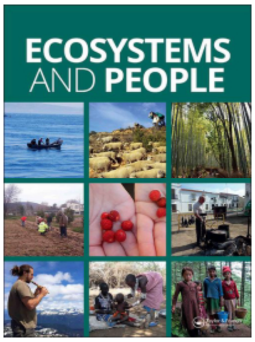

Ecosystems and People

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tbsm22

Knowledge co-production in the Helge å catchment: a comparative analysis

Katja Malmborg, Ida Wallin, Vilis Brukas, Thao Do, Isak Lodin, Tina-Simone Neset, Albert V. Norström, Neil Powell & Karin Tonderski

To cite this article: Katja Malmborg, Ida Wallin, Vilis Brukas, Thao Do, Isak Lodin, Tina-Simone Neset, Albert V. Norström, Neil Powell & Karin Tonderski (2022) Knowledge co-production in the Helge å catchment: a comparative analysis, Ecosystems and People, 18:1, 565-582, DOI: 10.1080/26395916.2022.2125583

To link to this article: https://doi.org/10.1080/26395916.2022.2125583

ECOSYSTEMS AND PEOPLE
2022, VOL. 18, NO. 1, 565–582
https://doi.org/10.1080/26395916.2022.2125583

Taylor & Francis
Taylor & Francis Group

RESEARCH

OPEN ACCESS Check for updates

Knowledge co-production in the Helge å catchment: a comparative analysis

Katja Malmborg [a,b,c*], Ida Wallin [d,e*], Vilis Brukas [e], Thao Do [f], Isak Lodin[e,g], Tina-Simone Neset [h], Albert V. Norström [a,i], Neil Powell [f,j] and Karin Tonderski [k]

[a]Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden; [b]Department of Biological Sciences, University of Bergen, Bergen, Norway; [c]Centre for Sustainable Area Management (CeSAM), University of Bergen, Bergen, Norway; [d]Chair of Forest and Environmental Policy, University of Freiburg, Freiburg, Germany; [e]Southern Swedish Forest Research Centre, Swedish University of Agricultural Sciences, Alnarp, Sweden; [f]Sustainability Learning and Research Centre, Department of Women's and Children's Health, Uppsala University, Uppsala, Sweden; [g]WWF Sweden, Stockholm, Sweden; [h]Department of Thematic Studies-Environmental Change, Centre for Climate Science and Policy Research, Linköping University, Linköping, Sweden; [i]Global Resilience Partnership, Stockholm University, Stockholm, Sweden; [j]The Sustainability Research Centre, University of the Sunshine Coast, Sippy Downs, Queensland, Australia; [k]Department of Management and Engineering, Environmental Technology and Management, Linköping University, Linköping, Sweden

ABSTRACT

Addressing sustainability challenges in landscape management requires processes for co-producing usable knowledge together with those who will use that knowledge. Participatory futures methods are powerful tools for attaining such knowledge. The applications of such methods are diverse and understanding the intricacies of the knowledge co-production process is important to further develop these research practices. To improve participatory futures methods and contribute to systematic and critical reflections on methodology, we present a comparative analysis of four research projects that applied participatory futures methods in the same study area. Conducted between 2011 and 2020, these projects aimed to co-produce knowledge about the future provision of ecosystem services in the Helge å catchment area in southern Sweden. For structuring the post-hoc, self-reflexive analysis, we developed a framework dividing the knowledge co-production process into three dimensions: settings, synthesis and diffusion. We based the analysis on documentation from the projects, a two-step questionnaire to each research team, a workshop with co-authors and interviews with key participants. The comparison highlights steps in project decision-making, explicit and implicit assumptions in our respective approaches and how these assumptions informed process design in the projects. Our detailed description of the four knowledge co-production processes points to the importance of flexibility in research design, but also the necessity for researchers and other participants to adapt as the process unfolds.

ARTICLE HISTORY
Received 24 February 2022
Accepted 12 September 2022

EDITED BY
Berta Martín-López

KEYWORDS
Futures methods; ecosystem services; landscape management; participatory methods; process evaluation; transdisciplinarity

Introduction

Our societies, and the natural landscapes that we depend upon, are facing multiple complex sustainability challenges, including climate change, biodiversity loss and environmental degradation. The measures suggested to address these challenges, however, often compete for the same resource base. Boreal production forests, for instance, are expected to provide resources for the necessary shift to a bio-based economy (Pülzl et al. 2017) while at the same time generating other ecosystem services such as carbon sequestration, temperature regulation (Bright et al. 2017), water purification (Gauthier et al. 2015) and thriving habitats for the protection of biodiversity (Gustafsson et al. 2020; Angelstam et al. 2020). To address these complex challenges, it is not enough to understand the biophysical processes that generate the necessary ecosystem services. We must also consider the potential trade-offs involved in managing for specific purposes (Sandström et al. 2011; McShane et al. 2011), understand the governance systems that these production landscapes are embedded in (Bernstein and Cashore 2012), as well as where potential leverage points for change might lie (Fischer and Riechers 2019). Knowledge co-production has emerged as a promising transdisciplinary approach to generate the knowledge needed to address sustainability challenges that involve multiple groups of people with different needs and interests and that are beset by biophysical, social, political and administrative uncertainties (Chambers et al. 2021).

Knowledge co-production is a process where researchers work with non-academic actors to both frame the research design and generate knowledge (Clark and Harley 2020; Norström et al. 2020). Knowledge co-production has gained traction both in the research community, among research funders, and in the policy sphere over the past decades (Lemos

CONTACT Katja Malmborg katja.malmborg@uib.no
*These authors contributed equally to this work.
Supplemental data for this article can be accessed online at https://doi.org/10.1080/26395916.2022.2125583

et al. 2018; Apetrei et al. 2021). Initiatives range from individual research projects focusing on participatory mapping of ecosystem services (Boeraeve et al. 2018; Malmborg et al. 2021) to long-term collaborations between researchers, policy-makers and industry actors in specific sectors or to address a specific issue (Tengö et al. 2017; Chambers et al. 2021). Participatory futures methods (or futures analysis), in which the participation of diverse knowledge-holders is seen as fundamental, have been used in knowledge co-production to increase understanding of complex landscape challenges (Oteros-Rozas et al. 2015; Pereira et al. 2021). Futures methods are used to develop scenarios or visions of the future with the aim to compare options, increasing anticipatory capacities and supporting strategic decision-making (Sardar 2010). Using participatory futures methods can, if carefully designed, increase creativity in landscape management (Börjeson et al. 2006; Pereira et al. 2018) and facilitate dialogue that overcomes entrenched positions and finds new options by focusing on commonly desired futures instead of the present (Nielsen and Nielsen 2016).

However, such processes of knowledge co-production tend to be complex in and of themselves. How and what kind of knowledge is generated in them, and by whom, is not always clear (Defila and Di Giulio 2015). Unexpected insights can emerge during the process (Sellberg et al. 2021b), and activities that contributed to specific outcomes might not become apparent until the completion of a project. For instance, local context matters, but exactly how begs further investigation (Lam et al. 2021). Researchers and participants alike also benefit from reflecting on when and what type of knowledge is created and what it is useful for (Mauser et al. 2013; Hakkarainen et al. 2022). Understanding these, and other, intricacies of the knowledge co-production process through reflexive post-hoc evaluations can therefore provide valuable insights into how to design future projects (Boeraeve et al. 2018).

In this paper, we examine four projects that applied participatory futures methods to co-produce knowledge about the future of ecosystem services generation in the Helge å catchment area in southern Sweden. All four projects ran over several years and focused on similar actor groups and general themes but drew on different bodies of theory and used different methodological approaches. The combination of similarities in geographic, social and temporal context and differences in approaches creates a unique opportunity for reflecting on and evaluating knowledge co-production processes. Choice of formats and methods in knowledge co-production should ideally be context-specific (Norström et al. 2020), but this also creates challenges for case study comparisons with the aim to reach more generalizable insights. The similarities in context between our four projects reduce this challenge, allowing us to analyse different approaches to knowledge co-production and the role that process design has for the usability of knowledge outputs. Through this analysis, we aim to provide a detailed conceptualization of a knowledge co-production process, and thus improve the potential for successful projects in the future.

In pursuit of this aim, we asked the following research questions: What were key influencing conditions in the knowledge co-production processes in these four, contextually similar projects? How did these conditions and researchers' decision-making influence the usability of the co-produced knowledge? We present a post-hoc in-depth comparison of the four research projects, conducted through a reflexive self-evaluation by the researchers and interviews with key participants. We developed an analytical framework for the knowledge co-production process to aid the comparison. Based on our in-depth comparison, we reveal tensions and insights into the design of knowledge co-production processes, and what these insights mean for future research aiming to co-produce usable knowledge for sustainability (Lemos et al. 2012; Clark et al. 2016a).

Materials and methods

Helge å catchment and the four projects

The Helge å river catchment area is one of the largest in southern Sweden, covering 4 749 km^2 (SMHI 2002) and overlapping with 13 municipalities in three counties. It encompasses all major land uses in the region, from production forestry in the north, mixed small-scale agriculture, animal husbandry, and forest patches in the center, to intensive agriculture in the south (Figure 1). In the downstream area, the river also passes through biodiversity-rich wetlands in the Kristianstad Vattenrike UNESCO Biosphere Reserve.

