the clear legal mandate that WMO has. From the examined documents, only two show concern with legal mandates in the provision of knowledge to policy making (WMO-NF and B-WaterSmart D5.1). WMO-NF uses the term 'mandate' 23 times. This is of analytical interest because the use of the term could be read as a performative move by WMO and its partner institutions to demarcate themselves from other knowledge provision organisations. As the document states, 'in each country, it is envisaged that the NFCS should be initiated and led by the country's NMHS, which is usually the *government-mandated* provider of weather, water and climate services' (p.9, our italics).

WMO-NF emphasizes that different institutions have different areas of specialisations and mandate, and that 'WMO, together with United Nations and other international organizations and WMO Members, established GFCS [the Global framework for climate services]' envisioning that:

> Improvements in climate services could only be realized if relevant institutions at global, regional and national levels work together to complement their efforts by sharing expertise and data in their respective areas of specializations and *mandate* to inform the development and delivery of high-quality user-oriented climate service (p.4, our italics).

WMO-NF recommends that actors establishing the GFCSs should examine in different national contexts whether 'clear mandates exist clarifying who is responsible for different aspects of the chain for climate and weather information generation, tailoring, advisory services delivery and communication/feedback' (p.12).

From an analytical-philosophical co-productionist perspective, it matters not only who one can think of as possible participants in (normative-procedural) co-production, for example to increase the salience of information or issues addressed. It is also important to consider who are the actors and forms of expertise that gain prominence in specific political cultures. Not all participants are allocated the same amount of power, authority, credibility, and legitimacy.

3.4.3 Step to building legitimacy

Third, some documents propose steps or procedures for achieving legitimacy. ISO/TS 14092 suggests consultations focused on drafts of the local climate adaptation plan:

> Consultations on the draft adaptation plan should be sought from relevant interested parties both within and outside of the local government and community. These consultations are critical to ensure the legitimacy, and therefore the delivery, of the adaptation plan and its component adaptation measures (p.26)

During these consultations, the local government and community should know who they will consult, what they will be consulting on, allocate the necessary time for the consultation process and offer a user-friendly process so that different parties can provide feedback.

A particularly interesting example is the case of RESCCUE D5.4 and the regulatory context of Barcelona. The RESCCUE deliverable describes the 'Regulations Governing City Participation' that the City of Barcelona approved in 2017 (a revision of this regulation is currently underway). These regulations define and identify 'the duty of local government in the setting out of channels and tools addressed to maximize the diversity of citizenship involved in the decision making processes' (RESCCUE D5.4, p.12). This regulation contributes to strengthen salience and legitimacy by defining phases of co-design processes aligned to deliberative democracy principles: 'information, discussion and proposals, consensus process, and feedback and communication' (p.31). This referencing to existing legal frameworks by best practice documents contrasts significantly with the first form of including legal contexts presented above. The difference is that in the RESCCUE case, the content of the regulations do have a strong relation with the content of the document.

Other procedures that contribute to the maintenance of legitimacy include the provision of transparency and accountability. In the examined documents, these dimensions receive limited attention. Yet, ISO/TS 14092 includes both terms in its list of principles. It states:

> **Accountability:** The local government and community acknowledge and assume responsibility for their climate change adaptation. They accept appropriate scrutiny, and also accept a duty to respond to this scrutiny (p.5).
>
> **Transparency:** Reports and communications on the climate change adaptation are based on an open, comprehensive and understandable presentation of information for interested parties (p.6).

Despite their inclusion in the principle definitions, the standard does not make more explicit reference to neither of the terms. Yet, a related recommendation it provides, is that:

> The local government and community shall document the adaptation actions that are to be implemented… along with explanations of why some actions were adopted and others were not. The document should include a description of the risks associated with the decision and their implementation, and potential ancillary benefits if appropriate (p.22).

Despite the claim above, we identified that recommendations provided by ISO/TS 14092 illustrate that there are contrasting ways of dealing with, and aiming for transparency. The standard suggests that 'the information above can be used internally and need not be publicly available' (p.23). Such a claim puts into evidence that definitions of what should be made transparent and to whom depend on context specific values and circumstances.

