WILEY   Environmental Policy and Governance

Joint knowledge production for improved climate services: Insights from the Swedish forestry sector

Åsa Gerger Swartling[1] [ORCID] | Sandra Tenggren[2] | Karin André[1] | Olle Olsson[1]

[1] Stockholm Environment Institute (SEI), Stockholm, Sweden

[2] ÅF, Stockholm, Sweden

Correspondence
Åsa Gerger Swartling, Stockholm Environment Institute (SEI), Box 24218, Stockholm, Sweden.
Email: asa.swartling@sei.org

Abstract

Science-stakeholder collaboration is becoming an increasingly common way to address mismatches between the knowledge needs of stakeholders and the research being done by scientists. This kind of mismatch is clearly evident in the field of climate change adaptation, arguing for the design and application of user- and decision-driven, coproduced climate services. Science-based participatory processes have shown clear benefits in establishing arenas for joint knowledge production on climate change and adaptation. However, multiple challenges remain. This paper presents and discusses findings from an assessment of a participatory climate services process conducted as part of a research program on climate change adaptation in the Swedish forestry sector. We identify enablers and barriers to successful science-stakeholder collaboration and put forward recommendations for more stakeholder-driven, participatory coproduction processes. Our analysis offers insights that could help achieve more informed decision-making and policy development and ultimately climate action under the Paris Agreement.

KEYWORDS

climate change adaptation, coproduction of knowledge, climate services, participatory action research, science-stakeholder processes

1 | INTRODUCTION

The urgency of climate change has led to the emergence of a new field of research and practice called "climate services" (WMO, 2011), which involves the generation, provision, and contextualization of information derived from climate science to guide decision-making at all levels of society (Vaughan & Dessai, 2014).

However, even as climate projections become more sophisticated and more confident, they are generally not being translated into adaptation decisions and action (Klein & Juhola, 2014; Larsen et al., 2012)—with some notable exceptions in the area of infrastructure and urban planning (Golding et al., 2017; Miralles-Wilhelm & Castillo, 2014). One likely reason for this is that climate services have tended

to have a supply-based perspective (Lourenço, Swart, Goosen, & Street, 2015), with climate issues and knowledge framed in scientific terms, and societal stakeholders perceived as passive receivers of information, as well as both contributors to and victims of climate change (O'Brien, Eriksen, Nygaard, & Schjolden, 2007). Climate service producers have also tended to assume that there is an active market of users waiting to benefit from science-based knowledge (Brasseur & Gallardo, 2016). There is evidence that climate service providers typically do not fully understand the contexts in which the decisions they hope to inform are being made (Klein & Juhola, 2014; McNie, 2007). This suggests that climate services would benefit from more collaborative processes, trust building, and knowledge coexploration between the service providers and the service users (Vaughan & Dessai, 2014).

Calls for innovation in climate service practice reflect some fundamental changes in how scientific knowledge is perceived, and in how it is produced and shared (Hessels & van Lente, 2008; Mobjörk, 2009), to ensure it translates into knowledge and action. These changes can be seen in concepts and approaches such as *Mode 2 knowledge production* (Gibbons, 1994; Nowotny, Scott & Gibbons, 2003), *postnormal science* (Funtowicz & Ravetz, 1993), and *"upstreaming" stakeholder engagement* in policy making (Rogers-Hayden & Pidgeon, 2007).

Past experience has demonstrated the value of collaborating with stakeholders to improve climate services (Bierbaum et al., 2013; de Bremond, Preston, & Rice, 2014). The way in which users obtain, receive, and participate in the production of information has been shown to critically affect their willingness to use it (Lemos, Kirchhoff, & Ramprasad, 2012). Exchange of information through joint reflection and learning has been shown to facilitate shared understanding and awareness raising, which ultimately helps shape research, influence decisions, and determine behavior (Gramberger, Zellmer, Kok, & Metzger, 2015; Pohl, 2008).

There has been a growing number of studies using science-stakeholder collaboration to generate actionable knowledge on climate change. They have, broadly speaking, emphasized two interpretations of the purpose of such joint knowledge production (JKP; van Kerkhoff & Lebel, 2015; Wyborn, 2015). The first is about reframing the science-society interface, and thus stresses the importance of local and cultural contexts for coproduction, and the value of the process itself (normative approach; Hulme, 2010; Jasanoff, 2004; see also Armitage, Berkes, Dale, Kocho-Schellenberg, & Patton, 2011; Sandström, 2015). The second is concerned with generating higher quality, more usable knowledge or boundary objects (instrumental approach; Dilling & Lemos, 2011; Lemos et al., 2012).

There is also a growing body of literature on the challenges involved in such cogeneration of climate knowledge, and how these can be overcome. There does, however, appear to be a growing demand for more systematic analytical approaches to improve the understanding of the benefits and limitations of participatory processes in research initiatives (Glaas & Jonsson, 2014; Runhaar, van der Windt, & van Tatenhove, 2016).

The case study presented here sets out to help fill this gap. It presents learning from a participatory action research (PAR) project within a program on adaptation in the Swedish forestry sector—Mistra-SWECIA—which involved scientists and stakeholders in cogenerating knowledge and potential action. The project is assessed based on testimony from people directly or indirectly involved, using an analytical framework developed by (Hegger, Lamers, Van Zeijl-Rozema, & Dieperink, 2012). The overall aim is to identify lessons learned on how to manage more user-driven and decision-oriented climate services.

Section 2 provides an overview of literature concerning science-stakeholder processes for coproduction of knowledge and the theoretical framework applied in our assessment. Section 3 presents the case study and the methods used. Section 4 describes the empirical results. Section 5 discusses their broader implications and lessons learned. Section 6 presents conclusions.

2 | INSIGHTS FROM THE LITERATURE

2.1 | The science-practice gap

Recent years have seen a reorientation in the interface between science and society, with the traditional one-way flow of knowledge from scientists to nonscientists displaced by two-way processes in which other types of knowledge are valued, and scientists are expected also to listen to and learn from nonscientists. Given the tangible gap between current climate science, on the one hand, and policy making and practice on the other, there is an evident need for user- and decision-driven, coproduced climate services. Although climate services are intended to serve users' needs, in reality, this has proved challenging (Vaughan & Dessai, 2014), and climate services have rarely been effective in informing climate decision-making (Brasseur & Gallardo, 2016; Lubchenco, 2011).

