User selection and engagement for climate services co-production

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ABSTRACT

Climate services are high in the international agenda for their potential to help combat the effects of climate change. However, climate science is rarely directly incorporated in the decision-making processes of societal actors, due to what has been identified as the usability gap. The cause behind this gap is partially due to a failure to timely and meaningfully engage users in the production of climate services, as well as misperceptions on which users can best benefit from climate service uptake. In this article we propose user selection and engagement guidelines that integrate important values from participatory science such as those of legitimacy, representativity and agency. The guidelines consist of 5 + 1 steps: defining the why, where, whom, which attributes, which intensity, and how to select and engage with stakeholders. Whilst these steps may be initially implemented by an ideally interdisciplinary team of scientists and service designers, the final step consists of an iterative process by which each decision is agreed together with the identified users and stakeholders under a co-production approach. We believe lack of willingness is not the major barrier but rather a lack of guidance for consistent user selection and engagement. Following a set of methodological guidelines is important to design climate services aligned to the actual needs of a wide and inclusive range of ultimately empowered societal agents.

SIGNIFICANCE STATEMENT

The review of the climate science and services literature and related research projects reveals that, despite the insistence to include users in all stages of the research process, users are often involved only sporadically and inconsistently, and when there is little room to change the climate service suitable for decision-making. Here we argue that a reason is the lack of user selection and engagement guidelines. Failure to implement a research design strategy for these decisions can lead to a lack of usability and applicability of the produced climate-related services, as well as hampering their long-term uptake. These guidelines can thus support the development of usable, co-produced, actionable climate science.

"It becomes obvious (...) that neither decision makers nor scientists working alone can specify what science products are needed, how they should be developed, and how they should be applied to climate adaptation" (Beier et al. 2017, p. 289)

1. Introduction

Climate services demand is on the rise due to the increasing awareness of the negative effects of climate change and the need for evidence-based responses (Street et al. 2019). Globally, a wide range of institutions foster the climate services market, from the World Meteorological Organisation and its Global Framework for Climate Services (GFCS) launched in 2009, to other initiatives such as the European Union's Copernicus Climate Change Service (C3S) (Bojovic et al. 2022). The C3S, for instance, aims to build a climate-resilient society by engaging a large number of experts on developing, distributing and using climate services, ensuring the quality of climate data and eliminating obstacles impeding its usage (Buontempo et al. 2020).

Among the obstacles identified that impede the use of climate data, scholars mention cognitive, social, institutional and knowledge barriers (Dilling and Lemos 2011; Kalafatis et al. 2015; Raaphorst et al. 2020). As an outcome of these obstacles, scholars have noticed that whereas the quality of climate services has been increasing, its usage by societal actors has not followed suit (Findlater et al. 2021). To address this gap, global scientific networks have asserted a change in paradigm in the way of producing climate and sustainability-related science. These actors promote the adoption of knowledge co-production processes to enhance scientific accountability towards society and ensure implementation of the scientific activity, whilst including different knowledge types in designing climate-related policy and strategies (van der Hel 2016; Owen et al. 2019; McCauley and Heffron 2018; Bremer et al. 2019).

Users are at the center of climate services by definition, as despite the wide range of products they encompass, climate services are identified with the key commonalities of being guided by users' needs, providing climate information for decision-making processes and involving dissemination and uptake practices (Bessembinder et al. 2019). Targeting the inclusion of diverse actors at key stages of the co-production process increases the chances to produce actionable knowledge that will be incorporated in decision-making (Armitage et al. 2009; Beier et al. 2017; Hill et al. 2020). Henceforth, successful co-production processes demonstrate the importance of including stakeholders and users across the stages of climate services production. In reality, nonetheless, few examples put this into practice (Vaughan et al. 2018). Most projects adopt rather supply-driven forms of producing services with the risk of not meeting users' needs (Buontempo and Hewitt 2018; Daniels et al. 2020; Findlater et al. 2021; Hewitt et al. 2020; Lemos and Morehouse 2005; Porter and Dessai 2017).

In this article we adapt the methodology of stakeholder analysis to the particularities of climate services. Our aim is to propose a methodology for enhanced user selection and engagement which increase the likelihood that climate information is incorporated in decision-making processes and considers the needs from different types of users, because currently there is a lack of guidance especially on systematically selecting a plurality of users. This is usually exacerbated by climate scientists' perceptions of users in the "mini-me" phenomenon, by which scientists expect users to have the same background despite this rarely being the case (Porter and Dessai 2017). Knowledge co-production is a participatory approach to science, and many such approaches depart from a set of principles infusing the range of methods through which they are implemented on the ground. The principles this guide aims to be infused with are those of valuing, equality, authenticity, transparency, agency, representation, deliberation, inclusion and transdisciplinarity (Reed et al. 2018; but for ethical principles in co-production and transdisciplinary research see also Wilmer et al. 2021). Inclusive research practices are very important: the better job we make in the selection of users that range from a variety of identities, backgrounds and knowledges, the better foundation we lay down for designing services that are accessible, welcoming, safe, ethical and inclusive for everyone. These principles have been linked to the steps proposed below, but they should represent the overarching theme throughout. In the next section we give an overview of the stakeholder analysis literature, followed by the proposed steps for stakeholder and user selection and engagement for climate services. In the discussion we dive into ways to successfully navigate the challenges that can occur during this process.