The B-WaterSmart project provides an original example of a procedure to achieve legitimacy. The B-WaterSmart project implemented living labs in six different European cities. In B-WaterSmart, living labs were defined as

> environments for collaborative innovation among public authorities, water companies, technological and solution providers, and research institutes… that select, connect and demonstrate smart technologies, management and data solutions for new business models based on the circular economy and smart water management (p.25).

Each living lab tested a number of smart water technologies in tandem with circular economy models and how these were affected by local policies and regulations. Moreover, it suggested what alternative policies and regulations could look like. B-WaterSmart D5.6 presents a rigorous mapping of regulations at the European, national and local level that affect water reuse – the focal area of the project. It refers, for example, to guidelines of the European Federation of National Water Service Associations, the EU urban wastewater

treatment directive COM(2022)541, Water Reuse Regulation and Environmental Quality Standards Directive. It also provides a history of changes in water regulations at the EU level from 1991 to 2023, and refers to an ISO standard on asset management. Furthermore, it presents the contrasting local regulations that apply in each living lab.

While the co-production method of B-WaterSmart is insightful and interesting, it is challenging to follow it as a best practice document because (1) different details are described across multiple and long deliverables, and (2) it is too focused on technology and business development as a particular form of climate adaptation.

Summing up our analytical section, the examined documents suggest and reveal different ways in which climate adaptation actions can achieve and maintain legitimacy. These go from the simple mentioning of existing legislation, to the more elaborate testing of technologies and business models while comparing the effects that different regulatory contexts have on them.

4 Conclusions

This deliverable is based on a 2-step approach. It combines a review of the scientific literature on co-production and standards and seeks to translate and apply the main findings to the field of climate services. It is complemented by a meta-review that explored selected documents that present best practices, guidelines, and standards for quality assurance of climate services that involve the public sector. Our analysis identified the documents' findings on how to provide quality assurance for climate services. Our conclusion is in three parts. First, we summarise our findings by illustrating how institutional and local contexts shaped the content of the documents. Second, we reflect what can be learnt in a co-productionist lens, based on the literature review. Third, based on both steps, we provide a number of take-home messages.

4.1 Comparative analysis of quality assurance advice

Using a comparative perspective, we identify differences and similarities between strategies for quality assurance that the documents propose. The documents we take for this comparative exercise include ISO/TS 14092, WMO-NF, and RESCCUE 5.4. Our intention is to demonstrate that the contexts in which each document was produced explain why some quality criteria are more emphasised than others.

ISO/TS 14092 pays more attention to (scientific) credibility than to salience and legitimacy. The organisations' long experience providing guidance to organisational processes is noted in its advice on the general steps required for developing a local climate adaptation plan. As an organisation recognised worldwide, its advice is expected to be implementable anywhere. Two features can be seen as facilitating this universal orientation. First, the clear organisational roles it proposes (i.e. core decision-making team, facilitation team, technical council, interested parties); and second, its focus on more explicitly scientific and quantitative methods and forms of data (e.g. risk, vulnerability and thresholds analysis; census and statistics on socio-economic factors). These can be seen as coming at the expense of aiming for an understanding of local forms of organisation and recognition of stakeholders. For example, the standard does not provide advice on how to identify what counts as a vulnerable population, which may mean different things in different geographical areas, depending on different understandings of vulnerability (O'Brien et al., 2007).

WMO-NF also stands as a guidance focused mostly on scientific credibility and legitimacy, to the expense of salience. The document highlights the legal mandate given to this organisation and to national hydrological

and meteorological organisations for the provision of climate services. However, its focus on these discipline-based organisations and on this form of legitimacy, by identifying whether legal mandates to organisations exist in different national contexts, casts a shadow on other forms of ensuring credibility and legitimacy. Regarding salience, while WMO-NF states that stakeholder mapping and engagement are relevant, this guideline nevertheless does not mention social sciences or other forms of knowledge in a serious way. In this regard, it is important to observe that there are discrepancies in the inclusion or exclusion of the social sciences between this document (WMO-NF) and the WMO Guidance on good practices for climate services user engagement.

