Impact and Collaboration in Environmental Research

Moving universities from evidence producers to co-producers

Discussion Paper
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The Agile Initiative

The world's researchers have been working to understand and solve societal challenges such as biodiversity loss and climate change for decades. However, decision makers in government, NGOs and business need to have this information available to them in the format they need and at the moment that they are making critical policy choices.

The Agile Initiative at the Oxford Martin School aims to put this essential knowledge in their hands, and revolutionise how world-class, high-impact research supports policymaking. It responds to specific social and environmental policy questions with fast-paced solution-focused 'Sprints' that deliver demand-led new research precisely when it's needed. In these Sprints, new interdisciplinary research teams drawn from across Oxford work with partners to feed evidence into the policy cycle in real-time.

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Abstract

This discussion paper explores the relationship between environmental research and its use in environmental policy. While there is a common perception of a gap between research and policy, efforts to bridge it often fall short of integrating knowledge effectively with environmental action. Common fixes, like improving dissemination and scientific literacy within government, overlook the politics and complexities of knowledge production and usage.

We explore universities' pivotal position in the science-policy ecosystem, particularly given their role in knowledge brokerage practices and the influence of 'impact' as a governance tool. Participatory approaches, such as co-production, offer promise for closing the 'usability gap' for research by facilitating collaborative generation of actionable knowledge.

Co-production features high user participation, contributing to higher-quality research, fostering trust, and giving voice to knowledge users and interested parties. Understood and deployed in various ways, co-production also faces challenges such as the high potential costs or replication of wider knowledge production risks. A reflective approach to co-production, considering positionality and recognising political influences, can mitigate these risks and optimise its benefits. We highlight the potential of co-production in environmental research and policy and offers valuable insights and recommendations for its effective implementation.

We hope that the material in this discussion paper provides a constructive basis for precipitating reflections and discussions amongst researchers and other people involved in the production and use of environmental research about their role in engaging with policy.

Discussion questions

Here, we outline a set of discussion and provocation questions which cover the themes in this report. They are intended to help readers engage with these themes and think through their relation to them.

For research funders, policy makers and practitioners

1. Do you see the outputs and processes of co-production as any more or less *credible* and *legitimate* than other forms of environmental science advice? Do you expect this view to be shared by others around you?
2. Do you favour certain modes of co-production over others? If so, what are the key benefits of specific modes of co-production to your practice?
3. Is it reasonable to expect co-production to lead to more useful outputs than other forms of environmental research? Does this view vary across the different stages of assessment and decision making relevant to your work?
4. Do you currently employ or encourage the use of co-production, or would you consider doing so if it is not currently used? Are there safeguards in place against the risks associated with co-production discussed in this document?

For researchers

1. In what ways do ideas of the 'knowledge-action gap' or incentives to achieve impact shape your approach to research?
2. Do you think that co-production could help your work achieve greater impact?
3. How comfortable are you with the idea of knowledge pluralism, i.e. different approaches to, and forms of, knowledge should be more equally valued?
4. To what extent are you ready to give over control in the form of expertise when engaging in co-production?

For the Agile Initiative

1. What does a strategic approach to co-production look like for Agile? Which actors does Agile look to co-produce with and are there risks in co-production that Agile needs to actively mitigate?
2. How might the positionality and processes of a Sprint team affect approaches to knowledge co-production? Are there tensions between the emerging sprint model and co-production?
3. How should Agile position itself in relation to government commissioned research, consultancies, and think tanks?
4. How does Agile support and engage with related initiatives for high-impact co-produced rapid research?

Contents

Introduction

In this discussion paper, we review literature on the production and use of evidence in environmental policy making. We find collaborative approaches have emerged as a common way to overcome the well-established idea of a 'knowledge-action gap' at the environmental science-policy interface.

Environmental researchers, policy makers, and practitioners regularly experience and describe the knowledge-action gap. To understand this gap and move towards 'actionable knowledge' we also explore the often-overlooked politics of evidence production and use.

Previous attempts to connect research and policy have often fallen short of their most ambitious goals, partly due to the context-dependent nature of interactions between knowledge production and use. While the knowledge-action gap is neither a fixed fact nor universally observed, practices around science advice can be improved. In this review, we explore how the perceived and realised knowledge-action gap gives rise to an impact agenda within universities, changing how research is approached and knowledge produced.

Concerns about the practical value of environmental research, and efforts to make it more impactful and policy-relevant, are longstanding. There have been many efforts to address the knowledge-gap, but it is difficult to know what has worked and what has not. Collaboration and co-production have emerged as broad solutions but are contested and interpreted in different ways, with practice varying widely. We attempt to plot a path through these topics, providing a sense of the key debates, and a set of discussion and provocation questions to reflect on production and use of environmental research.

This discussion paper has the following sections:

- In **Section 1**, we describe how this knowledge-action gap is conceptualised, perceived, and contested alongside the politics of knowledge production, leading us to how policy and research interact in environmental domains.
- In **Section 2**, we consider the influence of the impact agenda in shaping research practice and outcomes in universities, finding that collaboration among researchers and policy makers is a key route to bringing knowledge and action together. As one route towards bridging the gaps between knowledge and action, we suggest collaboration between researchers and policy makers, especially co-production.
- In **Section 3**, we unpack the variations in practice and purpose in co-production, potential pitfalls, and ways to overcome them. Section 3 provides a practical overview of co-production as one specific but contested approach with rich potential and multiple interpretations and uses.

Section 1: The problem of research in policy

In the face of serious environmental issues, there is an understandable urge to ensure that research supports policy in a timely and efficient manner. For science-policy interactions, this gives rise to the essential question of "what works?" (1). The succinct response is, "it depends" (2). Research is situated within a social, economic, and regulatory landscape, and is shaped by politics in its conception, delivery, and application. This section considers how environmental research and policy interact and describes the efforts to strengthen this relationship. We first examine how and why the knowledge-action gap has been theorised (Section 1.1). We subsequently reflect on the politics of knowledge production (Section 1.2) and the contextual factors that shape the use of scientific evidence in policy (Section 1.3).

1.1 The knowledge-action gap

"Research that is tailored to address real-world challenges—with the potentially daunting realities of wicked problems, urgent timeframes, and political acrimony and messiness that this entails—is not for everyone." (3)

It can be hard to get away from the sense that the knowledge produced by environmental researchers somehow falls short of its full potential for use by policy makers. Researchers can see policy makers as failing to incorporate their advice into decision-making (4). Policy makers, in turn, may not engage with research that they view as only passingly relevant to the policy questions at hand (5). This section examines how this disconnect between research and policy is conceptualised, exploring ideas of what makes knowledge useful and how evidence is (or should be) incorporated into policy making.

Concerns about the extent to which research informs policy revolve around the belief that knowledge, when fed into an environmental problem, should prompt a reaction. The failure to achieve the expected response, or indeed any response at all, is termed the 'knowledge-action gap', or sometimes the 'usability gap' or 'evidence-policy gap' (6–8). This understanding connects to longstanding views of researchers and policy makers as two distinct 'communities' (9). Focussing on this gap asserts that solutions for tying knowledge to action can be found in the differences between researchers, policy makers, and the cultural and institutional worlds they inhabit.