The evolution of the climate services movement has been propelled by climate service providers who generate supply-driven climate information services (Lourenço et al., 2015), whereas the connections between producers and societal users often remain weak or nonexistent (Lemos et al., 2012). Furthermore, the climate data and information provided by climate services are typically not contextualized or provided in a usable format and therefore are not taken into account in decision-making (Dilling & Lemos, 2011; Meinke et al., 2006).

These challenges have contributed to shifting the focus in climate services to participatory user-oriented research approaches, with climate scientists and service providers increasingly striving to work closely with sectoral experts, practitioners, and policy makers in problem solving (Vaughan & Dessai, 2014). At least in theory, this emerging field of participatory climate services contributes to "… services that are more effective, more usable, and more suited to users' needs" (Vaughan & Dessai, 2014, p. 590).

2.2 | Science-stakeholder processes

A range of participatory approaches have been developed within the field of environmental management, including *integrated assessments* (van Asselt & Rijkens-Klomp, 2002) and *PAR* (van Buuren, Eshuis, & van Vliet, 2015). According to de Bremond et al. (2014), to be effective, such participatory processes should (a) meet specific stakeholder needs, taking into account their perspectives and contexts, (b) be relevant and applicable at different decision-making scales, (c) recognize and deal with multiple factors and driving forces, and (d) include generation of policy options. Moreover, Cash (2001) and Cash et al. (2003) argue that the process must be perceived by the stakeholder(s) as credible, legitimate, and salient. Hegger et al. (2012) list as a criterion for effectiveness that stakeholders perceive the scientific information used and produced via the process to be understandable, relevant to their context, and developed transparently. Moreover, Bierbaum et al. (2013) argue that it is essential that stakeholder participation and influence is integrated across the different stages of the research process in order to achieve information that is coproduced and thus customized to the stakeholders' needs (Lemos et al., 2012).

However, there is agreement that what approaches and methods are appropriate differs depending on the specific stakeholders (Freeman, 1984) and researchers involved, the rationale for the project, the specific context, and the level and degree of involvement by participants (Forrester, Gerger Swartling, & Lonsdale, 2008; Stirling, 2008). This calls for careful consideration of which participatory approach is most effective for and conducive to science-stakeholder interactions in a given project.

Several writers highlight the importance of "boundary management," adept translation and mediation between multiple and often differing perspectives, motives, values and views (e.g., Cash et al., 2003; Kirchhoff, Lemos & Dessai, 2013; Tribbia & Moser, 2008). McGreavy, Hutchins, Smith, Lindenfeld, and Silka (2013) argue that science-stakeholder processes require a facilitator to lead this boundary management and ensure inclusive, frequent two-way communication between stakeholders and researchers.

A number of multilevel and cross-level challenges to coproducing knowledge and thus connecting climate science to policy and practice have been identified in the recent literature. These include (a) social factors such as stakeholders' risk perceptions, values, cultures, and perspectives relating to climate change impacts and adaptation measures (Adger et al., 2009; Vulturius & Gerger Swartling, 2015); (b) differences in how stakeholders and researchers frame and understand the problem being addressed (Groot, Hollaender, & Swart, 2014; Hegger et al., 2012; Larsen et al., 2012); (c) issues with identifying common research questions; (d) "fatigue" with research projects among stakeholders (Gramberger et al., 2015; Jönsson & Gerger Swartling, 2014); (e) identifying the "right" participants, including the size of the group and composition of knowledge systems (André, Simonsson, Gerger Swartling, & Linnér, 2012; Runhaar et al., 2016); (f) translation of climate data into lay terms, and the uncertainty of climate projections (Gramberger et al., 2015; Kok et al., 2015); and (g) commitment to the process on the part of participating stakeholders' organizations' and researchers (Groot et al., 2014; Jönsson & Gerger Swartling, 2014).

2.3 | Analytical framework

The project described in this article sought to elicit user needs for actionable knowledge through science-stakeholder processes. In order to retrospectively assess factors that influenced this process, we have applied an analytical framework proposed by Hegger et al. (2012): the JKP framework. The framework is designed specifically for assessment of climate adaptation processes that include stakeholders in knowledge coproduction. The framework draws on a large body of literature on science–policy interaction and conceptual analyses of science–policy relationships. The underlying assumption is that coproduction of knowledge is only successful when the stakeholders' thresholds of credibility, salience, and legitimacy (see above) are met.

Hegger et al. focus on four dimensions in participatory processes: the actors involved, the contents of dominant discourses, the rules used in the process, and the resources available. They further posit seven conditions for success, to be used as a starting point when assessing and analyzing JKP processes: (a) the broadest feasible coalition of actors involved; (b) shared understanding of problems and goals; (c) recognition of the

stakeholders' perspectives; (d) organized reflection on division of tasks by the participating actors; (e) clearly defined role of the researchers and their knowledge; (f) innovative incentive structures; and (g) availability of specific resources such as boundary objects, facilities, organizational forms, and competences (Hegger et al., 2012, p. 61). These seven success conditions help to structure our analysis of opportunities for, and barriers to, effective knowledge coproduction in the case study project.

3 | METHODS

3.1 | The case study context

The studied science-stakeholder process took place in the second phase of an interdisciplinary climate research program that ran from 2008 to 2015. The program included studies of how the climate is changing, its impacts, and possible strategies for adaptation. The second phase (2012–2015) focused on the Swedish forestry sector.

The Swedish forestry sector is a highly relevant case when it comes to adaptation challenges. As in other parts of the boreal zone, Swedish forestry is characterized by long rotation periods, above 100 years in the northern part of the country. With such long planning horizons, the sector could be expected to be an "early adapter" to climate change. Thus far, however, there has been a general lack of systematic adaptation action (Andersson & Keskitalo, 2018).

The sector is also subject to a wide range of stakeholder interests. For a long time, interests related to wood production dominated discourses and governance frameworks in the sector. However, recent decades have seen recreational value, concerns about biodiversity, and reindeer herding growing increasingly prominent (Lindahl et al., 2017). Moreover, the number of directly involved stakeholders is substantial, with half of Swedish forest land owned by around 320,000 individual forest owners (Swedish Forest Agency, 2018).