RESCCUE D5.4 strongly focuses on ensuring salience and legitimacy, but the document is not focused on the assurance of the scientific credibility of climate services. Content on credibility is left to multiple other RESCCCUE project deliverables (e.g. 'RESCCUE Resilient cities facing climate change e-book', also focused on best practices). The influence of the local context on the content of this document and the forms of quality assurance it focuses on can be seen in the following details. First, its first author is a technical staff member of the Urban Resilience Department of the City Council of Barcelona. As such, the document is representative of the legitimate government and advocates for its priorities and forms of operation. Second, the document highlights the Regulations Governing City Participation in the City of Barcelona and their role in planning for urban resilience to climate change and variability. The detail of information on methods and academic literature on stakeholder mapping and engagement, alongside experiential knowledge that the document provides, emphasises both the quality criteria of salience and legitimacy. Moreover, since it associates forms of maintaining salience – e.g. by identifying different forms of stakeholders and their vulnerabilities – to well-known methods in the social sciences, this document also contributes to the maintenance of credibility.

Such as a comparative approach is useful to identify salient commonalities and differences in the practices of quality control and to determine driving institutional and cultural patterns and policy trends. Our comparative research design seeks to provide broader insights into processes of providing climate information for adaptation and their relevance for broader design, long-term governance, and uptake. First, by comparing the provision of climate services with different trajectories, we aim to gain generalisable insights into salient factors driving institutional and cultural patterns of quality assurance for climate services. Our key findings are: The decision-making context/ 'ecology' and its logic shapes what form of knowledge is needed and is seen as salient and legitimate. Processes of providing legitimacy and credibility of climate services are difficult to formalise without diluting local specificities and contextual nuance. Instead, climate services should be both plastic enough to adapt to local needs and constraints of the several parties employing them. Second, from a comparative perspective, we seek to identify the variety of choices available for designing forms of quality control for climate services and to explore the space for possible intervention to increase their credibility, legitimacy, and salience.

Instead of seeking the 'one size fits all' gaze, we have taken a

- ***differentiated approach*** to conduct a careful empirical analysis of the specific empirical and local settings and (sometimes unintended) consequences.
- ***symmetrical cross-cutting approach:*** emphasizing the variety of ways as well as **the spectrum of alternative pathways** in which forms of quality control undergird diverse social, cultural, political, and economic endeavors and their varied implications

As a mode of summary, each document provides strengths that others lack. ISO/TS on the general process of developing a climate adaptation plan; WMO on reminding that legal mandates should be considered by climate service providers; and RESCCUE D5.4 provides social scientific methods that could complement the more formal quantitative methods that ISO tends to bring forward. Best practices, guidelines, and procedural standards for the development of good quality climate services could take these recommendations as general

criteria of quality. However, while these are clear actions that can be agreed upon, one can anticipate that different stakeholders will pay attention to specific issues, solutions, methods of risk assessment and stakeholder mapping, and framings of credibility, salience, and legitimacy depending on their own interests, resources, and capacities for action. Even when standards, standardised methods, and guidelines exist, actors have enough room to combine them in unique ways:

- Translation of formal and abstract categories to local contexts.
- Used and interpreted differently across different communities and tailored to specific information needs and local values.
- Formalising and constructing uniformities across time and space through the generation of agreed-upon rules and a common script (e.g. innovation, MIT model, sustainability).

The comparative research approach we have conducted in this deliverable thus provides the opportunity for mutual learning across concepts and practices, sectors and contexts. We have identified the diverging trends: the push towards upscaling and standardisation on the one side, and the push to translate formal information to local contexts and their specific information needs on the other side. These differences indicated that they are shaped by the institutional and local contexts in which the documents were produced — strengthening some criteria and weakening others.

Consequently, rather than clinging to the optimistic idea that more standards for quality control will automatically achieve greater impact and better outcomes, it is necessary to acknowledge that there will always be diverse views about inclusivity and appropriate representation, legitimacy and salience. The co-productionist lens helps to pay attention to the multiple ways and contexts in which the relevance and legitimacy of climate services is measured and governed across scientific fields, geopolitical contexts and cultures.

The STS approach also invites to rethinking assumptions of approaches to knowledge co-production and quality control: There is a pervasive belief, both, in sustainability science as well as on the side of climate activists like Greta Thunberg, that ways of enhancing the relevance and usefulness of knowledge by improving stakeholder participation will have an (almost automatic) impact on policy. More and better knowledge is seen as a driver of more and better public buy-in and policy response. Based on our empirical findings on knowledge-making practice, the linearity between knowledge co-production and sustainability transformation cannot be taken for granted.