Studies of these differences have identified multiple factors that, jointly or separately, serve to create the gap. One detailed study of the use of scientific evidence in conservation identifies 230 potential barriers (10). The most prominent factors identified by researchers include:

- structural and institutional differences between governments and academia (11–13)
- the incompatible timeframes of much research and policy (3,14)
- cultural barriers between academics and policy makers (15,16)

The gap matters because it influences science-policy interactions. The slow pace of research production can add to tensions among researchers and policy makers (14,17). Such tensions make it difficult to reconcile the different objectives, requirements, and practices of policy and research (16,18). Efforts to overhaul practice or established ideas may be undermined by concerns that the 'rules of the game' must remain consistent for stable governance, leading policy makers to reject research (15). Inherited blind spots from training and previous experience may further limit the uptake of research (19). Overall, the perceived gap between research and policy does little to integrate knowledge with action on environmental concerns.

1.2 The politics of evidence

"One may desire a political system based on value judgements and evidence, but should recognise and address the trade-offs between these aims, and that the production of evidence is also an inherently value-driven process." (20)

In emphasising that good research exists but is underused in policy, the knowledge-action gap may encourage solutions that, at their core, aim to simply bring research and policy closer together without drawing on the insights of policy scholarship (20). Researchers seeking to close the gap, for instance, have a tendency to propose that evidence needs to be better disseminated, or that governments need to develop greater scientific literacy (7,21). The goal of these efforts, which are framed by ideals of 'evidence-based policy making', is an increased use of evidence in policy that assumes a linear process of objective research informing policy. While this is an intuitive response to the problem gap, it pays insufficient attention to how knowledge is produced in the first place and how evidence is subsequently used in policy.

Evidence-based policy making emphasises the desirability of rational decision making, with a focus on 'what works'. Its current form began within health sciences to promote the use of evidence-based medicine (2). The wider application of evidence-based approaches to policy is based on the view that interventions must be evaluated, and their effects measured, according to objective standards. As sensible as this sounds, especially where scientific evidence is essential to understanding climate and ecosystem mechanics, it is based on widely

held but limited assumptions of a linear research-policy pipeline that ignores values, ideology, and politics (22,23). It also assumes a level of certainty and clarity to evidence, which in environmental issues where experimental designs and simple causal mechanisms are uncommon, is not typically present (24).

The idea of neutral science and objective policy making has been extensively challenged (25). Generating knowledge, turning it into policy-relevant information or recommendations, and using it to inform policy creation are all subjective and contextual acts (26). They cannot be removed from their value-laden contexts, which control the flows of resources and information to and from research. Incorporating science advice into policy making requires political processes of deliberation and re-evaluation by both researchers and policy makers. Evidence that can inform policy, such as climate statistics, does not have as much authority as it often conveys (20).

Over-confidence in the supposed neutrality and persuasive power of scientific evidence ignores complexity and context, and risks "hiding politics behind expertise" (27). This risks reducing complex issues which require political and social engagement to problems to be solved by experts (28,29). Researchers can inadvertently end up addressing their own questions and designing studies without the necessary connections to peoples' needs or values, the political context, or the actual policy requirements (30–32). Recognising the politics of evidence invites humility and reflexivity which allow researchers to engage more fully with the topics at hand, particularly towards supporting policy makers.

1.3 The actual use of research in policy

"Multiple considerations inform policy decisions—including political will and governmental competency—and the role of research and evidence as, at best, one input among many." (33)

The complicated relationships between researchers and policy makers outlined in the previous section are not intended to suggest that science is entirely divorced from policy. Reporting of research use in policy is generally low but never zero and can be very high for some policy makers (15). Here, we consider how research can be used in policy and how this use differs across research disciplines and policy domains.

A limitation of the 'knowledge-action gap' (Section 1.1) is the lack of attention paid to the way in which evidence use is distributed across the policy cycle (20). The concept of the cycle has itself been criticised for assuming that policy making, which is by nature both multi-layered and highly contextual, can be meaningfully abstracted to a model process (7). However, this does not remove the fact that policy making can be separated into different procedural phases that involve different actors and, importantly, different approaches to scientific evidence (34). The initial scoping of an issue that may require a policy response, for example, is meaningfully distinct from the formulation of policy options, implementation questions, and ex post evaluation of interventions.

Across these phases, scientific evidence is one of many factors influencing policy decisions (33). Scholarship on maximising science use in policy making focuses on the need for researchers to engage with the wider and more complex systems in which policy is formed (20). This view is echoed by researchers who pay close attention to the local specifics of science-policy interactions—the science-policy interface is neither singular nor fixed (35). As such, conventional views on hierarchies of evidence and the intrinsic value of scientific insights should be reconsidered, instead looking at multiple ways in which knowledge can be produced and used within the overall science-policy system.

Table 1: Theories of knowledge use in policy. Based on Beyer (1997), March and Olsen (2011), Kirchhoff et al. (2013) & Dewulf et al. (2020) (36–39)

Stance	Theory	View of knowledge use
Goal-driven: ***focus on the ends towards which decision makers use research***	Instrumental	research results are applied to policy making
	Conceptual	ideas derived from research inform policy
	Symbolic	research is used to legitimate predetermined policy decisions
Context-driven: ***seek to better understand the factors influencing a policy maker***	Risk-based	research is used according to the clarity and scale of the environmental risk it is associated with
	Logic of appropriateness	research is used according to its 'institutional fit' and how it conforms to the rules and norms that guide policy decision processes
	Logic of meaningfulness	foregrounds the complexity and ambiguity of environmental policy making; research is used if it makes sense of things by offering a new perspective, or extending or changing a narrative

Theories of research use within policy from the knowledge user's perspective can be broadly seen as either goal-driven or context-driven (Table 1). Although goal-driven approaches were initially influential, this has diminished as idealised cause-and-effect models of science-policy relations have been replaced by more nuanced views (40). Context is key in understanding institutional dynamics across research and policy. Table 2 outlines three categories of context. As well as helping us to think through many of the hidden factors that might influence the use of research in the policy process, context-driven theories of knowledge use also help draw attention to the important realities that shape science-policy interactions.

Just as important research decisions can be shaped by resource availability (30), low capacity among public servants can lead to the rejection of ostensibly useful science advice (41,42). Current policy making is also likely to be operating under time-constraints, while having to retain a focus on measurable outputs, cost-benefit analyses, and, more broadly, the need to support ongoing economic activity and growth (31,43,44). This already complex context further depends on the research and policy discipline (see Box 1). There is no one-size-fits-all approach or model that can be extracted from the literature. The need instead is to maintain, as best as possible, a reflexivity and openness with regards to the multiple contextual factors that shape environmental science-policy relations.

Table 2: Contexts that may influence the extent to which research is used in policy. Based on Maas et al. (2022) (45).

Category	Example contextual factors
Institutional context	Formal mandates of and procedures within an institution that influence the scope and freedom of individual researchers.
Policy context	The scale at which a policy operates (e.g. local, national, global), and the sensitivity of the associated political and public debates.
Spatial configuration	The proximity of organisations and individuals to one another, including the formal and informal meeting and discussion spaces that aid information exchange.