The four research projects in this comparison are INTEGRAL, BONUS MIRACLE, ALTERFOR and a Ph.D. project at Stockholm Resilience Centre in collaboration with Kristianstad Vattenrike Biosphere Office (henceforth SRC-KVB) (Table 1). KVB is a bridging organization with responsibility to manage the biosphere reserve, coordinated by Kristianstad Municipality. As with SRC-KVB, ALTERFOR had partner organizations: Södra Skogsägarna, a forest owner association, and Kronoberg County Administrative Board. The four projects were each active for 3–5 years in 2011–2020 and were conducted by three different research groups. In INTEGRAL and ALTERFOR, the research teams partially overlapped. ALTERFOR can therefore be considered a follow-up

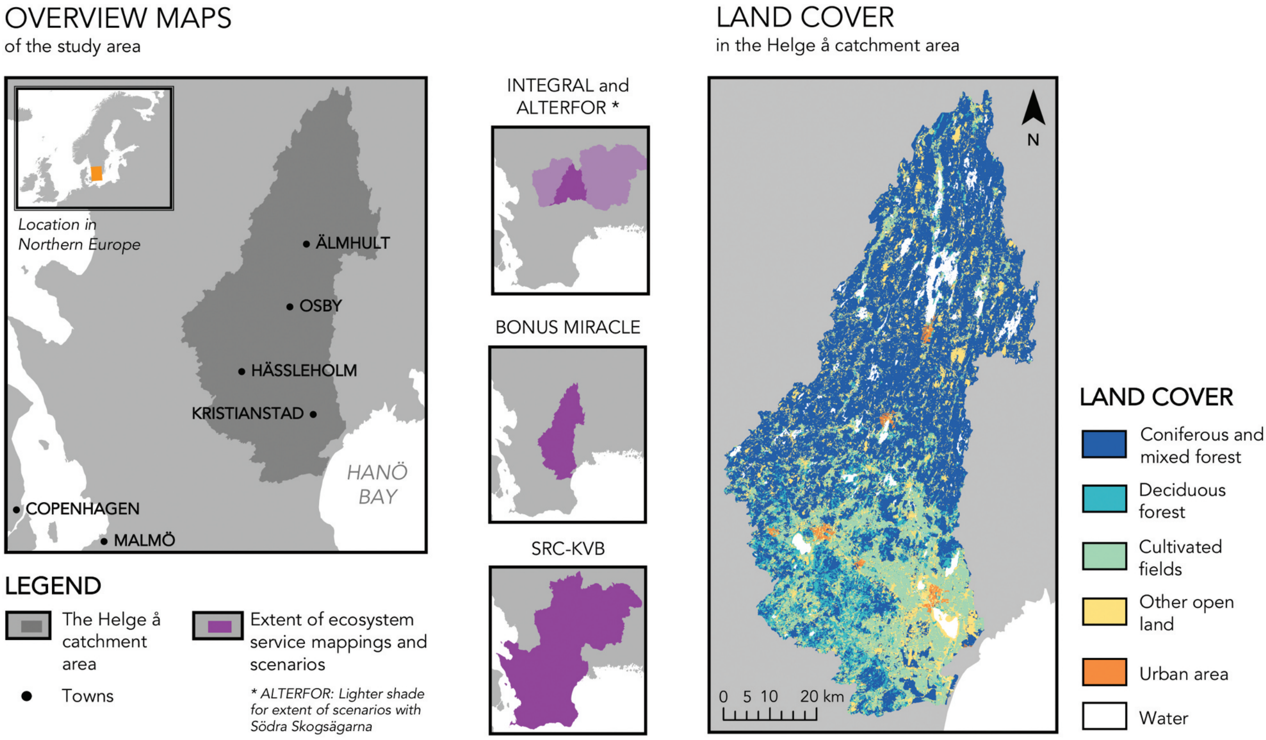

Figure 1. Overview map, spatial extent of mappings and scenario analyses in the four projects, and land covers in the Helge å catchment area. Based on Fastighetskartan from © Lantmäteriet.

Table 1. Overview of the four futures-oriented research projects that were included in this comparative analysis.

Project name	Years active	Funding	Institution(s)	Research group
INTEGRAL	2011– 2015	EU FP7	Swedish University of Agricultural Sciences	Ida Wallin, Vilis Brukas, Renats Trubins, Ola Sallnäs
ALTERFOR	2016–2020	EU Horizon 2020	Swedish University of Agricultural Sciences Project partner: Södra Skogsägarna & Kronoberg County Administrative Board	Isak Lodin, Vilis Brukas, Ljusk-Ola Eriksson, Adam Felton, Matts Lindbladh, Eric Agestam, Kristina Wallertz
BONUS MIRACLE	2015–2018	EU FP7 through BONUS; national research funders in Denmark, Germany, Latvia, Poland and Sweden	Linköping University, Uppsala University, Swedish Meteorological and Hydrological Institute, University of Copenhagen	Karin Tonderski, Tina-Simone Neset, Neil Powell, Thao Do, René Capell, Johannes Carolus, Søren Marcus Pedersen
SRC-KVB	2015–2019	Swedish Environmental Protection Agency (SEPA)	Stockholm Resilience Centre Project partner: Kristianstad Vattenrike Biosphere Office	Katja Malmborg, Elin Enfors-Kautsky, Albert V. Norström, Lisen Schultz

project of INTEGRAL. Except for SRC-KVB, all projects contributed with case studies to larger EU-funded research consortia focused on case comparisons across Europe.

Analytical framework: the knowledge co-production process

To compare the knowledge co-production processes in the four projects, we developed an analytical framework (Figure 2). It builds on the *Conceptual model of an ideal – typical transdisciplinary research process* (Lang et al. 2012) and the *Inventory of synthesis* (Defila and Di Giulio 2015). The *Conceptual model* is focused on the transdisciplinary research process, whereas the *Inventory of Synthesis* is a framework for analysing the integrated results of inter- and transdisciplinary research. By building on these two frameworks, we can compare knowledge co-production processes while giving special attention to the participating knowledge-holders and how their expertise became transferred through the process steps resulting in individual knowledge outputs and outcomes. Our framework is organized into the dimensions *Settings* (underlying assumptions and points of departure), *Synthesis* (integration and/or synthesis building) and *Diffusion* (dissemination and integration in different academic and non-academic fields). Based on relevant literature on knowledge co-production, participation and knowledge utilization, we identified six separate

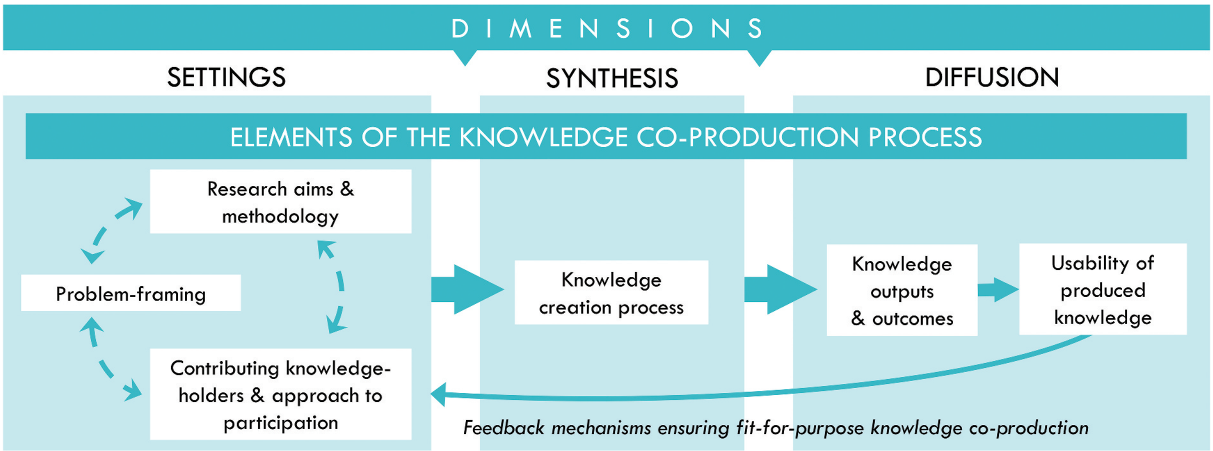

Figure 2. Analytical framework for comparing knowledge co-production processes using *Settings*, *Synthesis* and *Diffusion* dimensions. *Settings* include the elements *Research aims and methodologies*, *Contributing knowledge-holders and approach to participation* and *Problem-framing*. This dimension corresponds with the Problem-framing and team building phase in Lang et al. (2012). *Synthesis* consists of the element *Knowledge creation process* and corresponds with the Co-creation phase in Lang et al. (2012) as well as the Inventory of synthesis (Defila and Di Giulio 2015). *Diffusion* consists of the elements *Knowledge outputs and outcomes* and *Usability of produced knowledge*, which corresponds with the (Re-)integration and application phase in Lang et al. (2012).

key elements organized within the three overarching dimensions. Below, we describe them as a series of sequential steps. In practice, however, they are closely connected and often developed or defined through non-sequential staging as a series of interactions that occur in parallel and/or through iterative cycles. They also often evolve and change throughout a project.

First dimension: settings

Settings consist of three overlapping elements. First, *Research aims and methodologies* include the explicit research aims that have been stipulated for the project, the theory, approach or range of methodologies that guide decisions about design and tools, and potential requirements put on the research by, for example, funders. This also includes normative assumptions that can be either explicit or implicit, like the project's theory of change. A project's theory of change describes assumptions about how (future) actions and outcomes are connected and how they can lead to predictable and desirable change (Oberlack et al. 2019).

The second element is the *Contributing knowledge-holders and approach to participation*. It encompasses the categories of knowledge-holders, including actors with both academic, practical and local knowledge (Tengö et al. 2014), and the motivation for inviting them. Levels of engagement, ranging from communication and consultation to deliberation and co-production (Hurlbert and Gupta 2015; Reed et al. 2018), can be used to describe a project's approach to participation. To further distinguish between different types of contribution, we include the extent to which the participants are expected to ensure the usefulness and usability of the co-produced knowledge. Usefulness of knowledge describes the potential value to the user but does not consider if it is easily picked-up and integrated into decision-making (Lemos et al. 2012). The usability of knowledge is decided by its ability to inform decision-making and the ease with which it can be applied by the user (Clark et al. 2016a). Usable knowledge needs to be credible (valid and reliable), but also salient (relevant) and legitimate (respectful of the diverse values of its intended users) (Cash et al. 2003). The production of knowledge also needs to be feasible, meaning that the resources required to generate it are on par with the resources available in the decision-making context in question (Gómez-Baggethun and Barton 2013). In a knowledge co-production process, ensuring that these criteria are met can be distributed between different participant groups (Clark et al. 2016b). For instance, a participating researcher might ensure the credibility of a hydrological model, while a municipality politician contributes to its saliency by ensuring that suggested policy interventions that are used to create scenarios from the hydrological model are relevant considering the local context and decision-makers' mandates.

The third element, *Problem-framing*, is defined by the focal sustainability challenge and can be achieved either within the interdisciplinary team of researchers or in collaboration with participants from practice and policy. For successful co-production of knowledge, it is generally recommended to include participants from practice already in the problem-framing stage (Chambers et al. 2021). However, as an articulation of problem-framing is often demanded by funders already in the application stage, it is not always possible to include non-academic participants in the initial framing. In this case, transparency regarding how the project was framed is important for understanding how later stages evolve.

