United Nations | Department of Economic and Social Affairs

CEPA strategy guidance note on the

Science-policy interface

March 2021

The United Nations Committee of Experts on Public Administration (CEPA) has developed a set of principles of effective governance for sustainable development. The essential purpose of these voluntary principles is to provide interested countries with practical, expert guidance on a broad range of governance challenges associated with the implementation of the 2030 Agenda. CEPA has identified 62 commonly used strategies to assist with the operationalization of these principles. This guidance note addresses the science-policy interface, which is associated with the principle of sound policymaking and can contribute to strengthening the effectiveness of institutions. It is part of a series of such notes prepared by renowned experts under the overall direction of the CEPA Secretariat in the Division for Public Institutions and Digital Government of the United Nations Department of Economic and Social Affairs.

In reading this guidance note, individuals in government ministries and agencies who are less familiar with the topic will be able to understand the fundamentals. Those who have perhaps taken initial steps in this area with limited follow-through or impact will be able to identify how to adjust elements of their practice to achieve better results and to better embed and institutionalize the strategy in their organizations. Those who are more advanced in building the science-policy interface will be able to recognize the practices which contribute to its success.

Understanding the strategy

At the 2020 session of the United Nations High-level Political Forum, ministers made a collective commitment to "strengthen the science-policy interface through evidence-based policymaking,[1] support for research and development, harnessing science, technology and innovation, and leveraging technologies to promote inclusive digital economy and promote resilience across sectors." [2] Sustained national investment in each of these areas is fundamental to achieving the 2030 Agenda. However, such investments are less about strengthening the science-policy interface (SPI) as they are about being strengthened *by the SPI* and in turn making progress toward the Sustainable Development Goals (SDGs).

This is because the SPI is not simply the state of relations between the domains of science and public policy. Rather it is a dynamic ecosystem of processes, actors and organizational arrangements, intended to facilitate the exchange of scientific evidence and place it in the context of social values so that together these can inform some of the most complex policy problems. In doing so, SPIs serve to ensure that knowledge production simultaneously reflects the needs and expectations of experts and policy actors, including citizens, to improve the effectiveness and legitimacy of policy decisions.[3]

Thus, the goal of an SPI strategy is to enhance the policymaking process itself by making complex systems more understandable and manageable. Complex problems are not only due to technical complexity though. More often, they are the policy problems for which values and evidence are in dispute. Even when there is broad societal consensus on the nature of the problem, there can also be multiple and competing proposed solutions, each with various trade-offs depending on perspective. These are the very types of problems represented by the SDGs. (For additional information on synergies and trade-offs, see the strategy note in this series on promotion of coherent policymaking.)

The relationship between scientific research and policy processes rarely, if ever, entails a simple linear transfer of knowledge from scientists to policymakers across an interface. Moreover, scientists and policymakers often do not share clearly articulated norms, values and interests.[4] By the same token, the fundamental differences in goals and incentives between scientific

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[1] Although the ministers' declaration used the term 'evidence-based policymaking' the more generally accepted concept has become 'evidence-informed policymaking' to reflect the notion that, in a democracy, there are many factors on which policymaking will be based. Scientific evidence is expected to be high among these factors, but not exclusive.
[2] E/2020/L.20-E/HLPF/2020/L.1
[3] van den Hove, Sybille. 2007. "A Rationale for Science–Policy Interfaces." *Futures* 39(7): 807–26; and United Nations Environment Programme. 2017. Strengthening the Science-Policy Interface: A Gap Analysis. https://wedocs.unep.org/xmlui/handle/20.500.11822/22261 (December 13, 2020).
[4] Douglas, Heather E. 2009. Science, Policy, and the Value-Free Ideal. Pittsburgh: University of Pittsburgh Press. https://muse.jhu.edu/book/3730 (January 14, 2021).

research and policymaking are often poorly recognized on both sides. Such characteristics make the relationship between them a challenge, and especially in the face of contested policy issues that can undermine mutual and public trust. For science, trust is established through the methodologies, peer review and replicability of research. For policymaking in a representative democracy, it is electoral and legislative transparency that are the cornerstones of the trust and legitimacy needed to make decisions on behalf of citizens. But these standards of trust differ between science and policymaking, which has led at times to contradiction and public contestation, and which has prevented the collective action needed to decarbonize economies, achieve gender parity, ensure food security and other complex and shared challenges encapsulated by the SDGs.

In response to such a challenge, the practices of both scientific research and policymaking are evolving to be more open and inclusive of citizens, of other stakeholders, and of each other, thereby creating multiple and diverse interfaces between science and policy. The foregoing broad and dynamic interpretation of SPIs depicts an iterative strategy for engaged knowledge production and application. Within this strategy, there are generally three instrument types:[5]

- Targeted research funding to enable the co-production of new policy-relevant knowledge. Practical examples include the use of collaborative research design by academics, joint fact-finding and co-design by policy professionals, and collaborative research training and capacity building within the public science system.
- New or newly aligned institutional structures to provision and channel evidence-informed advice, which integrates the needs of policymakers, the expertise of the public research community and the values and experiences of citizens. Practical examples include establishing expert panels, advisory committees, evidence provisioning services embedded in public administrations, targeted communication tools and campaigns.
- Guiding principles and knowledge policies that prioritize transparency and collaboration in the development and/or the application of knowledge. Practical examples include the World Health Organization Values Framework and prioritization Roadmap for Covid-19 vaccine distribution.

Depending on how they are structured and the policy problems they address, they may be established for both short-term (that is, crisis) and long-term use (that is, chronic issues). Activities within this broad typology of tools may be formal or informal, such as dialogue with political or policy officials as they develop ideas.[6] However, even informal SPI activities are

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[5] Van Enst, Wynanda I., Peter P. J. Driessen and Hens A. C. Runhaar. 2014. "Towards Productive Science-Policy Interfaces: A Research Agenda." Journal of Environmental Assessment Policy and Management 16(01): 1450007.
[6] Gluckman, Peter, Anne Bardsley and Matthias Kaiser. "Brokerage at the Science-Policy Interface: From Conceptual Framework to Practical Guidance." *Humanities & Social Sciences Communications* 8.1 (2021): 1-10.

usually facilitated through formally constituted structures such as the offices of chief science advisors, where these exist.

Within the scientific community, these characteristics and the establishment of SPI strategies to address them, have been referred to as the practice of 'post-normal science'.[7] It is a way of conducting research that is based on the growing understanding that scientific research and public values are *interdependent* rather than separate.[8] Thus, the chosen SPI approach must do more than simply bring evidence to bear on a policy issue. Instead, an SPI strategy must enable the collaborative framing and structuring of a policy problem so as to synthesize evidence from multiple, and sometimes competing, perspectives. This is why the way that public research funding is structured and delivered is an important part of a comprehensive SPI strategy.

By way of illustration, we have seen how framing the impact of Covid-19 as either a public health issue, an economic issue or an individual rights issue has led to very different strategies and related evidence.[9] Despite the increasingly well-described biology of the virus, it seems that a collective perception about the nature of the problem it poses still eludes the global community. This is largely because perceptions about the societal implications of the pandemic and the trade-offs implied by various interventions vary in different social contexts.