2. Adapting stakeholder analysis to climate services

Stakeholder analysis matured in the management literature in the 1980s, with the recognition that engaging actors external to an organisation was critical to the very survival of the organization (for a review of stakeholder analysis definitions see Yang 2014). From this literature emerged the most often cited definition of stakeholder, understood as "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman 2010, p. 46 from 1984 ed.). In the 1990s, evidence that the governance of natural resources was increasingly adopting hybrid regulatory, market and network-led forms of governance, raised the interest from scholars to tailor this organisational science to the issues faced in natural resource management. Natural resource management and climate services have some elements in common such as the complexity of the issue at stake, the general initial disconnection between involved stakeholders, and a context of human-environment interactions (Beier et al. 2017). However, the particularities of climate information and services create the need to narrow down stakeholder analysis methodologies through a human-centered approach as proposed below.

Buontempo and colleagues (2020, app. 1) define a climate services stakeholder as, "an individual or an organisation who is interested in the project and who has a critical decision which can be informed by climate information." As it subsequently follows, stakeholder analysis for climate information is the process that: i) identifies individuals, groups and organisations who can benefit from using a climate service; ii) prioritises these individuals and groups for involvement in the climate service co-production process; and, iii) defines a climate service which can be of support to their decision or action. For instance, in the context of flood risk management in a local area of Germany, Reimann and colleagues (2021) mapped disaster-impacted societal actors who represented different interests and invited them to co-design a climate service to inform adaptation decisions for coastal flooding. The activities conducted to identify and engage with these stakeholders encompass the process of stakeholder analysis. The extent to which the stakeholder might become a user is part of the steps in the guidelines.

This involvement, and especially for climate services, may take a holistic and human-centered approach, as increasingly being introduced in climate services through service design. Service design involves the practice of creating and engaging with efficient user experiences, by making the users and stakeholders part of the whole lifecycle of the service and products. It uses methods from different disciplines to solve problems by first co-creating better service definitions that begin with understanding human needs and then co-designing solutions to address them. Human-centered design cultivates deep empathy with the people that will be interacting with the service, both end-users and stakeholders, as a requirement of usable climate services (Christel et al. 2018; Terrado et al. 2022b).

Next, we present the guidelines on selecting stakeholders, and within the initial selection, engage a group of committed users. As shown in Fig. 1 below, the guidelines adopt and adapt the principles from participatory scientists which include (based on Bell and Reed 2021): valuing, equality, authenticity, transparency, agency, representation and deliberation, to which we add interdisciplinarity and inclusivity (Glavovic et al. 2021; Cologna and Oreskes 2022).

3. Results: the guidelines

This section presents the guidelines for the user-oriented analysis, summarized in Fig. 1:

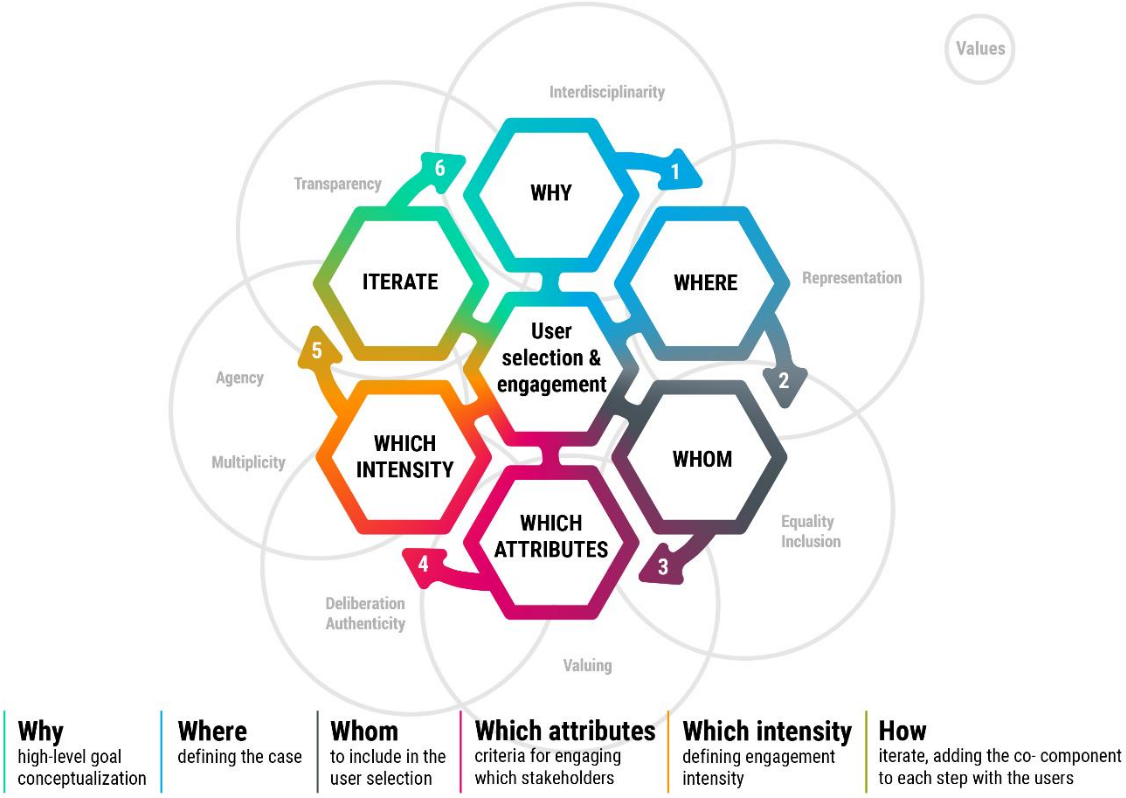

Fig. 1. Stakeholder and user analysis for climate services co-production processes

Step 1: Why - High-level goal conceptualization

The literature recommends as the first step to focus on the conceptualization of the high-level goal or problem, rather than on the specific climate service or indicator to be developed which will be done later with users (Beier et al. 2017; Norström et al. 2020; Prell et al. 2009). High-level goals can imply a wider range of aspects, as for instance, quoted from Norström and colleagues (2020):

- Achieving changes in policies and practices
- Changes in attitudes and perceptions
- Creation of new relationships and networks of collaboration
- Increased agency of previously marginalised actors, or even impacts

Or also, more concrete for climate services:

- Supporting mid-term decision-making processes linked to policy
- Improving the sectoral applications of predictions and projections

In practical terms, project discussions usually start among ideally an interdisciplinary team of social and physical climate scientists, as well as service designers, to decide on which high-level goal to pursue.

This will allow the project team to continue with the follow-up steps, but we should return to these steps once the stakeholders are engaged (step 6.1), to specify the objectives, confirm the shared understandings and ensure alignment to the user needs as the second component of goal-definition. Issue or action definition should be conceived as a flexible and iterative process, moreover because the pool of stakeholders might change across the life cycle of a project and ensuring shared understanding among the project network is key for reaching milestones (Norström et al. 2020). For example, a project has the original high-level goal to improve the sectoral application of decadal predictions in agriculture. Upon discussion with the engaged users (step 6.1.), information at a decadal time scale can prove less relevant for the service, as the amount of yield is determined by the climate in the months before the harvest. Hence, seasonal predictions are identified by stakeholders as the most appropriate in this case and thus the high-level goal needs to be adjusted. This is also related to Step 2.

Step 2: Where - Defining the case

Climate services depart from applied climate science and are generally related to a specific context including a climate-sensitive sector, scale and governance system. Relevant to the sector -agriculture, energy, forest- is that climate science generally encompasses boundary-spanning issues that should be viewed in its relation to complex, interconnected systems (Cash et al. 2003). The scale and the governance system imply a recognition of the multiple spatial, temporal, jurisdictional and institutional levels that intervene in human-environment systems (Cash et al. 2006). The recognition of this complexity is the departure point for the knowledge co-production process to determine where the users are located. Again, this is an interactive step that will have to be repeated with stakeholders once identified and engaged (step 6.2, below, and in terms of scale, see step 6.3). In this iteration, the case can be further defined: for instance, stakeholders and users can help identify an event that can become the subject of a climate service co-production process (Terrado et al. 2022a).

The European Commission funded climate science and climate services projects such as FOCUS-Africa, PRIMAVERA, EUCP, MED-GOLD or the prototypes evaluated in

EUPORIAS, add a range of case studies to apply developments in science to specific contexts, from the local to the supranational. This practice is recommended by the very need of applied climate science or climate services to support a decision or action which is likely to be context-bounded, independently of the context being as broad as, for instance, the European level (see, e.g. Athanasiou et al., 2020, for a EUCP example). An alternative is for climate services that are of technical readiness and that have already been developed with a use-case in mind, such as wine producers in the MEDGOLD project.