Second dimension: synthesis

The dimension of *Synthesis* is where knowledge is synthesized and/or integrated. The key element here is the *Knowledge creation process*, where new knowledge is jointly created (Tengö et al. 2017). This encompasses process design (format) and project activities over time (methods) (Lam et al. 2021), including multi-actor workshops where tools and exercises are used for social learning and to generate new insights; elicitation of opinions and information from relevant actors through interviews or surveys; and data analyses and modeling conducted within the interdisciplinary research team. As this element focuses on activities, its different parts can generally be mapped over time. This is not to say that every step of a process needs to be pre-planned. Unexpected insights often emerge and including a degree of flexibility into the design is beneficial (Sellberg et al. 2021b).

Third dimension: diffusion

The last elements are *Knowledge outputs and outcomes* and *Usability of produced knowledge*. These are both parts of the *Diffusion* dimension, in that they represent the potentially transferable knowledge that the process resulted in (Lang et al. 2012). Knowledge outputs and outcomes can range from concrete results, like ecosystem service maps or modeled scenarios of the future, to more intangible outcomes, such as participants learning new concepts. However, there is an analytical motivation for distinguishing between outputs and outcomes on the one hand, and knowledge use on the other (Rich 1997; Hoffmann et al. 2019). As researchers, we are often concerned with outputs. How knowledge will reach people and how it is to be used is easily overlooked (Clark and Harley 2020). Usability can be achieved by including the intended users in knowledge co-production. However, the knowledge outputs are not automatically fit-for-purpose just because the intended users have been part of the production process. Feedback mechanisms between intended knowledge uses and how the project is initially framed are required. This can be achieved through the participation of intended users in the formulation of the research aims before the project starts (Marre and Billé 2019) or by incorporating insights from previous research projects in the initial design (Blackstock et al. 2007; Wall et al. 2017). The usability of knowledge outputs and outcomes can therefore be assessed based on who the intended users are, the type of knowledge that has been generated and the extent to which it addresses current sustainability challenges in the eyes of the intended users (Barton et al. 2018). Efforts by researchers to interact and build trust over time also increase usability (Lemos et al. 2012).

Reflexive self-evaluation and interviews with participants

The four projects were compared through a reflexive self-evaluation protocol by members of the respective research teams. Information was collected in four ways: through a two-step questionnaire; an analysis of project reports and publications; in a facilitated virtual workshop; and interviews with eight key non-academic participants from the projects.

The first step of our reflexive self-evaluation (Boeraeve et al. 2018) was a questionnaire (please see the supplementary materials, S1) based on an existing evaluation framework of participatory scenario planning (Oteros-Rozas et al. 2015). The questionnaire covered a broad range of questions relevant for understanding participatory futures-oriented research. It was completed by each research team. After an initial analysis of the responses, a second iteration of the questionnaire was shared with the team to fill some important information gaps. This iteration focused on the elements in our analytical framework (Figure 2). To complement the questionnaires, we analysed project reports and scientific publications from the respective projects, in particular, to extract details about knowledge outputs (see list in S2). Additionally, we discussed initial findings and emerging topics in a virtual workshop in February 2021 with representatives from all projects (all co-authors of this paper).

Finally, in May–July 2021, we conducted virtual interviews with eight key non-academic participants (Table 2). When identifying key participants, we

Table 2. Interviewed key participants, including their affiliations and which projects they participated in.

Participant	Affiliation	INTEGRAL	ALTERFOR	BONUS MIRACLE	SRC-KVB
A	Farmers or forest owners' association	X			
B	Farmers or forest owners' association	X			
C	Governmental agency	X			
D	Governmental agency		X	X	X
E	Municipality			X	X
F	Industry representative		X		
G	Municipality				X
H	Farmers or forest owners' association			X	

considered participating actors from partner organizations as well as participants with particularly high attendance rates in the projects' participatory components. Our selection was limited to the participants who were still employed by the same organizations or still active in the role that motivated their participation to begin with. The interviews focused on what the participants remembered from the project activities, what they had found interesting and if they explicitly used any of the knowledge outputs since the projects ended (interview guide S3). To prompt recollections, they were shown figures from the respective projects. Some participants had participated in multiple projects, in which case they also compared strengths and weaknesses between the processes. These interviews lasted 1 hour on average. Swedish, which is the language the interviews were conducted in, does not distinguish between 'useful' and 'usable' in the same way as English. Hence, we collected data on both of these aspects of knowledge use. When analyzing the interviews for evaluative information concerning use of knowledge outputs and outcomes, however, usability emerged as more prominently emphasized by the participants. We therefore focus on usability, rather than usefulness, in the Results.

The research in this paper was approved by the Stockholm Resilience Centre research ethics committee as part of the first author's PhD project. All participants were asked for oral informed consent before being interviewed.

Results

First dimension: settings

Research aims and methodologies

All four projects focused on ecosystem service production and sustainable landscape management in the face of climate change, but the sustainability challenges that defined the problem framing varied (Table 3). All projects also had the dual-research aim to generate social learning among the participants. For the projects that were part of larger EU-funded research consortia (all except SRC-KVB), most decisions regarding approaches and methods were taken at the consortia level, to make outputs comparable between cases. INTEGRAL and ALTERFOR had top-down approaches to change, while BONUS MIRACLE and SRC-KVB both were based on theoretical bottom-up approaches (Table 3).

Problem-framing

While INTEGRAL and ALTERFOR focused on alternatives for future forest management, BONUS MIRACLE aimed at reducing nutrient discharge into the Baltic Sea.

Table 3. Research aims and methodologies of the four projects.

Aspect	INTEGRAL	ALTERFOR	BONUS MIRACLE	SRC-KVB
Sustainability challenge in focus, as defined by project aim	Understand trade-offs in forest management with regards to future ecosystem service provision. Focus on land-use structures and key drivers of change.	Examine alternative forest management models and assess the impact of different management models in terms of their capacity to deliver ecosystem services and reduce socio-ecological risks on the European and landscape level.	Generate knowledge to reduce nutrient enrichment in the Baltic Sea Region. Analysis of both governance systems and modeled biophysical responses.	To map multiple ecosystem services across the Helge å catchment, generate a social-ecological system understanding for the study area, and develop a strategic action plan towards a positive future vision.
Process aim	Generating transdisciplinary knowledge about the project topic. Integration of results in decision-support tools and making recommendations for policy.	Facilitate implementation of desired forest management models in Kronoberg county/ the upper Helge å catchment and in other cases in Europe. Improve cross-national knowledge transfer regarding their benefits, costs, etc.	Enact social learning process that would lead to the identification of new configurations for governance.	Develop tools, facilitate learning and create spaces for cross-sectoral collaboration to address complex sustainability challenges using a resilience approach.
Targeted ecosystem services	*Provisioning*: Forest production *Regulating*: Carbon sequestration, biodiversity, water quality (leakage of mercury and dissolved organic content)	*Provisioning*: Forest production *Regulating*: Carbon sequestration, biodiversity, water quality *Cultural*: Recreational and aesthetic value	*Regulating*: Water quality (losses of N and P) and flood control.	*Provisioning*: Forest, milk, meat, fruit, food and fodder crop production *Regulating*: N and P retention, water quality, landscape diversity, *Cultural*: Outdoor recreation, hunting, horseback riding, biodiversity heritage
Theory of change	Top-down: produce empirical-based evidence that can guide policy making. *Theoretical approach*: Logics of human behaviour incl. homo economicus, -sociologicus and – interpreter.	Top-down: Researchers make alliances with powerful actors. Strategies are hard to implement if they are not in line with the interests of the powerful actors. *Theoretical approach*: Research, Integration and Utilization (RIU) model (Böcher 2016)	Bottom-up: Local practitioners' practices lead to change. Social learning among stakeholders is used for adopting research. *Theoretical approach*: Soft Systems Methodology	Bottom-up: Local practitioners' practices lead to change. Aim to highlight participants' own agency and to create/acknowledge important strategic alliances. *Theoretical approach*: Wayfinder/Resilience thinking (Enfors-Kautsky et al. 2021)

Originally, the BONUS MIRACLE consortium intended to have flooding as a systemic issue for all four cases around the Baltic Sea. In the issue framing phase, however, participants in the Helge å case expressed a strong concern about browning of the river water (brownification). The original systemic issue was therefore exchanged for brownification, to accommodate local concerns. SRC-KVB did not have a targeted challenge from the get-go. Instead, they mapped multiple ecosystem services to generate a social-ecological system's understanding for the landscape. Their aim, articulated by the biosphere office, was to explore the potential of these methods to support collaboration in addressing complex sustainability challenges in the Helge å landscape.

Contributing knowledge-holders and approach to participation

The disciplinary backgrounds of members in the research teams were similar, with an emphasis on ecology and geosciences, environmental policy analysis, and either post-normal or sustainability science (detailed affiliations in S4). Similarly, there was a large overlap in the affiliations of the non-academic participants, with all projects including actors with an interest in the forestry sector. The projects also included participants from other sectors to varying degrees (Table 4 and S4).

All projects motivated the inclusion of non-academic participants by acknowledging the value of local and practical knowledge in the research process. Participants were expected to contribute to the saliency of the produced knowledge outputs by providing insights into what is relevant and possible to do (or use) in specific governance contexts. They were also expected to contribute to the legitimacy of the process outputs. In BONUS MIRACLE, a process design centered on social learning contributed to legitimacy, while for INTEGRAL, two exercises were important (the prioritization of factors of change and articulation of a normative vision). Nevertheless, both projects experienced challenges connected to saliency and legitimacy when proposing certain problem-framings to the participants (example from BONUS MIRACLE described in Problem-framing). The narratives by the research teams (in S5) and the interviews with key participants (in S6) contain further evidence of resistance to the original research focus in these two projects.

ALTERFOR and SRC-KVB both had non-academic partner organizations that contributed to framing the project aims and identifying the key challenges. In ALTERFOR's case, this exercise was designed to ensure that the eventual knowledge outputs would address specific knowledge needs of the partner organizations (saliency). The early involvement of the partner organizations contributed to both saliency and legitimacy of knowledge outputs in the eyes of the partner organizations themselves (as powerful actors in the study area). SRC-KVB was designed to be flexible to the emergent interests of the participants. In this case, the partner organization contributed to the initial framing and to the legitimacy of the process in the eyes of the other invited participants.