For instance, as the IPCC case shows, more and better science on causes and impacts of climate change does not move societies to action. The overwhelming scientific evidence for the need to transform (as just published by IPCC AR5, III) will not catalyse sustainable transformations. Additionally, our case studies elsewhere on Future Earth illustrate why optimistic ideas that more and better knowledge co-production with stakeholders will automatically achieve better outcomes fails, and paradoxically, lead to its opposite (S. Beck, 2021; S. Beck and Forsyth, 2020).

The provision and use of climate services also changes the context in which such knowledge is applied. The political and performative nature of knowledge production also raises questions about the kinds of authority, agency and authority asserted in it and, consequently, about the accountability, representativeness, and legitimacy of experts who claim to speak for the group. As a result, a number of alternative thoughts can be brought forward:

1. Understanding forms of engagement as open-ended processes rather than as directed to implement predefined goals and how and to what end are they are embedded in real-world contexts. They can have unintended consequences and require regular evaluations and readjustments

2. Exploring underlying models of politics and mapping publics/issues: to what end are stakeholders invited and wider publics recognised: for instrumental, substantive or normative reasons?

3. Understanding *reflexive learning* as the actor's or group's capacities to continually evaluate the impacts of its objectives and actions in relation to their changing contexts, to critically examine (and thus render open to change) their own basic assumptions, and then to adjust them in the light of this newly acquired knowledge.

Thus, the discussion on quality assurance for climate services would benefit from shifting attention from the how to the why of co-production, to the broader significance and political implications of particular knowledge-making activities and uses of climate services. In our understanding, the main challenge is to evaluate its performance of climate services and understand its unintended effects in a systematic way that is useful for climate service providers. The crucial question is therefore not how much co-production is desirable but what kind of co-production; who should participate in it; and for what purposes. Our analysis also indicates that public transparency and accountability matter in order to open key methodological decisions addressing the nature of climate services' change as well as their evaluation to political debate or public scrutiny if they have major governance implications.

A more reflexive and inclusive approach to understanding and enabling quality assurance implies worrying less about the inclusion and exclusion of actors within the uptake and production of climate services and more about how their visions of a sustainable world are represented through the selection of evidence and actors. It is therefore important to ask whether practical–procedural processes of knowledge co-production can include or represent diverse people and perspectives as intended, as well as to ask how far different visions and values drive the inclusion of selected people and perspectives. This is an important task for the provision and quality control of climate services and for ongoing monitoring, evaluation and synthesis.

Reflexive co-production, therefore, offers to overcome some of the challenges of quality control by fully acknowledging that visions of a sustainable world are deeply normative and political, and hence are legitimate objects of political debate and choice. One of the future challenges is to raise questions of trust, public accountability and representation in more explicit ways in order to address the legitimacy of those who speak for climate providers and decide what counts as credible, legitimate, and salient climate services.

4.1.1 Going forward

Based on such a comparison of design choices, we explore the space for possible intervention to shape standardisation in a more responsible and sustainable way.

In sum, there are a number of concrete proposals we can suggest for those interested in co-producing climate services with and for the public sector:

1. The first is that no guideline can provide all the required advice. Climate service or climate service standards users or developers should feel encouraged to see different guidance documents as complementary.

2. The provision of climate services as well as their quality assurance must be responsive and account for their social and situated embeddedness.

3. Using a comparative approach to map climate services can help practitioners and producers better understand the diverse landscape, local context, diverse meanings of risk and impact, identify the political realities and thus better anticipate unintended outcomes, encourage collaboration and identify potential weaknesses and gaps.

4. Recognising that best practices and guidelines that truly account for the spatial and temporal diversity in the use and circulation of climate services cannot be formalised.

5. However, processes of expert validation like peer-review, means of conflict resolution, conflicts of interest policies, and circulation of knowledge in climate services can be standardised using formalised processes of quality assurance. These formal processes of quality assurance need to be monitored and evaluated regularly to respond to changing contexts and challenges, and to readjust their working.

6. Climate services developers and users should be aware of how definitions of risks emerging from climate variability and change, and their remedies, are defined both by science and socio-political understandings.