In order to identify adaptation needs, barriers, opportunities, and effective strategies in such a complex governance landscape, the project applied a PAR approach (Kindon, 2009). This was a separate component within the program. The project had the following aims (a) to strengthen interactions and knowledge exchange between researchers and stakeholders on climate change, (b) to identify areas of common interest for additional investigation, (c) to maintain stakeholder engagement and interest throughout the PAR process; (d) to keep stakeholders' needs in focus; and (e) to embed flexibility in the process. The PAR involved researchers from different disciplines and representatives of different stakeholders engaged in adaptation within Swedish forestry (see Table 1). This interdisciplinarity and diversity was expected to enrich the coproduced knowledge and shared learning.

To maximize the practical relevance of the project, the PAR process was carried out over an extended period (3 years), and the group was given ample flexibility in terms of agenda setting. A "contract" containing guidance on roles and responsibilities, and setting out the aim of the project, was agreed between the various participants. This was intended to promote continuity, commitment, and mutual understanding between the participants.

A core science-stakeholder group of 17 people met in person once per year. Telephone conferences, e-mail exchanges, and

TABLE 1 Composition of the science-stakeholder group in the participatory process

Members
Four representatives from different Swedish county administrative boards
One individual from the Swedish Forest Agency
Representatives from industry associations
Five social scientists from the research program
Four natural scientists from the research program

document sharing were used in between these meetings to maintain contact and continuity within the group and keep everyone updated on the status of ongoing work. The group jointly developed and ran project activities such as a stakeholder-researcher synthesis study and science-stakeholder group meetings, as well as two excursions and a seminar for larger groups of stakeholders (see Table 2).

The larger research consortium behind the Mistra-SWECIA program appointed one of the partners as a boundary organization. This partner was tasked with managing the participatory process. The (research) organization had expertise in environmental social sciences and policy, participatory research methods, and stakeholder engagement.

One researcher from the organization was nominated component leader. This researcher had been active in the design phase and had considerable experience in multistakeholder processes and policy development. The component leader was given no special tasks related to outputs but acted solely as a facilitator and knowledge broker in the science-stakeholder group. The role included communicating knowledge (Meyer, 2010) between participants and thus served as a bridge between scientists and stakeholders. During the final year of the program, the first component leader left the organization and was replaced by another person with similar skills and experience, including a background in forest resource management.

The climate services employed a variety of formats and science-stakeholder interactions, which were discussed and agreed with the component leader who helped frame and contextualize the information for the stakeholders and the project activities. More specifically, they provided global and regional forecasts and projections for climate-related variables such as precipitation and temperature, generated by climate researchers at the Rossby Centre of the Swedish Meteorological and Hydrological Institute. Also, ecosystem experts at Lund University provided ecosystem model simulations of climate change scenarios and forest management options.

The information presented to the stakeholders showed that climate change is expected to have both positive and negative impacts for the Swedish forestry sector: a longer growing season, increased production, and opportunities to grow new crops and tree species, on the one hand and impacts on local flora and fauna, increased risk of damage by pests and pathogens, including invasive species, and increased risk of damage caused by extreme weather events such as wind storms and drought, on the other.

Forest owners and practitioners were invited to assess the climate information provided and its relevance for adaptive forest management and decision-making. In addition, they had opportunities to share hands-on experiences through field demonstrations regarding their forest management practices, decision contexts, and climate information needs.

3.2 | Data collection

To assess this PAR process, we employed a case study design informed by Yin (2009). Empirical data was collected through 22 semistructured interviews (Kvale, 1996) with individuals directly or indirectly involved in the participatory process. The approximately 1-hr interviews were conducted by telephone or in person between February and April 2016. All members of the science-stakeholder group (Table 1) were interviewed except the Swedish Forest Agency representative. External observers interviewed included four members of the program's management board and two scientists who had opted out of getting involved in the PAR process.

The interviews were undertaken by a social scientist who had not been involved in the process. Their purpose was to capture respondents' experiences of the PAR process and their views and recommendations for future participatory processes in this field. All respondents were guaranteed confidentiality. The interviews were qualitatively analyzed using the JKP framework.

TABLE 2 Summary of joint activities in the participatory process

Activity or event	Theme or objective	No. of participants
Meetings	Twice a year over three years, with science-stakeholder group (Table 1)	17
Seminar/workshop[a]	Need for decision support tools for climate change adaptation	60
Forest excursion[a]	Climate change adaptation challenges in Swedish forestry	50
Roundtable talk	Challenges and opportunities of biodiversity management in a changing climate	20
Forest excursion[a]	Strategies for managing climate risks in forestry (organized in collaboration with the Swedish Forestry Association)	120
Synthesis study	Applied the program's research on forestry climate change adaptation strategies to the forest holdings of one of Sweden's major forest industry companies	17

[a]These activities were open to the public and attracted forest owners, researchers, local government staff, and other stakeholders.

TABLE 3 Summary of findings from the case study, structured according to success factors

Success factors, per Hegger et al. (2012)	Case study findings	Lessons learned for future processes
Broadest possible actor coalition within limits of the project and context	Overall good coverage of relevant actors. But trade-off between covering all relevant actors and keeping the group to a size where people are seen, heard, and trust each other.	Ensure representation from all relevant actor groups while also keeping the size manageable and that representatives have organizational backup throughout the process.
Shared understanding on goals and problem definitions	Facilitated process perceived as open and collaborative, operating in a conducive environment. Trust built over time. First forest excursion perceived as key for improved mutual understanding and sense of community.	Prioritize highly skilled facilitation. Establish a carefully designed and facilitated process to allow time, space, and flexibility for joint problem definition and scoping of study; allow group dynamics to mature and trust to be built in a safe, collaborative environment.
Recognition of stakeholder perspectives	Stakeholders were involved in setting of process agenda to ensure their priorities and needs were taken into account. Stakeholders played an increasingly active role over the course of the process.	Make sure to strengthen stakeholders' sense of ownership so that they feel valued and comfortable steering the process. Recognize the value of diversity of knowledge and perspectives.
Organized reflection on division of tasks by participating actors	Boundary organization took lead and managed workflow continuously, with tasks assigned to individual participants.	Recognize the critical role of the facilitating and/or boundary organization, especially in establishing and maintaining a conducive work environment. Allow all participants equal say and promote openness.
Role of researchers and their knowledge is clear	Differences between scientific disciplines played an important role. Easier for social scientists to see a value in the participatory process.	The facilitator must be equally attentive to intra-academic differences and differences between researchers and stakeholders.
Innovative reward structures	A flexible mandate with few deadlines or predetermined products set in the project description. Funder entrusted the process with a high degree of autonomy in adaptively managing the process.	Funders must recognize that stakeholder-driven processes are adaptive by nature and cannot be required to deliver a report on X by time Y.
Presence of specific resources such as boundary objects, facilities, organizational forms, and competences	Forest excursions (particularly the first) were highly appreciated and facilitated a more collaborative spirit and enabled practical knowledge to be acknowledged.	Arrange activities at stakeholders' "home turf" and let them coarrange to build ownership, promote active engagement, and increase the practical relevance of the process and its outcomes.