In SRC-KVB, the iterative process design (including certain exercises) required all participants to contribute to both content and prioritizations within the outputs (ecosystem service assessment and system model building), effectively involving all participants in ensuring the credibility of knowledge outputs. In the other three projects, credibility was mainly ensured by the research teams, except for components of the outputs that addressed specific local knowledge about management and governance practices and potential implications of implementing certain management measures.

Second dimension: synthesis(knowledge creation process)

When analyzing the project timelines, we identified six overarching types of activities, to varying degrees engaged in by all projects (Figure 3, individual project timelines in S7).

The extent to which non-academic actors participated in the activities varied. Certain activities, like *Data analysis* and *Synthesis*, involved research teams only. *Interviews* were used in two ways: First, to elicit information about the study area to inform data analyses (INTEGRAL, ALTERFOR and SRC-KVB). Second, in SRC-KVB, follow-up interviews at the end of the project with non-academic participants were used to assess learning. ALTERFOR and SRC-KVB also started with *Planning meetings* with their respective project partners to help frame consecutive analyses and workshops. The *Workshops* involved the highest degree of participation by a broad range of actors. The number of workshops ranged from two in

Table 4. Range of affiliations of participating actors.

All projects	Forestry sector representatives (land owners' associations, industry representatives and nature protection)
	Representatives from public administration (municipalities, county boards, national agencies)
BONUS MIRACLE & SRC-KVB	Agriculture sector representatives (farmers' association)
INTEGRAL & SRC-KVB	Regional business development organizations
	Associations for outdoor recreation

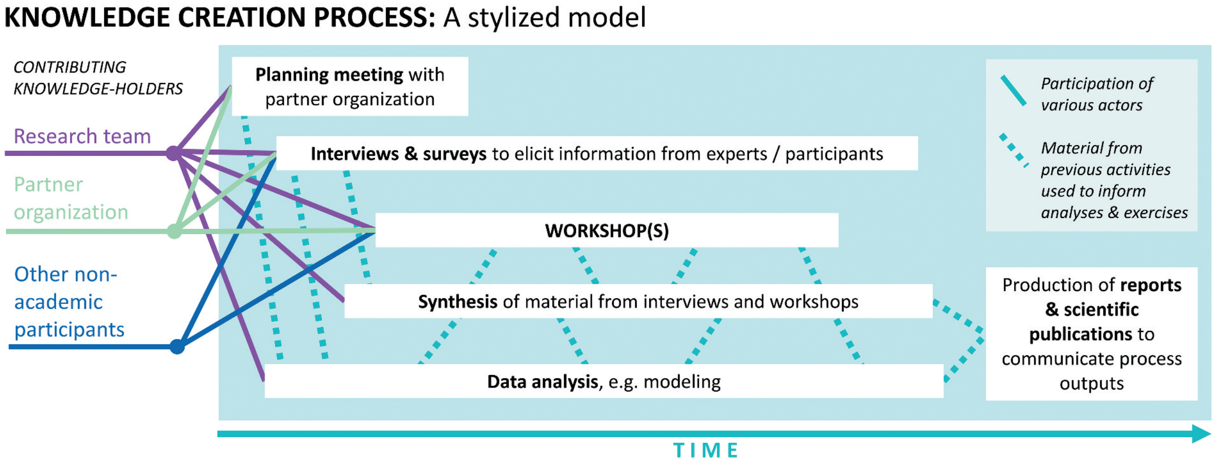

Figure 3. Stylized model of a knowledge creation process and the different types of activities it may involve.

ALTERFOR, three in INTEGRAL, to five in SRC-KVB and seven in BONUS MIRACLE. All workshops in SRC-KVB included the same group of participants. In the other projects, results from previous interactions were presented at each workshop and there was generally some overlap in participants; however, each event was mainly with a new group of actors.

The researchers' reflexive self-evaluation revealed methodological struggles that arose in the knowledge creation processes of INTEGRAL, ALTERFOR and BONUS MIRACLE. In INTEGRAL, early interactions where participants had criticized workshops for having a too narrow focus motivated the researchers to change the consortium-prescribed method for vision development. Similar adjustments were made in ALTERFOR, but in relation to global versus local modeling simulations. In BONUS MIRACLE, outputs (about nutrient loading) from the predefined hydrological model did not address the local participants' main water-related concern (brownification), while time-consuming adjustments had to be made to the cost–benefit analysis to make it locally relevant. These examples highlight trade-offs in balancing local needs with research aims and consortia comparisons, requiring additional efforts by the research teams. The changes within INTEGRAL were even of a magnitude that the Helge å vision development ultimately could not be included in one consortia publication. None of the researchers, however, expressed regret making these adaptations.

Similar resistance from participants occurred in SRC-KVB related to an initially proposed key challenge (sustainable food production). However, due to the purposefully flexible design of this process, two additional sustainability challenges could be added as foci for exercises and analyses (decreasing brownification of the river water and increasing diversity of tree species in production forests). This meant that relevance for participants could be maintained without major changes to the original process design. Detailed recollections of these events in all projects are presented as narratives in S5.

Third dimension: diffusion

Knowledge outputs and outcomes

All projects produced futures-oriented outputs and ecosystem service analyses (Table 5). They also included exercises that scoped potential for change, lists of external drivers, and articulated strategies for how to achieve the desired change in the study area. In INTEGRAL and BONUS MIRACLE, these 'Roadmaps' or 'Pathways to change' were developed by the research teams and took the form of strategies for how to address targeted sustainability challenges through existing governance systems. The impact of those pathways on water flow and nutrient transport in different climate change scenarios was modeled quantitatively in BONUS MIRACLE. The 'Strategies for change' in SRC-KVB were formulated in similar terms but were developed as part of a suite of exercises by the participating local actors themselves. In ALTERFOR, 'Pathways' in the form of different specific management interventions in the forests were suggested in collaboration with the two project partners, after which the interventions were used as treatments in the modeled future scenarios.

Potential usability of knowledge outputs – from the research teams' perspective

For the local actors in INTEGRAL, ALTERFOR (beyond the partner organizations) and BONUS MIRACLE, the research team considered the main benefits of participation to be the learning from the model outputs, to discuss and connect with other participants, to have their views communicated to actors at higher levels of governance through the EU-funded research consortia and to use the co-produced pathways as vehicles to transform governance. The

Table 5. Knowledge outputs that were produced, with an emphasis on those outputs that are comparable between the projects.

Knowledge output	INTEGRAL	ALTERFOR	BONUS MIRACLE	SRC-KVB
Vision (normative) defined by process participants	Living countryside with high quality of life. Certified forests, processing industry focused on renewable forest-based alternatives. Collaboration between actors.	*County administrative board*: Increased nature values in production forests. *Södra Skogsägarna*: Increased wood production.	A broad range of visions representing different stakeholders' aspirations, such as improved water quality, improved conditions for aquatic species, improved understanding and use of ecosystem services	A mosaic landscape. Diversity of jobs connected to the landscape. Focus on quality of life. People have an interest in and value the outdoors.
Key sustainability challenges defined by process participants	Weather situation; View upon/Knowledge about the landscape; Ownership rights; Forest market development; EU policies; "Green" values; National rules and legislation; Taxation; Age structure of population; Owners' knowledge and skills	*County administrative board*: Fragmentation of nature values in production-dominated landscapes. *Södra Skogsägarna*: Restrictions on production due to nature conservation.	Brownification and related issues such as aquatic and terrestrial biodiversity, hydroelectricity, tourism and nutrient enrichment.	Brownification; Species diversity in production forest; Local production of sustainable food.
Scenarios – Typology by Börjeson et al. (2006)[1]	4 explorative-external scenarios developed by exploring different manifestations of important drivers of change (factors); 1 normative scenario (see Vision above)	Multiple explorative-strategic model simulations produced by combining global scenarios (climate & timber market) with treatments of various management strategies	Multiple explorative scenarios of modelled hydrological and hydro-chemical effects of different development pathways, climate and land use change scenarios	1 normative vision (see Vision above)
Ecosystem service (ES) analyses	Simulations of ES provision modeled for study area based on scenarios and forest management regimes. *Number of ES*: 4 *Spatial resolution*: One value for whole study area *Temporal resolution*: Current and in 25–30 years	Simulations of ES under different management regimes using explorative scenarios. *Number of ES*: 5 *Spatial resolution*: One value for whole study area *Temporal resolution*: Current and in 100 years	Simulations of water flow and nutrient transport in different explorative scenarios. *Number of ES*: 2 *Spatial resolution*: One value for each sub-catchment around the Baltic Sea *Temporal resolution*: Current and in 15–35 years	Mapping of provision of individual ES and distribution of ES bundles. *Number of ES*: 15 *Spatial resolution*: One value for each municipality in study area *Temporal resolution*: Current
Additional components	Analysis of forest owner types; ABM as preparatory step for ES scenarios; Roadmap of actions	Global scenarios of climate and market development	Analysis of water governance system and agency of stakeholder groups; "Roadmap" action points; Economic analysis (cost-effectiveness, and qualitative cost-benefit); Tool to visualize model simulations in workshop	Historical timeline of land use change; Conceptual system models; Analysis of deep leverage points for change; Strategic action plan
Knowledge outputs in peer-reviewed publications [2]	2 papers (Wallin et al. 2016, Trubins et al. 2019)	3 papers (Nordström et al. 2019, Lodin et al. 2020, Lodin and Brukas 2021)	4 papers (Carolus et al. 2018, 2020, Zilans et al. 2019, Chambers et al. 2022, 2019)	2 papers (Malmborg et al. 2021, 2022)

intended users of the knowledge outputs varied, where ALTERFOR focused on the two partner organizations, allowing the partners to test their proposed management options against climate and ecosystem service models. The target users of INTEGRAL's knowledge outputs were national decision-makers and various actors within the EU system, as the modeled outputs were designed to be comparable with the other European cases in the research consortium. BONUS MIRACLE had a focus on local stakeholders in four study areas, as well as regional policy-makers around the Baltic Sea. The comparison of these four Baltic case studies was supported by an interactive visualization tool (Neset et al. 2019). In SRC-KVB, the intended users and process participants overlapped, as the project was focused on learning and development of tools in the process itself. This also meant that the knowledge outputs in SRC-KVB had less potential to be transferable beyond the immediate participant group, compared to the other projects.

