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Strengthening the Science-Policy Interface:

A gap analysis

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Foreword

With a growing number of environmental challenges to resolve, robust, easy to understand scientific data is a crucial building block for policy makers. This report analyses the gap in collaboration between scientists and policy makers, and tries to explain how closing it can protect this planet and its people. With growing momentum for change, two clear trends are emerging. First, international scientific experts are re-aligning their work to be more useful for policy makers. Instead of focussing on the nature of problems, they are looking towards solutions and understanding the implications for countries and citizens. Second, stakeholder groups are increasingly aware that a lack of knowledge sharing is hampering their ability to influence policy development. Therefore, the report suggests that non-state actors can be more closely involved in policy design. This might include businesses, city networks and non-governmental organizations who understand what's involved in implementing specific policies. The report also highlights the importance of making high quality scientific data easily available to the right people. For example, access to air quality data showing tangible threats to human health is strengthening political pressure to tackle air pollution and improve the design of air quality related policies.

However, science and policy are at a crossroads and need effective governance to promote better interaction. There is growing evidence that sound science can play an important role in creating the political will to shape policies that can deliver the Sustainable Development Goals. For example, Dr Andy Cope, Director of Insight at Sustrans, partnered with the UK Research Councils funded iConnect research consortium to evaluate a UK Big Lottery funded active travel programme. Together they made a very compelling case for legislation and policy supporting walking and cycling in the United Kingdom. This includes promoting the Active Travel Act in Wales, increasing investment by the Public Health Agency in Northern Ireland, supporting a Cycling and Walking Investment Strategy for England, and significantly increasing investment in active travel in Scotland through the Cycling Action Plan for Scotland. The challenges facing our environment have never been greater, but then the opportunities to address them have never been greater either. I hope scientists, policy makers and decision makers from industry and civil society, will use the new tools and approaches in this report to create a better future for all of us.

Erik Solheim
Executive Director, United Nations Environment Programme

Glossary

Evidence: Promotes the use of a wide variety of information at different stages of a decision-making process, rather than implying prescriptive or unitary sources of knowledge (Sutcliffe and Court 2005). This incorporates both hard research and context specific analysis (Sutcliffe and Court 2005). It also refers to evidence based on findings developed from systematic, replicable and objectively conducted observation, measurement and experimentation as to ascertain its validity and ensure that the policy is based on "what actually works".

Evidence Informed Decision-Making (EIDM): An effort to reform or restructure decision-making processes in order to place greater emphasis on research and data in informing policy development.

Gender-disaggregated data: Collection and presentation of information that is based on people's gender (United Nations Environment Programme 2016a p. 219).

Gender mainstreaming: The systematic assessment of implications for both women and men of any planned action including in the formulation and implementation of legislation, policies, programmes and research, ensuring that both women and men's perspectives are taken into consideration and are central to policy development - the ultimate goal being the achievement of gender equality (United Nations 2002 p. 3).

Integrated Environmental Assessment (IEA): An assessment that includes environmental, social and economic aspects in an analysis of environmental state and trends linked with policy analysis. It usually covers a broad spectrum of issues and policies and all aspects of the environment including habitats, species and ecological, physical and chemical processes. It may incorporate global, sub-global and national perspectives as well as historical and future perspectives in an integrated analysis of environmental change and human and societal well-being.

Lay, Local and Traditional Knowledge: Knowledge, innovations and practices of indigenous peoples and local communities embodying traditional lifestyles. In this report, it incorporates endogenous knowledge.

Science-Policy Activity: Activity taken to improve the functioning of the science-policy interface.

Science-Policy Interface: The productive exchange of evidence between individuals who can use this information to influence the outcomes of policy decisions on the environment.

Science-Policy Interface Organisation: An organisation or an initiative set up to promote the productive exchange of evidence for policy use.

Contents

Executive Summary

1. Context: why do we need an improved science-policy interface?

The world is increasingly faced with environmental challenges which are exacerbated by an absence of coordination among different actors around the globe. In a global political context where scientific evidence is not often understood or used by policy-makers, there is a growing disconnect that has emerged, which not only dismisses, but excludes opportunities for collaboration.

Science and policy are at a crossroads. The interface needs to be framed by an effective and efficient governance structure to promote better interaction between the two. This intersection can be facilitated by operational knowledge from non-state actors.

A dynamic science-policy interface can be a core instrument to support well informed decision making on the environment while also engaging the right actors in achieving the Sustainable Development Goals.

1.1 Mandate and scope for the report

United Nations Environment Programme Member States have long recognized the need for a stronger sciencepolicy interface and have pushed for addition guidance through the following decisions and resolutions:

United Nations Environment Programme Governing Council decision 27/2:

"*Decides that the governing body of the United Nations Environment Programme will promote a strong science policy interface by reviewing the state of the environment….*" *and "requests the Executive Director to identify critical gaps and present a report, with recommendations, to the governing body*" (United Nations Environment Programme 2014a p. 17).

United Nations Environment Assembly (UNEA) 1 resolution 1/ 4:

"*reiterates the request to the Executive Director to submit a gap analysis report on environmental data, information and assessments as well as recommendations on policy instruments for a strengthened science-policy interface to the United Nations Environment Assembly at its second session*" (United Nations Environment Programme 2014b).

In this context, this report aims to identify new ways to improve the science-policy interface by:

- Providing a summary of the characteristics of an effective science-policy interface.
- Identifying the gaps found in practice in science-policy interfaces.
- Providing practical steps that Member States and international organisations can take to fill these gaps.

2. What does a gap-free, effective science-policy interface look like?

Science-policy activity is evolving to meet the challenges of delivering impact and supporting the achievement of the environmental dimension of the Sustainable Development Goals. Identifying the key elements of an effective science-policy interface allows for the identification of the internal gaps that act as barriers to such processes, and which impact decisions. There are three key elements for an effective science-policy Interface:

a. Links in the chain: Motivated and capable individuals, able to utilise and exchange evidence and expertise to
b. influence decision outcomes
c. The right evidence: Availability of the appropriate data and expertise
d. Productive exchange: of this evidence between individuals in the pathways

2.1 Key challenges facing the science-policy interface and its evolution

Participants at the Member State Forum for Science, Technology and Innovation for the Sustainable Development Goals in 2016 recognised the implications of one of the new challenges facing science-policy activity. They concluded: "*Sustainable Development Goals are disruptive. They imply a radical departure from business as usual…. likely to require new ways to approach the science-policy interface*" (E/HLPF/2016/6 p.2,3). In the environmental area, three challenges have driven an evolution in science-policy interface activities:

a. Achieving the Sustainable Development Goals: The achievement of the 2030 Agenda for Sustainable Development will require the co-operation of a multitude of decision-makers with divergent primary priorities, scientists from a wide-range of disciplines and a great degree of understanding of interactions between achievement of parallel goals. In the spirit of 'leaving no one behind' it is crucial that gender mainstreaming is adopted in all science-policy activities, failure of which might lead to policies that aggravate the existing unintended consequences that further intensify inequality (United Nations Environment Programme 2016a).
b. Supporting Policy Implementation at the regional and country level: To tackle continued environmental degradation, despite well-developed global environmental governance, science-policy activity is moving further towards supporting implementation of international environmental agreements in countries and regions.

c. Engaging with a 'post-normal' scientific context: The political context for science-policy work has changed: decisions are urgent, uncertainty is high and political will fluctuates rapidly.