Box 1: Research context: metrics, scales, and place-based approaches

While research and policy landscapes are discussed broadly in this document, there are also points which must be understood in context. 'Environmental' issues are varied, spanning sectors, disciplines, and branches of government. Ease of measurement, scales of impacts and governance, and contextual (or 'place-based') approaches are important to understand in environmental research and policy. Comparing climate change and biodiversity loss, we unpack some of the variability within environmental research and we hope to provide some grounds to understand why considering the context in which environmental actionable knowledge is pursued becomes crucial for effective knowledge production supporting policy making.

Not all environmental variables can be observed, and many more cannot be simply measured to produce single-number metrics without bringing in value judgements. The location and extent of environmental impacts determines the research approach and appropriate interventions and governance: local sound pollution from a single factory is different in scale to atmospheric pollutants with regional-to-global governance implications. Meaningful locations can be understood as 'place' (**46**), and when environmental issues are situated in place (e.g., sites of loss or impact, sites which drive change), 'place-based' knowledges, practices, and perspectives are crucial for understanding them. While temperature or CO2e are useful, widely accepted metrics for comparing climate change impacts, equivalent metrics are lacking for biodiversity (**26**). 0.1℃ or 1 kg CO2e are more universal than species counts, which raise questions of species concepts, nativeness, charisma, rarity, and cultural or economic relations and services which vary with place (**47**). Spatiality is important in climate change's drivers and effects—the social consequences are deeply contextual—but there are more unified metrics and less localised variability and value judgements when considering biodiversity and climate change metrics (**48**).

The spatial scales and heterogeneity of biodiversity loss can differ dramatically from climate change impacts. This latter occurs globally, with some large-scale regional patterning such as Arctic amplification (**49**). The way we think about biodiversity loss, however, can focus on very small scales, influenced by local drivers (land-use change, overharvest/exploitation, disease), but may also consider vast species ranges. Local value judgements also shape what is a conservation priority (or worth measuring at all). This challenges generalising or observing patterns, and multi-scalar, species-and-habitat-specific relationships are highly contextual. Climate change, however, needs global governance, and demarcating responsibility becomes a key challenge. While these issues are interlinked, they operate across different scales and require appropriate solutions.

Biodiversity holds greatly localised cultural (e.g., spiritual, aesthetic, recreational) significance, meaning place-based approaches are necessary, which are challenging to scale (**50**) and govern (**51**). A foundational, beloved species in one place may be a detrimental pest in another (**52**,**53**). This also applies to the social consequences of climate change: while warming is easily measured, social and cultural implications of warming and knock-on effects are inherently place-based. The complexity of these metrics across scales and how they interface in wider policy arena challenge translating climate policies and instruments to biodiversity (**54**), as with biodiversity banking, credits, and offsets.

Recognising disciplinary variability within environmental research and associated policy domains is a useful starting point for both policy makers and researchers (**55**). Generating effective policy-research collaborations is challenging and requires institutional and personal self-reflection alongside varied expertise (**56**). Translating knowledge production and brokerage arrangements across fields, even if both are environmental and interact as 'twinned crises' (**57**,**58**), demands closer work between research and policy (**59**).

Section 2: Universities in context: impact and collaboration

In this section, we develop the importance of the context of knowledge production, connecting the perceived underuse of research in policy discussed in the previous section with the central role that universities occupy in the science-policy ecosystem (Section 2.1). University researchers produce outputs with varying levels of direct usefulness for policy makers. While guiding researchers towards policy-relevant problems can be helpful, it also risks biasing research processes in pursuit of 'impact'. Here, we consider what impact means, and how it shapes university research (Section 2.2) and knowledge brokerage (Section 2.3) We conclude by suggesting collaboration between researchers and policy makers (Section 2.4), leading to Section 3 for details on co-production.

2.1 Universities and the science-policy ecosystem

"The effectiveness of the transfer of information and the generation of impact highly depends on organisations that enable more extensive flows throughout the network." (60)

Universities have a central role in the science-policy ecosystem through producing knowledge, analysing policy and knowledge production, and facilitating collaboration. This role also encompasses the early training provided to future policy makers and researchers (61). Researchers contributing to the debate over the nature of the relationship between universities and civil society have proposed that it should be founded on their contributions towards environmental concerns (62). The diverse roles of modern universities locate them as key actors in the science-policy ecosystem, exerting direct and indirect influence across research and policy spheres (63).

Systems-oriented scholars have mapped the science-policy ecosystem, visualising the arrangement of actors and, to an extent, their relative influence (60,64,65). This approach reinforces the fact that universities are not independent producers of knowledge separated from their wider context, as the conventional linear model of science-policy interactions suggests. They exist within a broader ecosystem and university research is influenced by other actors. Considering the extent to which research is used in policy, this influence can be distilled into a single word: impact.

2.2 Impact as governance tool of university research

> **"As far as glimpses into the future go, the UK seems to have placed its bets on performance-based resource allocation and funding-based incentivisation of organisational and individual behaviour." (66)**

Outputs from UK universities are formally evaluated for impact by the Research Excellence Framework (REF). Using impact as a core measure of university research is intended to align the outputs of universities to policy need with central funding streams tied to quantified research impact (66,67). The implications of this 'impact agenda' have been extensively interrogated, both with reference to the REF and its predecessor, the Research Assessment Exercise. Rather than equalising access to funding on the grounds of objectively and consistently measured impact, the UK's hierarchical university sector continues to exert a strong influence with higher status institutions enjoying a higher proportion of the rewards (68). The REF is strongly associated with a 'problem-solving' interpretation of knowledge use (69), excluding the other rationales identified in Section 1.2. Other researchers see it as drawing a distinction between research impact and research excellence, with the former not necessarily implying the latter (70). Such findings demonstrate the underlying politics of academic research and how this can influence or impede knowledge production (71).