4.2 Next steps of WP5/T5.3

The insights produced in this deliverable will direct forthcoming activities of Task 5.3, WP5, and the CE2 project more broadly. Discussions within WP5 suggested that Horizon 2020 and Horizon Europe projects could be complemented with an analysis of projects from the LiFE programme. LiFE projects were suggested as more likely to develop and implement more operationable climate services in the long term. Consequently, we requested from WP4 partners a database containing information of relevant projects. We obtained a list of 58 projects. We observed that these projects produce less documentation and deliverables than Horizon 2020 and Horizon Europe projects, or at least not many documents are available for all the projects. Consequently, we decided to select a limited number of projects for more careful analysis. We decided to consider currently active projects that are in an advanced phase so that they had produced lessons learned and potentially more documentation. Four projects were selected for detailed document analysis and interviews which will contribute to make our findings on the standardisation and local flexibility of climate services more robust (in France, Greece, the Netherlands, and Spain). Thus far, our partners from BSC and Ramboll (France and Belgium) have conducted at least one interview with participants in these projects. The findings will inform our next deliverable, 'D5.4. Policy brief: pathways from standardisation of climate services to climate action'.

The findings of this deliverable will be shared with participants in the CE2 Belgrade Festival in September-October 2025. The interaction will help us to inform D5.4 through a participatory pathway-building approach. Finally, this deliverable will contribute to the development of a training module in coordination with WP4.

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6 Appendices

6.1 Annex 1. D5.3/D5.4 Research guide

Introduction |This document provides clear information about the aims and goals for the elaboration of Deliverable 5.3 *"Review of best practices guidelines and criteria for science-policy interactions to support the standardisation of CS (M34)."*

Science-policy interactions in the realm of climate adaptation are extremely vast. Vertically they extend to all levels of government, and horizontally to a broad range of organizations dedicated to the development and implementation of climate adaptation policies and dedicated scientific organizations. These levels have been well explored and presented in previous deliverables, in particular D4.5 and D5.2.
In order to make the work more focused, we will explore quality assurance guiding science-policy interaction. Our focus is on existing best practice guidelines produced by a variety of organizations including ISO, WMO, and more locally produced best practices and guidelines developed in European projects (i.e. Horizon 2020, Horizon Europe, LiFE). When there aren't best practices or guidelines available, as in the case of the LiFE projects, we will explore with interviews those relations between local co-production of climate services and the broader institutional landscape of science policy interactions.

Contents of this guide| This guide contains the main research questions that the deliverable will address, an interview guide, and a guide for the analysis of both interviews and documents such as EU project deliverables.

6.1.1 D5.3/D5.4 Interview Guide

PART I: Introductory questions:

1. Can you describe your role and responsibilities within your organization? What is the mandate of your organization in adaptation policy? At what level?
2. For how long have you worked there?
3. What is your role in the development or implementation of climate adaptation initiatives?

PART II: Climate adaptation knowledge demand and supply

4. What are the information needs of your organization to inform decisions regarding climate adaptation policies?
5. Where does your organization search for knowledge/ support to inform decisions regarding climate adaptation policies?
6. How do you assess or secure your knowledge sources' scientific quality and soundness (quality control for evidence-based policymaking)?
7. What legally binding regulations (EU/ national) establish how to use and assess knowledge?
   (Example: the German Strategy for Adaptation to Climate Change 2024 (DAS 2024). With the new national climate adaptation strategy, the Climate Impact and Risk Analysis 2021 (KWRA) is required for formulating and implementing adaptation measures and plans; https://www.bmuv.de/en/download/2024-german-climate-adaptation-strategy
8. How does the use of information required for adaptation policies differ according to legally binding legislation at the EU, regional and local level?

PART III: Climate services

9. Does your organization use climate services to inform decision making regarding climate adaptation?

    a. What sorts of climate services (information/ tools and/ or processes)?
10. Why do you use climate services – to what end, for what function(s)?
11. What criteria does your organization use to assess climate services? ("usable", "sound", "fair", "equitable" …?
12. Who produces climate services used by your organization? (Providers of climate services)
13. Are there legal regulations governing the use of climate services? How do they govern the use of climate services?
14. What is an example where climate services are fit for function?
15. Are there best practices or guidelines on how to use climate services? Why are they "best practices"? What works? Why? Where are limitations? How can the provision of climate services be improved? What are limitations and weaknesses of climate services? Where or for what function can't they be used?
16. If your organization is not using climate services, what alternatives to climate services are used as a knowledge base for informing your decisions?