An aspect that emerged as particularly interesting to compare is how the ecosystem service concept was perceived. Ecosystem service analyses constituted outputs in all projects, either as separate analyses (in SRC-KVB) or as part of the modeled future scenarios (in INTEGRAL, ALTERFOR and BONUS MIRACLE). The concept functioned as a useful tool to synthesize diverse information about processes in the landscape. In the interactions with project participants, however, perceptions diverged. As a concept, it was experienced as either too complicated or not specific enough by the researchers when communicating with non-academic participants in INTEGRAL, ALTERFOR and BONUS MIRACLE. Team members in these projects chose to use other terminology when interacting with local actors. In SRC-KVB, on the other hand, the ecosystem service concept emerged as a valuable tool that was appreciated by both researchers and non-academic participants. This perceived difference in usability probably has two interacting causes. First, that SRC-KVB assigned considerably more time to discussing the concept as such, before any analyses were presented. Second, there was a wide push for the use of the ecosystem service concept in Sweden following the introduction of the national environmental interim goals in 2012 (Ds 2012:23 2012). The later timing of the last three workshops in SRC-KVB, compared to the other projects, likely meant that participants had more time to be exposed to the ecosystem service concept also outside project activities, making them more familiar with this academic term.

Usability of knowledge outputs – from the non-academic participants' perspective

In interviews with key participants from each project (summaries in S6), an obvious issue that emerged was relevance: Were the main concerns of the participating local actors really being addressed? In INTEGRAL and BONUS MIRACLE, the initial focus of the projects was not the sustainability challenge that the participants were most keen on addressing at that point in time. For example, BONUS MIRACLE aimed at modeling and assessing measures for tackling nutrient loading in the Baltic Sea, while the local actors were more concerned about local causes and consequences of brownification in the Helge å river. They adjusted their focus for the project as a whole to also encompass brownification, but the modeling component could unfortunately not be changed. This confirms the need to coordinate project focus and key challenges with local actors before a project starts (as in ALTERFOR), or to include flexibility in the process design, allowing adjustments according to emerging topics (as in SRC-KVB, and partially in BONUS MIRACLE).

It also became apparent that good process design and facilitation was important. Good facilitation included organizing workshops so that all participants were activated and discussions not hijacked by single individuals. Good design included a clear framing for the project, and communication of how participants were expected to contribute. Unclear project framing was an issue in INTEGRAL, where one interviewed participant felt unsure about the purpose of the discussions and experienced frustration as a result. The open format that the INTEGRAL researchers advocated for became confusing for the participants, as its rationale was not explicitly communicated. In SRC-KVB, on the other hand, the iterations, a clear wrapping-up during the last workshop and through follow-up interviews, as well as the materials that were distributed (workshop reports written for the participants and print-outs of knowledge outputs) were highly appreciated and created a sense of achievement.

Additionally, for SRC-KVB, a participant emphasized a difference from other science-policy-practice interactions they had experienced, in that the workshop participants perceived themselves as producers of knowledge (rather than only recipients). As stated in the section about approach to participation, SRC-KVB stood out as the only project that included non-academic participants in ensuring not only the saliency and legitimacy of the co-produced knowledge but also its credibility. Thus, there seems to be a connection between this aspect of approach to participation and the degree to which participants felt activated in knowledge creation.

In general, the most prominently featured use mentioned by key participants in all projects was the opportunity for networking. Overall, they found it enlightening and interesting to interact with both researchers and other local practitioners, as well as to learn about recent scientific developments. For the three projects that were part of larger consortia, the participants also found the comparisons between different case studies insightful. For instance, key participants in ALTERFOR felt that examples from across Europe could inspire new ideas also for southern Swedish forestry. Participating in the projects had also led to other collaborations between local actors. This was suggested as a potential future benefit for all projects. In BONUS MIRACLE, such a collaboration had already been realized. A group of participants and members from the research team applied and received funding for a workshop on brownification, which eventually led to a scientific synthesis publication (Kritzberg et al. 2020) and a conference for local practitioners.

The usability of specific knowledge outputs varied between the projects. The interviews suggest that informative and appealing figures were valued, as those were the outputs that to date have been used in practice. These include the ecosystem service bundles and conceptual system models from SRC-KVB, which have been used when communicating and teaching about landscape management, ecosystem services and forestry in different settings. Another example is how the collaborative modeling results in ALTERFOR have influenced strategies in one of the partner organizations. Analyses without good visualisations or outputs that did not match with the participants' everyday needs were forgotten or remembered as confusing. This mis-match is evident, for example, in the scenario outputs from BONUS MIRACLE. The resolution of the outputs was too high to directly feed into the GIS software at the agency where one of the interviewed participants worked, and this participant lacked the expertise to correctly aggregate the spatial data themselves. Similarly, the usability of outputs in ALTERFOR decreased due to limitations in the capacity of models to address important current challenges: no simulations of wildlife browsing and insufficient resolution of data about border zones.

Discussion

We have developed and applied an analytical framework to analyze the knowledge co-production processes in four participatory futures-oriented research projects. Through this comparative analysis, and in the contrasts between the contextually similar projects, detailed insights emerged concerning knowledge co-production processes in general. Below, we present these insights by looking across the three dimensions of our analytical framework, Settings, Synthesis and Diffusion, and discuss implications for research practice.

Adapting to local context: costs and benefits of different strategies

High-quality co-production of knowledge requires context-specific processes that address local issues and generate outcomes that are aligned with local interests, beliefs and needs (Marre and Billé 2019). Each project in our analysis took a different approach to acknowledging current issues and interests, which led to diverging outcomes. The two projects with partner organizations (ALTERFOR and SRC-KVB) experienced least resistance regarding project focus, likely due to their partners' early involvement. Participants in BONUS MIRACLE, while agreeing with problem definitions and pathways, expressed resistance towards the role of modeling. INTEGRAL, on the other hand, experienced resistance from participants concerning the methodology and the use of specific terminology. These experiences contribute to existing literature that highlights the shortcomings of prescriptive approaches in knowledge co-production (Chambers et al. 2021). Beyond partnering with local organizations, researchers can overcome this issue by engaging in preparatory activities such as spending time in the study area to build relationships with local actors (Dick 2021; Horcea-Milcu et al. 2022) and by scoping previous research in the study area, in case it could be leveraged, used or built upon (Bennich et al. 2020).

Additionally, the comparison confirmed the relevance of also assessing the level of technical and scientific knowledge of the participants beforehand (Posner et al. 2016). This is exemplified by the ecosystem service analyses, where the research teams in INTEGRAL and BONUS MIRACLE decided not to use ecosystem service terminology in interactions with local actors. The term was perceived as too complicated and a barrier for communication. The project outputs describing ecosystem services therefore lost some of their usability from the perspective of the local actors, who were not (yet) familiar with the concept. Meanwhile, the iterative, learning-focused and more time-consuming approach in SRC-KVB resulted in the ecosystem service analysis emerging as one of the strongest and most appreciated outcomes by the participants (Malmborg et al. 2022). This suggests that academic terminology and sophisticated scientific analyses do not necessarily have to be avoided or translated into lay terms, but that co-learning the applicability of academic concepts together with all participants (researchers included) can be integrated into project objectives. Participants may thus be given the opportunity to learn how outputs can be instrumentally or strategically utilized in their respective professional contexts (McKenzie et al. 2014).

Situating research processes in the local context poses its own challenges. Many research funders require clear problem framings already in the proposal stage, while funding for the project might not be granted until much later (if at all). As the worlds of research and local policy and practice move at different speeds, this can create mis-matches (Angelstam et al. 2013; Horcea-Milcu et al. 2022). New topics of local interest sometimes emerge fast, as experienced in BONUS MIRACLE with the brownification issue. Worth considering is also who should be involved in agenda-setting. ALTERFOR was specifically designed to meet the needs of two powerful actors, following the Research, Integration and Utilization (RIU) model (Böcher 2016). This ensured fit-for-purpose knowledge outputs, in the sense that the partners had defined the focus of the analyses and therefore were interested in the resulting outputs. A common motivation for engaging in participatory futures methods, however, is to challenge and inspire the participants (Oteros-Rozas et al. 2015; Wallin et al. 2016). This benefit was also highlighted in the interviews, for example, that participants in BONUS MIRACLE and ALTERFOR were inspired by learning about challenges and alternative solutions from other case studies in the research consortia. It is therefore necessary to find a balance between research being salient, that is, fit-for-purpose, while at the same time maintaining the potential to be inspirational and challenging the status quo (Pereira et al. 2020). Inevitably, when an issue is high on the political agenda, extra attention and additional resources are required of the researchers to ensure that the process is not co-opted by powerful actors and that a diversity of voices are being heard (Clark et al. 2016b; Turnhout et al. 2020).

In short, adaptability is central to knowledge co-production processes (Moallemi et al. 2021; Sellberg et al. 2021b). However, despite strategies to accommodate local needs and interests, research projects face challenges and need to compromise. A flexible design requires a larger time-commitment by both research teams and other participants. In the case of ALTERFOR, tensions between the needs of research and local actors arose despite adaptability being built into the methodology. As experienced in INTEGRAL, too much flexibility can also be experienced as frustrating by individual participants, as it can come across as lacking clarity, causing a difficulty to set expectations. Here, transparency already in the setting-up phase and formulating common goals with the participants is key (Horcea-Milcu et al. 2022), even if those goals are formulated in general terms such as focusing on learning or collectively exploring a diversity of sustainability challenges in the study area.

Changes along the way: researchers' situational judgement and co-productive agility

Apart from integrating adaptive features in the process design, unforeseen events may also necessitate ad hoc adjustments later on. When and how to adjust may be guided by a research methodology, but such guidance is rarely perfectly adapted to the particular situations in which researchers find themselves (Brunet et al. 2018).

In their narratives (S5), the researchers clearly describe conscious decisions to depart from prescribed methodologies and adapt to local needs, to the detriment of research objectives. The consequences of adaptations in the four cases could not be fully known when changes were implemented. In these complex situations, generalist knowledge and technical know-how are not enough to act (Bornemark 2017). Instead, the decisions described in the narratives can be understood as situational judgement or co-productive agility. Situational judgement instructs the practitioner on how to interpret unfolding events and to decide on a better course of action, based on the needs of those involved, process objectives and context (Bornemark 2017). Co-productive agility takes this further, to specifically describe participants' ability to navigate between roles in knowledge co-production, in order to engage with evolving agendas and to navigate power dynamics (Chambers et al. 2022). None of the researchers expressed regret concerning the final outcomes, despite later revelations that some intended comparisons with other consortium cases were made impossible. Evidently, the researchers made use of situational judgement and agility regarding their adjustments to the specific situation of their projects, which in turn contributed to higher value for the participants.