Science-policy activities aim at more than the synthesis of scientific research. They are designed to influence policy where the existing availability of evidence alone has not influenced outcomes. These three challenges above have brought two additional hurdles to science-policy activities being effective in this mission:

a. Working with divergent viewpoints: Improved outcomes come from engaging policy-makers who hold significantly divergent viewpoints on the importance of the environment, but whose decisions influence environmental outcomes, for example officials in economics or agriculture ministries.
b. Dealing with complexity: Achieving the Sustainable Development Goals requires scientific advice on complex interactions between goals achievement, which are dynamic, non-linear and uncertain. Policy processes are also complex – with interactions of multiple parties producing uncertain outcomes.

These additional hurdles not easily fit into the movement through the data-information-knowledge-action chain, which requires processes that are predictable, include the right actors and that are designed to achieve impact.

2.2 Changes to the practice of science-policy activity

The response of science-policy organizations to these new challenges is an evolution of their activities, including moving away from highlighting the nature of problems towards providing solutions and assessing their implications, for example by improved scenario-building. The trends are illustrated by adaptations in practices by some of the major scientific assessments: the Intergovernmental Panel on Climate Change (IPCC); Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem Services (IPBES), United Nations Environment Programme's Global Environment Outlook (GEO) Assessment process; and the International Resource Panel (IRP) – shown in the **table below.**

These changes have created strong interest from United Nations Environment Assembly Member States in understanding the full range of changes to science-policy activity needed to more effectively improve environmental outcomes, in the face of these challenges, and where gaps exist in current practices.

Evolution	IPCC	IPBES	GEO	IRP
1. From identifying problems to uptake of solutions	Agreed outline of IPCC's next (AR6) assessment has an 'IPCC 2.0' concept - assessing the solutions that will improve people's lives" (Climate Centre 2017).	One of IPBES work mandates is policy support through provision of 'policyrelevant tools' and catalysing their use.	The logic behind GEO-6's Outlook and Scenarios section was based around 'How to' rather than 'What if'.	IRP aims to tackle environmental degradation through the uptake of resource efficient technologies.
2. Dealing with wider audiences and divergent viewpoints	IPCC AR5 develops shared socio-economic pathways.	IPBES nurtures input from indigenous and local knowledge and uses a multidisciplinary advisory board.	GEO-6 is guided by an Intergovernmental and Stakeholder advisory group, group, in addition to a Scientific Advisory Panel.	IRP reports include economic assessments of resource efficiency.
3. Increase effective exchange of evidence	IPCC partners with European Climate Foundation (ECF) to gain strategic communications expertise.	IPBES partners with UNEP, UNEP-WCMC and other relevant partners to gain their expertise in interaction with national and regional policy processes.	GEO-6 is a participatory process producing outputs tailored to local and thematic issues.	IRP partners with Systemiq to gain external expertise in engagement of policy and business stakeholders.

A wide range of organisations are active in the science-policy interface, and have the potential to reduce these gaps through several initiatives. These include: United Nations Environment Programme Integrated

Environmental Assessments, interfaces linked to Multilateral Environmental Agreements, exchange and capacity building initiatives like the Science-Policy-Business Forum, and national and regional initiatives like national science academies.

Gender equality in science-policy activities

There is a pressing need to effectively promote gender equality in science-policy activities in a bid to decrease existing gender gaps. Various governments have made commitments in support of gender equality and these commitments ought to be followed up and implemented. The following 'Transformative Actions' developed by the Gender Advisory Board of the United Nations Commission on Science and Technology for Development, provide useful suggestions to address gender-gaps in Science and Technology (Schiebinger 2010 p. 5-6) :

1. Establishing gender equity in science and technology education
2. Removing obstacles to women in scientific and technological careers
3. Making science responsive to the gender dimension
4. Making the science and technology decision-making process more gender aware
5. Relating better with local knowledge systems
6. Addressing ethical issues related to gender in science and technology
7. Improving the collection of gender-disaggregated data for policy-makers
8. Equal opportunity for entry and advancement into larger-scale science, technology, engineering, mathematics disciplines (STEM) and innovation systems (Schiebinger 2010 p. 5-6).

3. Remaining gaps in the Science-Policy Interface

The identification of the remaining gaps in any science-policy interface comes out of understanding the specific challenges and solutions in relation to altering any environmental problem or outcome. This depends on:

a. Who needs evidence to reach a changed policy outcome, what their current perspectives are;
b. What evidence needs they have; and
c. What the best pathways, intermediaries, content, processes or form are, for them to take-up and use evidence.