Gerring (2016) in his seminal book on case study research discusses several techniques and criteria for choosing a place-based case, depending on the high-level goal (step 1) of the scientific project, which we have adapted for developing climate services:

Criteria	**Explanation**	**Examples**
Intrinsic importance	The case contains certain characteristics that are of theoretical or practical significance for the application of a climate service.	The project APPLICATE conducted several case studies in the Arctic. The cases were selected in the region following a co-production process. The Arctic was of intrinsic importance as the high-level goal was to improve climate predictions in the region (Terrado et al. 2022a, 2018).
Logistics	Pragmatism can also be a criterion, particularly as budget constraints are identified as obstacles for knowledge co-production. Logistics is defined in Gerring (2016, p. 40) as "accessibility of evidence for a case".	In the Impetus4Change project, part of the project team is based in the city which will be one of the climate service demonstrator cities (Barcelona). Similarly, in a different project Barcelona served as a case study for assessment of the impacts of an air quality policy of the city (high-level goal) (Rodriguez-Rey et al. 2022).
Within-case evidence	It is related to the criterion of logistics, but it implies not case-level but within-case characteristics. It hints that the case contains part of the variables that are considered of relevance for the climate service. What characteristics are relevant depends on step 1.	The project MEDGOLD selected 5 regions to explore the relevance of decadal predictions for the agricultural sector (high-level goal). Among the attributes of interest was that these regions had high wheat production (Solaraju-Murali et al. 2022).
Representativeness	Representativeness is important when the climate service is implementable in multiple contexts (upscalable), but it is at a stage that application to only a specific case or cases can help its finer-tuning.	The EUPORIAS project revised several prototypes developed in the context of EU-funded projects. The prototypes used case studies which were thought of being representative for a broader number of cases (Buontempo et al. 2018).

Case independence	This criterion is relevant if, for instance, the climate service is being 'tested' as e.g., proof of concept, in various cases simultaneously (N cases > 1). It requires these cases to be independent of each other in terms of the "outcomes of concern" (Gerring, J. 2016, p. 41). Similar to regression analysis requirements.	In the project GREENSCENT several schools from different countries were selected to study air quality awareness, without the schools being connected to each other, so cases were not influencing study outcomes. This purposive selection also ensured that different contexts were considered.

Table 1: Criteria for place-based case selection for climate service co-production and examples

Stakeholder and network studies have shown that errors at the stage of defining case boundaries can incur validity issues, but equally impact the feasibility of the chosen approach to step 3: stakeholder identification (for more guidance see Borgatti, S. P. et al. 2018 Ch. 3). This step, as furthered in the discussion, is crucial if one considers aspects of scalability or replication of the climate service.

Step 3: Whom to include - Stakeholder and user identification

The vision of the user is of relevance and initial pre-conceptions about them should be openly discussed by the group involved in a climate service project. Generally, the literature describes the effect of the "mini-me", by which scientists misinterpret the profile of the user, who they see as someone with similar perceptions, background and decision-making rationales as themselves despite being rarely the case (Porter and Dessai 2017). Participatory methodologies are generally added to scientific processes to address initial (mis)perceptions, challenge assumptions, and facilitate mutual learning between participants, which implies that users have as much to learn from scientists as scientists have to learn from users. As a sign of recognition, some projects differently label the users more intensively engaged in co-production (see a review on the different notions of co-production in Bremer and Meisch 2017). For instance, there are labels such as superusers (ASPECT), companion-partner users (EUCP), fellow-users (FOCUS-Africa), champion users (PRIMAVERA) or next-user (Otto et al. 2016).

Whom to include relies again on the previous steps and can imply only a small handful of stakeholders identified as potential users or a broad circle of over 100 stakeholders, as it depends on the high-level goal and case(s) (see e.g. Zingraff-Hamed et al. 2020). In the table below we show the range of possible categories from which the pool of stakeholders/users can be identified. This step brings again considerations about the sector and scale, which partially depend on the decisions taken in the previous steps. Many of these stakeholder categories have presence at several scales (e.g., an NGO can have headquarters at EU level, and have local offices), and the scale should meet the scope of influence of the "decision or action" which the climate service is supporting, being this the local, subnational, national or supranational level.

Categories	Types
Policy-maker	Local, sub-national, national and supranational level.
Governmental body	Environmental and conservation agencies, climate change offices, funding agencies.
Resource manager (public)	Local, regional, and national authorities or resource authorities (e.g., river basin management authorities), public utilities, resource suppliers.
Resource manager (private)	Landowner associations, professionals, mediators, practitioners.
Data-related stakeholder	Data provision, supplier, purveyor, developers, manager.
Civil society/community representatives	Citizen associations, local communities (hybrid), consumer associations, citizen representatives, social movements, youth representatives.
NGO, foundations	Local, regional and national NGOs.
Private sector	Companies, industry representatives, associations.
Networks	Transnational networks, global initiatives, umbrella organisations.
Media	Journalists, specialised media.
Other	Non-project related scientists, technologists (vendors, computing centres, etc.), experts; educators.
Sources: (Raaphorst et al. 2020; Roux et al. 2017; Directorate-General for Research and Innovation (European Commission) et al. 2015), own.	

Table 2: Proposition of user categories with typologies to guide user identification

There is no requisite that these categories should all be represented, but they can help in brainstorming because, depending on the high-level goals and selected case(s) (step 1 and 2), the potential pool of stakeholders and users will vary. Here, being mindful of the distinction between levels of aggregation is relevant: treating individuals as such or individuals as representatives of organisations.