Thus, the way in which complex policy issues are addressed is a political values-based choice, not a scientific one. For more diffuse 'wicked' policy problems, such as achieving the societal transformations needed to tackle global climate change and specific SDGs, a societal consensus (or at least a compromise that most people can live with) on the nature of the problem is essential to producing the evidence needed to address it.

The SPI in practice

The interdependence of scientific knowledge and normative public values means that SPIs must be structured to enable *ongoing* processes of research co-development, dialogue and interpretation. To do this, there are at least two distinct models of SPIs, each responding to different stages in the policy process or context.

The **linear process model** of SPIs tends to place decision makers on one side of the interface, with the expectation that they will take up information that is supplied by scientists and other experts on the other side. This process may be in response to policymaker requests, or it may

[7] Funtowicz, Silvio O. and Jerome R. Ravetz. 1993. "The Emergence of Post-Normal Science." In *Science, Politics and Morality*, ed. René Von Schomberg. Springer Netherlands, 85–123. http://link.springer.com/chapter/10.1007/978-94-015-8143-1_6 (March 15, 2016).
[8] Jasanoff, Sheila. 2004. *States of Knowledge: The Co-Production of Science and Social Order*. Routledge Taylor & Francis Group.
[9] Allen, Kristiann et al. 2020. *Tracking Global Evidence-to-Policy Pathways in the Coronavirus Crisis:* International Network for Government Science Advice (INGSA).

be undertaken proactively by experts, through research dissemination.[10] This model is often best suited to:

- Contexts where scientific and technical knowledge are applied to a well-defined question of safety or efficacy. This may be in a regulatory context, or at specific points in policy development when consensus has already been reached on the framing of an issue and the type of knowledge sought to address it is already agreed.

- Situations where evidence-informed input is not expressly sought by policymakers, but targeted communication could raise awareness of an issue and create more demand for evidence or expert advice. Such awareness raising has occurred around issues of anti-microbial resistance, or pollinator vulnerabilities and habitat loss, for instance.

- Strategic research settings where the research community is incentivized to engage through directed funding or commissioned research and knowledge translation activities such as on well-defined societal challenges.

In the **iterative process model** of SPIs, experts, non-experts (including citizens) and policy professionals *jointly* identify the relevant knowledge gaps and the type of evidence required to fill them.[11] In this model, multiple sources and types of evidence are marshalled and synthesized to develop a comprehensive and jointly held perspective of the policy problem or system of problems. Policy options and their related trade-offs can then be identified for consideration by policymakers with, or on behalf of, communities.[12] In practice, the iterative process model is often applied to all types of policy problems encompassed in the sustainability agenda, and specifically for:

- Policy problems for which there are multiple relevant domains of knowledge and multiple, often conflicting, consequences of policy action (trade-offs), such as the goal of decarbonizing our economies with affordable and clean energy and responsible production.

- Problems for which a systems-based understanding is needed and there are multiple response options, such as addressing the experience of intergenerational poverty.

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[10] Dunn, Gemma and Matthew Laing. 2017. "Policy-Makers Perspectives on Credibility, Relevance and Legitimacy (CRELE)." *Environmental Science & Policy* 76: 146–52.
[11] Funtowicz and Ravetz, 1993; Gluckman, Bardsley and Kaiser. Forthcoming; and Wesselink, Anna, and Robert Hoppe. 2020. "Boundary Organizations: Intermediaries in Science–Policy Interactions." *Oxford Research Encyclopedia of Politics*. http://oxfordre.com/politics/view/10.1093/acrefore/9780190228637.001.0001/acrefore-9780190228637-e-1412 (January 1, 2021).
[12] Heink, Ulrich et al. 2015. "Conceptualizing Credibility, Relevance and Legitimacy for Evaluating the Effectiveness of Science–Policy Interfaces: Challenges and Opportunities." *Science and Public Policy* 42(5): 676–89.

A 'theory of change' is the map of steps, resources and pre-conditions needed to achieve a policy goal. In the case of an SPI strategy, however, the SPI is not intended to achieve a specific policy goal by itself, but to enhance the policymaking process so as to help achieve other public policy goals, and in particular to achieve the SDGs. In this way, SPIs work indirectly by influencing policymaking conditions.

When complex policy problems such as those encompassed in the SDGs are given the space and platform in SPIs to be openly and collaboratively shaped and framed, then the potential trade-offs and inequities they might pose can be examined and attended to transparently. The policy options that emerge will be both socially and scientifically robust, thereby giving them the best chance of successful implementation.[13] As a result, there is an increasing consensus of theory and practice that the SPI **iterative process model** offers the most promising approach to achieve socially acceptable and evidence-informed policy decisions.[14]

Taking the iterative approach in SPI is rarely the easiest route because integrating the requirements of science, policymaking, and civil society means simultaneously accepting both scientific methods and social values as sources of legitimacy, even when they might make contradictory claims.[15] Balancing this tension in SPI is known as **boundary work**.[16] A departmental science advisor who is seconded from Academia to work in government undertakes boundary work, as does a committee of experts (ad hoc or statutory) to advise the government. In essence, the actors and mechanisms that deliberately straddle knowledge

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[13] These ideas have been similarly articulated by scholars developing the related theories and practices of transdisciplinary research (in Bernstein, Jay Hillel. 2015. "Transdisciplinarity: A Review of Its Origins, Development, and Current Issues." *Journal of Research Practice* 11(1): R1–R1), post-normal science (in Funtowicz and Ravetz 1993; Petersen, Arthur C. et al. 2011. "Post-Normal Science in Practice at the Netherlands Environmental Assessment Agency." *Science, Technology, & Human Values* 36(3): 362–88; and Sluijs, Jeroen P. van der. 2012. "Uncertainty and Dissent in Climate Risk Assessment: A Post-Normal Perspective." *Nature and Culture* 7(2): 174–95), and the more recent practical approaches to the idea of 'co-production' of evidence (Bremer, Scott, and Simon Meisch. 2017. "Co-Production in Climate Change Research: Reviewing Different Perspectives." *WIREs Climate Change* 8(6): e482).

[14] Mair, D. et al. 2019. *Understanding Our Political Nature: How to Put Knowledge and Reason at the Heart of Political Decision-Making.* Joint Research Centres of the European Commission; OECD. 2020. *Addressing Societal Challenges Using Transdisciplinary Research*. OECD Science, Technology and Industry Policy Papers. https://www.oecd-ilibrary.org/science-and-technology/addressing-societal-challenges-using-transdisciplinary-research_0ca0ca45-en (January 14, 2021); Stevance, Anne-Sophie et al. 2020. "The 2019 Review of IPBES and Future Priorities: Reaching beyond Assessment to Enhance Policy Impact." *Ecosystems and People* 16(1): 70–77; and Wesselink and Hoppe, 2020.

[15] Here an obvious tension is created in accepting the legitimacy of facts and values, yet there can also be tensions between different research methodologies that can be difficult to reconcile.