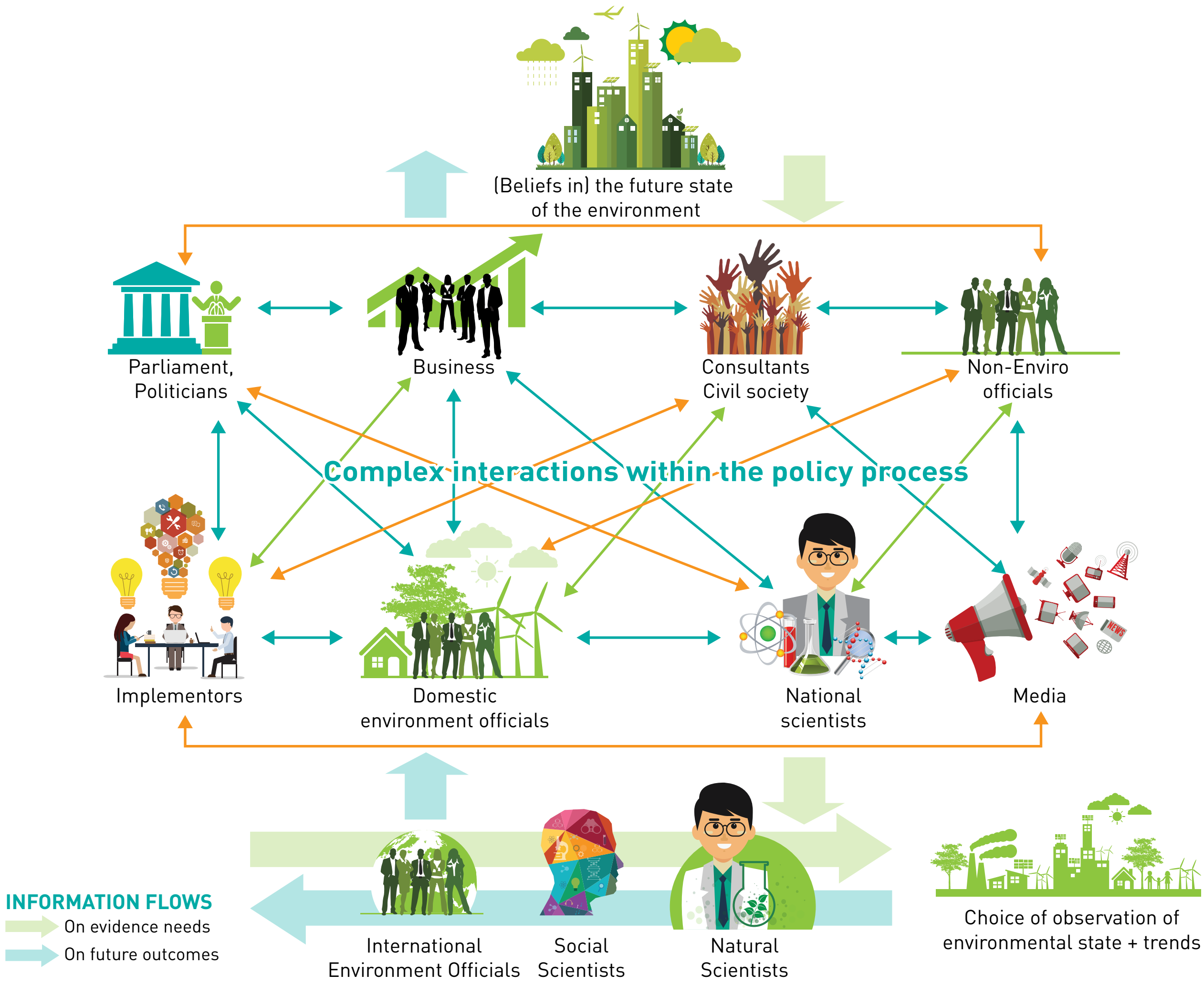
The answers to these questions are not always obvious. For example, evaluative research of sciencepolicy activities shows that personal exchange with the most relevant decision makers is the most frequent way to bring about use of evidence. The reasons for this are explained in the report.

The **figure next page** shows current thinking on the stylised information and evidence flows within participants in a science-policy interface, to help consideration of gaps and solutions.

Based on this understanding, gaps in any sciencepolicy interface can be identified, prioritised and tackled. Many organisations have completed or undertaken reviews to gain this understanding: e.g. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is starting an internal review process, and the International Resource Panel (IRP) discussed a new strategy to increase impact in November 2017.

Gaps can be found in three areas:

1) gaps in the chain of capable, motivated people exchanging evidence between scientists and final decision makers; 2) gaps in available evidence and 3) gaps in the effective transfer of evidence between the people in this chain.



4. Possible ways to address these gaps

Many gaps are persistent or recurring (United Nations Environment Programme 2014a), suggesting that existing practices in the science-policy interface are hard to change. Steps to change existing practices are needed to fill gaps, for example, by changing the governance frameworks of organizations involved in the science-policy interface.

The five categories below present ten steps which may be a helpful guide to action:

Step 1: Build your own understanding of gaps and capacities

- Seek to understand the links in the chains by which evidence could impact on the chosen environmental outcomes, determining which policy processes are relevant, who are the key players in those policy processes, what are their current viewpoints and their evidence needs. Build a more specific sketch of the pathways to impact – or 'theory of change'- for each intervention.
- Understand what information is missing about these pathways to your impact, and from whom and how you could find it. Learn through feedback from your own activities – through improved use of evaluation of impacts, and from the lessons and examples of other organizations.
- Prioritize your activities on these understandings. Dedicate resources to actions to build your capacity to engage with the new challenges – e.g. in skills, external expertise, networks or new decision processes. Build new partnerships to strengthen your capabilities.

Step 2: Build partnerships to grow your capacity to act

- Gain access to specific complementary expertise, sectoral and geographic networks and access to important decision makers by forming partnerships with external organizations with shared interests in improved policy outcomes.
- Use ongoing partnership activities to promote learning of new perspectives and process skills in your organization's officials and academic and governmental participants.

Steps 3 and 4: Fill gaps in available evidence

- **3.** Stimulate greater investment in monitoring and reporting of environmental states, particularly in those areas with clear links to welfare – like air quality. Fund long-term environmental monitoring to deliver trend data that can be openly accessed online by decision makers.
- **4.** Build statistical capacities, nationally and globally, to deliver reliable and timely statistics that can stimulate and inform policy debates. Promote the standardization of methods to allow comparability across countries.

Steps 5, 6 and 7: Build the capacities of other participants (or links in the chain to outcomes)

- **5.** Increase the professional rewards for scientific participants engaging in science-policy activity, through changes to national funding metrics. Build capacities to engage in trans-disciplinary, multi-stakeholder science-policy processes, e.g. placements and skills training.
- **6.** Promote changes to decision-making cultures and processes in nations and regions that move towards Evidence Based Policy Making, to give more incentives for individuals to apply evidence in policy.
- **7.** Design the participatory processes in science-policy interfaces in ways that increase the learning opportunities of all participants on ways to deliver more effective science-policy activity.

Steps 8, 9, 10: Create practices for the effective exchange of evidence

- **8.** Move away from 'dissemination' and 'outreach' to promoting productive exchange and learning by prioritized participants. Re-design science-policy participatory processes for more productive exchange between individual participants, planning activity around the needs of the relevant decision makers (or intermediaries).
- **9.** Put important assessment processes on a secure financial and structural footing to ensure that they can plan and adapt to future challenges.
- **10.** Create written outputs that fit participant's needs, tailoring form, frequency and content of outputs to different audiences in different contexts and potential use. Increase transparency of evidence and the processes to agree it, providing open-access to underlying data. Support legitimacy and trust in evidence through comprehensive review processes.