There are several methods to identify the first pool of stakeholders, ranging from basic desk research activities to more sophisticated content analysis of policy documents to detect stakeholders or stakeholder networks surrounding a given topic (see e.g. Kalafatis et al. 2015). After a very initial identification of some stakeholders, among more resource-intensive methods there are focus groups and helicopter interviews – approaching actors with different perspectives on the state of the art (Hajer, 2006)., with or without integrating the practice of snow-ball sampling by which the initial contacts nominate other potential stakeholders (Reed et al. 2009). This stage of user identification requires technical skills and demands from scientists to couple them with a capacity for social analysis (Reed et al. 2009; Walker et al. 2008). Finally, project network personal contacts can be included, but it is important that they are subjected to step 4, to be aware of possible conflict of interests or power positions.

Step 4: Which attributes: from stakeholders to users

The identified actors will not all need to be involved with the same degree of engagement intensity, hence this step asks: ‘Why would we like to count with this stakeholder or potential user in the co-production process?’. In terms of attributes, Mitchell (1997) proposes to characterize stakeholders based on influence, power and legitimacy (Jepsen and Eskerod 2009, p. 336; see Reed et al. 2009, p. 1938 for alternatives). Adapting this approach to climate services, users can be fit into profiles based on: (1) the user’s power and influence to determine the type and characteristics of climate service(s) that will be developed; (2) the urgency with which the climate service is needed; (3) multiplicity of interests and perceptions, including legitimacy considerations; and in relation to this latter: (4) knowledge types.

Attributes	**Definition**	**Self-assessment questions**
Influence	Defined as ‘‘the way the stakeholder can affect the project”, as well as tactics to establish conflict or cooperation dynamics to achieve their interests (or stakes) for participating in the process (Jepsen and Eskerod 2009, p. 336).	• *How much of the success (e.g. achieving uptake in decision making) of designing the climate service depends on [this] stakeholder?* • *What interest/stake may the stakeholder have in the climate service? (e.g., increasing sales)* • *What means (money, time, expertise, local knowledge, access to a network, trust – as in, trusted member of a marginalised community) does the stakeholder bring in?*
Power	Power can be exercises in an infinite range of forms, some more directly observable than others. It can be seen as the combination of, “agency (the individual capacity to make a choice) and opportunity structure (the institutional context in which this decision is made)” (see a discussion and references in Schiffer 2007 p. 5).	• *Will the presence of certain stakeholders preclude a meaningful engagement of others?* • *Will any stakeholder be harmed by participation in the project?* • *What aspects (literacy, cultural, technical infrastructure) may preclude meaningful engagement?*
Urgency	Degree to which the climate service is needed by a given societal agent or group of agents. ‘Need’ is viewed here from the perspective of common goods, by which society in general will benefit.	• *Is it expected that the climate service can help deal with an expected increase in the severity of a disaster? (e.g., yearly floodings).* • *Can the climate service efficiently support existing practices or legitimately replace them?*
Multiplicity	Multiplicity defined as “degree of multiple, conflicting, complimentary, or cooperative stakeholder claims made” (c.f. Neville and Mange, 2006 in de Bakker and den Hond 2008, p. 11). The degree of multiplicity desired will depend on the high-level goal (e.g., if the climate service	• *Are different perspectives taken into account?* • *Are several stakeholder groups (public authorities, private and third sectors) represented?*

	needs to be used by stakeholders from different countries, high multiplicity in terms of e.g., cultural backgrounds is desired).	• *Is the first pool of stakeholders gender, race and intergenerationally diverse?* • *Are several stakeholder groups (public authorities, private and third sectors) represented?*
Legitimacy	Legitimacy considers the participation of different societal representatives in the co-production process to make the climate service more democratic and inclusive. It is linked to all other attributes.	• *Are marginalised groups that could benefit from the climate service included in the process?* • *Will the voices heard make the climate service usable by different types of stakeholders? (if applicable)*
Knowledge	Different types of knowledge can be experiential, local, traditional, academic and official (Nel et al., 2016). Knowledge can also mean access to certain networks (see also Clifford et al. (2020) for the importance of incorporating different knowledge in the design of climate services).	• *What types of expertises are present among the initial pool of stakeholders?* • *Is context-bounded (step 2) knowledge represented?* • *Does the stakeholder have access to certain networks that can benefit from the uptake of the climate service?*

Table 3: Definition of attributes for stakeholder selection and assessment questions

After this step, scientists can proceed to establish a desired level of involvement.

Step 5. With which intensity - Defining engagement intensity

Once the reasons why a stakeholder is desirable to be included is checked, the next step is to propose an involvement degree for the co-production process. The attributes of step 4 can be assessed together in a multi-attribute exercise to link them to elements of a co-production process that range from passive to more active.