[16] Clark, William C. et al. 2011. "Boundary Work for Sustainable Development: Natural Resource Management at the Consultative Group on International Agricultural Research (CGIAR)." *Proceedings of the National Academy of Sciences*: 200900231; Gieryn, Thomas F. 1983. "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists." *American Sociological Review* 48(6): 781–95; and Guston, David H. 2001. "Boundary Organizations in Environmental Policy and Science: An Introduction." *Science, Technology, & Human Values* 26(4): 399–408.

production in the research community and knowledge application in the policymaking community are engaged in boundary work.

The concept of boundary work combines two distinct functions in SPIs. It **coordinates** the multidirectional exchange of information, integrating multiple perspectives to help process a complex policy problem and it **demarcates** those perspectives. That is, it protects the integrity of science from political influence, while also protecting political (or values-based) input from potential technocracy.[17] This dual accountability of boundary work necessitates ongoing and open negotiation and dialogue rather than a linear knowledge transfer. Most often, this work takes place in formal settings such as government commissions, advisory committees or other institutional structures which are classified as **boundary organizations**.[18]

Public sector situation and trends

The 2019 Global Sustainable Development Report (GSDR) issued a list of recommendations that best describe how SPI structures, processes and skills can be institutionalized at the national and international levels. Although it was based on pre-pandemic analysis, the GSDR's list nonetheless constitutes a useful and generalizable statement of the instruments needed to undertake meaningful and productive SPI processes to advance the SDGs. The list calls for the institutionalization of:

- knowledge sharing platforms with data interoperability and accessibility;
- permanent national expert panels in key areas of sustainable development;
- science-society collaboration and co-design mechanisms;
- investment in sustainability science, which brings together scientific, practical and indigenous worldviews;
- investment in quality science journalism; and

[17] Wesselink and Hoppe, 2020.
[18] Gustafsson, Karin M. and Rolf Lidskog. 2018. "Boundary Organizations and Environmental Governance: Performance, Institutional Design, and Conceptual Development." *Climate Risk Management* 19: 1–11; Guston 2001; and White, Dave D., Kelli L. Larson, and Amber Wutich. 2018. "Boundary Organizations and Objects Supporting Stakeholders for Decision Making on Sustainable Water Management in Phoenix, Arizona USA." In *Transformations of Social-Ecological Systems: Studies in Co-Creating Integrated Knowledge Toward Sustainable Futures*, Ecological Research Monographs, eds. Tetsu Sato, Ilan Chabay, and Jennifer Helgeson. Singapore: Springer, 333–52. https://doi.org/10.1007/978-981-13-2327-0_18 (January 15, 2021).

- investment in science diplomacy to encourage global research cooperation, especially South-South and South-North relationships.

Such recommendations presume ongoing national commitments to investment in national knowledge systems. That is, the strengthening of research, science and innovation funding and capabilities, and the continued and enhanced monitoring of internationally comparable environmental, sustainability and social wellbeing indicators. Yet, international inequities in knowledge system infrastructure and accessibility are enduring issues, making science diplomacy, regional collaboration and the role of the multilateral community particularly important for successful SPI strategies.

At the national level, these GSDR recommendations may take many forms through boundary work, whether countries are just beginning to implement them or have a long history of supporting SPI activities. In general, there tend to be a mix of:

- issue-specific structures: such as advisory panels or designated agencies.
- generalized structures: such as national academies that develop reports on longer-term issues or offices of science advisors that report to the government. Legislative science advice is also a growing area of boundary work, depending on constitutional arrangements.[19]

At the global level, boundary work can be doubly difficult due to the need to span the boundaries between science and policy, and the ideological and political boundaries between countries. Two such examples are the international science assessment processes, the International Panel on Climate Change (IPCC), and the International Panel on Biodiversity and Ecosystem Services (IPBES). These panels were designed to enable and incentivize collaboration between countries in the framing of policy questions and the assessment of evidence with participation from national scientists, policymakers and representatives of civil society. However, a main criticism has been their lack of impact and transparency because member governments tend to appoint scientists at their own discretion and choose the extent of their engagement. Thus, despite producing high profile public reports, their success in building the collaborative framing and knowledge consensus to meaningfully address complex problems has been limited.

Beyond the major multilateral SPI platforms such as IPBES, IPCC, and some efforts to map global actors in the science-to-policy ecosystem,[20] there is no global database that indexes

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[19] Akerlof, Karen et al. 2020. "New Methods in Creating Transdisciplinary Science Policy Research Agendas: The Case of Legislative Science Advice." *Science and Public Policy* 47(4): 536–47.

[20] InterAcademies Panel 2019, Improving scientific input into global policymaking (https://www.interacademies.org/index.php/publication/improving-scientific-input-global-policymaking-focus-un-sustainable-development-goals).

current SPI activities such as advisory committees, joint knowledge production platforms or other formal boundary organizations at the national and subnational levels. However, a few projects have started to register certain SPI instruments at specific points in time.[21] One promising development, since 2016, are the changes made by the Organisation for Economic Co-operation and Development (OECD) to its biennial survey of national research and innovation systems. The survey now includes more data about policy-relevant research priorities and programmes, as well as the establishment of new boundary organizations. The collection of this type of SPI design data is a promising start but will require more systematic comparative analysis to ascertain trends. For instance, closing the gap between knowledge generation and application has been a growing trend in most national science and research systems and it directly strengthens SPIs. This and other broad trends are discussed below.

Methods of implementation

The boundary organizations and boundary workers established as part of an SPI strategy perform one or more of the key functions that serve to coordinate across diverse interests and perspectives, while also demarcating these perspectives to maintain their integrity and legitimacy among their respective communities. In this section, we describe these functions, list the boundary organizations that might typically perform them, and outline the SPI processes where these functions are performed.

Drawing on practical experience and science policy literature, SPI functions are distilled into a four-part typology[22] which can help leaders identify the functional SPI gaps in their national (or international) ecosystem:

- scientific knowledge generators;
- scientific knowledge synthesizers;
- scientific knowledge brokers; and
- science communicators.[23]

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[21] Wilsdon et al. 2014. "Science Advice to Governments: Diverse Systems, Common Challenges." http://ingsa.org/wp-content/uploads/2014/08/Science_Advice_to_Governments_Briefing_Paper_25-August.pdf (March 15, 2016).
[22] Gluckman, Bardsley and Kaiser, forthcoming; and Pielke, Roger A. 2007. *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge; New York: Cambridge University Press.
[23] These concepts have been referred to elsewhere as 'evidence synthesis' and 'evidence brokerage.' It is recognised that 'evidence' and 'knowledge' are distinct philosophically and materially, however the terms are often used interchangeably in the practice of evidence-informed policymaking. That is because the mobilization of scientifically derived 'knowledge' within SPIs is presumptive 'evidence' by virtue of the fact that it is de facto

Scientific knowledge generators are the researchers and technical experts who generate knowledge according to the international standards of their respective scholarly disciplines. This may be fundamental science that is not directly linked to a policy problem, or more directly applicable knowledge, which is generated in response to a strategic request by government decision makers. Strengthening national research systems generally will support knowledge generators, but incentivizing research toward SDG-related questions and supporting a diverse and collaborative public research community should be a priority for governments and other funders.