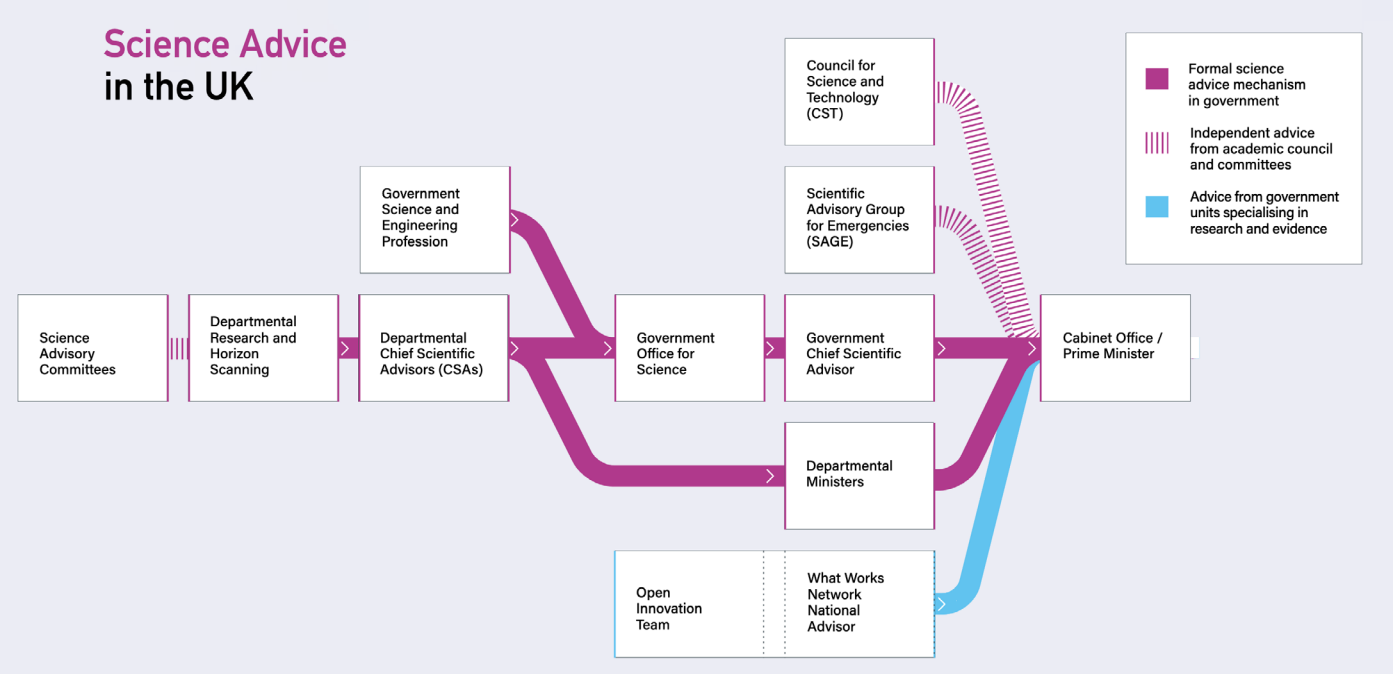


Figure 1: Public funding of academic research in the UK. Reproduced from Hopkins et al. (2021) (64) under a Creative Commons Attribution-NonCommercial 4.0 International License.

Clear links have been drawn between the demand for impact and the nature of research undertaken by academics (72,73). For example, impact agendas may incentivise universities to target research with more obvious impact, such as government contract research (74). While the implications of shifting research patterns have not been extensively studied, existing literature is suspicious of over-alignment between research and policy, with evidence that standardised evaluations disfavour qualitative research methods (75) and that researchers undertaking contract work publish less (76). Others reasonably question how institutions engaged in contract research, typically focused on short-term delivery and implementation, can effectively differentiate themselves from "non-academic organisations, such as consultancies, think tanks, sector-governing bodies and charities" (p. 183) (68).

2.3 Tensions between impact and the honest broker

"How far should scientists go to persuade policy makers to act on their evidence?" (20)

Scholars use the term 'boundary work' to describe the direct and indirect interactions between researchers and policy makers that occur in the spaces where science and policy meet. The objective of much boundary work, at least in principle, is to align the languages and cultures of academia and policy making to smooth communication between the different institutional contexts.

A key component of boundary work is knowledge brokerage. Roger Pielke developed the 'honest broker' as the embodiment of a policy-engaged researcher or institution (77). In contrast to 'pure scientists', 'science arbiters', and 'issue advocates' who Pielke depicts as delivering information and either assuming or asserting its significance, the honest broker seeks to present information as useful policy alternatives sensitive to the needs of policy makers. Since its introduction, the honest broker has evolved into a model towards which many researchers and universities aspire (78,79).

One complication with Pielke's model is that the broker must be aware of the policy context while remaining neutral in their presentation of policy options. In this way they are seen as being distinct from advocates who are invested in the choice of the policy maker. While brokers are not expected to be value-free, they are supposed to be non-directive in the policy making process (80). How to engage with the policy context without considering the political pressures on research is not fully addressed.

By making the drive for policy impact central to university research, impact agendas press on this tension within knowledge brokerage. In their study of dedicated policy engagement bodies within universities, initiatives often seen as an institutional response to the impact agenda, Durrant and MacKillop argue that knowledge brokerage is only one of four approaches to policy engagement (33). They found that universities

were more likely to follow a politicised approach over the policy neutrality pursued by honest brokers. 'Impact cultures' within universities enshrine the importance of impact in qualities such as research values and individual purpose (81). This raises one of the ethical dilemmas of knowledge brokerage – how far should a broker go to convince policy makers to act on their advice? (20) When the broker is incentivised to achieve impact, this dilemma is not easily resolved.

2.4 Beyond the honest broker: collaboration as a broad solution

"When scientists leave the ivory tower and interact more closely with a variety of societal actors, the opportunities to generate knowledge that is highly meaningful to those actors multiply." (36)

Alternatives to knowledge brokerage seek to either move away from or evolve Pielke's model. Some scholars encourage researchers to act as 'policy entrepreneurs', able to persuade and advocate for the use of their research within policy (82,83). Others arrange Pielke's original types along a spectrum of interaction between producers and users of knowledge, with pure scientists the least engaged and honest brokers the most engaged (84). The question then becomes who might be more engaged than honest brokers?

This new role is filled by 'participatory knowledge producers' (Figure 2) who go beyond bridging the gap between science and policy, instead facilitating their closer involvement by integrating knowledge production and use (84) (see also Table 3). Within systems-focussed environmental policy scholarship, recommendations for maximising research use normalize participatory approaches to knowledge production: actors come together to increase the usability of knowledge and promote collaborative practices (85). The promotion of collaboration is particularly noticeable in environment and climate research (39,86–90), and to a slightly lesser extent, biodiversity (91,92).

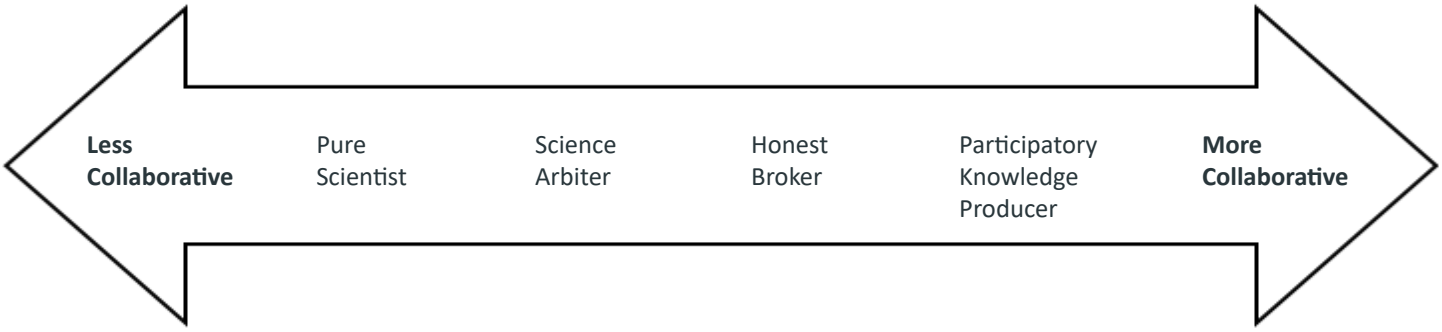


Figure 2: Approaches to science-policy engagement for researchers on a spectrum of less to more collaborative. Adapted from Turnhout et al. (2013) (84).