The multi-attribute exercise can be done qualitatively or adding a quantitative approach (e.g. likert scales, see for instance Bourne and Walker 2005). The criteria can have different weights as illustrated by the following example for the criterion of ‘knowledge’: depending on the high-level goal and/or the timeline of the project, familiarity with the topic (climate information, climate change, climate services) is considered relevant. Thus, not all types of knowledge may be required for the co-production process. Moreover, 'new' users not familiarised with climate information may need capacity building, which might not be possible in the case of short projects with less time for engagement.

We envisage three degrees of engagement based on the framework for climate services presented in Bojovic and colleagues (2021): awareness raising (for all stakeholders), involvement (for those stakeholders who have characteristics of potential users) and empowerment (for those stakeholders who may be final users). The framework proposes different methods by engagement degree.

Stakeholder	**Influence**	**Urgency**	**Knowledge**	**…**	***Engagement***
NGO 1	Med (network mobilisation)	Low (not direct user)	Official/ academic	…	***Awareness raising***
City council	High (funds)	Med	Official	…	***Involvement***
Smallholder farmer	Low	High (drought threats)	Local/practitioner's	…	***Empowerment***

Table 4: Example of a multi-attribute exercise to determine engagement degree

Step 5 includes asking the identified stakeholders for their willingness to engage in the project to the desired degree. This is challenging due to the observed reality of stakeholder burnout (Delzeit et al. 2021).

To be successful on engaging stakeholders, scholars have identified several techniques:

- Carefully designed and tailored communication strategies are key to engage the user in a way that matters for them and these can differ depending on the stakeholder/user needs (Bojovic et al. 2021; Christel et al. 2018, p. 201).
    - Targeted email communication including for instance: the use of the contact name details (if available); attaching an official letter from e.g., the funding body project office; proposing a date for a call for discussing further details, which can serve as a safe space to define the stakes of climate service from the stakeholder perspective. Effective but more invasive techniques are follow-up calls in case of receiving a non-response to the email.
    - After the stakeholder has agreed to participate, it is important also to confirm the needed degree of confidentiality that the user will require.
- Identifying influential stakeholders who can become sponsors of the project or climate service, such as for example, scientists with high reputation or policy brokers, can be beneficial. These are committed individuals or groups, who may act as links between social groups and motivate others to participate (Armitage et al. 2009; Reinecke 2015; Baulenas et al. 2021). Additionally, identifying intermediary agents such as community-based organizations, to monitor and ensure

a power-balanced and transparent process can be important to avoid marginalization of certain groups (Thinyane et al. 2018).

- Some scholars propose monetary compensation (Klenk et al. 2015), in acknowledgement that the scientists and service developers are being paid to attend stakeholder-engaged meetings, while stakeholders may be taking time away from their actual jobs or other sources of income.

The benefit of conducting an exhaustive user identification and mapping (step 3) is that per each profile considered relevant to participate in the process, there can be “backup” stakeholders in case of unwillingness to participate, discontinuing participation in the middle of the project (attrition) or intermittent availability during the process.

Step 6: How - Iteration: adding the co- component to each step

The final step is the most important and starts once the stakeholders and users have been engaged in the process. This step returns back to step 1 to 5 and revises them adding the co-production component to counter the top-down approach that has guided the previous steps.

Sub-step 6.1 consists of co-specifying the goals and decision-making process. The high-level goal (step 1) needs to be agreed upon and further elaborated and specified between scientists and stakeholders. Studies on participative approaches have shown that joint goal definition can impact the success of the project (Reed et al. 2018, sec. 9). This step also generates problem ownership, which is important to maintain interest of stakeholders during the project (see e.g. Delzeit et al. 2021). As the climate service definition also implies a decision-making context, at this step it can be co-decided which decision can be supported by the climate service, and which types of capacity building processes this might require.

Sub-step 6.2 consists of co-defining the case study, which implies decisions on the specificities of the case study: specific events or locations. For instance, step 2 selected “Barcelona”, step 6.2 with stakeholders selects “the 2007/2008 severe drought in Barcelona” (Martin-Ortega et al. 2011; March et al. 2013). To support this step with a co-production approach, Terrado and colleagues (2022a) proposed eight best practices for the selection of events with stakeholders in climate services.

The other sub-steps (6.3, 6.4 and 6.5) consist of co-validating the results of the exercises that the project team have conducted in steps 3, 4 and 5 respectively. For instance, step 3 identified the initial list of stakeholders: the currently engaged stakeholders can help identify other stakeholders that were not originally identified using snow-ball sampling. Step 4 has established attributes for each participant. To some extent, the general attributes of the current network of engaged stakeholders can be shared. This can help raise awareness on the values that have been considered when including several profiles and the rationale behind themselves (the stakeholders) being present in the project, which can also positively contribute to project ownership. Sub-step 6.5 can validate if the communication strategy is suitable to the stakeholder realities.