4 | RESULTS

We used the interview response data to identify drivers of and barriers to effective collaboration in the participatory process, as perceived by the participating researchers and forest stakeholders. Table 3 provides a summary of our empirical results. Three key themes that emerged are discussed below, with illustrative quotes from the interviews.

4.1 | Collaboration within the participatory process

The general sentiment among involved participants was that the science-stakeholder process had been an interesting and well-functioning component of the research program: "[It] has been one of the most positive parts of the entire program, it's been inspiring and fun to be a part of the group. I've learnt a lot."

Several interviewees—both forest stakeholders and scientists—felt there was a respectful atmosphere and a "safe space" had been created, spurring interesting and inclusive discussions: "The meetings had a warm, cheerful and nice atmosphere, which made me feel safe and confident."

Interviewees stressed the value of allowing time and resources to build relationships and understanding and to establish mutual

trust early on in the process. Many perceived their needs and views to be in focus, and they had ample opportunity to influence the meeting agendas. The researchers said the process had helped them to identify new research questions and gain a greater understanding of stakeholders' practical needs and priorities. The process had clearly benefited from the coordination and facilitation of the boundary organization under the lead of two participation experts.

Both scientists and stakeholders were perceived to have gained valuable insights into different actors' perceptions and heuristics on, and diverse motives for, adaptation. A number of researchers emphasized the value of wide stakeholder representation and close collaboration. They believed they had learned how to frame and communicate their research in a more stakeholder-friendly way. The diversity of perspectives and disciplines was perceived to have contributed to creation of a comprehensive body of knowledge, which was considered necessary to address complex issues such as adaptation. Some researchers said they had begun the process skeptical towards multidisciplinary research, but in most cases, this changed over time due to their positive experiences.

The ambition to maintain a collaborative spirit and the prioritization of stakeholder needs were perceived as valuable elements. The process design, including a mix of smaller face-to-face meetings to facilitate immediate and direct assessments and knowledge exchange,

and larger events involving a wider representation from the national adaptation community, were equally appreciated.

4.2 | Coproduction of knowledge

Most of the scientists observed that over time, it became clearer that for climate adaptation to happen, both societal actors and scientists from across disciplines need to be involved in the knowledge production as the issues are complex, contextual, value based, and uncertain. Some researchers pointed to challenges in understanding stakeholders' needs and in reaching common ground, values, and understanding between scientific disciplines: "It took some time for the different research groups to understand each other but after a few years of working together we started to overcome this barrier and were able to collaborate to create interdisciplinary research."

A number of respondents said uneven levels of forestry knowledge among the involved scientists sometimes made communication difficult. Scientists with expertise on adaptation policy and conservation issues but with limited knowledge of forestry testified to the challenge of assessing adaptive forest management practices from the perspective of a forest owner: "I work mainly with climate adaptation issues and not forestry matters, which made the work somewhat abstract and at times hard to grasp."

Most respondents spoke highly of the two forest excursions, which provided opportunities for diverse actors to interact outside of the regular work environment (in most cases). Researchers highlighted the benefits of experiencing the real forest landscape where practical adaptation measures are implemented. This real-world setting and the nature of the informal interactions helped them to learn about the practical needs and challenges that face forest owners, which are somewhat remote from the world of the climate science community.

Our analysis also points to communication challenges between scientific disciplines and disparate views of the value of different types of project deliverables. For example, the research synthesis study on adaptation, which was agreed by all members of the science-stakeholder group, was not equally valued by all the participants. Although a number of scientists stressed the value of "creating something tangible together," the synthesis study and resulting report on forestry climate change adaptation strategies seemed to have made little or no impression on the stakeholders and were rarely if ever mentioned. This suggests that researchers and stakeholders had different priorities and expectations for their engagement in, and the resulting outputs from, the participatory process.

4.3 | Capacity and time to engage

The interviews revealed several barriers to achieving full engagement in the initiative. Notably, there appeared to be a difference in terms of levels of commitment and time availability between researchers and stakeholders. Most scientists felt they had lacked the time to engage to a satisfactory degree, whereas most stakeholders felt they had had adequate time.

The scientists, representing different natural and social science disciplines, had disparate motives for collaborating with stakeholders

and expectations of the process. Although the social scientists overall saw the PAR process and its opportunities for mutual learning and knowledge cogeneration as strong motives for engaging, the natural scientists typically did not. One of two scientists who opted out from the process explained that "the aim of the process wasn't relevant for my work" and that the stakeholders in the project were not "their" stakeholders. Both were skeptical about the nature of this interdisciplinary, stakeholder-oriented approach to climate research.

Most stakeholders reported a lack of support from their respective organizations for active engagement in the science-stakeholder process, despite having been given approval to participate from the outset. They also said they had struggled to anchor their experiences within their own organization. They had shared their insights with their directors and other colleagues but felt incapable of putting their newly acquired knowledge into practice in their own work environment: "I learnt so much from the forest excursion so I decided to conduct one myself where I invited my organization. No one came. I was terribly disappointed." This indicates that participatory research processes that are external to stakeholders' formal professional roles and networks may lack legitimacy and that the learning outcomes may be difficult to embed in formal, everyday contexts.

5 | DISCUSSION

Besides the results presented above, our study also generated some other valuable insights. These seem relevant for the adoption of more stakeholder-oriented and decision-driven approaches to climate services that would be better able to inform adaptation decision-making and policy processes.