Conclusion

Gaps in evidence or between actors engaged in the science-policy interface mean that desired outcomes are unlikely to be achieved. As knowledge on effective science-policy work has grown over the last decades, it has driven an evolution in the practice of science-policy activity. This evolution reflects innovation and experimentation by the leading actors in sciencepolicy interfaces. Science-policy organisations require dedicated change processes to their governance models to have impact in the future, including providing information for achieving the Sustainable Development Goals. The evidence that they provide plays an essential role in creating the political will to develop policy. This report suggests to Member States, and to all key actors in the data-information-knowledge-action chain, different tools and methods in which gaps between science and policy can be filled, while providing encouragement for collaboration among these networks.

PART 1

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1. INTRODUCTION: CONTEXT AND THE ROLE OF THIS REPORT

1.1 The context surrounding the science-policy interface

1.1.1 Search for Impact

The last 40 years have seen a significant expansion of scientific research into environmental challenges and their drivers, international environmental governance structures and international science-policy work on environmental issues (European Environment Agency 2009).

Science, and the evidence that it provides, play an essential role in policy decisions that lead to better environmental outcomes and enhanced human wellbeing. For instance, a 2015 United Nations Environment Programme publication on air pollution-related diseases in Asia-Pacific and a corresponding improvement in the technologies for measuring air quality demonstrated much higher estimates on the number of premature deaths caused by air-pollution than previously expected. This strengthens the evidence base for the design of air quality-related policies (United Nations Environment Programme 2016b).

Yet, the growth of this work has not been matched by a slow-down in environmental degradation. Indeed, globally, the environment continues to deteriorate, and in some geographical areas the rate of this degradation is actually increasing (United Nations Environment Programme 2009).

The gap between science and its use for improving policy outcomes has catalysed a strong interest from United Nations Environment Assembly Member States, who wish to better understand how science-policy activities can more effectively lead to improved environmental outcomes. In this context, the United Nations Environment Programme has been requested to provide this 'Gap Analysis' (United Nations Environment Programme 2009) to guide Member States and international organisations in their future science-policy activities.

1.1.2 Interface activities and their evolving challenges

Science-policy activities can be distinguished from the production of scientific research. They are designed based on the understanding that the availability of evidence alone has not been sufficient to influence political outcomes, and they aim at promoting the use of this evidence in policy development processes.

The purpose of evidence goes beyond simple synthesis; however it must maintain the objective neutrality of science. It includes the role of stimulating political debate about particular issues, where adequate policy processes to consider that evidence do not yet exist. This is clearly demonstrated by the work of the Intergovernmental Panel on Climate Change (IPCC).

Three challenges have been driving an evolution in science-policy interface activities in the environmental sphere:

a. Achieving the Sustainable Development Goals (SDGs): The achievement of the 2030 Agenda for Sustainable Development will require the co-operation of many decision-makers with divergent primary priorities, the participation of scientists from a wide-range of disciplines and a better common understanding of the interactions toward the achievement of all Sustainable Development Goals.
b. Supporting Policy Implementation: In order to discuss continued environmental degradation, despite the existence of a well-developed global environmental governance regime, science-policy activity is moving further towards supporting the successful implementation of international environmental agreements at the national and regional levels.
c. Engaging with a 'post-normal' scientific context: The political context for science-policy activity has changed: decisions are urgent, uncertainty is high and political will can fluctuate rapidly.

In addition, these three challenges above have occasioned two additional hurdles that further inhibit the effectiveness of science-policy activities (Kowarsch *et al*. 2017b):

a. Working with divergent viewpoints: Engaging policy makers who hold significantly divergent viewpoints on the importance of the environment, and whose collective decisions influence environmental outcomes.
b. Dealing with complexity: Achieving the Sustainable Development Goals requires scientific input on the complex interactions between the individual Goals: dynamic, non-linear and uncertain. Policy development processes are also complex – with multiple parties interacting and producing uncertain outcomes.

1.2 Mandate and scope of this report

United Nations Environment Programme Member States have long recognized the need for a stronger science-policy interface and have pushed for addition guidance through the following decisions and resolutions:

United Nations Environment Programme Governing Council decision 27/2:
"...Decides that the governing body of the United Nations Environment Programme will promote a strong science policy interface by reviewing the state of the environment...." and "requests the Executive Director to identify critical gaps and present a report, with recommendations, to the governing body" (United Nations Environment Programme 2014a).

United Nations Environment Assembly (UNEA) 1 resolution 1/ 4:

"reiterates the request to the Executive Director to submit a gap analysis report on environmental data, information and assessments as well as recommendations on policy instruments for a strengthened science-policy interface to the United Nations Environment Assembly at its second session" (United Nations Environment Programme 2014b).

In the recent second session of the United Nations Environment Assembly held in Nairobi on 23 - 27 May 2016, the resolution 2/5 on "Delivering on the 2030 Agenda for Sustainable Development" was adopted (United Nations Environment Programme 2014b).

This resolution confirmed the need to re-enforce the science-policy interface recognizing the United Nations Environment Program and the United Nations Environment Assembly as key players in this sense.

In 2016, actors at the Member State Forum for Science, Technology and Innovation for the Sustainable Development Goals recognised the implications of the Goals and, also, the challenges that they pose, concluding that *"Sustainable Development Goals are disruptive. They imply a radical departure from business as usual.... likely to require new ways to approach the science-policy interface"* (E/HLPF/2016/6).

This report provides the gap analysis that has been requested by United Nations Environment Assembly Member States, to identify new ways to approach the science-policy interface entailing:

- A summary of the characteristics of an effective science-policy interface.
- An identification of the gaps found in practice in science-policy interfaces
- A set of practical steps that Member States and international organisations can take to fill these observed gaps.

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2. WHAT DOES A GAP-FREE, EFFECTIVE SCIENCE-POLICY INTERFACE LOOK LIKE?

2.1 Introduction: Knowledge on science-policy interfaces comes from practice

This analysis of the gaps in science-policy interfaces is informed by knowledge of how effective science-policy interfaces achieve improved environmental outcomes. This is based on the practical experiences and reflections of people that have been deeply involved in science-policy work, comments and analyses in academic journals, and outcomes from evaluations and operational research (including the recent Future of Global Environment Assessment Making [FOGEAM] project, jointly developed by The Mercator Research Institute on Global Commons and Climate Change (MCC) and the United Nations Environment Programme) (Kowarsch *et al*. 2017a). In total, this research included almost 200 interviews and several participatory workshops.