The methods proposed under knowledge exchange (user forums, surveys, workshops, learning labs, interviews) are a good choice to conduct step 6 and its sub-steps, which can be done in the same get-together event (see for more detail Bojovic et al. 2021).

Finally, to consolidate joint decisions and formalise the type of co-production process that will be conducted with the stakeholders/users to develop the climate service, as well as ensure intersubjectivity, there are several possible actions. Klenk and colleagues (2015, p. 744) proposed a memorandum of understanding, "outlining goals, principles, and intellectual property rights of partnerships with non-academic stakeholders; clear roles and responsibilities of knowledge co-producers and guidelines for how partnerships will accumulate, store, and mobilize data.". This memorandum can be a living document accessible to all engaged stakeholders. Accessibility here may include devising versions of this document also as a non-computerized document available on community notice boards. The necessity for this will need to be assesses at an *ad hoc* basis.

Step 6 is also challenging because users might bring in different and sometimes irreconcilable needs that cannot feasibly be addressed with the future climate service, in what is recognised as the multiplicity of stakeholder interests (de Bakker and den Hond 2008). In the Discussion, we provide some trouble-shooting techniques for these cases.

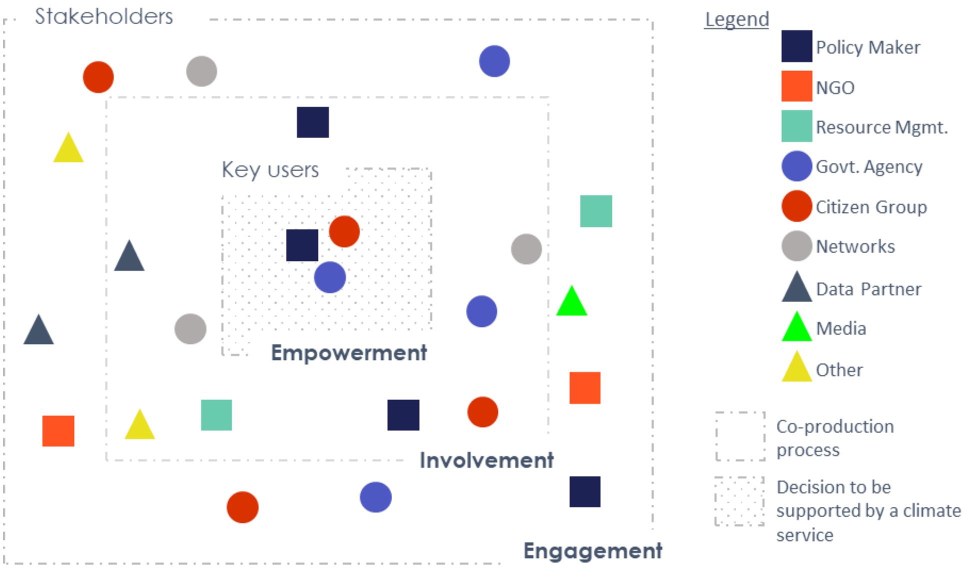

Fig. 2. Idealized outcome of implementing the guidelines

4. Discussion

Climate information and services are linked to climate science, and as Owen and colleagues mentioned (2019, p. 152), "value-laden problems like climate change call out the need for socially engaged research processes to generate (...) knowledge that is useful-for and usable-by society to confront these so-called wicked problems". We firmly believe that a consistent user selection and engagement practice can ensure climate services meet these two success criteria: useful-for and usable-by society and societal representatives, from policymakers to local communities. Such wicked problems are multidimensional, and this multidimensionality makes it clear the reasons behind collaborative, adaptable and solution-centered approaches to science in which the complexities of human behaviour are taken into account (Bednarek et al. 2018). There cannot be innovative solutions without the participation of stakeholders and users beginning with the conceptualization of the climate service itself.

To achieve these standards, user selection and engagement in co-production processes is a task that should not be conducted ad hoc. The stakes that come with this process include legitimacy concerns, the possibility to empower previously marginalised but vulnerable groups, and enabling of long-term uptake of climate services to strengthen adaptation and mitigation actions to combat our changing climate. At worst, ignoring the different types of knowledge found in climate-sensitive contexts can exacerbate the side-lining of the groups most impacted by the climate crisis, produce biased results and be an obstacle for building the necessary trust in scientific activity required for acted-upon and evidence-based policymaking. As scholars point out, “A lack of process for identifying and involving stakeholders often leads to a very long initiating process and significant delays in implementation” (Zingraff-Hamed et al. 2020, p. 3). At the same time, we recognize that user selection and engagement is a very demanding process for which there has been insufficient emphasis and no guidelines in the field of climate services (Vaughan et al. 2018). In this paper we have aimed at addressing this gap and in this section we share some trouble-shooting techniques to overcome part of these challenges that might arise during its implementation.