5.1 | Meeting needs and expectations

Our empirical analysis using the JKP framework (see Table 3) reinforces the findings of previous studies (e.g., Groot et al., 2014; Jönsson & Gerger Swartling, 2014; Vulturius & Gerger Swartling, 2015) suggesting that barriers to effective participatory processes are closely linked to maintaining stakeholder commitment and engagement throughout the process. Strong stakeholder engagement is also important to overcome language barriers and to clearly identify needs, perceptions, and expectations of the process (André et al., 2012; Larsen et al., 2012).

Previous studies have demonstrated that such barriers can be overcome by involving a boundary partner or organization and/or a knowledge broker to act as a bridge, mediator, and translator between participating stakeholders in climate science, policy, and practice (e.g., Groot et al., 2014; Tribbia & Moser, 2008). In our case study, the assignment of an actor with participatory research skills, with the sole purpose of facilitating and managing the process, proved to have multiple benefits: it enabled continuity, and it helped to manage participants' expectations and allow them to develop their roles, influence the research process, and engage meaningfully in knowledge cogeneration.

However, some have argued that while involving a boundary organization is a key step towards proactively accommodating

stakeholders' expectations and needs (Kirchhoff, Lemos, & Kalafatis, 2015; Parker & Crona, 2012), other measures should also be considered to ensure the effectiveness of the process (Senecah, 2004).

Our findings further suggest that attention should be directed to ensuring stakeholders feel they are truly part of the process and that their views and knowledge are equally embraced in the assessments. Respondents generally felt that participatory exercises where diverse actors came together in a well-designed and carefully facilitated process were key to effective knowledge exchange and learning (cf. Reed, 2008). For example, the highly appreciated forest excursions were developed, designed, and implemented jointly, whereas the synthesis study and resulting report, which made such little impression on the stakeholders, were solely in the hands of researchers. This reflects the importance of identifying outputs that are usable for all participants (Borg, Karlsson, Kim, & McCormack, 2012) and of conducting activities jointly.

5.2 | Building trust and partnerships

Our findings also underline the importance of trust and partnership building. This is in line with earlier findings (e.g., Juerges, Viedma, Leahy, & Newig, 2017; San Antonio & Gamage, 2007). Trust and partnership building are linked to process design and facilitation style (Reed, 2008). Worth noting are the respondents' comments about the participatory process offering a safe space for participants to express themselves and feel valued. To foster communication and interaction across disciplines and fields of expertise, it appears to be crucial to achieve a mutual understanding and acceptance of different viewpoints, motives, and values upon which trust can be built and a collegial atmosphere realized (Hegger et al., 2012). If these elements are in place, barriers rooted in differences in scientific disciplines or professional expertise are more likely to dissipate. Thus, to achieve a well-functioning science-stakeholder platform, there needs to be a focus on soft measures to increase trust and mutual understanding at early stage. This echoes the analysis of Hegger et al. (2012) on the importance of establishing clear objectives at the outset and of continuous reflection on those objectives throughout the process.

Early action to enhance collaborative learning would also help to overcome epistemological and ontological challenges that may arise in, and undermine, participatory processes on adaptation (cf. Groot, Bosch, Buijs, Jacobs, & Moors, 2015; Larsen et al., 2012). Efforts to create multistakeholder platforms enabling respectful discussions and mutual knowledge exchange are, based on our study, therefore worthwhile and should be encouraged. These platforms should preferably take place outside the normal work environment, enabling participants to step out of their professional roles, power hierarchies, and professional agendas and enter an equal, neutral space for a mutual, iterative learning process. Thus, the importance of creating informal, safe, equitable spaces for more effective, participatory climate services deserves more attention in the wider climate services discourse.

Activities such as field trips, retreats, and social events that typically offer such spaces for informal networking, as well as knowledge exchange and coproduction, therefore appear promising for supporting participatory climate services for adaptation decision-making and action. The contract agreed between the participants at the start of the process also appears to have helped to generate mutual understanding and trust between the participants, as well as to maintain mutual commitment and a respectful and collaborative atmosphere. Such contracts should be revisited and adjusted where needed throughout the project, and their potential benefits for coproduced climate services is another area that deserves increasing recognition in the literature.

5.3 | Commitment to the process

Another aspect subject to scholarly investigation is the role of early and careful selection of stakeholders when designing participatory processes for research projects (van Buuren et al., 2015; Welp, de la Vega-Leinert, Stoll-Kleemann, & Jaeger, 2006). However, the selection is not only a question of ensuring broad representation and the "right" stakeholders but also of identifying those with both an interest and stake in the issues (Mitchell, Agle, & Wood, 1997) as well as the ability to commit over time and ultimately to embed the obtained knowledge, and possibly also effect changes, in their own organizations (Gramberger et al., 2015; Groot et al., 2014).

Our results further indicate that if stakeholders play an active role in the process—for example organizing or hosting meetings—they are more likely to develop a stronger sense of ownership and commitment. Some stakeholders expressed a lack of support and recognition from their own organizations, which tempered their willingness to fully engage over time. Research suggests that if the expected value added does not outweigh the perceived costs in terms of time and resources, stakeholders are less likely to engage (Cottrell et al., 2014).

However, although the stakeholders felt they had sufficient time and capacity to fully engage, the scientists in the case study process typically perceived they did not. Although this may reflect researchers' challenges in managing competing tasks, it presumably also reflects a prevailing view that participatory research implies costs that outweigh the benefits (Reed, 2008). Researchers are primarily evaluated based on scientific peer-reviewed outputs, and thus, the inherent incentive or reward structures within academia tend to be poorly aligned with the goals of stakeholder engagement processes, which are not geared towards producing such outputs. Worth remembering here are the statements by the invited researchers who opted out of the project as they did not anticipate immediate benefits for their work. This indicates that time and capacity are not the only inhibiting factors but also lack of interest and willingness.

These three criteria, time, willingness, and capacity to participate, are interlinked and can only be met if the researchers have the incentive and sufficient knowledge to participate (Jönsson & Gerger Swartling, 2014). This is a complex issue, as it relates both to the kinds of project deliverables requested by the concerned funding agency and to the inherent reward systems within academia. Given the significance of incentive structures for fostering socially relevant, inclusive bottom-up approaches to climate science, it is somewhat surprising that this theme has received such modest attention in the climate services debate.