2.2 Science-policy interface practices are evolving

As the knowledge on effective science-policy work has grown over the last decades, it has driven an evolution in the practice of science-policy activities. This evolution has been catalysed through the innovation and experimentation of the leading actors in science-policy interfaces. Their understanding and vision of routes to more effective outcomes has changed many people's perception of what the work involves.

In recent years, major assessments have moved towards the provisioning of solutions and their implications (i.e. via scenarios) – a position reflected by the Chair of the Intergovernmental Panel on Climate Change, Hoesung Lee, in his 2015 statement that the "next cycle of IPCC assessments should be more focussed on opportunities and solutions" (Goldenberg 2015).

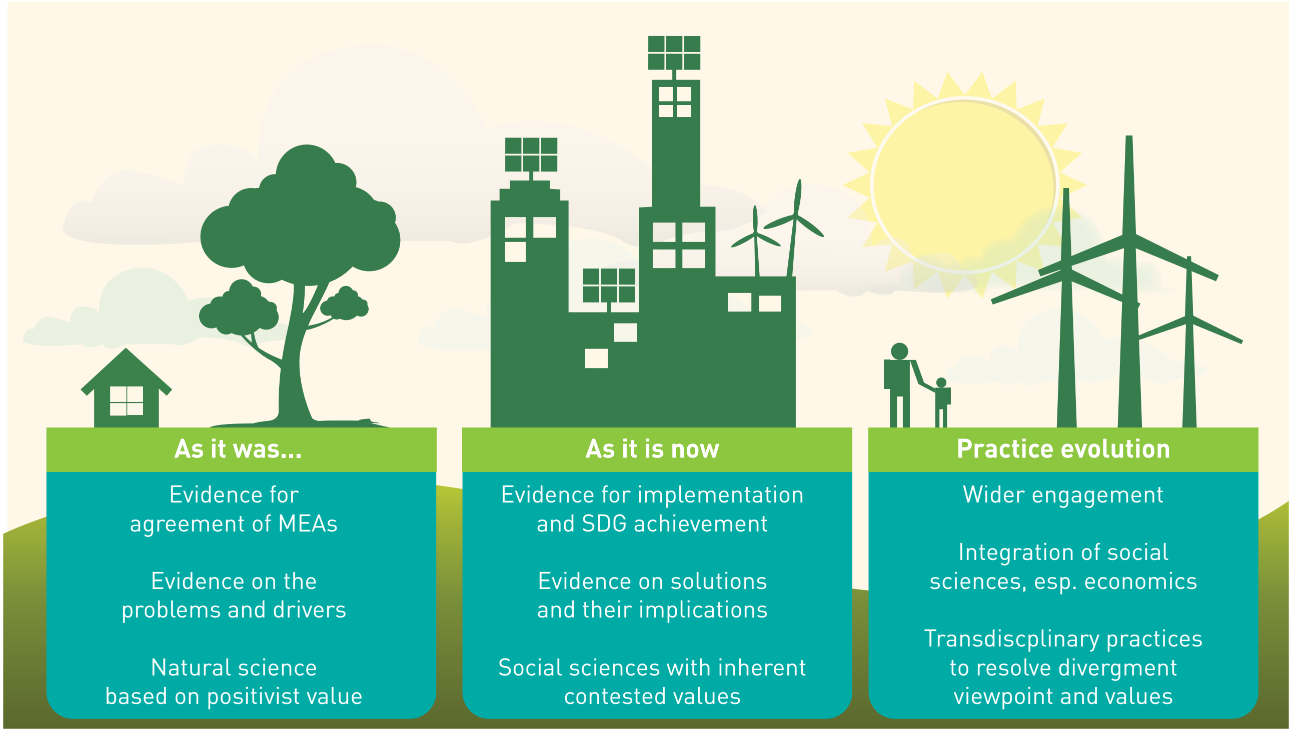
This evolution in the practice of science-policy interfaces can be seen across the range of international science-policy interface organisations. Illustrations can be seen in the adaptation in the practice of the Intergovernmental Panel on Climate Change, of the Global Environment Outlook's (GEO) process, of the International Resource Panel, and the set-up and practices of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) **(Table 1)**.

Table 1: Evolution in the practice of science-policy interfaces

Evolution	IPCC	IPBES	GEO	IRP
1. From identifying problems to uptake of solutions.	Agreed outline of IPCC's next (AR6) assessment has an 'IPCC 2.0' concept - assessing the solutions that will improve people's lives" (Climate Centre 2017).	One of IPBES' work mandates is policy support through the provision of 'policy-relevant tools' and catalysing their use.	The logic behind GEO-6's Outlook and Scenarios section is based around 'How to' rather than 'What if'.	IRP aims to tackle environmental degradation through the uptake of resource efficient technologies.
2. Dealing with wider audiences and divergent viewpoints.	IPCC AR5 developed shared socio-economic pathways.	IPBES nurtures input from indigenous and local knowledge and uses a multi-disciplinary advisory board.	GEO-6 is guided by an intergovernmental and stakeholder advisory group, in addition to a scientific advisory panel.	IRP reports include economic assessments of resource efficiency.
3. Increasing effective exchange of evidence.	IPCC partners with ECF to gain strategic communications expertise.	IPBES partners with UNEP, UNEP-WCMC and other relevant partners to incorporate their expertise into interaction with national and regional policy processes.	GEO-6 is a participatory process producing outputs tailored to local and thematic issues.	IRP partners with Systemiq to acquire external expertise in the engagement of policy and business stakeholders.

In summary and in response to the nature of the challenges, science-policy interfaces have expanded their role **(Table 2).**

Table 2: Evolving Roles: From the nature of problems to stimulating uptake



As it was...	As it is now	Practice evolution
Evidence for agreement of MEAs	Evidence for implementation and SDG achievement	Wider engagement
Evidence on the problems and drivers	Evidence on solutions and their implications	Integration of social sciences, esp. economics
Natural science based on positivist value	Social sciences with inherent contested values	Transdiscplinary practices to resolve divergment viewpoint and values

As a result of this expansion, science-policy interfaces have been made and have been undergoing consequential changes, including on how they engage audiences **(Table 3)**

Table 3: Consequential Change 1: Widening the audience

As it once was...	As it is now...	How practices evolved...
Institutional connection to defined MEA audiences	Choices on who to engage with, for impact on outcomes, given limited resources	• Selection of the most relevant audiences and individuals • Use of "Theories of change"
Environmental policy makers as audience	Key audience is non-environmental policy makers	• Understanding the interests and perspectives of divergent audiences
Key audience is engaged with the environmental problem	Key audiences are primarily concerned with other issues (e.g. human welfare, economic success)	• Engagement of audiences through personal interaction and intermediaries that are part of the audiences' existing trusted networks