Unless care is taken, participation and collaboration can risk being seen as an end in themselves rather than the route to improved use of research in policy. This form of uncritical approach can lose sight of the importance of methodological pluralism (93) and the need to adapt collaborative practice to the actors involved and the policy making phase it is connected to. It is also necessary to recognise that political sponsors who endorse collaborative approaches are also keen to see a usable return on their investment (94). Researchers are not ignorant of this particular point, in some cases explicitly arguing for funding structures to promote and reward collaborative knowledge work (8,87). However, it is unclear whether this impact-oriented approach can uphold the ethical objectives of meaningful engagement of diverse knowledge systems for more inclusive environmental governance (95–97).

Collaborative and participatory approaches nevertheless hold great promise and may be an effective means of closing the usability gap. Emphasising bidirectional exchange and constructive iteration throughout knowledge and policy production, they provide a valuable alternative to linear models of science-policy relationships. They also provide spaces where differences are neither total nor sources of conflict but may instead yield alternatives. Section 3 of this document examines these rationales and risks relating to knowledge co-production, a collaborative approach of particular relevance to environmental science and policy (98).

Section 3: Zooming in on knowledge co-production

This section considers knowledge co-production as a model for generating actionable knowledge that has quickly gained momentum and is increasingly well-established among researchers and practitioners (86,99). After framing co-production as a science-policy collaboration model and research approach (Section 3.1), we look both at how this is understood in various fields of environmental research and policy making, and at co-production's key benefits (Section 3.2). We then delve deeper into the modes of co-production, considering the different actors involved and levels of implementation, types of knowledge and methodologies of different modes, and major potential benefits of each (Section 3.3).

After considering how co-production is subject to the costs and risks at the core of wider knowledge production (Section 3.4). We conclude by looking at practical tips to assess an institution's or initiative's capacity for co-production and how this can help prevent the replication of risks when employing and facilitating co-production (Section 3.5).

3.1 Framing knowledge co-production

"Co-production can be understood as a spectrum of practices between macro-knowledge systems and micro-interactions aimed at increased knowledge utilisation." (93)

Co-production is typically framed as ensuring knowledge produced is salient, credible, and legitimate (93). 'Repertoires' are a useful concept for understanding co-production, defined as expectations for research-policy interactions which can guide co-production implementation (Table 3). Co-production sits in the wider landscape of research approaches, characterised by high user participation and knowledge-driven research motivation (Figure 3). According to the typology of repertoires provided in the table below, when properly implemented, co-production manages to *facilitate* the creation of knowledge through multi-stakeholder participation, with the aim of integrating knowledge production and use. However, when not properly facilitated, co-production struggles to do so and can end up remaining a form of suppling or bridging knowledge for policy making (45). We consider credibility of knowledge co-production and what we mean by effective implementation and facilitation later in this section.

Table 3: Summary of the three repertoires, based on Turnhout et al. (2013) and Dewulf et al. (2020). Reproduced from Maas et al. (2022) under a Creative Commons License CC BY 4.0 DEED.

	Supplying	Bridging	Facilitating
Knowledge brokering repertoire	The science–policy practice aims to provide policy makers with knowledge produced by experts	The science–policy practice aims to answer questions policy makers have with relevant knowledge produced by experts	The science–policy practice enables policy makers and experts to collaborate to co-produce knowledge
Logic of decision-making	Logic of consequentiality: decisions are based on their expected consequences	Logic of appropriateness: decisions are based on rules prescribing what to do in what situation	Logic of meaning: decisions are based on what is meaningful to decision-makers

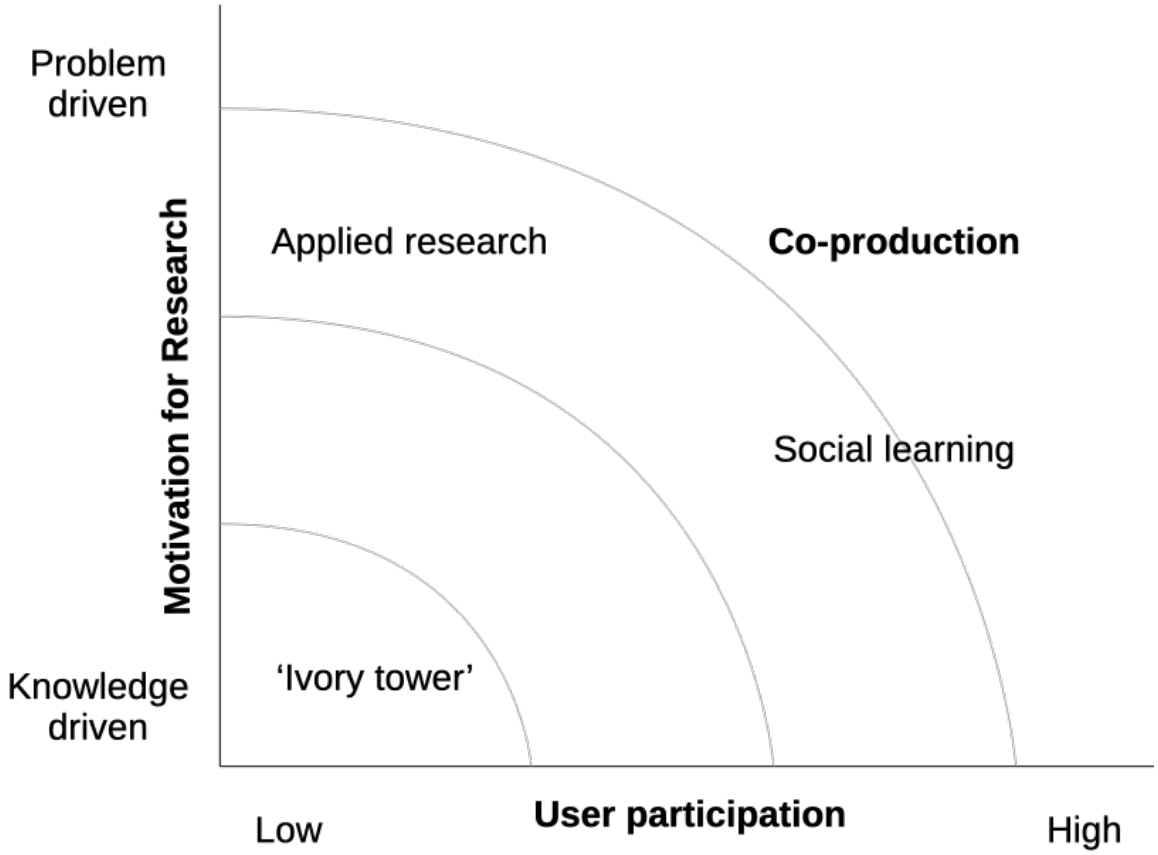


Figure 3: Situating co-production in wider landscape of research approaches based on user participation and research motivation, adapted from Kirchhoff *et al.* (2013, p.397).

3.2 Understandings and envisioned benefits of co-production

"Knowledge co-production can create impacts that go beyond the research arena, occurring over space, throughout time, and crossing scales" (100)

Here, we look at how co-production has been conceptualised and deployed across different areas of environmental research and the benefits for science-policy collaboration that are attributed to it.