Scientists need to invest both time and resources to accommodate the needs of stakeholders. We propose that to support this, funding agencies could apply a more lenient and flexible approach to project reporting. Another plausible option could be to invest additional funds into research projects to allow them to expand their scope beyond conventional scientific outputs. In practice, this could mean (increased) budgets for targeted education and training on design and implementation of participatory research methods, facilitation techniques, and sociocultural and ethical aspects of participatory research, as well as for communication, outreach, and capacity-building activities. This would hopefully encourage a more creative environment where researchers and other experts can adjust the time plan, outputs, and activities to accommodate stakeholders' needs and the specific process at hand. The issue of strategic resource investment for boundary work (including PAR) is, however, largely absent in the climate services discourse and thus warrants further exploration and analysis.

6 | CONCLUSIONS

This paper has investigated the opportunities for and barriers to effective knowledge coproduction resulting from science-stakeholder processes, by means of a case study on climate services and adaptation in the context of Swedish forestry. Using the JKP framework, our analysis identifies some important lessons for future research, policy development, and practice that appear useful for more user-oriented and decision-driven climate services. Several of our findings echo those found in the environmental management literature, such as trust building and the importance of highly skilled facilitation, allowing and designing an enabling environment, and coproduction processes.

The key lessons can be summarized as follows:

- ensure representation from all relevant actor groups and that participants have backup from their organizations;
- use a carefully designed and facilitated process that is conducive to trust building, mutual collaboration, joint problem definition, and scoping of the study;
- strengthen stakeholders' sense of ownership and recognize diversity of knowledge;
- recognize the key role of the facilitating and/or boundary organization;
- allow all participants equal say and promote openness;
- acknowledge and embrace intra-academic differences and diversity between the perspectives of researchers and stakeholders, as well diversity in individual participants' perspectives; and
- ensure the practical relevance of the process and its outcomes by encouraging coarrangement and cocreation activities to build ownership, interest, and commitment.

More responsive, relevant, and participatory climate services will be essential to realizing the United Nations Framework Convention on Climate Change's call to "go further, faster, together for climate action" under the Paris Agreement.

ORCID

Åsa Gerger Swartling http://orcid.org/0000-0003-3616-7323

REFERENCES

Adger, W., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D., … Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change*, *93*(3), 335–354. Retrieved from https://doi.org/10.1007/s10584-008-9520-z

Andersson, E., & Keskitalo, E. C. H. (2018). Adaptation to climate change? Why business-as-usual remains the logical choice in Swedish forestry. *Global Environmental Change*, *48*, 76–85. https://doi.org/10.1016/j.gloenvcha.2017.11.004

André, K., Simonsson, L., Swartling, Å. G., & Linnér, B. (2012). Method development for identifying and analysing stakeholders in climate change adaptation processes. *Journal of Environmental Policy & Planning*, *14*(3), 243–261. https://doi.org/10.1080/1523908X.2012.702562

Armitage, D., Berkes, F., Dale, A., Kocho-Schellenberg, E., & Patton, E. (2011). Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change*, *21*(3), 995–1004. https://doi.org/10.1016/j.gloenvcha.2011.04.006

Bierbaum, R., Smith, J. B., Lee, A., Blair, M., Carter, L., Chapin, F. S., … Verduzco, L. (2013). A comprehensive review of climate adaptation in the United States: More than before, but less than needed. *Mitigation and Adaptation Strategies for Global Change*, *18*(3), 361–406. https://doi.org/10.1007/s11027-012-9423-1

Borg, M., Karlsson, B., Kim, H. S., & McCormack, B. (2012). Opening up for many voices in knowledge construction. *Forum: Qualitative Social Research*, *13*(1). https://doi.org/10.17169/fqs-13.1.1793

Brasseur, G. P., & Gallardo, L. (2016). Climate services: Lessons learned and future prospects. *Earth's Future*, *4*(3), 79–89. https://doi.org/10.1002/2015EF000338

Cash, D. W. (2001). "In order to aid in diffusing useful and practical information": Agricultural extension and boundary organizations. *Science, Technology & Human Values*, *26*(4), 431–453. https://doi.org/10.1177/016224390102600403

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N. M., Eckley, N., Guston, D. H., … Mitchell, R. B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences*, *100*(14), 8086–8091. https://doi.org/10.1073/pnas.1231332100

Cottrell, E., Whitlock, E., Kato, E., Uhl, S., Belinson, S., Chang, C., … Guise, J.-M. (2014). *Defining the benefits of stakeholder engagement in systematic reviews*. Rockville, MD: US Agency for Healthcare Research and Quality. Retrieved from http://www.ncbi.nlm.nih.gov/books/NBK196180/

de Bremond, A., Preston, B. L., & Rice, J. (2014). Improving the usability of integrated assessment for adaptation practice: Insights from the U.S. Southeast energy sector. *Environmental Science & Policy*, 42, 45–55. https://doi.org/10.1016/j.envsci.2014.05.004

Dilling, L., & Lemos, M. C. (2011). Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. *Global Environmental Change*, 21(2), 680–689. https://doi.org/10.1016/j.gloenvcha.2010.11.006

Forrester, J., Gerger Swartling, Å., & Lonsdale, K. (2008). *Stakeholder engagement and the work of SEI: An empirical study* (No. SEI Working PaperStockholm Environment Institute. Retrieved from https://www.sei.org/mediamanager/documents/Publications/Policy-institutions/stakeholder_engagement_workof_sei.pdf

Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Boston, MA: Pitman.

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 25(7), 739–755. https://doi.org/10.1016/0016-3287(93)90022-L

Gibbons, M. (Ed.) (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: SAGE Publications.