Specific project (for Horizon or LiFE projects)

17. What is your role and the role of your organization in the project?
18. ~~How is your area of work [e.g. urban resilience, flood management, agriculture] organized in your municipality/region?~~
19. ~~Do you know how the consortium for the project came together?~~
20. How does the project address information needs of your organization, and for climate adaptation policies?
21. Is decision-making support also produced or delivered by the project?
22. Do regulatory requirements governing the use of knowledge play a role? (e.g. the use of a particular risk assessment)
23. Which information needs are addressed by the project? To what extent are the information needs and expectations of the public sector addressed? How?
24. If not, what has been missing? What has not been working?
25. ~~Can you think of any frictions that may exist between different actors?~~
26. Have the project outputs informed policy? Or how do you think they will inform policy?
27. Besides [specific project], have there been other projects to inform and develop climate adaptation and mitigation strategies?

PART IV: Standards for climate services

28. What role do standards play in adaptation strategies and plans?
    a. At the local, regional, national, EU, international levels?
29. What standards are used (e.g. ISO 14090 or 14091 series; ISO/TS 1492 Adaptation to climate change?
30. What forms of standards are used (tools or processes)?
31. To what end are standards used?
    a. To make knowledge base for providing climate services "sound"?
    b. To make climate services usable
    c. To meet users' needs?
    d. …
32. Are there legal requirements guiding adaptation planning for local governments and communities in general, the use of standards in particular?
33. What are examples of successful use of standards in climate adaptation? According to what end?

34. What are challenges or limitations related to the implementation of standards in climate adaptation? If so, what are they?
35. Can climate service standards help to improve the fit between the demand and supply of climate services in particular? Knowledge provision and demand in general?
36. What are standards NOT good or helpful for? Why?
37. What can be alternative concepts, approaches, procedures or mechanisms to standardization?
38. Are there other best practice guidelines for climate adaptation and mitigation that you can think of?

6.1.2 Analysis guide

Analysis guide | The following are the main elements we expect to identify in the document analysis. Also relevant for interviews.

Main elements	Specific dimensions	Definition formulation
Who (ecosystems of actors)	(1) Participation	Who participates in co-production processes of climate services? • Which governmental departments of included? (e.g. urban planning, flood management, environmental reporting…)? • When, how and to what end are citizens included? • Who are the experts consulted for what function (institutional affiliation, disciplinary background, source of expertise, knowledge input…).
	(2) Mandate (mode of delegation)	How is epistemic and political authority allocated between key actors? Who is entitled to speak for science, the state and the public and hence performs such authority?
	(3) Transparency/ accountability	According to what rules of political and cultural accountability are state and non-state actors operating? (e.g. confidential, beyond closed doors…)
	(4) Regulatory or decision making context	What are legal or regulatory requirements for providing climate service or evidence-based policy making? For monitoring, reporting, and verification of greengas inventatories … (MRV) according to FCCC, EU, national law
How (mode of delivery and evaluation)	Co-production "method"	a. Is there a particular script or tool that guides how co-production is made? b. Are references provided? Where is this method coming from?
	How are the credibility, salience, legitimacy, and accountability of the co-production processes maintained? By what processes and procedures?	a. How is the (scientific) credibility of climate services maintained? (e.g. methods of assessment or expert review/ quality control, evidentiary rules …, monitoring, evaluation) b. How is the salience and usability of climate services maintained? (e.g. stakeholder participation, consensual procedures…) c. How is the legitimacy of climate services maintained? (e.g. broad and inclusive

		participation, representation … , information disclosure)?
What role for standards?	What processes can be formalized & standardized?	1. Quality control 2. Coping with uncertainties 3. Meta-assessment 4. methodological consistency 5. Stakeholder engagement 6. ….
	What processes cannot be formalized & standardized?	7. Informal Consultation 8. Translation/ application to local contexts/ context-specific knowledge 9. Conflict resolution 10. Leadership … 11. Trust … 12. Commitment to the process …
Outcomes	What are main outcomes?	• Maps • Tools • Best practices • Standards • Capacity building • Platforms/ interfaces • …
	How is the implementation and compliance with best practices/ standards monitored, reported and evaluated)?	