Bandola-Gill *et al.* (93) represents a first effort to bring together different understandings of co-production across fields (summarised in Table 4, below). In their account, environmental science in the specific domain of climate change, seems to understand co-production as a way for science to supply evidence and new knowledge for climate policy. For the rather global and technical nature of climate change, as much less localised phenomenon compared to biodiversity loss (see box 1 above), co-production in climate change governance remains within the logics of supplying and bridging expert knowledge to policy makers, rather than realising one of facilitation (see table 3 above). Environmental management understands co-production as a way to restore local ecological knowledge within mainstream environmental governance (101,102).

The case of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) represents a global-scale example of the practice of matching the supply of and demand for science in policy through a co-created approach – i.e., *facilitating* beyond *supplying* and *bridging* (Table 1). As Beck *et al.* (103) emphasise, IPBES was set up with a governance structure which reflects the specificities of regional and local experiences and needs of biodiversity and ecosystem services loss. Further to this, it also identified regional and global knowledge gaps. Based on those, it provides a platform for local and meso-level actors, not yet voiced in existing governance centres like the Intergovernmental Panel on Climate Change (IPCC), to come together and co-create knowledge to fulfil such knowledge needs.[1]

Co-production can involve actors from diverse knowledge systems and disciplines. This interdisciplinarity is highly relevant to sustainability science research, which is often required to consider a multitude of socio-cultural factors (see Box 1, above). Co-production has the potential to stimulate new forms of knowledge which may in turn give rise to solutions beyond those accessible to ordinary science-policy collaborations. Sustainability science, as a discipline, consequently employs co-production as an instrumental tool to integrate knowledge production and use, a point which emphasises its problem-solving potential for groups affected by shared environmental issues (85).

Science and Technology Studies (STS) provides an alternative view, defining co-production as a transformational process that, if effectively employed, is able to support and facilitate social change through science-politics relationships (93,94). In its original development, STS takes a more analytical stand and has been mostly concerned with critically evaluating social and political outcomes of co-production processes. This will become crucial in informing elements to consider to effectively pursue knowledge co-production discussed at this end of this report.

1 See IPBES (2022)(104).

As a point somewhat in between the fields of sustainability science and STS, public administration scholarship and practitioners understand co-production as: (i) involving a diverse set of actors that may not normally work together in conventional models, and (ii) resulting in knowledge that addresses shared issues across scales and parties (25,59). Overall, in public administration scholarship, co-production is understood as academic-practitioner collaboration through all stages of knowledge creation, including conceptualisation, design, fieldwork, analysis, and dissemination. In this field, for the purpose of public service provision, co-production is understood and employed to develop and deliver public services through a user-centric approach based on users' choices and behaviours (105,106).

Table 4: Understandings of co-production across fields of environmental research based on Bandola-Gill et al. (2023).

Area/Scholarship	Understanding of co-production	Aim of co-production
Environmental sciences (climate change)	• Matching the supply of and demand for science in policy	Bridging or supplying evidence for environmental policy making
Environmental management	• Fostering knowledge democracy by facilitating knowledge pluralism • Redeeming Local Ecological Knowledge (LEK) in environmental management	Widening participation to inform more effective resource management strategies
Sustainability science	Fostering interdisciplinarity through an instrumental employment of co-production to: • stimulate creation of new forms of knowledge • facilitate new solutions to shared sustainability issues, unable to flourish within isolated disciplines or approaches	Collaboration for transformation through knowledge and value pluralism
Science and Technology Studies (STS)	• Critically evaluating social and political outcomes of co-production processes themselves – *evaluative tool* • Realising social change through science-politics relationships	Collaboration for transformation through critical evaluation of instrumental employment of co-production
Public administration / Practitioner	• Bringing academics-practitioners collaboration through all stages of policy cycle • Developing user centric provisioning of public services	Collaboration for transformation

Overall, the desired benefits of co-production go beyond discipline-specific considerations. Co-production can link research and praxis through high user participation in problem-driven research (39) (Figure 2), addressing existing pitfalls of science-policy collaboration and the knowledge-action gap (Section 1.1). Some key benefits discussed in the literature include:

- Higher-quality, more holistic research (107), including better representation of different knowledge systems (95,108)
- Effective utilisation and sharing towards user-targeted priorities (109)
- Accountability of publicly funded research away from 'science paternalism' toward user empowerment (110–113)
- Building trust between researchers, policy makers, and other stakeholders (21,114)
- Bringing academics closer to practitioners to create a shared praxis (100,115)

3.3 Modes of knowledge co-production

"The success of 'co-production' as a term used across such a variety of fields might be due to its flexibility and definitional ambiguity." (93)

This section considers the different modes of co-production with particular attention paid to scales of environmental governance, the actors involved, assumptions made in the process, and the major outcome each mode leads to (Table 5).

Chambers *et al.* (99) provide a useful typology of co-production modes. They define mode 1 as *researching solutions*, where scientists and policy makers come together to produce scientific knowledge grounded in realist (scientific) methods. Here, knowledge is implied to be scientific only and rather top-down or expert-led, feeding into existing policy development structures.

Co-production processes falling in mode 2, *empowering voices*, involve interdisciplinary scientists and researchers working with local government bodies and communities for local issues. Despite its greater social diversity when compared with mode 1, mode 2 struggles to make local voices and actors visible at higher scales of mainstream environmental governance, so is limited in challenging larger-scale, expert-led approaches (99,116)

Mode 3, *brokering power*, involves powerful actors coming together to produce direct policy actions – rather than just new knowledge as in previous modes. This remains grounded in realist approach to knowledge use and methodologies. It speaks to powerful actors while trying to re-shape their thinking.

Reframing power, mode 4, brings marginalised voices, powerful actors from academia, policy, and influential non-governmental actors to the co-production table. In this mode, perspectives and validation of more marginal actors' views is investigated by researchers through relativist methods, and knowledge is framed to shift power towards more marginal actors.

Initiatives falling in mode 5, *navigating differences*, place value in all forms of knowledge (knowledge pluralism). Somewhat similar to Pielke's honest broker, such processes minimise hierarchies to engage actors across power dynamics, creating a 'safe space' for co-creation which mode 4 struggles to.[2]

In mode 6 processes aimed at *reframing agency*, knowledge is implied to be a plural-creation process. These initiatives are usually led by researchers from relativistic or systems thinking scholarship and have been successful in shifting power and agency at the local level.

2 see also Holmes (2011)

Table 5: Modes of co-production with scale of environmental governance they speak to, the actors involved, assumptions made in the process, and the major outcome each mode leads to. Based on Chambers et al. (2021).