The role change also affected how they engage decision-makers at the national and regional level **(Table 4).**

Table 4: Consequential Change 2: Improving the use of evidence in nations and regions

As it once was...	As it is now...	How practices evolved...
Synthesised information for international audiences	Specific information for national, local or sectoral audiences	• Engagement of national, local or sectoral partners or intermediaries to translate science • Giving access to underlying data
Assessments given in large, multi-annual synthesis reports	Synthesis reports complemented by responsive, tailored outputs for audience needs	• The needs of the audience drive and define content and timing of scientific output • External organisations tailor outputs for their specific audiences
Evidence is disseminated	Evidence is used, by being learnt and exchanged	• Science-policy work has greater focus on capacity building and learning

For more information on the evolution of science-policy interfaces, **see Section 5.**

2.3 The science-policy interface is wider than previously perceived

2.3.1 Past concepts of the science-policy interface

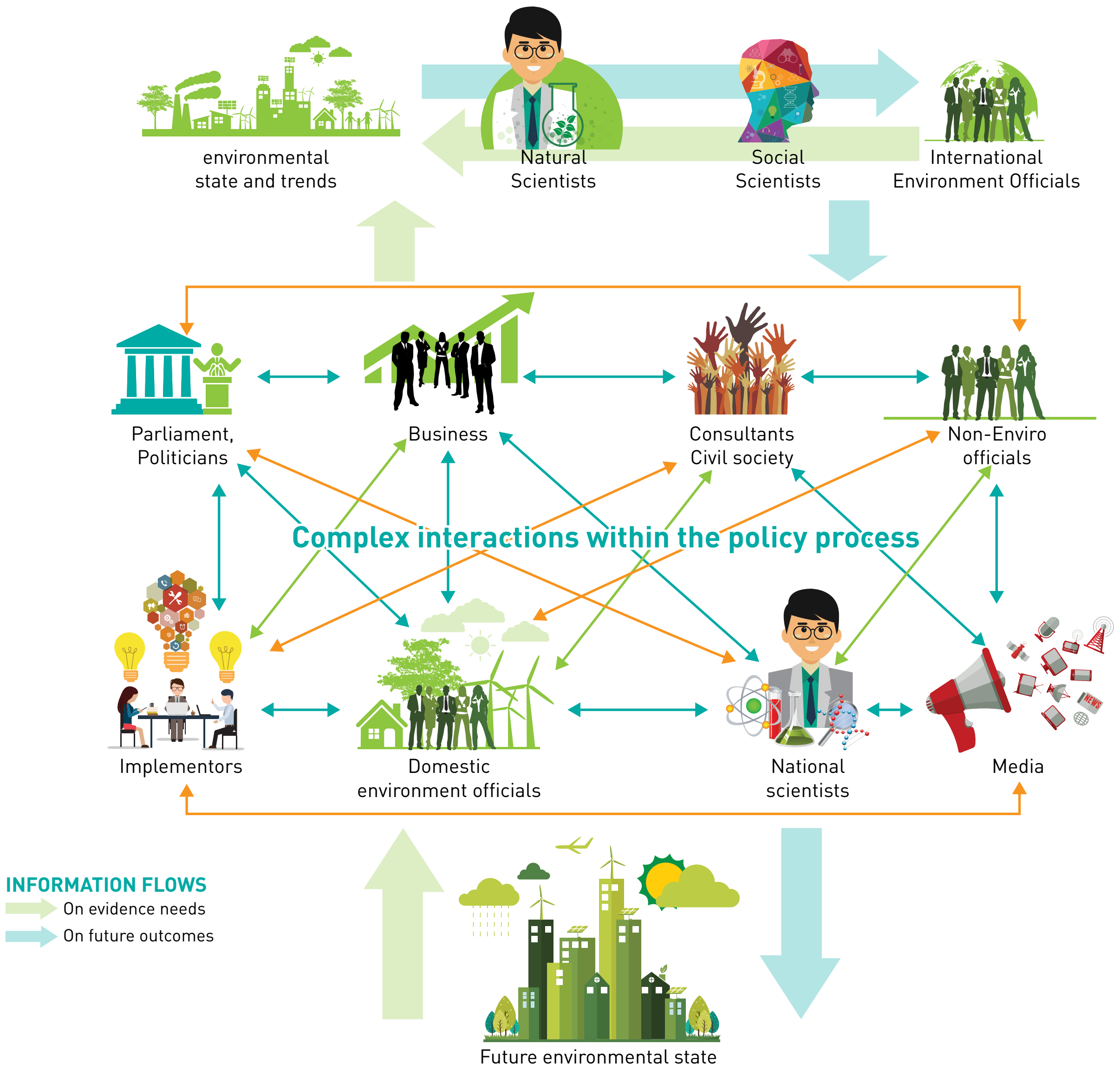
In the past, the science-policy interface was predominantly perceived as an organisation or platform, which enabled scientists to synthesise and present information to decision-makers. **Figure 1** illustrates the past scope of science-policy interfaces:

Figure 1: The past scope of science-policy interfaces

2.3.2 Current concept of the science-policy interface

The science-policy interface is now understood to be much wider and includes many more decision-makers **(Figure 2)**. It engages with the complexities of policy-making as represented by the blue box and is a two-way flow of evidence and information, with the needs and perceptions of decision-makers in one direction, and the potential future outcomes in the other (Wesselink *et al*. 2013).

Figure 2: The science-policy interface includes the wide range of people who could use science to influence the set of decisions that affect future environmental states



The interface consists of evidence and information that flows along one or more pathways of connections between a wide diversity of individuals. The flows of information in decision-making are complex, and the description of a 'chain' of connections is a simplification of an elaborate system.

2.3.3 Actors in the science-policy interface

The actors in an environment-related science-policy interface are individuals, working across a great variety of organisations. They include: scientists, decision-makers in international organisations, scientists in government services, campaigners in non-governmental organisations (NGOs), policy makers in government offices, business leaders, politicians and staff in implementing agencies **(Table 5 below)**.

Many of these may not identify themselves as influencing environmental decision-making. Their interests are often primarily economic, and yet their decisions have a significant influence on environmental state and trends. Indeed, business sector actors including: multinational corporations, state-backed enterprises and international development banks have a greater impact on global environmental outcomes than many public decision-makers[1].