Scientific knowledge synthesizers have specialized skills in meta-analysis and are able to integrate knowledge generated through different disciplines and methodologies, bringing it to bear on a policy problem, thereby effectively turning collected knowledge into structured evidence. Synthesizers understand the relative strengths and weaknesses of different research methods and are alert to any bias as they control for methodological differences that could skew findings. Diversity of experience and skill is a key asset for knowledge synthesis. When such unique skills are unavailable in individuals, a team-based approach can provide the necessary diversity. Thus, any committee chair or lead analyst seeking a synthesis report on an issue should carefully consider the selection of experts with broad experience.

Scientific knowledge brokers serve as the multidirectional conduit between SPI stakeholder groups, helping to shape and frame the policy problem so that divergent perspectives can be attended to in its solution. Brokers must understand very pragmatically the lived experience and changing contexts of the research and policymaking communities, including the diverse set of external relationships that are increasingly important to the work of each. For these reasons, brokers must also have recognized authority and legitimacy in the eyes of many diverse stakeholders. Transparent mechanisms for broker accountability can be helpful in this regard. For instance, in countries where the role of knowledge brokerage is vested in a chief science advisor or advisory committee to the head of government or the legislature, the appointment process should be transparent and well-balanced. A public consultation and vetting process of shortlisted candidates could further strengthen legitimacy for high level knowledge brokerage.

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applied to policy problems. Therefore, the terms are used largely interchangeably in this paper. Importantly, scientifically derived 'knowledge' in the context of SPIs includes the natural, data, physical and social sciences and often humanities disciplines as well, with each one contributing to a comprehensive understanding of a policy problem. This means that 'standards of evidence' are according to the internationally accepted standards of respective disciplines rather than any supposed hierarchy of evidence. Indigenous and local knowledge(s) also are recognised as significant contributors to policymaking. But where this meaning of 'knowledge' is intended, it would be explicitly stated as such, as is the convention in policy practice.

An increasing number of countries are recognizing the need to deliberatively curate knowledge brokerage because it does not happen naturally. Programmes such as paid fellowships for academic scientists within government departments, secondments to government and the establishment of offices of chief science advisors to governments are among the types of SPI tools that strengthen and build further capacity for knowledge brokerage.

Science communicators constitute an essential function of this ecosystem. A generation ago, good science communication may have been considered both necessary *and sufficient* for evidence-informed policymaking. However, today's more sophisticated and critical understanding of policy dynamics and strategic communication means that communicators are now understood as part of a larger constellation of boundary workers, operating at different timescales and toward different audiences, inside and outside of policymaking.

At the national level, the SPI functions discussed above are often found within issue-specific 'policy networks' such as the experts, policy professionals and stakeholder communities involved in land-use and planning or watershed conservation.[24] More generally, they are embedded in the broader national knowledge ecosystems. Table 1 below lays out a non-exhaustive list of ecosystem actors who may be expected to engage in one or more of the four main SPI functions, depending on national institutional context and capacities, the issue at hand and the stage of policy development of the issue.

Table 1. Main SPI functions and types of boundary organization performing them

	SPI functions			
Types of boundary organization	Scientific knowledge generation	Scientific knowledge synthesis	Scientific knowledge brokering	Science communication
Universities	X	X		X
Academic societies/professional bodies		X		X
National academies		X	X	X
Government labs	X	X		
Regulatory agencies and statutory bodies	X	X	X	
'What Works' and similar expert advice units within governments		X	X	X
Government advisory boards/science councils (permanent or ad hoc)		X	X	
Science advisors (advice mechanisms) to executive branch of government		X	X	

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[24] Rhodes, R. a. W. and David Marsh. 1992. "New Directions in the Study of Policy Networks." *European Journal of Political Research* 21(1–2): 181–205.

Science advisors (advice mechanisms) to legislative branch		X	X	
Independent think tanks	sometimes	X	X	X

Source: Modified from Gluckman et al. 2021.

SPI processes in action

To address complex policy problems meaningfully, whether to solve a specific issue or deal with the interconnected transformations needed to achieve the SDGs, SPI functions are mobilized in various ways through a four-part SPI process comprising:

- problem framing;
- problem structuring;
- knowledge selection, including production and synthesis; and
- the underpinning regulation of relationships between stakeholders.[25]

The rest of this section discusses considerations in each part of the SPI process, working through the example of SDG 15 (Life on land) and its target 15.1 (Conserve and restore terrestrial and freshwater ecosystems).

Problem framing is the first step in the process. Here the boundary work consists of reaching an agreement on the *nature* of the problem. For instance, is the health of a freshwater ecosystem seen as an environmental or an agricultural issue? Different scientific disciplines, different knowledge holders and different stakeholder groups may hold different views on this question within the national context. In international SPIs such as IPCC or IPBES, countries with vested economic interests may try to frame problems strategically in order to minimize any potential impact on nationally important but contaminating industries. Thus, in negotiating consensus on problem frames, the roles of knowledge brokers are crucial. It is here that transdisciplinary research offers a way to bring such diverse views and their underlying ontologies into closer conversation.[26]

Related to framing, **problem structuring** involves minimizing disagreement and uncertainty in the normative and cognitive aspects of the policy problem. From a normative perspective, this means reaching consensus on the policy aim (what is the socially acceptable water quality

[25] Wesselink and Hoppe, 2020.
[26] McGregor, Sue L. T. 2018. "Philosophical Underpinnings of the Transdisciplinary Research Methodology." *Transdisciplinary Journal of Engineering & Science*. http://atlas-tjes.org/index.php/tjes/article/view/115 (January 16, 2021).

goal?), once the nature of the problem is agreed. From a cognitive perspective, it means reducing scientific uncertainty about the causal mechanisms of the issue. Problem structuring in SPI thus involves knowledge generators, synthesizers and brokers, negotiating between the normative and cognitive aspects of the problem.

Knowledge selection is the process of determining relevant knowledge that can help structure a problem and advance possible solutions. It is tempting to think of this step as the unbiased and technical domain of experts, but the selection of knowledge and developing evidence has normative implications. It can either reveal or mask key aspects of an issue. It can minimize or amplify certain perspectives depending on the type of knowledge chosen. For instance, surface water quality monitoring data can differ at different locations, times of day or seasonally. Multi-party and multi-stakeholder agreement on national monitoring standards and practices for freshwater ecosystems can help ensure robust knowledge selection. This is why problem framing and values balancing are so important at the outset.

Finally, underpinning all three steps in the SPI process is **regulating relations** between society/politics and experts. In this, knowledge synthesizers provide a summary of the available knowledge and evidence, while knowledge brokers mediate dialogue between stakeholders who can have opposing perspectives. The presence of brokers and synthesizers helps to protect the integrity and legitimacy of those perspectives, while bringing them to bear on possible solutions in an emergent and holistic way. National forums or commissions often include sectoral stakeholder sub-groups to organize sector-specific submissions to a broader question, for instance.