Mode	Actors involved	Scale of governance	Epistemic & Methodological approach	Major benefit
1. Researching solutions	• Technical scientists • High level policy makers	High	• Scientific knowledge • Realist methodological approach[3]	Production of scientific knowledge for existing knowledge-policy regime
2. Empowering voices	• Interdisciplinary scientists • Local governments and communities	Meso and local	• Knowledge pluralism • Social diversity	Creation of local solutions
3. Brokering power	• Technical scientists • Powerful actors (with high decision-making power and influence)	High	• Policy action grounded in scientific knowledge • Realist methodological approach	Development of policy action-oriented knowledge rather than knowledge *per se*
4. Reframing power	• Influential researchers • Powerful policy makers • Powerful actors with systemic decision-making influence • Marginalised actors	High-meso-local	• Mainly relativist[4] • Methodological pluralism	Shifting power from high-level to marginal and local actors
5. Navigating differences	• Influential researchers • Powerful policy makers • Powerful actors with systemic decision-making influence • Marginalised actors	High-meso-local	• Knowledge pluralism • Social diversity	Creation of a safe and non-hierarchical space for co-creation
6. Reframing agency	• System thinking and relativist researchers • Powerful policy makers • Powerful actors with systemic decision-making influence • Marginalised actors	High-meso-local	• Social diversity • Epistemic and methodological pluralism • Knowledge as context-relevant and not aggregable in global-scale efforts	Re-localisation of power and agency

3 Realist researchers seek to explain the underlying 'cause' or mechanisms that generate observed phenomenon (117).

4 The relativistic perspective views science as constructing various views of reality (117)

Each of these modes strives for knowledge and methodological pluralism to foster integrated environmental research that draws from both social and environmental sciences. Such pluralism can also facilitate more equitable consideration of different metrics, regimes, knowledge systems, and initiatives across actors and scales to address these crises locally-to-globally (27,101).

When speaking to the pluralism that co-production can facilitate, Chambers *et al.* (99)[5] shed light on the dual tension at the core of science-policy collaborations, namely (i) *impact vs process* and (ii) *control vs inclusion*. The former refers to the value placed on either the process or its impacts, balancing contributions of co-production to social transformation with high-quality, legitimate process. The latter refers to the power dynamics in place throughout the design and implementation of knowledge co-production. This can directly impact researchers who may have to relinquish control of the knowledge production process to facilitate more inclusive and empowering outcomes.

To address these tensions, Chambers et al. (89) speak about *co-productive agility*. This has the potential to mitigate these tensions as it represents "the willingness and ability of diverse actors to iteratively engage in reflexive dialogues to grow shared ideas and actions that would not have been possible from the outset" (p.1) (89). In the next section we consider how co-productive agility is key in addressing this dual tension and ensuring the credibility and effectiveness of co-production.

3.4 The credibility of knowledge co-production

"Co-production agility is inherently political as it facilitates the 'constructive exploration of tensions to support transformation in roles, paradigms, practices, relationships, and structures'." (3).

Co-production is not a panacea for producing actionable knowledge that will always support positive social transformation. Here, we look at the costs for the stakeholders involved and the risks associated with mis-implementing co-production, something often attributable to process facilitators failing to embrace co-productive agility.

Consider again the dual tension the previous section concluded on. A conventional approach to tension 1 (impact vs process) typically means that impact is seen to hinder process, or vice versa. Co-productive agility, on the other hand, reframes this tension so that process is seen as a positive influence on impact. Equally, an agile approach to tension 2 (control vs inclusion) sees inclusion as a strategic benefit, rather than a threat to the role of the expert (for example, the scientists or high-level professionals facilitating the knowledge production process).

5 see also Chambers et al., 2022.

Devolving and sharing knowledge production among other actors facilitates constructive plurality, with personal agendas put aside. Knowledge co-production has the potential to reshape basic assumptions about the relationship between science and policy by defining new "roles and competencies for researchers as well as policy actors involved" (p.1) (45). However, co-production comes with high costs (128–132) and risks (89,99) throughout the process. We pay attention the former in Table 6, shedding light on some of these across different stakeholders involved. We consider the latter in Table 7.

Table 6: Costs of implementing process aimed at knowledge co-production affecting different stakeholders involved, informed by Facer & Enright (2016), Fotaki (2015), Kara (2017) Mulvale & Robert (2021), Oliver, Kothari & Mays (2019), and Williams et al. (2020).

Type	Cost	Researchers	Practitioners	Other stakeholders involved
Practical	Resource contraints: time and money			
	May reduce trust and turn researchers into another lobby group			
	Over-reliance on non-experts can lead to negative outcomes			
Professional	Co-production displaces other forms of knowledge production that may be held in higher regard			
	Can delay progress and 'waste time' with recruiting, informing, and engaging stakeholders, or produce 'dull', 'derivative' research			
Personal	Co-production is never easy and might end up being an unrewarding experience if it does not go well			
	Time and energy commitment, and need of sharing sensitive information			

Experienced	
N/A to stakeholder	
Not discussed	

Ineffective or poorly implemented and facilitated co-production risks reiterating, if not exacerbating, major risks of conventional science-policy interactions. The major risks are summarised below, and Table 7 illustrates how they relate to the six modes of co-production introduced earlier in this section (89,94,106,123–125).

1. Replication of a traditional flow from science to others as knowledge recipients rather than co-producers, creating an "expectation gap" between rhetoric and practice.
2. Uneven representation or misrepresentation of less powerful actors and respective values, knowledge systems, interests, perceptions on issues, solutions, and their trade-offs, limiting knowledge and value pluralism.
3. Uneven policy outcomes based on the creation of *status quo* echo-chambers through a superficial or tokenistic consideration of the marginalised, with their contributions seen as less "scientifically valid".
4. Overlooking local experiences and becoming too big to include all the parties which should be involved. This can lead to the replication of 'expert' environmental solutions that either overlook local social and cultural factors or exacerbate tensions across actors and scales.

Table 7: Major risks associated co-production and susceptibility of each mode to such risks, informed by Chambers et al. (2021; 2022).

	1. Replication of a traditional flow of knowledge from producer to user	2. Lack or scarce knowledge and value-pluralism	3. Poor representation or mis-representation of marginalised voices	4. Re-production of environmental techno-management solutions
1. Researching solution				
2. Empowering voices				
3. Brokering power				
4. Reframing power				
5. Navigating differences				
6. Reframing agency				

Applicable to mode	
N/A to mode	
Not discussed	

3.5 From costs and risks to practical mitigation tips

"Knowledge co-production is strengthened through purposeful partnerships that foster critical dialogs, create trust among members, and remain open to new ideas" (100)

In light of these different risks, we consider the *political* character of co-production, explaining risks and mitigation strategies to pursue effective knowledge co-production. Co-production, like all knowledge production, is embedded in and subject to its political context (see Section 1.2). The failure of researchers and policy makers to recognise the complex politics behind these processes drives mis-implementation of co-production and increases the likelihood of replicating the risks considered above (59,94,106).

In other words, these risks are replicated if we fail to recognise that co-production initiatives take place in political environments, subject to autonomy and knowledge sovereignty, and influenced by the existing political interests and agendas of all actors (94,106). This can make co-production unable to address – if not counterproductive to – the very reasons for which it was sought, namely fostering actionable knowledge pluralism to answer multifaceted and complex issues and eventually drive equitable change (94).

Studies that explore what it means to implement co-production successfully have identified the importance of 'co-productive capacities' (126,127). An initiative's capacity is determined by its institutional structures, resourcing, and social dimensions. Due to the variable nature of co-production and the range of contexts in which it takes place (for instance, environmental discipline, governance scale, or phase of decision making), capacity building is positioned as a more useful exercise than attempts to define best-practices for process design (126).