Glaas, E., & Jonsson, A. C. (2014). Facilitating cross-sectoral assessments of local climate change vulnerability. *International Journal of Urban Sustainable Development*, 6(2), 174–189. https://doi.org/10.1080/19463138.2014.931858

Golding, N., Hewitt, C., Zhang, P., Bett, P., Fang, X., Hu, H., & Nobert, S. (2017). Improving user engagement and uptake of climate services in China. *Climate Services*, 5, 39–45. https://doi.org/10.1016/j.cliser.2017.03.004

Gramberger, M., Zellmer, K., Kok, K., & Metzger, M. J. (2015). Stakeholder integrated research (STIR): A new approach tested in climate change adaptation research. *Climatic Change*, 128(3–4), 201–214. https://doi.org/10.1007/s10584-014-1225-x

Groot, A., Hollaender, K., & Swart, R. (2014). Productive science-practice interactions in climate change adaptation: Lessons from practice. In *No. CIRCLE-2 research policy brief*. Lisbon: Foundation of the Faculty of Sciences.

Groot, A. M. E., Bosch, P. R., Buijs, S., Jacobs, C. M. J., & Moors, E. J. (2015). Integration in urban climate adaptation: Lessons from Rotterdam on integration between scientific disciplines and integration between scientific and stakeholder knowledge. *Building and Environment*, 83, 177–188. https://doi.org/10.1016/j.buildenv.2014.07.023

Hegger, D., Lamers, M., Van Zeijl-Rozema, A., & Dieperink, C. (2012). Conceptualising joint knowledge production in regional climate change adaptation projects: Success conditions and levers for action. *Environmental Science & Policy*, 18, 52–65. https://doi.org/10.1016/j.envsci.2012.01.002

Hessels, L. K., & van Lente, H. (2008). Re-thinking new knowledge production: A literature review and a research agenda. *Research Policy*, 37(4), 740–760. https://doi.org/10.1016/j.respol.2008.01.008

Hulme, M. (2010). Problems with making and governing global kinds of knowledge. *Global Environmental Change*, 20(4), 558–564. https://doi.org/10.1016/j.gloenvcha.2010.07.005

Jasanoff, S. (2004). *States of knowledge: The co-production of science and the social order*Routledge.

Jönsson, A. M., & Gerger Swartling, Å. (2014). Reflections on science–stakeholder interactions in climate change adaptation research within Swedish forestry. *Society & Natural Resources*, 27(11), 1130–1144. https://doi.org/10.1080/08941920.2014.906013

Juerges, N., Viedma, A., Leahy, J., & Newig, J. (2017). The role of trust in natural resource management conflicts: A forestry case study from Germany. *Forest Science*. https://doi.org/10.5849/FS-2016-050

Kindon, S. (Ed.) (2009). *Participatory action research approaches and methods: Connecting people, participation and place (Reprinted)*. London: Routledge.

Kirchhoff, C. J., Lemos, M. C., & Dessai, S. (2013). Actionable knowledge for environmental decision making: Broadening the usability of climate science. *Annual Review of Environment and Resources*, 38, 393–414. https://doi.org/10.1146/annurev-environ-022112-112828

Kirchhoff, C. J., Lemos, M. C., & Kalafatis, S. (2015). Narrowing the gap between climate science and adaptation action: The role of boundary chains. *Climate Risk Management*, 9, 1–5. https://doi.org/10.1016/j.crm.2015.06.002

Klein, R. J. T., & Juhola, S. (2014). A framework for Nordic actor-oriented climate adaptation research. *Environmental Science & Policy*, 40, 101–115. https://doi.org/10.1016/j.envsci.2014.01.011

Kok, K., Bärlund, I., Flörke, M., Holman, I., Gramberger, M., Sendzimir, J., ... Zellmer, K. (2015). European participatory scenario development: Strengthening the link between stories and models. *Climatic Change*, 128(3–4), 187–200. https://doi.org/10.1007/s10584-014-1143-y

Kvale, S. (1996). *InterViews: An introduction to qualitative research interviewing*. Thousand Oaks, CA: Sage.

Larsen, R. K., Gerger Swartling, Å., Powell, N., May, B., Plummer, R., Simonsson, L., & Osbeck, M. (2012). A framework for facilitating dialogue between policy planners and local climate change adaptation professionals: Cases from Sweden, Canada and Indonesia. *Environmental Science & Policy*, 23, 12–23. https://doi.org/10.1016/j.envsci.2012.06.014

Lemos, M. C., Kirchhoff, C. J., & Ramprasad, V. (2012). Narrowing the climate information usability gap. *Nature Climate Change*, 2(11), 789–794. https://doi.org/10.1038/nclimate1614

Lindahl, K. B., Sténs, A., Sandström, C., Johansson, J., Lidskog, R., Ranius, T., & Roberge, J.-M. (2017). The Swedish forestry model: More of everything? *Forest Policy and Economics*, 77, 44–55. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-10905

Lourenço, T. C., Swart, R., Goosen, H., & Street, R. (2015). The rise of demand-driven climate services. *Nature Climate Change*, 6(1), 13–14. https://doi.org/10.1038/nclimate2836

Lubchenco, J. (2011). *Creating a NOAA climate service, written statement presented in the President's FY 2012 budget, § Committee on Science, Space and Technology*. Washington, DC. Retrieved from https://web.archive.org/web/20111208232453/http://www.noaanews.noaa.gov/stories2011/20110622_climateservice.html

McGreavy, B., Hutchins, K., Smith, H., Lindenfeld, L., & Silka, L. (2013). Addressing the complexities of boundary work in sustainability science through communication. *Sustainability*, 5(10), 4195–4221. https://doi.org/10.3390/su5104195

McNie, E. C. (2007). Reconciling the supply of scientific information with user demands: An analysis of the problem and review of the literature. *Environmental Science & Policy*, 10(1), 17–38. https://doi.org/10.1016/j.envsci.2006.10.004

Meinke, H., Nelson, R., Kokic, P., Stone, R., Selvaraju, R., & Baethgen, W. (2006). Actionable climate knowledge: From analysis to synthesis. *Climate Research*, 33, 101–110. https://doi.org/10.3354/cr033101

Meyer, M. (2010). The rise of the knowledge broker. *Science Communication*, 32(1), 118–127. https://doi.org/10.1177/1075547009359797

Miralles-Wilhelm, F. R., & Castillo, R. M. (2014). *Climate services: a tool for adaptation to climate change in Latin America and the Caribbean: Action plan and case study applications* (No. IDB-TN-531Inter-American Development Bank. Retrieved from https://publications.iadb.org/bitstream/handle/11319/6845/Climate-services-a-tool-for-adaptation-to-climate-change-in-Latin-America-and-the-Caribbean.pdf?sequence=1

Mitchell, R. K., Agle, B. R., & Wood, D. J. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *Academy of Management Review*, 22(4), 853. https://doi.org/10.2307/259247

Mobjörk, M. (2009). *Crossing boundaries: The framing of transdisciplinarity*. Örebro, Sweden: Centre for Urban and Regional Studies, University of Örebro.