Multiplicity: dealing with multiple demands, interests and perceptions

Conflict and conflicting views are regarded in network studies as something functional which can lead to innovation, to the point that certain network management techniques are deliberately targeting the presence of different profiles (Provan and Kenis 2007). The presence of different perceptions, views and interests is inherent to knowledge co-production processes in climate services and service design (Porter and Dessai 2017). The interests can be partially derived by the position of the individual, moreover if the individual acts at mezzo-level and thus representative of an organisation, and these can be identified in the initial stages of the user mapping and identification. However, these different expectations from the climate service need to be carefully managed through targeted methods such as focus groups, interviews or workshops. Trained social scientists are here essential members of the team applying these methods. m.

Lacking a theme, a team

The proposal stage of research projects is key for planting the seeds of successful co-production processes and of user selection and management. At the proposal stage not only objectives and tasks are defined, but very practical aspects such as the budget distribution among project partners. Lessons learned from climate services projects suggest that it is important to factor in this aspect (see e.g. Buontempo et al. 2018; Klenk et al. 2015). Proposals may incorporate a theme on knowledge co-production process (a dedicated work package), or alternatively encourage the incorporation of experts across several teams. Given the importance of design for obtaining successful outcomes in engagement processes, engaging in-house or external experts is always recommended.

Mutual, negative and un- learning

Whilst learning is often thought-of as always beneficial per se, the literature on policy learning in climate policy making shows that some processes can also move towards undesired pathways (Biesbroek and Candel 2020). Additionally, some learning processes require "unlearning" as well. As Neij and colleagues highlight (2021, p. 12), "Importantly, deep-seated changes are also suggested to require the need for unlearning of existing practices". For instance, a forest owner who has never used climate services to base her decision-making processes (e.g., type of management), might be reluctant to change practices, which might be influenced by long-standing family traditions and the practices of other community members such as local leaders (Oliva et al. 2016). Using co-production methods -and having different disciplines in the scientist team- can help create a climate of trust among the project scientists and stakeholders and convert the project into a platform of exchange and learning. In this platform of exchange, reciprocity -ensuring all parts gain from taking part in the process- can be more easily obtained.

Visualising power

Norström and colleagues (2020, p. 5) observed that: "Asymmetrical power relations can prevent some actors from engaging in knowledge co-production and will reproduce knowledge hierarchies, in which certain knowledge and expertise are seen as being more legitimate than others". This will impact the quality of the engagement process and bias results. In fact, the very implementation of participatory processes is a response to the willingness to balance power not only among societal groups but also between researchers and users. Collaboration and deliberative processes within can help create more equalized dynamics (Mosley, Layna 2013, p. 70). There are several tools in place to identify power relations in projects (see e.g., Reed et al. 2009; Schiffer 2007). Depending on the type of context under which the project is developed, stakeholders might know each other and here social network analysis can help to understand the linkages between stakeholders as well as inherent power dynamics.

Scale and scalability

These guidelines may be applied to any scale of decision-making, from local, over regional to supranational, targeting stakeholders concerned with problems that pertain to each of these scales. The framework can in addition support scalability and replicability of case studies, especially when thoroughly conducting step 3 for case selection. For scaling up activities, the stakeholder mapping needs to be adjusted to the institutional and socio-political frameworks existing at different decision-making scales. However, similar or same figures can recur in different scales as well as stakeholder categories. For example, civil protection may be an independent agency in one country, but it can also be situated in a department in the Ministry or be distributed as a network pertaining to several sectors. Overall, these trouble-shooting techniques may support in creating usable and legitimate science which contributes to the decision-making processes for a wide range of societal actors, strengthening adaptation and mitigation actions to combat climate change. Finally, whilst the proposed steps for user selection and engagement may provide a robust approach, they also have some limitations. For instance, we have addressed several important topics such as power, scale and values in research, only briefly. Thus, these guidelines may need to be supported with additional references, some of which we have already added when discussing these topics. Our assumption is nonetheless that these guidelines may be used by a team with expertise that can understand the repercussions of these key aspects in the selection and engagement of stakeholders in climate services co-production processes.

5. Conclusion

In this article we adapted stakeholder analysis methodologies to offer a hands-on roadmap for user selection and engagement in climate services. The six steps consist of: (1) why: the definition of the high-level goal(s); (2) where: delineation of the case; (3) who: user mapping and identification; (4) which attributes: multi-attribute analysis for selection criteria; (5) with which intensity: deciding on the engagement intensity and finally (6) introducing co-production to each step. As an outcome, the proposed steps introduce context (step 2), scalar fit (step 3), power (step 4) and design (step 5) considerations, which in Reed (2018) are not only shown to determine the success of different types of engagement but also to counteract the normativity of infusing projects with principles. We advocate for an iterative collaborative process that engages in a dialogue among different expertise to consistently incorporate climate services into decision-making for a climate-resilient society, viewing users as experts of their own knowledge domain.

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Data Availability Statement

No datasets were generated or analyzed during the current study.

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