Depending on the context, SPIs can regulate relationships structurally (such as through statutory agencies such as commissions or expert panels), or procedurally (such as through skills selection and terms of reference for a specific enquiry or study). However, for these implementational aspects of SPIs, contextual specificities make full standardization impossible and indeed inappropriate. Nonetheless, some general principles for successful SPI implementation are worth recalling.

- SPIs are often issue-specific networks of boundary organizations and individuals nested within the larger national knowledge ecosystem.
- SPIs are aimed primarily at unstructured (often contentious) policy issues, with the goal of jointly framing and structuring the problem and co-developing evidence to inform solutions.
- Boundary work within SPIs should acknowledge the socially constructed nature of both policy problems and the knowledge brought to bear.
- Boundary work in SPIs is a non-linear and iterative process that can evolve over time as the policy problem evolves in an interdependent (mutually influencing) way.

In addition, the factors that can influence the success of SPIs include:[27]

- the political culture and institutional frameworks regarding the status and role of science in policymaking, including the trustworthiness and strength of both political and scientific institutions;
- the culture of the specific policy sector;
- the availability of boundary skills; and
- the existing degree of 'structuredness' of the policy problem, which is related to the institutional context (what laws or policies already govern the issue?) and the skills of boundary workers (does the introduction of new or new types of information change how the issue should be governed?).

Measuring progress

As with most strategies aimed at improving policy outcomes, it is impossible to attribute success and impact to an SPI strategy alone. Many influences and implementation complexities sit outside the scope of SPI processes.[28] The goal of an SPI strategy is to create the tools and conditions for the joint identification and response to policy challenges by experts, the public and policy professionals. Thus, success can be measured in reduced scientific uncertainty and the absence of public controversy surrounding a policy issue, which are conditions that enable policy action. In other words, if SPIs are defined as a process, then it is process indicators that can help assess their success.

For instance, with the benefit of practical experience and growing theoretical sophistication, the IPBES review found that "for IPBES to have its anticipated transformative impact […] the policy aspects of IPBES work need to be strengthened and greater emphasis needs to be placed on the co-design and co-production of assessments" and "a more collaborative approach to stakeholders is needed." Similarly, the Mercator Climate Centre/United Nations Environment Programme's "Future of Global Environmental Assessments" project (2014–2017) also considered policy processes. In doing so, it found that boundary organizations need to focus on establishing both the institutional conditions *and* the individual skills for quality boundary work within SPIs.[29]

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[27] Reed, Mark S., Rosalind Bryce, and Ruth Machen. 2018. "Pathways to Policy Impact: A New Approach for Planning and Evidencing Research Impact." *Evidence & Policy: A Journal of Research, Debate and Practice* 14(3): 431–58; and Wesselink and Hoppe, 2020.
[28] Owens, Susan. 2012. "Experts and the Environment—The UK Royal Commission on Environmental Pollution 1970–2011." *Journal of Environmental Law* 24(1): 1–22.
[29] Kowarsch, Martin et al. 2017. "A Road Map for Global Environmental Assessments." *Nature Climate Change* 7(6): 379–82.

Such findings demonstrate the importance of two distinct types of success indicators to assess SPI strategies. These indicators are linked to the two functions of boundary work: 'coordination' (i.e. do you have access to the right policy actors and experts?) and 'demarcation' (i.e. does your evidence or advice have integrity? Is it seen as legitimate by multiple actors?).

Multiple frameworks exist to help policymakers consider such indicators and assess SPI strategies. This section looks at three of them: the CRELE framework places importance on the qualities of the knowledge produced and applied in SPIs; the ACTA framework focuses more on whether the needs of policymakers are met; and a third approach – 'balancing the landscape of tensions' – acknowledges that inherent tension is a defining feature of SPIs and focuses on whether the tension is managed well. Policymakers establishing or enhancing SPIs may prefer a single framework or combine elements of each of them.

CRELE: Credibility, Relevance and Legitimacy

The CRELE framework assesses the credibility, relevance and legitimacy of SPI activities from the perspective of multiple audiences.[30] According to this framework:

- Credibility asks whether the knowledge produced and used in the SPI is trustworthy and valid. Collaborative peer review and transparency mechanisms can help achieve credibility.
- Relevance/salience asks whether the information is useful to stakeholders. Surveys and interviews of knowledge users can help assess relevance/salience.
- Legitimacy asks whether the knowledge is fair, unbiased and integrative of stakeholder values. This can be assessed by surveys, but media scans of the public discourse surrounding contentious policy issues are also a useful source of information if done systematically.

Applying CRELE indicators to assess the success of SPI boundary work is not straightforward, however. The most obvious challenge is that each of the indicators can be defined differently according to different perspectives or at different times in SPI processes. In conceptualizing the CRELE attributes, it has been observed that the "credibility of knowledge is renegotiated when it enters the policy arena […]. In these cases, credibility is taken to mean not only scientific credibility but as political credibility."[31] Additional challenges to applying the CRELE framework are the complementarities and incompatibilities between the CRELE indicators in different contexts. For instance, in the time it takes for scientific knowledge to be validated

[30] Cash, David et al. 2003. "Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making." *SSRN Electronic Journal*. http://www.ssrn.com/abstract=372280 (January 15, 2021).
[31] Heink et al. 2015; and Cairney, Paul. 2016. *The Politics of Evidence-Based Policy Making*. London: Palgrave Macmillan UK.

and thus credible, it may have lost its salience in the policymaking arena.[32] These challenges raise the question of both the needs of the policymakers and the inherent tensions in SPIs, two challenges which are addressed by the other two frameworks.

ACTA: Applicability, Comprehensiveness, Timing, Accessibility

An arguably less complex approach to assessing SPIs is to give priority consideration to the policymaking perspective.[33] To this end, the ACTA framework considers whether the SPI can produce and broker policy relevant knowledge with applicability, comprehensiveness, timing and accessibility. While each of these attributes is inherently sensible in the policymaking arena, the downside of the ACTA framework is that it assumes a linear process of simple knowledge transfer. The linear process works for some SPI activities, as discussed, but for the most part, it is the fundamentally integrative and iterative aim of knowledge co-development for truly transformational impact toward achieving the SDGs that is the SPI priority. Hence assessing an SPI strategy on the basis of ACTA may not provide a comprehensive picture of success or failure.

Balancing the landscape of tensions

Another option is to fully embrace the inherent tensions in SPI boundary work by basing assessment measures on how well these tensions are handled. In other words, if a boundary organization can demonstrably "balance the landscape of tensions" in SPIs, then they are deemed successful.[34] This means demonstrating simultaneous disciplinary and transdisciplinary expertise; having a long-term and short-term focus; and aiming at both scientific autonomy and practical consultancy. In this balancing act, boundary organizations are fulfilling the SPI's aim of structuring the social relations and related expectations across interfaces in an ongoing adaptive and iterative process.