Making space and time for open, reflexive discussions among researchers is therefore highly recommended in order to improve project design and adaptability (Wittmayer and Schäpke 2014; Hakkarainen et al. 2022), as well as to hone researchers' capacity to make situational judgements (Bornemark 2017) and be agile in the co-production process (Chambers et al. 2022). In these safe spaces, openly reflecting on one's own and others' experiences and impressions, discussing dilemmas and connecting to different theories of thought can provide guidance about important issues related to the quality of the process as it unfolds (Bornemark 2017; Alonso-Yanez et al. 2019; Sellberg et al. 2021a).

Usability of knowledge outputs

High quality and informative knowledge outputs, in the form of materials and figures, as well as networking with other participants and researchers, emerged as the most important features for increasing diffusion of the co-produced knowledge in the four projects. However, using knowledge outputs and outcomes, through institutionalization and communication with others, is highly dependent on the individual participant and the organizational structures they are embedded in (Clark et al. 2016a). Several interviewees emphasized that the co-produced knowledge benefited their own practice but was not necessarily diffused into their organizations. The perceived usability of ecosystem service analyses, already discussed in a previous section, also speaks to the importance of time: the later timing of SRC-KVB, compared to the other projects, meant that the participants who were active in public administration were in a more favorable stage of the policy process (Tomich et al. 2004; Posner et al. 2016). Additionally, the emphasis on capacity-building in SRC-KVB meant that the participants developed both a deeper understanding, opportunities for experimentation and a shared language connected to ecosystem services, all of which support usability of knowledge in co-production (van Bommel et al. 2016; Caniglia et al. 2021). Organizations that have internal structures for facilitating learning between colleagues, therefore, have the potential to benefit more from their members' or employees' participation in knowledge co-production processes (Johannessen and Hahn 2013). A sense of ownership or commitment to the research from the participating organizations, and not only individual participants, is also important for successful diffusion (Hoffmann et al. 2019). Such buy-in was to varying degrees lacking in all four projects.

Furthermore, a trade-off appears to exist, at least for certain types of outputs, between usability in the local context, and opportunities to generate transferrable knowledge (Newig et al. 2019). Aiming to fill scientific knowledge gaps might also undermine other outcomes from co-production (Chambers et al. 2021). This trade-off is clearly illustrated by the tension in two of the projects, where the connection to EU-level research consortia meant that methods and outputs had to be consistent between consortia case studies. The consistency offers an opportunity to compare and generate less context-specific insights. These are crucial to bridge the gap between local case studies and regional or international understanding and decision-making (Stringer et al. 2006), in this case, environmental governance in Europe. However, the demands on consistency also reduce the flexibility of the process in individual case studies. This trade-off is important to acknowledge in transdisciplinary research (Lam et al. 2021). It might not be possible to meaningfully generate outcomes that meet all types of goals, ranging from social learning, impact on local change processes and high-quality, internationally generalizable science (Chambers et al. 2021). Researchers may have to prioritize between these and then be transparent about their priorities to those expected to contribute with their time and knowledge, in order to set reasonable expectations.

Improving knowledge co-production practices

Building on our comparison, we have described several strategies that can guide researchers in setting up more successful processes of knowledge co-production for sustainable landscape management. Ultimately, researchers engaging in co-production need to consider diffusion early and understand the needs and limitations of the intended decision-making context (Barton et al. 2018; Marre and Billé 2019). Real integration, where insights from knowledge co-production are used to reconfigure how actors in an organization work, requires deep engagement and a significant amount of time by both participating researchers and multiple members or employees of the targeted organization (Posner et al. 2016). Therefore, a crucial consideration for researchers and research funders alike is to critically assess and discuss the actual need for participation (Mascarenhas et al. 2021; Moallemi et al. 2021). The risk when involving local actors without clear aims for their participation includes participation fatigue and disappointment (Lindstad 2018). In some cases, interviews or surveys can be more efficient and less invasive tools for ensuring salient and legitimate data to inform models and other analyses (Mukherjee et al. 2018).

We are certainly not the first to point out the problems of participation fatigue (Wesselink et al. 2011), professionalization of stakeholder participants (Kleinschmit et al. 2018), varying capabilities and motivations for participation, and problems due to unclear expectations (Jagannathan et al. 2020). Conducting research in stand-alone projects (projectification) is also limiting, as it risks leading to projects that are restricted by their inevitable short-term framing and unnecessary overlap between projects, undermining the potential for research users to become engaged in longer-term learning (Allan 2012). Researchers need to reflect on the role of the project as a format and take action to avoid too much reductionism, risk-avoidance (Allan 2012) and depolitization of their research (Turnhout et al. 2020).

From our unique vantage point, however, with a time horizon of 9 years in one case study area and the involvement of different research groups and disciplines, we believe there is an often-untapped potential in bridging between projects (Angelstam et al. 2013). Long-term relationships can be formed between practitioners and researchers, which over time can inspire new directions for practice and research alike (Campbell et al. 2016; Lam et al. 2021). These relationships build personal and organizational trust and improve communication (Coleman and Stern 2018). To further strengthen these qualities, researchers may train local actors as so-called co-researchers through resource sharing and local capacity-building (Garnett et al. 2009). Creating well-structured spaces for reflection in projects, where participants can openly discuss different types and usability of knowledge and decenter academic expertise, can also allow non-academic actors to take more active leadership roles in transdisciplinary research (Alonso-Yanez et al. 2019). Assessing impact throughout the process, connected to participants' reflexivity practices, would also support broader leadership and improve positive outcomes from co-production (Sellberg et al. 2021a; Chambers et al. 2021, 2022).

Additionally, learning continues beyond project activities. Communication of key messages from a single project may not be enough for learning to take place. This insight calls upon researchers to take responsibility for the aftermath of a knowledge co-production process and to consider the long-term consequences of their intervention (Schauppenlehner-Kloyber and Penker 2015), as well as in relation to other research projects that are active simultaneously (Allan 2012). Evaluating past projects is important. Here, our analytical framework proved valuable in structuring a post-hoc reflexive self-evaluation. Revisiting our projects has been a valuable exercise for all researchers involved, as some insights need time to mature. In our cases, the self-evaluation was initiated between 1 and 5 years after the final participant interaction took place. Based on our experiences, 2 to 4 years after the conclusion of a project (depending on its duration) might be a time period that balances the need to remember while still allowing time for insights to mature. However, our methodology is limited by the patchiness of memory. In order to increase the usability of future post-hoc reflections, we recommend implementation of protocols for project documentation, not just in terms of final results but also to produce evaluative information continuously (Hakkarainen et al. 2022)for example, through field-notes about important decisions that were taken as the process evolved.

Importantly, our analytical framework was developed to facilitate our systematic comparison and is therefore specifically appropriate for analyzing knowledge co-production in bounded research projects. It would be less appropriate for analysing transdisciplinary research that is cyclical (e.g. action research) or research commissioned to researchers by research users. The distinction between the dimensions and elements facilitated a systematic comparison between the projects. When designing future projects, however, the dimensions and elements should not be considered as temporally separated steps, but as facets that co-evolve in parallel and/or iteratively.

Conclusion

Knowledge co-production processes, through participatory, futures-oriented research like the projects described in this paper, can generate usable knowledge for sustainable landscape management. We therefore conclude that it is a valuable tool for anyone striving to address complex sustainability challenges in landscape management. However, these processes need to be designed with care, with clear goals, transparent and adaptable procedures and produce knowledge outputs that meet the needs of the intended decision-making contexts. Researchers and other participants in knowledge co-production also need to engage in reflexive practices to improve the quality of the processes. Otherwise, the transformative potential of knowledge co-production is undermined.

Notes

1. Scenario typology (Börjeson et al. 2006): Predictive (What will happen? Probability, likelihoods); Explorative (What can happen? Explore possible futures, often from a variety of perspectives and long time horizons. 2 sub-categories – External and Strategic); Normative (How can a specific target be reached? Has explicitly normative starting points, focus on certain future situations or objectives and how these could be realized).
2. Full reference in supplementary material S2.

Acknowledgment

We would like to thank all participants in the original workshops, especially those who participated in our follow-up interviews. We are grateful to Maria Tengö, Jan Kuiper, My Sellberg and colleagues at the Chair of Forest and Environmental Policy for invaluable advice regarding our analysis and earlier drafts of this paper. This study did not have any dedicated funding but would not have been possible without the original projects. We therefore would like to acknowledge funding to INTEGRAL from EU FP7, ALTERFOR from EU Horizon 2020, and SRC-KVB from the Swedish Environmental Protection Agency under Grant "Värdet av ekosystemtjänster (VEST)" (ref. 13/116). BONUS MIRACLE was funded from the joint Baltic Sea Research and Development Programme (Art 185), funded jointly by the EU and the Innovation Fund Denmark

(4114-00005B), Forschungszentrum Jülich GmbH, Latvian Ministry of Education and Science, Polish National Centre for Research and Development, and Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Katja Malmborg http://orcid.org/0000-0003-1660-4514
Ida Wallin http://orcid.org/0000-0003-2735-0409
Vilis Brukas http://orcid.org/0000-0003-2424-1354
Thao Do http://orcid.org/0000-0002-5353-8918
Tina-Simone Neset http://orcid.org/0000-0003-1151-9943
Albert V. Norström http://orcid.org/0000-0002-0706-9233
Neil Powell http://orcid.org/0000-0002-8665-2370
Karin Tonderski http://orcid.org/0000-0002-0722-6083

References

Allan C. 2012. Rethinking the 'project': bridging the polarized discourses in IWRM. J Environ Policy Plann. 14 (3):231–241. doi:10.1080/1523908X.2012.702012.

Alonso-Yanez G, House-Peters L, Garcia-Cartagena M, Bonelli S, Lorenzo-Arana I, Ohira M. 2019. Mobilizing transdisciplinary collaborations: collective reflections on decentering academia in knowledge production. Global Sustain. 2. doi:10.1017/sus.2019.2.