Assessing capacity comes with challenges, most notably the incomplete understanding of institutional support structures for knowledge co-production – an area that requires more research (128). However, there are recurrent ideas within the literature that can guide researchers seeking to reflect on the conditions for effective co-productive practice.

Co-productive structures

The institutional and social structures that are likely to support the implementation and development of co-production can be grouped into three broad overlapping types (100):

- **Organisations** that 'bridge' disciplines by providing a space for different stakeholders to collaborate towards a common goal (129).
- **Networks** that facilitate the social communication of co-production, for example by allowing researchers to easily and informally engage with policy makers early in the policy process, or by providing researchers with a trusted line of communication through which to promote the credibility of co-production (60).
- **Communities of practice** that provide a forum for those involved in co-production to collectively reflect on their experiences and iterate on shared learnings in future projects.

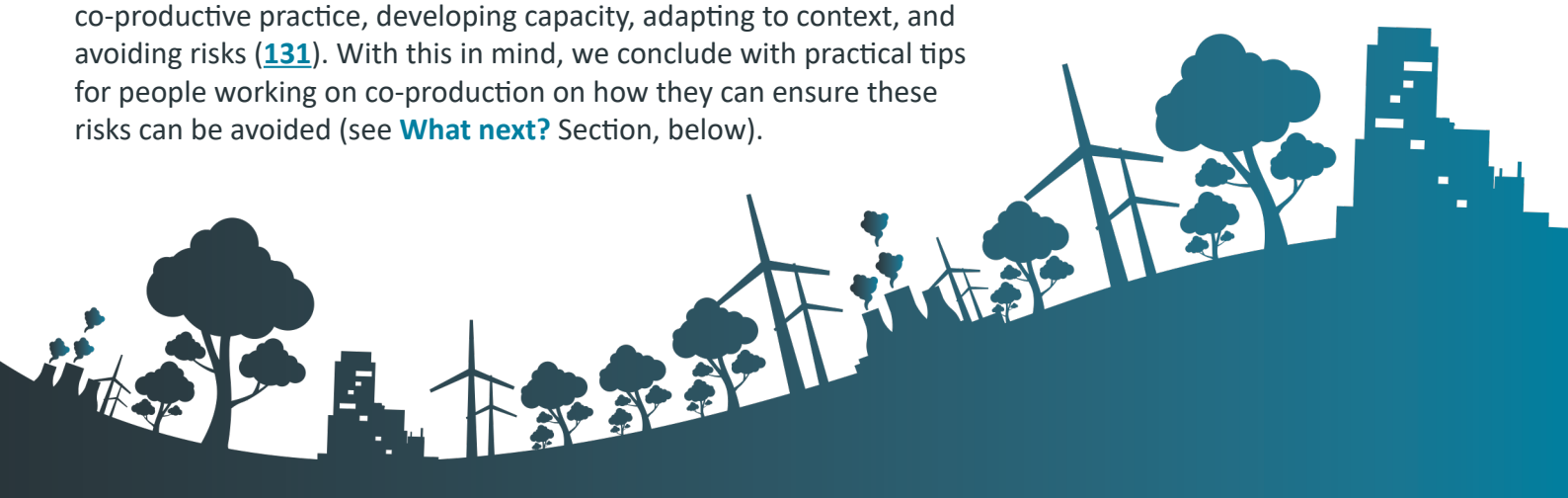
It should be recognised that these are porous terms. Communities of practice, for instance, can take the form of a network or organisation (100). Nevertheless, the categories are helpful in inviting a consideration of relevant institutional and social dynamics and how they may influence the design, implementation, and impact of co-production. Looking beyond the mechanics of co-production to the ways in which collaboration may be institutionalised has been linked to highly impactful examples of co-production (89). This approach may also be instructive for prompting high level strategic deliberation over how to formalise the role of co-production in both the governance and the delivery of a research project, and indeed whether it should be present in both areas (129).

Resourcing and incentivising co-production

Knowledge co-production can proceed unevenly. Resourcing co-production consequently requires an openness to its need for flexibility (88). Access to flexible funding, for example, to enable the hire of a new skillset mid-project, is therefore of great benefit to co-production (130). Researchers also need time to develop relationships with policy makers (60). To ensure that these resource needs can be accommodated, some researchers recommend either actively collaborating with funders in advance of a grant application, or making co-production a criterion for funding (88,128,129).

Researchers have also noted the importance of promoting and incentivising activities relevant to co-production in job descriptions (130). Conversely, they have highlighted some institutional barriers to successful co-production, including inflexible management, procedural limitations, and unresolved tensions over the relative status and priority of the actors involved in co-production (129,130).

There is no well-mapped path for negotiating these varied considerations to arrive at a realistic assessment of an initiative's co-productive capacity – and by extension, an assessment of the conditions required for successfully implementing co-production and avoiding the risks we have identified. What is needed instead is a reflexive approach to research that considers the conditions under which co-production success might be achieved. Such an approach is essential for iteratively improving co-productive practice, developing capacity, adapting to context, and avoiding risks (131). With this in mind, we conclude with practical tips for people working on co-production on how they can ensure these risks can be avoided (see **What next?** Section, below).



Conclusion

This discussion paper has considered the emergence, implications, and potential solutions to the knowledge-action gap. The idea of research and policy as distinct communities with entirely different practices and limited interaction is commonly held but not universally observed; the uptake of research in policy generation is highly variable. At the same time, research is deeply political in its production, as well as in its application, with universities shaped by the pursuit of 'impact' in research. So, intertwined processes of research and policy making have a lot to gain from collaboration.

Co-production has emerged as one approach to collaboration which can address the knowledge-action gap to produce applicable advice on relevant timescales for policy. Co-production is a varied practice with its own risks, pitfalls, and vulnerabilities. Above, we outline the underlying logics and modes of co-production between researchers and policy makers, offering some key recommendations for robust and reliable practice. Whilst not a silver bullet, when done well and with due critical consideration, co-production between researchers and policy makers holds great potential for actionable knowledge that supports positive environmental outcomes.

What next?

Below we draw out clear suggestions on *how* co-production processes can be implemented in ways that consider the sensitivities that we have highlighted in our discussion (85,86,129):

The team facilitating co-production across both academia and public administrators should carefully consider how their own positionality can affect the process itself, starting from the very identification of the actors invited and the kind of space created for them.

Conflicts, including within the collaborative team itself and the communities which different members belong to, as well as the dynamics in the wider landscape of universities and the public sector should be carefully considered and negotiated, rather than suppressed.

Recognise the political character of the environments where co-production is being pursued and recognise hidden agendas, whether consciously or unconsciously brought in, and how these might affect the process and its outcomes.

Work towards an empowering recognition of actors and procedures. This can foster an inclusive approach to diverse and potentially contrasting values and knowledge systems. Work through rather than against tensions that emerge from this diversity.

Co-production of environmental knowledge offers a chance bring knowledge and action closer to one another with the aim of overcoming environmental issues. We invite readers to consider whether co-production is a useful response to issues observed in their own field, especially concerning the time-sensitivity of responding to such issues and the stage(s) of policy processes where co-production may be best implemented. Novel approaches to environmental research and policy generation are needed to address intersecting issues, and we propose co-production as a suitable means of reconciling knowledge and action.

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