Case studies

As discussed throughout this paper, SPI strategies often comprise a combination of many different types of mechanisms. Some of these are formal 'science advice' mechanisms. These include offices of chief science advisor or chief scientist, which have been popular in Westminster-style governments (such as Canada, Australia, New Zealand and the United Kingdom). Other similar structures have broader committee-like composition. Some are attached to national or supra-national governments (e.g. the European Union Science Advice

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[32] Sarkki, Simo et al. 2014. "Balancing Credibility, Relevance and Legitimacy: A Critical Assessment of Trade-Offs in Science–Policy Interfaces." *Science and Public Policy* 41(2): 194–206.
[33] Dunn and Laing, 2017.
[34] Gustafsson and Lidskog, 2018.

Mechanism and the United States Office of Science and Technology Policy). Some are outside of governments, in national academies with a remit for government service nationally (e.g. Council of Canadian Academies and the Academy of Science of South Africa) or supra-nationally (e.g. European Academies Science Advisory Council and the African Union Science and Technology Division).

Beyond 'science advice to governments', other types of SPI structures have long existed within the regulatory sphere such as Environmental Protection Agencies (for example in New Zealand and the United States) or Technology Assessment agencies. Many of the established agencies work closely with lower income countries to build local capacity and undertake assessments. Although such mechanisms have most often adopted a linear model of knowledge transfer and policy advice from experts to decision makers, increasingly, there is broadened scope for public input and policy considerations in a more collaborative and iterative mode of operation. A good example is seen in the devolution of regulatory implementation to local authorities such as watershed agencies. Doing so promotes engagement with societal and scientific partners in local contexts and provides a feedback system for future regulatory reform.

In some sectoral SPI strategies, the regulatory ecosystem includes civil society (non-governmental) organizations, which are contracted or specially designed to deliver part of the strategy, such as public engagement activities, or networking for joint data gathering, interpretation and management. These may be long-standing or ad hoc to serve specific projects. The following sub-sections briefly present four SPI mechanisms used to build consensus and develop knowledge for policy. The selection of these mechanisms deliberately goes beyond the types of SPI that are embedded in government institutions, to instead depict the breadth and diversity of mechanisms, especially those which can help to advance the SDGs at the local and regional levels.

African Great Lakes Research Centre and Information Platform

In May 2017, the Nature Conservancy, together with academics and regional freshwater regulators organized the African Great Lakes Conference in Entebbe, Uganda. It closed with a call to "establish a 'Network of African Great Lakes Basin Stakeholders' to coordinate action and exchange on priority issues defined by the African Great Lakes Conference and subsequent gatherings supported by the experience of the African Network of Basin Organizations and the International Network of Basin Organizations, as it develops its structure and functions" (Resolution #21). At the same time, it called for greater focus on education and training for the next generation of freshwater scientists and managers to help inform and influence policy for the sustainable use of water in the region. The outcome of this conference was the establishment of the African Center for Aquatic Research and Education (ACARE), a government-academic-civil society collaboration hosted by the University of Nairobi.

ACARE has since been working to establish a long-term process for scientific, academic, policy and management communities, and other stakeholders, to collaborate through what it terms a "structured process" to prioritize research and conduct collaborative research that "results in useful, harmonized data and ideas to influence positive change."[35] In fact the specific goals of ACARE precisely describe an SPI. They are to:

- strengthen global and regional partnerships and collaborative networks to bring together the vast, existing knowledge on freshwater resources;
- establish long-term inter-jurisdictional lake advisory groups to harmonize and promote joint multi-lakes research monitoring projects; and
- build the capacity of freshwater scientists through experiential education and public engagement.

To meet these goals, ACARE has begun with an approach developed through the international sharing of ideas from the Great Lakes Fishery Commission's collaborative arrangement on the North American Great Lakes, where lake-specific advisory groups are established as a mechanism for transboundary cooperation. Thus, ACARE has established the African Great Lakes Information Platform (AGLI), an online information exchange platform to combine global, regional and local knowledge. AGLI is based at the University of Nairobi within ACARE and is funded by the McArthur Foundation and the Nature Conservancy with a view to institutional capacity development in SPIs.

The Gauteng City Region Observatory

The Gauteng City-Region Observatory (CGRO) was established in 2008 as a partnership between the University of Johannesburg, the University of the Witwatersrand, and the Johannesburg and Gauteng provincial and local governments. The overall goal of CGRO is to provide strategic intelligence and engagement processes for better planning, management and co-operative governance in this economically important region of South Africa. That is, the observatory was established to provide "improved data, information, analysis and reflective evaluation essential to the setting of clear strategic agendas shared across government, and between government and its civil society and business partners."

With multi-disciplinary expertise in urban environments (e.g. infrastructure planning and engineering, economics, sociology, and industrial and innovation policy), the observatory operates by providing:

[35] Obiero, Kevin et al. 2020. "Advancing Africa's Great Lakes Research and Academic Potential: Answering the Call for Harmonized, Long-Term, Collaborative Networks and Partnerships." *Journal of Great Lakes Research* 46(5): 1240–50; and also https://www.agl-acare.org/.

- on-request policy analysis and support structures, processes and interventions to connect governments to academic expertise and vice-versa, where academic work has policy implications;
- a clearinghouse of data, through infrastructure, visualisation, indicators and benchmarking exercises;
- medium- to longer-term applied research, of which some is at the request of governments and some through self-initiated projects;
- scholarly contributions as well as locally engaged research contributions; and
- the ability to build partnerships at all levels and across sectors to better integrate and harmonise knowledge.

The Caribbean Disaster Emergency Management Agency

Climate adaptation and resilience is fast becoming a priority for most countries, particularly for small island developing States (SIDS), where seasonal storms are becoming more extreme, leaving populations even more vulnerable and preventing their equitable development.

To better prepare for regular hurricanes and other natural disasters, the Caribbean Disaster Emergency Management Agency (CDEMA) was established in 1991 with primary responsibility for the coordination of emergency response and relief efforts to participating countries. At that time, the effects of climate change were not yet as pronounced. Since then, the decades of planning, coordination and relief efforts have translated into one of the world's foremost disaster management agencies, which is now well-prepared to protect the regional population from the worst effects of climate-induced disaster by combining on-the-ground knowledge with state-of-the-art data collection, processing and interpretation expertise.

In 2009, CDEMA embraced the principles and practices of comprehensive and long-term disaster management, which requires planning, training and consensus-building. It launched its knowledge mobilization strategy including guidance to governments on the development of a national Safe Schools programme, which was a collaboratively agreed priority sector in the region. As a disaster management agency, CDEMA is primarily an implementer with SPI elements and qualities rather than a specific SPI organization or process. This case demonstrates that SPIs do not have to be dedicated structures but can be embedded into other entities.

The 2020 Human Development Report process

Whereas the previous cases discussed SPI mechanisms in the form of specifically designed or adapted entities (i.e. organizations or agencies), the final case example presented here illustrates the concept of SPIs as a *process* carried out by an ad hoc committee, which is another common type of SPI. In this case, an SPI process was established to critically review and update measures of human development to inform the 2020 United Nations Human Development Report. More broadly, the process sought a new conceptual framework of human development to guide analysis, measurement and decisionmaking to support the achievement of the SDGs.