Angelstam P, Andersson K, Annerstedt M, Axelsson R, Elbakidze M, Garrido P, Grahn P, Jönsson KI, Pedersen S, Schlyter P, et al. 2013. Solving problems in social–ecological systems: definition, practice and barriers of transdisciplinary research. AMBIO. 42 (2):254–265. doi:10.1007/s13280-012-0372-4.

Angelstam P, Manton M, Green M, Jonsson B-G, Mikusiński G, Svensson J, Maria Sabatini F. 2020. Sweden does not meet agreed national and international forest biodiversity targets: a call for adaptive landscape planning. Landsc Urban Plan. 202:103838. doi:10.1016/j.landurbplan.2020.103838.

Apetrei CI, Caniglia G, von Wehrden H, Lang DJ. 2021. Just another buzzword? A systematic literature review of knowledge-related concepts in sustainability science. Glob Environ Change. 68:102222. doi:10.1016/j.gloenvcha.2021.102222.

Barton DN, Kelemen E, Dick J, Martin-Lopez B, Gómez-Baggethun E, Jacobs S, Hendriks CMA, Termansen M, García- Llorente M, Primmer E, et al. 2018. (Dis) integrated valuation – assessing the information gaps in ecosystem service appraisals for governance support. Ecosyst Serv. 29:529–541. doi:10.1016/j.ecoser.2017.10.021.

Bennich T, Maneas G, Maniatakou S, Piemontese L, Schaffer C, Schellens M, Österlin C. 2020. Transdisciplinary research for sustainability: scoping for project potential. Int Soc Sci J. doi:10.1111/issj.12245.

Bernstein S, Cashore B. 2012. Complex global governance and domestic policies: four pathways of influence. Int Aff (Royal Inst Int Aff 1944-). 88(3):585–604.

Blackstock KL, Kelly GJ, Horsey BL. 2007. Developing and applying a framework to evaluate participatory research for sustainability. Ecol Econ. 60(4):726–742. doi:10.1016/j.ecolecon.2006.05.014.

Böcher M. 2016. How does science-based policy advice matter in policy making? The RIU model as a framework for analyzing and explaining processes of scientific knowledge transfer. For Policy Econ. 68:65–72. doi:10.1016/j.forpol.2016.04.001.

Boeraeve F, Dufrene M, De Vreese R, Jacobs S, Pipart N, Turkelboom F, Verheyden W, Dendoncker N. 2018. Participatory identification and selection of ecosystem services: building on field experiences. Ecol Soc. 23(2). doi:10.5751/ES-10087-230227.

Börjeson L, Höjer M, Dreborg K-H, Ekvall T, Finnveden G. 2006. Scenario types and techniques: towards a user's guide. Futures. 38(7):723–739. doi:10.1016/j.futures.2005.12.002.

Bornemark J. 2017. Neutrality or phronetic skills: a paradox in the praxis of citizen dialogues organized by municipal administration. Pedagogika Spoleczna. 3 (65):51–66.

Bright RM, Davin E, O'Halloran T, Pongratz J, Zhao K, Cescatti A. 2017. Local temperature response to land cover and management change driven by non-radiative processes. Nat Clim Change. 7(4):296–302. doi:10.1038/nclimate3250.

Brunet L, Tuomisaari J, Lavorel S, Crouzat E, Bierry A, Peltola T, Arpin I. 2018. Actionable knowledge for land use planning: making ecosystem services operational. Land Use Policy. 72:27–34. doi:10.1016/j.landusepol.2017.12.036.

Campbell LK, Svendsen ES, Roman LA. 2016. Knowledge co-production at the research–practice interface: embedded case studies from urban forestry. Environ Manage. 57 (6):1262–1280. doi:10.1007/s00267-016-0680-8.

Caniglia G, Luederitz C, von Wirth T, Fazey I, Martín-López B, Hondrila K, König A, von Wehrden H, Schäpke NA, Laubichler MD, et al. 2021. A pluralistic and integrated approach to action-oriented knowledge for sustainability. Nat Sustain. 4(2):93–100. doi:10.1038/s41893-020-00616-z.

Cash DW, Clark WC, Alcock F, Dickson NM, Eckley N, Guston DH, Jäger J, Mitchell RB. 2003. Knowledge systems for sustainable development. Proc Nat Acad Sci. 100(14):8086–8091. doi:10.1073/pnas.1231332100.

Chambers JM, Wyborn C, Klenk NL, Ryan M, Serban A, Bennett NJ, Brennan R, Charli-Joseph L, Fernández-Giménez ME, Galvin KA, et al. 2022. Co-Productive agility and four collaborative pathways to sustainability transformations. Glob Environ Change. 72:102422. doi:10.1016/j.gloenvcha.2021.102422.

Chambers JM, Wyborn C, Ryan ME, Reid RS, Riechers M, Serban A, Bennett NJ, Cvitanovic C, Fernández-Giménez ME, Galvin KA, et al. 2021. Six modes of co-production for sustainability. Nat Sustain. 4 (11):983–996. doi:10.1038/s41893-021-00755-x.

Clark WC, Harley AG. 2020. Sustainability science: toward a synthesis. Annu Rev Environ Resour. 45(1):331–386. doi:10.1146/annurev-environ-012420-043621.

Clark WC, Tomich TP, van Noordwijk M, Guston D, Catacutan D, Dickson NM, McNie E. 2016b. Boundary work for sustainable development: natural resource management at the Consultative Group on International Agricultural Research (CGIAR). Proc Nat Acad Sci. 113(17):4615–4622. doi:10.1073/pnas.0900231108.

Clark WC, van Kerkhoff L, Lebel L, Gallopin GC. 2016a. Crafting usable knowledge for sustainable development. Proc Nat Acad Sci. 113(17):4570–4578. doi:10.1073/pnas.1601266113.

Coleman K, Stern MJ. 2018. Exploring the functions of different forms of trust in collaborative natural resource management. Soc Nat Res. 31(1):21–38. doi:10.1080/08941920.2017.1364452.

Defila R, Di Giulio A. 2015. Integrating knowledge: challenges raised by the "inventory of synthesis. Futures. 65:123–135. doi:10.1016/j.futures.2014.10.013.

Dick B. 2021. Facilitating participatory research. In: Burns D, Howard J, Ospina SM, editors. The SAGE handbook of participatory research and inquiry. London (UK): SAGE Publications Ltd; p. 207–219.

Ds 2012:23. 2012. Swedish environmental goals—specifications of the environmental quality objectives and a first set of interim targets (in Swedish). Stockholm: Government Offices, Department of the Environment.

Fischer J, Riechers M. 2019. A leverage points perspective on sustainability. People Nat. 1(1):115–120. doi:10.1002/pan3.13.

Garnett ST, Crowley GM, Hunter-Xenie H, Kozanayi W, Sithole B, Palmer C, Southgate R, Zander KK. 2009. Transformative knowledge transfer through empowering and paying community researchers. Biotropica. 41 (5):571–577. doi:10.1111/j.1744-7429.2009.00558.x.

Gauthier S, Bernier P, Kuuluvainen T, Shvidenko AZ, Schepaschenko DG. 2015. Boreal forest health and global change. Science. 349(6250):819–822. doi:10.1126/science.aaa9092.

Gómez-Baggethun E, Barton DN. 2013. Classifying and valuing ecosystem services for urban planning. Ecol Econ. 86:235–245. doi:10.1016/j.ecolecon.2012.08.019.

Gustafsson L, Bauhus J, Asbeck T, Augustynczik ALD, Basile M, Frey J, Gutzat F, Hanewinkel M, Helbach J, Jonker M, et al. 2020. Retention as an integrated biodiversity conservation approach for continuous-cover forestry in Europe. AMBIO. 49(1):85–97. doi:10.1007/s13280-019-01190-1.

Hakkarainen V, Mäkinen-Rostedt K, Horcea-Milcu A, D'Amato D, Jämsä J, Soini K. 2022. Transdisciplinary research in natural resources management: towards an integrative and transformative use of co-concepts. Sustain Dev. 30(2):309–325. doi:10.1002/sd.2276.

Hoffmann S, Thompson Klein J, Pohl C. 2019. Linking transdisciplinary research projects with science and practice at large: introducing insights from knowledge utilization. Environ Sci Policy. 102:36–42. doi:10.1016/j.envsci.2019.08.011.

Horcea-Milcu A-I, Leventon J, Lang DJ. 2022. Making transdisciplinarity happen: phase 0, or before the beginning. Environ Sci Policy. 136:187–197. doi:10.1016/j.envsci.2022.05.019.

Hurlbert M, Gupta J. 2015. The split ladder of participation: a diagnostic, strategic, and evaluation tool to assess when participation is necessary. Environ Sci Policy. 50:100–113. doi:10.1016/j.envsci.2015.01.011.

Jagannathan K, Arnott JC, Wyborn C, Klenk N, Mach KJ, Moss RH, Sjostrom KD. 2020. Great expectations? Reconciling the aspiration, outcome, and possibility of co-production. Curr Opin Environ Sustain. 42:22–29. doi:10.1016/j.cosust.2019.11.010.

Johannessen Å, Hahn T. 2013. Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden. Glob Environ Change. 23 (1):372–381. doi:10.1016/j.gloenvcha.2012.07.009.

Kleinschmit D, Pülzl H, Secco L, Sergent A, Wallin I. 2018. Orchestration in political processes: involvement of experts, citizens, and participatory professionals in forest policy making. Forest Policy Econ. 89:4–15. doi:10.1016/j.forpol.2017.12.011.

Kritzberg ES, Hasselquist EM, Škerlep M, Löfgren S, Olsson O, Stadmark J, Valinia S, Hansson L-A, Laudon H. 2020. Browning of freshwaters: consequences to ecosystem services, underlying drivers, and potential mitigation measures. AMBIO. 49(2):375–390. doi:10.1007/s13280-019-01227-5.

Lam DPM, Freund ME, Kny J, Marg O, Mbah M, Theiler L, Bergmann M, Brohmann B, Lang DJ, Schäfer M. 2021. Transdisciplinary research: towards an integrative perspective. GAIA - Ecol Persp Sci Soc. 30(4):243–249. doi:10.14512/gaia.30.4.7.

Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ. 2012. Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustain Sci. 7(1):25–43. doi:10.1007/s11625-011-0149-x.