Nowotny, H., Scott, P., & Gibbons, M. (2003). Introduction: "Mode 2" revisited: The new production of knowledge. *Minerva*, *41*(3), 179–194. Retrieved from https://www.jstor.org/stable/41821245

O'Brien, K., Eriksen, S., Nygaard, L. P., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy*, *7*(1), 73–88. https://doi.org/10.1080/14693062.2007.9685639

Parker, J., & Crona, B. (2012). On being all things to all people: Boundary organizations and the contemporary research university. *Social Studies of Science*, *42*(2), 262–289. https://doi.org/10.1177/0306312711435833

Pohl, C. (2008). From science to policy through transdisciplinary research. *Environmental Science & Policy*, *11*(1), 46–53. https://doi.org/10.1016/j.envsci.2007.06.001

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, *141*(10), 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014

Rogers-Hayden, T., & Pidgeon, N. (2007). Moving engagement "upstream"? Nanotechnologies and the Royal Society and Royal Academy of Engineering's inquiry. *Public Understanding of Science*, *16*(3), 345–364. https://doi.org/10.1177/0963662506076141

Runhaar, H. A. C., van der Windt, H. J., & van Tatenhove, J. P. M. (2016). Productive science–policy interactions for sustainable coastal management: Conclusions from the Wadden Sea area. *Environmental Science & Policy*, *55*, 467–471. https://doi.org/10.1016/j.envsci.2015.09.002

San Antonio, D. M., & Gamage, D. T. (2007). Building trust among educational stakeholders through Participatory School Administration, Leadership and Management. *Management in Education*, *21*(1), 15–22. https://doi.org/10.1177/0892020607073406

Sandström, P. (2015). *A toolbox for co-production of knowledge and improved land use dialogues: The perspective of reindeer husbandry*. Umeå: Department of Forest Resource Management, Swedish University of Agricultural Sciences.

Senecah, S. L. (2004). The trinity of voice: The role of practical theory in planning and evaluating the effectiveness of environmental participatory processes. In S. P. Depoe, J. W. Delicath, & M.-F. A. Elsenbeer (Eds.), *Communication and public participation in environmental decision making*. Albany, NY: State University of New York Press.

Stirling, A. (2008). "Opening up" and "closing down": Power, participation, and pluralism in the social appraisal of technology. *Science, Technology & Human Values*, *33*(2), 262–294. https://doi.org/10.1177/0162243907311265

Swedish Forest Agency (2018). *Strukturstatistik: Statistik om skogsägande 2017 [Structural statistics: Statistics on forest ownership 2019]* (No. Report no. 2018/12Swedish Forest Agency. Retrieved from https://www.skogsstyrelsen.se/statistik/statistik-efter-amne/struktur-i-skogsbruket/

Tribbia, J., & Moser, S. C. (2008). More than information: What coastal managers need to plan for climate change. *Environmental Science & Policy*, *11*(4), 315–328. https://doi.org/10.1016/j.envsci.2008.01.003

van Asselt, M. B. A., & Rijkens-Klomp, N. (2002). A look in the mirror: Reflection on participation in integrated assessment from a methodological perspective. *Global Environmental Change*, *12*(3), 167–184. https://doi.org/10.1016/S0959-3780(02)00012-2

van Buuren, A., Eshuis, J., & van Vliet, M. (Eds.) (2015). *Action research for climate change adaptation: Developing and applying knowledge for governance*. London; New York: Routledge, Taylor & Francis Group.

van Kerkhoff, L. E., & Lebel, L. (2015). Coproductive capacities: Rethinking science-governance relations in a diverse world. *Ecology and Society*, *20*(1). https://doi.org/10.5751/ES-07188-200114

Vaughan, C., & Dessai, S. (2014). Climate services for society: Origins, institutional arrangements, and design elements for an evaluation framework: Climate services for society. *Wiley Interdisciplinary Reviews: Climate Change*, *5*(5), 587–603. https://doi.org/10.1002/wcc.290

Vulturius, G., & Gerger Swartling, Å. (2015). Overcoming social barriers to learning and engagement with climate change adaptation: Experiences with Swedish forestry stakeholders. *Scandinavian Journal of Forest Research*, *30*(3), 217–225. https://doi.org/10.1080/02827581.2014.1002218

Welp, M., de la Vega-Leinert, A., Stoll-Kleemann, S., & Jaeger, C. C. (2006). Science-based stakeholder dialogues: Theories and tools. *Global Environmental Change*, *16*(2), 170–181. https://doi.org/10.1016/j.gloenvcha.2005.12.002

WMO (2011). *Climate knowledge for action: A global framework for climate services: Empowering the most vulnerable: The report of the high-level taskforce for the global framework for climate services*. Geneva: World Meteorological Organization.

Wyborn, C. A. (2015). Connecting knowledge with action through coproductive capacities: Adaptive governance and connectivity conservation. *Ecology and Society*, *20*(1). https://doi.org/10.5751/ES-06510-200111

Yin, R. K. (2009). *Case study research: design and methods*. London: SAGE.

AUTHOR BIOGRAPHIES

Åsa Gerger Swartling (PhD) is a senior research fellow at SEI. Her areas of interest and experience include participatory governance, science-stakeholder dialogues, and learning, with focus on climate adaptation, disaster risk reduction, and natural resource management.

Sandra Tenggren is a sustainability consultant at ÅF in Stockholm, Sweden. Her work includes supporting the implementation of climate adaptation measures in the private sector in Sweden.

Karin André (PhD) is a research fellow at SEI. Her research interests include climate adaptation processes in private and public sectors, the role of science-practice interaction, and stakeholder dialogues in managing complex environmental issues.

Olle Olsson (PhD) is a research fellow at SEI. His work is focused primarily on energy, the bioeconomy, and the role of businesses and industry in sustainability transitions.