The process began with the launch, by the Human Development Report Office of the United Nations Development Programme (UNDP), in partnership with the International Science Council (ISC), of a global call for expert contributions on the theme, "Rearticulating Human Development." An international panel of experts was then established to consider the contributions and to try to reach consensus on a new definition and way to measure human development. The new paradigm goes beyond the conventional economic and educational indicators, which are insufficient to capture the impacts on human development of new technologies, socio-political realities and significant environmental changes.

The complexity of these interacting socio-technical and socio-environmental issues were clearly articulated in the SDGs, but without a framework to understand or measure them, making it difficult for policymakers to take action. Now, by integrating emerging evidence on broader dimensions of human development, the Human Development Report provides clearer international guidance for relevant policy action at all levels of government.

Peer-to-peer learning and research

This section provides information on the networks, tools and resources that have shown success in helping to build capacity for structuring and supporting SPIs. The focus is on peer-to-peer learning at individual, institutional and regional levels. The increasingly sophisticated understanding of the importance of institutional and cultural contexts means that South-South and South-North collaborations for peer learning are particularly important.

Outside of the United Nations structure, most of the main international initiatives which currently support SPI capacity-building are found within the OECD, the European Union's Joint Research Centers (JRC) and the ISC, including its affiliated organization, the International Network for Government Science Advice (INGSA). Complementary work on SPIs in the Global South has been undertaken by the International Network for Advancing Science in Policy (INASP). Working together and individually, these organizations have been developing transnational networks and exchange platforms for peer-to-peer learning.

Linking knowledge generation with public values and policy use

As funding agencies mediate national knowledge needs, a recent development has been the direct inclusion of citizens to help define the research agenda according to public values. Inclusive research agenda-setting has led, for instance, to the 'missions' identified in the new

European research framework, Horizon Europe (2021-2027). Indeed, this kind of inclusive research funding and governance represents an important component of SPIs that is beginning to be addressed more deliberatively.[36]

A related national research system change is in public funders' increasing acceptance – indeed encouragement – of transdisciplinary research, which is defined as the integration of academic researchers from different disciplines with non-academic participants, working together to co-create new knowledge and a theory of change towards a common transformative goal.[37]

To this end, and in support of advancing the SDGs, a major effort has been underway since 2016 to encourage and enable countries globally to better align their public research efforts with the 2030 Agenda. Supported foremost by the United Nations Department of Economic and Social Affairs (DESA), the World Bank and the government of Japan, the 'STI for SDG Roadmap' development process has identified five pilot countries that will work to combine their national knowledge Science, Technology and Innovation (STI) strategies, their national SDG strategies and their national development plans. Creating deliberate alignment of the national knowledge sector with national SDG strategies is a major step forward for the kind of coordination that SPIs require. However, a mid-2020 progress report of the pilot countries indicated that, indeed, the most challenging part of the process has been engaging research, innovation and government sector stakeholders in developing roadmaps.[38] It is indicative of the complexity in establishing aligned SPIs when the very process that could best help institutionalise them is itself experiencing the challenges of stakeholder engagement.

To be sure, this process has also been delayed by the Covid-19 global pandemic, as national STI systems have turned to Covid-19 response and recovery research. As such, a more recent intervention has been the collaborative development and launch of the United Nations Research Recovery Roadmap, which lays out a plan aimed at encouraging countries to not lose sight of progress and gains in aligning their national research systems towards socially beneficial research and support, even as they turn to innovation for economic development in the wake of the disastrous economic effects of Covid-19.[39]

In practical terms, the intention of both of these knowledge system road-mapping exercises can be effectively advanced if countries begin by aligning actors, institutions and funding around the SDG clusters that make the most policy sense in the local context.

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[36] Rovenskaya, Elena, David Kaplan and Sergey Sizov. 2021. *Strengthening Science Systems*. International Institute for Applied Systems Analysis and International Science Council. http://pure.iiasa.ac.at/id/eprint/16821/.
[37] OECD, 2020.
[38] UNDP report on pilot countries, 2020. https://sustainabledevelopment.un.org/content/documents/269424_Pilot_Progress_Report_Executive_Summary_final.pdf.
[39] United Nations. 2020. *UN Research Roadmap for the COVID-19 Recovery: Leveraging the Power of Science for a More Equitable, Resilient and Sustainable Future*. New York.

Greater recognition of context

Indeed, a growing number of case studies, particularly from the field of sustainability science, point to the importance of context as another trend in SPIs.[40] That is, the explicit recognition that the configuration of SPIs – whether they are issue-specific or more generalized around sustainability transformations – must be closely linked to contextual conditions including a nation's institutional arrangements and cultural dynamics.

For instance, the Covid-19 global pandemic has provided a unique opportunity to identify, classify and closely examine the existing, enhanced or new boundary organizations involved in SPIs for pandemic response across the world. While many such boundary organizations operate primarily within the public health sector, as the pandemic and its responses evolve, an increasing number of policy sectors are engaging in SPI and boundary work.

INGSA has tracked the types of scientific evidence and evidence pathways employed to inform policy decisions in more than 100 global jurisdictions during the first six months of the pandemic.[41] INGSA found that the ways in which countries made sense of the pandemic (i.e. their interpretation of the problem) arose from distinct national contexts, and subsequently served to structure response strategies, including SPI arrangements.[42]

For instance, while New Zealand's circumstances enabled it to envisage an elimination strategy, supporting the strategy necessitated the mobilization of expertise within public research institutes and universities, facilitated by an extant small science advisory system. Even then, scientific evidence alone did not determine public acceptance of highly stringent national measures. A combination of informative and consistent science communication and proactive oversight by an ad hoc parliamentary committee served to enhance the trustworthiness of evidence-informed decisions by government, even as these threatened New Zealand's tourism economy. In this way, evolving SPIs helped to maintain a publicly acceptable response framework, which kept the focus on public health measures as an economic response.

In many other countries the relationship between political priorities (for example, public health, the economy and individual freedoms, among others) was less clear, which created a reluctance to declare public health lockdowns. Even where apparently strong SPIs already existed, terms of reference lacked the clarity to help reach appropriate problem framing and option vetting in sufficient time.[43] But SPIs and the boundary organizations that constitute them have also evolved as the pandemic has evolved. Many boundary organizations have been

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[40] Clark, William C., Lorrae Van Kerkhoff and Gilberto Gallopin. 2016. "Crafting Usable Knowledge for Sustainable Development." *Proceedings of the National Academy of Sciences* 113(17): 4507–78.
[41] https://www.ingsa.org/covid/policymaking-tracker/
[42] Allen et al. 2020.
[43] Sasse, Tom, Catherine Haddon, and Alex Nice. 2020. *Science Advice in a Crisis*. London: Institute for Government.

ad hoc, created specifically to deal with Covid-19, especially in countries with no preexisting institutionalized boundary structures.[44] Another Covid-19 policy tracker project, Coronanet,[45] offers the possibility to search for "new taskforce, bureau or administrative configuration" in their database of Covid-19 response policies.