Lemos MC, Arnott JC, Ardoin NM, Baja K, Bednarek AT, Dewulf A, Fieseler C, Goodrich KA, Jagannathan K, Klenk N, et al. 2018. To co-produce or not to co-produce. Nat Sustain. 1(12):722–724. doi:10.1038/s41893-018-0191-0.

Lemos MC, Kirchhoff CJ, Ramprasad V. 2012. Narrowing the climate information usability gap. Nat Clim Chang. 2 (11):789–794. doi:10.1038/nclimate1614.

Lindstad BH. 2018. 'What's in it for me?' — contrasting environmental organisations and forest owner participation as policies evolve. Forest Policy Econ. 89:80–86. doi:10.1016/j.forpol.2017.01.003.

Malmborg K, Enfors-Kautsky E, Queiroz C, Norström A, Schultz L. 2021. Operationalizing ecosystem service bundles for strategic sustainability planning: a participatory approach. AMBIO. 50(2):314–331. doi:10.1007/s13280-020-01378-w.

Malmborg K, Enfors-Kautsky E, Schultz L, Norström AV. 2022. Embracing complexity in landscape management: learning and impacts of a participatory resilience assessment. Ecosyst People. 18(1):241–257. doi:10.1080/26395916.2022.2061596.

Marre J-B, Billé R. 2019. A demand-driven approach to ecosystem services economic valuation: lessons from Pacific island countries and territories. Ecosyst Serv. 39:100975. doi:10.1016/j.ecoser.2019.100975.

Mascarenhas A, Langemeyer J, Haase D, Borgström S, Andersson E. 2021. Assessing the learning process in transdisciplinary research through a novel analytical approach. Ecol Soc. 26(4). doi:10.5751/ES-12631-260419.

Mauser W, Klepper G, Rice M, Schmalzbauer BS, Hackmann H, Leemans R, Moore H. 2013. Transdisciplinary global change research: the co-creation of knowledge for sustainability. Curr Opin Environ Sustain. 5(3):420–431. doi:10.1016/j.cosust.2013.07.001.

McKenzie E, Posner S, Tillmann P, Bernhardt JR, Howard K, Rosenthal A. 2014. Understanding the use of ecosystem service knowledge in decision making: lessons from international experiences of spatial planning. Environ Plann C Gov Policy. 32(2):320–340. doi:10.1068/c12292j.

McShane TO, Hirsch PD, Trung TC, Songorwa AN, Kinzig A, Monteferri B, Mutekanga D, Thang HV, Dammert JL, Pulgar-Vidal M, et al. 2011. Hard choices: making trade-offs between biodiversity conservation and human well-being. Biol Conserv. 144(3):966–972. doi:10.1016/j.biocon.2010.04.038.

Moallemi EA, de Haan FJ, Hadjikakou M, Khatami S, Malekpour S, Smajgl A, Smith MS, Voinov A, Bandari R, Lamichhane P, et al. 2021. Evaluating participatory modeling methods for co-creating pathways to sustainability. Earth's Future. 9(3):e2020EF001843. doi:10.1029/2020EF001843.

Mukherjee N, Zabala A, Huge J, Nyumba TO, Adem Esmail B, Sutherland WJ. 2018. Comparison of techniques for eliciting views and judgements in decision-making. Meth Ecol Evol. 9(1):54–63. doi:10.1111/2041-210X.12940.

Newig J, Jahn S, Lang DJ, Kahle J, Bergmann M. 2019. Linking modes of research to their scientific and societal outcomes. Evidence from 81 sustainability-oriented research projects. Environ Sci Policy. 101:147–155. doi:10.1016/j.envsci.2019.08.008.

Nielsen BS, Nielsen KA. 2016. Critical utopian action research: the potentials of action research in the democratisation of society. Page Commons, Sustainability, Democratization. Routledge.

Norström AV, Cvitanovic C, Löf MF, West S, Wyborn C, Balvanera P, Bednarek AT, Bennett EM, Biggs R, de Bremond A, et al. 2020. Principles for knowledge co-production in sustainability research. Nat Sustain. 3 (3):182–190. doi:10.1038/s41893-019-0448-2.

Oberlack C, Breu T, Giger M, Harari N, Herweg K, Mathez-Stiefel S-L, Messerli P, Moser S, Ott C, Providoli I, et al. 2019. Theories of change in sustainability science: understanding how change happens. GAIA - Ecol Persp Sci Soc. 28(2):106–111. doi:10.14512/gaia.28.2.8.

Oteros-Rozas E, Martín-López B, Daw T, Bohensky E, Butler J, Hill R, Martin-Ortega J, Quinlan A, Ravera F, Ruiz-Mallén I, et al. 2015. Participatory scenario planning in place-based social-ecological research: insights and experiences from 23 case studies. Ecol Soc. 20(4). doi:10.5751/ES-07985-200432.

Pereira L, Frantzeskaki N, Hebinck A, Charli-Joseph L, Drimie S, Dyer M, Eakin H, Galafassi D, Karpouzoglou T, Marshall F, et al. 2020. Transformative spaces in the making: key lessons from nine cases in the global South. Sustain Sci. 15 (1):161–178. doi:10.1007/s11625-019-00749-x.

Pereira L, Karpouzoglou T, Frantzeskaki N, Olsson P. 2018. Designing transformative spaces for sustainability in social-ecological systems. Ecol Soc. 23(4). doi:10.5751/ES-10607-230432.

Pereira L, Kuiper JJ, Selomane O, Aguiar APD, Asrar GR, Bennett EM, Biggs R, Calvin K, Hedden S, Hsu A, et al. 2021. Advancing a toolkit of diverse futures approaches for global environmental assessments. Ecosyst People. 17(1):191–204. doi:10.1080/26395916.2021.1901783.

Posner SM, McKenzie E, Ricketts TH. 2016. Policy impacts of ecosystem services knowledge. Proc Nat Acad Sci. 113 (7):1760–1765. doi:10.1073/pnas.1502452113.

Pülzl H, Giurca A, Kleinschmit D, Arts B, Mustalahti I, Sergent A, Secco L, Pettenella D, Brukas V. 2017. The role of forests in bioeconomy strategies at the domestic and EU level; p. 36–51.

Reed MS, Vella S, Challies E, de Vente J, Frewer L, Hohenwallner-Ries D, Huber T, Neumann RK, Oughton EA, Sidoli Del Ceno J, et al. 2018. A theory of participation: what makes stakeholder and public engagement in environmental management work? Restor Ecology. 26(S1):S7–S17. doi:10.1111/rec.12541.

Rich RF. 1997. Measuring knowledge utilization: processes and outcomes. Knowl Policy. 10(3):11–24. doi:10.1007/BF02912504.

Sandström C, Lindkvist A, Öhman K, Nordström E-M. 2011. Governing Competing Demands for Forest Resources in Sweden. Forests. 2(1):218–242. doi:10.3390/f2010218.

Sardar Z. 2010. The Namesake: futures; futures studies; futurology; futuristic; foresight—what's in a name? Futures. 42 (3):177–184. doi:10.1016/j.futures.2009.11.001.

Schauppenlehner-Kloyber E, Penker M. 2015. Managing group processes in transdisciplinary future studies: how to facilitate social learning and capacity building for self-organised action towards sustainable urban development? Futures. 65:57–71. doi:10.1016/j.futures.2014.08.012.

Sellberg MM, Cockburn J, Holden PB, Lam DPM. 2021a. Towards a caring transdisciplinary research practice: navigating science, society and self. Ecosyst People. 17 (1):292–305. doi:10.1080/26395916.2021.1931452.

Sellberg M, Quinlan A, Preiser R, Malmborg K, Peterson G. 2021b. Engaging with complexity in resilience practice. Ecol Soc. 26(3). doi:10.5751/ES-12311-260308.

SMHI. 2002. Län och huvudavrinningsområden i Sverige. Faktablad nr 10. The Swedish Meteorological and Hydrological Institute.

Stringer L, Dougill A, Fraser E, Hubacek K, Prell C, Reed M. 2006. Unpacking "participation" in the adaptive management of social–ecological systems: a critical review. Ecol Soc. 11(2). doi:10.5751/ES-01896-110239.

Tengö M, Brondizio ES, Elmqvist T, Malmer P, Spierenburg M. 2014. Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. AMBIO. 43(5):579–591. doi:10.1007/s13280-014-0501-3.

Tengö M, Hill R, Malmer P, Raymond CM, Spierenburg M, Danielsen F, Elmqvist T, Folke C. 2017. Weaving knowledge systems in IPBES, CBD and beyond—lessons learned for sustainability. Curr Opin Environ Sustain. 26–27:17–25. doi:10.1016/j.cosust.2016.12.005.

Tomich TP, Chomitz K, Francisco H, Izac A-M-N, Murdiyarso D, Ratner BD, Thomas DE, van Noordwijk M. 2004. Policy analysis and environmental problems at different scales: asking the right questions. Agric Ecosyst Environ. 104(1):5–18. doi:10.1016/j.agee.2004.01.003.

Turnhout E, Metze T, Wyborn C, Klenk N, Louder E. 2020. The politics of co-production: participation, power, and transformation. Curr Opi Environ Sustain. 42:15–21. doi:10.1016/j.cosust.2019.11.009.

van Bommel S, Blackmore C, Foster N, de Vries J. 2016. Performing and orchestrating governance learning for systemic transformation in practice for climate change adaptation. Outlook Agric. 45(4):231–237. doi:10.1177/0030727016675692.

Wallin I, Carlsson J, Hansen HP. 2016. Envisioning future forested landscapes in Sweden – revealing local-national discrepancies through participatory action research. Forest Policy Econ. 73:25–40. doi:10.1016/j.forpol.2016.07.010.

Wall TU, Meadow AM, Horganic A. 2017. Developing evaluation indicators to improve the process of coproducing usable climate science. Weather Climate Society. 9 (1):95–107. doi:10.1175/WCAS-D-16-0008.1.

Wesselink A, Paavola J, Fritsch O, Renn O. 2011. Rationales for public participation in environmental policy and governance: practitioners' perspectives. Environ Plann A: Econ Space. 43(11):2688–2704. doi:10.1068/a44161.

Wittmayer JM, Schäpke N. 2014. Action, research and participation: roles of researchers in sustainability transitions. Sustain Sci. 9(4):483–496. doi:10.1007/s11625-014-0258-4.