Table 5: Likely key actors in the science-policy interface

Actors	Example
Environmental and physical scientists	Professors of Ecosystem Science
Social scientists: e.g. economists, sociologists	Professors of Climate Change, Economics or Environmental Policy
Scientists involved in applying synthesised information to national, or local issues	Scientists involved in national scientific academies or advisory bodies (See Annex 5)
Government scientific advisors	Chief Scientific Advisors to Prime Ministers, to Foreign Ministries, Environment Ministries
Government officials engaged in international environmental co-operation	Foreign Affairs Official, Environment Ministry
Scientists, policymakers, gender scholars and stakeholders in science systems (Gender Summits 2017) to examine new research evidence from a gender perspective	Gender Summits provide a platform for dialogue on when, why, and how biological differences (sex) and socio-cultural differences (gender) between females and males impact on outcomes
Staff in public science-policy interface organisations (e.g. UN)	United Nations Environment Programme staff, including those engaged with MEAs secretariats

1 In this report, the word 'policy' includes strategic decisions of private actors

Civil society organisations or individuals active on environmental issues	Staff in NGOs with influence on national policy (e.g. Friends of the earth)
Staff in organisations linking the business sector to sustainability policy	Staff in the World Business Council on Sustainable Development, Business and Sustainable Development Commission
Decision-makers in industry with influence on environment or resource use	Directors in food or mining multinationals
Staff in organisations linking science to society and policy: think tanks, private research institutes, consultancies	World Resources Institute, European Climate Foundation, the Ellen MacArthur Foundation, New Climate Economy
Specialist and general media	Guardian International, Solutions Journal
Officials in government working on decisions with significant impacts on the environment	Officials in industry, agriculture, trade, economy, fisheries, planning, natural resources, research, infrastructure or consumer ministries
Parliamentarians and politicians involved in policy decisions	Members of Parliament and their staff
Officials working on implementing policy	Environmental enforcement officers, Statistical officers

2.3.4 Science-policy interface organisations and initiatives are one part of the interface

Science-policy organisations – like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services or even United Nations Environment Programme – are an important part of the science-policy interface. Such organisations have been established to fill previously observed gaps in the science-policy interface. Their activities can, but do not necessarily, span the pathways from scientific observation to decision outcomes.

Examples of activities of these organisations include: a) Multilateral Environmental Agreements Assessments (e.g. scientific assessment activities associated with the work and implementation of Multilateral Environmental Agreements; the Global Ecosystem Assessment, the World Oceans Assessments, and assessments on sand and dust storms) b) Other assessments promoted by United Nations Environment Programme outside the scope of Multilateral Environmental Agreements (e.g. The Emissions Gap report) c) dynamic science-policy platforms (e.g. the International Resource Panel) d) exchange platforms (e.g. the Science-Policy-Business Forum) and e) capacity building initiatives (e.g. International Network of Government Scientific Advisors). The Annexes to this report contain descriptions of some of the scientific boards, institutes and networks that form part of the science-policy interface, particularly in relation to the Multilateral Environmental Agreements.

2.4 Three key elements of an effective science-policy interface

Identifying the key elements of an effective science-policy interface allows for the identification of the internal gaps that act as barriers to such process, and which impact decisions. There are three key elements:

a. Links in the chain: Motivated and capable individuals, able to utilise and exchange evidence and expertise to influence decision outcomes
b. The right evidence: Availability of the appropriate data and expertise
c. Productive exchange: of this evidence between individuals in the pathways

The qualities of each of these elements are discussed briefly over the next 4 pages. For a more detailed analysis on the factors behind effective science-policy interfaces, **see Section 6**.

2.4.1 1st Key Element: Motivated, capable actors and audiences

The first key element of an effective interface is the presence of capable actors who possess the motivation and opportunities to exchange evidence and expertise, and who are able to play a role in influencing decision outcomes.

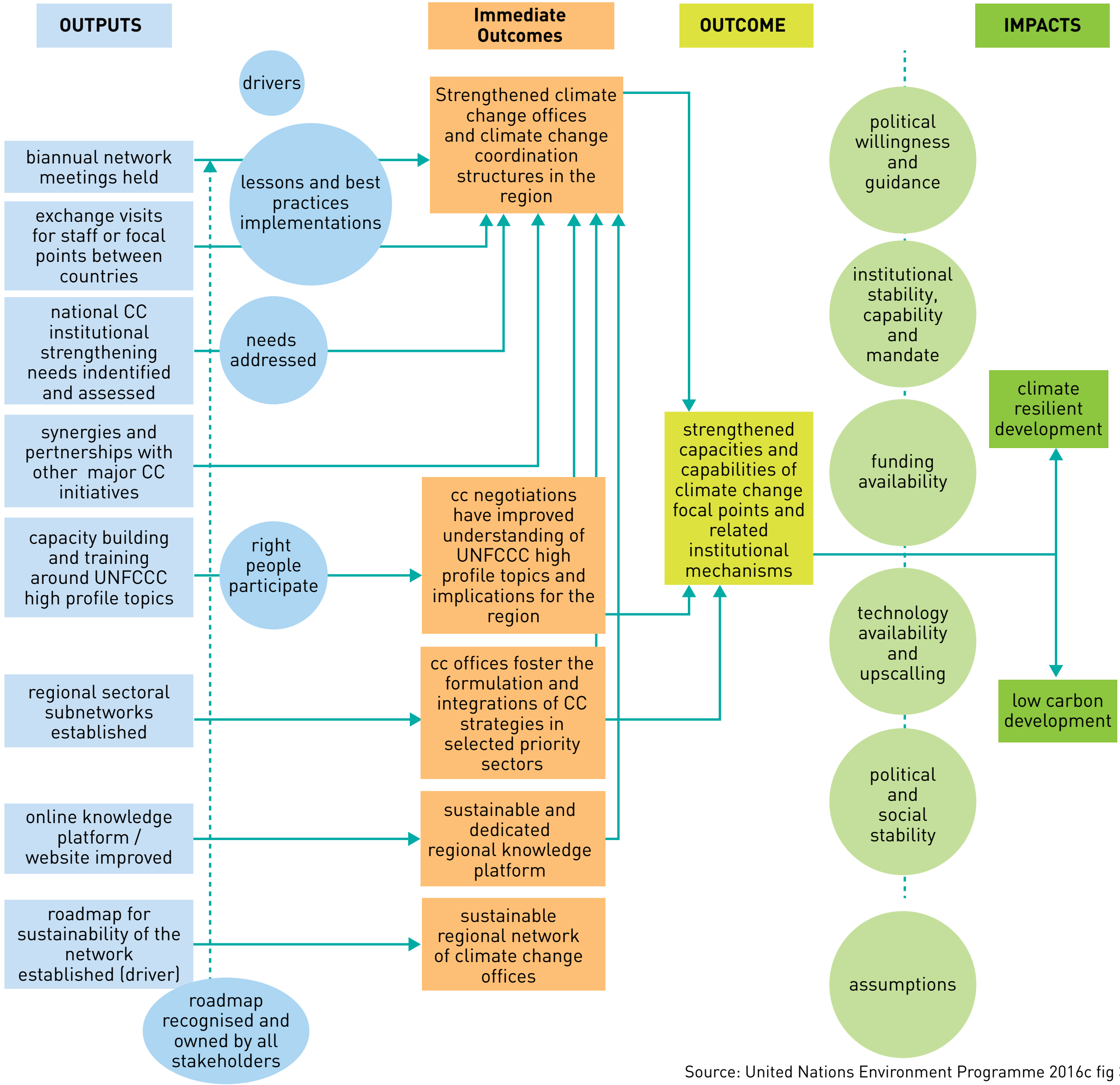
Factor 1: Engaging the actors able to influence decision outcomes