This recognition of context has been made evident in the recommendations of the 2019 GSDR, which suggested that knowledge for sustainable development "should consider relevant societal norms and objectives," and that "more effort is needed to integrate regional perspectives [into global assessments]." [46]

The GSDR also points to a third key trend in SPIs, which is to recognize the importance of diverse and multiple interactions within SPIs rather than limiting it to 'science' and 'policy' communities. To quote the report: "the knowledge and solutions needed to reconcile conflicting demands will probably emerge only from new, even unlikely, alliances." [47]

Skills and capacity building for boundary work in SPIs

The OECD, JRC and INGSA have long collaborated on characterizing and building capacity for SPIs. The OECD also recently released a report supporting Building Capacity for Evidence Informed Policy Making. For their part, the JRC has launched the programme *EU4Facts* which includes the development of a community of practice across Europe. They have trained over 500 JRC researchers on the practice of informing policy through evidence. The curriculum for the 2-day course is available on the EU4Facts Community of Practice. In 2021, the JRC is launching a Training-of-Trainers programme with the objective of building the capacity of trainers in Member States to deliver the 2-day course to researchers in their home country. This programme has included the development of a 'Science for Policy' handbook.

In addition, the JRC's recent project 'Strengthening and connecting eco-systems of science for policy across Europe' (until September 2021) focuses on the analysis of science for policy institutions and processes at the national and sub-national levels in European Union Member States – with a view to mapping mechanisms in place and better understanding what works well and what does not. Data is collected through surveys and an online workshop series that has involved more than 350 professionals from all across Europe working on the science-policy interface. Topics centre on "science for policymaking" within governments, regulatory agencies and parliaments; in regions and cities; by citizens; as well as the roles of national academies, public research institutes and universities.

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[44] Gluckman and Mendisu in UNESCO World Science Report (forthcoming).
[45] https://www.coronanet-project.org/
[46] Independent Group of Scientists appointed by the Secretary-General. 2019. *Global Sustainable Development Report 2019: The Future Is Now – Science for Achieving Sustainable Development,*. New York: United Nations.
[47] Independent Group of Scientists, 2019.

JRC also released an e-learning module on science for policy targeting early and mid-career researchers aiming to increase the policy impact of their research results.

In addition to such professional development training, pre-professional programmes such as the short term fellowships offered by the American Association for the Advancement of Science (AAAS) and Africa's Next Einstein Forum offer the opportunity for emerging scientists to gain boundary skills within government agencies. There is also a growing recognition that boundary work and SPI development require a set of core competencies in their own right. This is an emerging area of teaching and scholarship that needs to be more fully developed for it to realise its promise in advancing the SDGs.

At the multilateral level, the foremost organization for establishing discourse and agenda-setting on SPIs is the ISC, for which the programme of work includes the mapping and development of SPIs generally, as well as within the United Nations system.

International development cooperation

This section highlights some of the organizations that provide technical guidance and respond to requests from governments for advisory services and technical assistance for strengthening SPIs. Much of the focus of technical assistance has been on establishing SPI system infrastructure (such as, data for benchmarking and strengthening knowledge systems) so as to better provision evidence for policymaking.

The OECD/European Union Science Technology and Innovation Policy (STIP) Compass toolkit typically conducts biennial surveys of national research science and innovation systems. In recent years, this survey has added questions about boundary organizations that include policy and industry stakeholders and the 2020 survey round had specific questions about SPIs in response to the pandemic. Responses are collated here: https://stip.oecd.org/covid/.

With the benefit of STIP survey results over the years, the OECD has prepared a Knowledge Transfer and Co-creation Policy Guide to help policymakers design and implement mission-oriented research and innovation policies to enhance the knowledge generation component of SPIs toward public policy-relevant knowledge. This guide is currently in the development phase and the OECD is in the process of fine-tuning it.

Within the United Nations system, UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments (Go-SPIN) performs a similar function as the STIP Compass, through case studies of a more diverse set of countries. A searchable database by policy type also makes available information on policies aimed at developing or mobilizing science for the SDGs. Some, but not all of these instruments could be classed as boundary work in the collaborative process model of SPIs.[48]

ISC and the World Federation of Engineers are co-organizing partners of the Science and Technology Major Group at the United Nations, which draws its expertise from the vast membership of both organizations and spans the natural and social sciences and engineering. It also mobilizes scientific expertise from international research programmes such as Future Earth, Urban Health and Wellbeing, and Integrated Research on Disaster Risk.

In addition, under the auspices of the ISC, INGSA has established a strong global network of individuals and institutions active in SPIs. In particular, through its devolved governance model of regional chapters, INGSA provides opportunities for peer learning between countries within a region and between regions on the structures and skills to support SPIs that are responsive to diverse contexts. Through funding from the International Development Research Centre, INGSA chapters develop autonomous programmes of work to suit their regional contexts, while the INGSA Secretariat coordinates sharing and global integration to help ensure that the expertise and experience of the Global South has a strong presence. As a result of this work, the INGSA Asia chapter has recently launched a regional network of science advisors, and plans are underway to develop a similar initiative on the African continent. INGSA has also worked with the JRC in the context of the European Science Advisors Forum (ESAF), having held a joint meeting in 2019 to reinforce the community of practice. INGSA also maintains a dedicated webspace for sharing tools and resources across its network.

Knowledge system strengthening

While SDG 9 reflects the need for strengthening innovation systems and infrastructure, this should not be seen simply as a goal in itself, but a means to support all of the goals. As such, in 2016, the United Nations SDG Technology Facilitation Mechanism launched a process to develop Science Technology and Innovation (STI) system roadmaps to enable the generation of knowledge in support of the SDGs.

The Global Pilot Programme on Science, Technology and Innovation for SDGs Roadmaps launched in July 2019 at the United Nations High-level Political Forum, with an initial group of five pilot countries.[49] Through a partnership with the JRC and the government of Japan, a comprehensive guidebook of technical advice for building and enhancing STI systems that

[48] UNESCO had planned to focus more explicitly on SPIs and their boundary organizations through the development of an Atlas of Science Advisory mechanisms, however this project has not yet eventuated due to funding constraints.
[49] These are Ethiopia, Ghana, India, Kenya and Serbia.

help fulfill the SDGs was launched in February 2020. This guidance revolves around the three pillars: Build, Boost, and Broker:

- Build up national STI capabilities to address COVID-19 recovery and the SDGs;
- Boost international knowledge and technology flows for the SDGs; and
- Broker international STI collaborations for the SDGs.

Unfortunately, the launch of the guidebook was all but eclipsed by the Covid-19 pandemic, a coincidence which impacted rollout as reported in the July 2020 status report. Thus, while pilot countries have made some progress, the focus necessarily has shifted to a Covid-19 recovery research roadmap, which can now assist countries in strengthening their knowledge systems for pandemic response and recovery without losing gains or momentum on the SDGs.

In addition to and complementing the tools and networks listed above, is the work of the International Network for Advancing Science in Policy (INASP, formerly the International Network for Access to Scientific Publications). INASP aims especially at supporting the development of equitable knowledge systems with a focus on open and accessible science and on building South-South and North-South collaborations for stronger knowledge systems.

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