Success in science-policy work is achieved when a connection is made with those individuals and organisations that, in practice, have the ability to influence the outcomes of a policy decision. Given that only finite resources are available for outreach and engagement, this success requires making a careful selection of whom to engage with. These could be the public officials in national ministries or key business players.

Writing on his experience of science-policy work, New Zealand's Chief Scientific Advisor, Peter Gluckman, describes the nature of the policy aspect of the science-policy interface: *"...policy-making is messy. Although a tidy, analytically driven cycle of policy-making might seem logical to scientists trained in the tradition of hypothesis generation and testing, policy-making is instead a networked process in which scientific evidence is only one of many inputs"* (Gluckman 2016 p. 969).

In identifying the right actors, the United Nations Environment Programme's evaluation Office recommends that science-policy organisations plan their engagement strategy and select their actors on the basis of a "Theory of Change". This is a conceptual best estimate of the pathway of actors by which a chain of information exchange may lead to outcomes. **Figure 3** provides such an example. Section 6.4 describes how the "Theory of Change" it is used as a key part of creating outcomes.

Figure 3: An example of a "Theory of Change" for Climate Change capacity building



Source: United Nations Environment Programme 2016c fig 3

The core of a successful approach in this context is displayed by the New Climate Economy. The New Climate Economy is an initiative that provides independent research on the relationship between economic performance and reducing the risk of climate change and it is directed by Helen Mountford, former Deputy Director, Environment Directorate of the Organisation for Economic Cooperation and Development (OECD). The New Climate Economy started by identifying their target audience and specifying those people outside of the groups usually interested in their messages (e.g. economic policy makers), eventually identifying 100 selected organisations. They target existing fora and networks, and engage key stakeholder groups by partnering with them to conduct joint research.

Additionally, specific efforts to involve women must be made; people-smart environmental policies call for gender equality as a driver of change. Existing environmental and gender commitments by governments including in the 2030 Agenda and the UN Framework Convention on Climate Change (UNFCCC), require urgent implementation and follow through (United Nations Environment Programme 2016a). Identifying high-profile gender champions in the science-policy interface is crucial.

Factor 2: Motivated, capable people with opportunity to engage: strong links in the chain

The second necessary factor for a working chain of connections is for each of the actors (from scientists to the people implementing policy) to have:

a. Motivation: Professional incentives or personal values that promote the use of evidence.
b. Capability: Personal capacities and characteristics to interpret and communicate evidence.
c. Opportunity: The opportunity and resources, particularly time, to learn and exchange evidence.

As the scope and nature of the science-policy interface has expanded, assumptions made in respect of these three conditions are often overly optimistic. Solutions-oriented science-policy work aims to incorporate individuals where these are limited (ACCOMPLISSH 2017). For example:

a. Non-environmental officials (e.g. in industry, agriculture ministries) are important decision-makers in the context of environmental outcomes but may not be incentivised by or interested in environmental issues, therefore not motivated to apply the evidence in practice.
b. Politicians and officials in developing country ministries may have had a limited scientific education, making it hard to evaluate, interpret and use evidence.
c. Policy makers with a high workload, receiving a large amount of policy-related information and administrative tasks may not have the time to learn new information or perspectives.

In 2014, the International Network of Government Scientific Advisors (INGSA) was established and its membership now includes the United Nations Environment Programme Chief Scientist and scientific advisors from more than 70 countries. Its aim is to strengthen the science-policy interface across governments worldwide, through exchange and research and specifically to build capacity on both the supply (scientist) and demand (audience) sides of the interface.

Whilst capacity development can be a stand-alone activity, it may also represent a key benefit from certain science-policy activities. Some participants in the development of the Intergovernmental Panel on Climate Change 5th Assessment Report stated that they had greatly benefited from their increased understanding of the science behind the report, its implications and the political context of its use.

2.4.2 2nd Key Element: Availability of the appropriate data and expertise

Availability of timely data linking the state of environment to social objectives

Environmental data needs to play a key role in future decision-making and particularly in efforts to achieve the cross-cutting 2030 Agenda for Sustainable Development. Its importance lies in its ability to explain interactions between the natural environment, human systems and outcomes for key social goals, such as health and prosperity.

There is a fundamental requirement for the availability and accessibility of high quality scientific knowledge, in the form of data and statistics. These are the cornerstone of scientific assessments and ultimately of evidenced and informed policymaking and implementation (A/RES/66/288). The different types of environmental data in question and the need for an effective framework for the data[2] are described in the **Annexe 4**.

A great potential for enhanced environmental data is arising from improvements in computing technology (generating so called "big data"), satellite imagery, remote sensing technology, database integration techniques and statistical modelling. Information and Communications Technology (ICT) can provide and receive much greater public interaction, and links to transactional and citizen data that can result in huge improvements in both scientific knowledge and its understanding.

Use of Lay, Local and Traditional Knowledge

One form of evidence that is often absent in international science-policy work is the unstructured or informal knowledge acquired from lay, local or traditional sources and indigenous peoples (sometimes called endogenous knowledge). These sources can often provide alternative routes towards solutions to environmental problems, routes which would otherwise remain undiscovered. These forms of knowledge are particularly valuable when

2 UN Environment recommends the use of the DPSIR framework

solutions are required within specific cultural and religious contexts. It is also an essential part of facilitating productive exchange with audiences on relevant information needs and assisting in implementation.

2.4.3 3rd Key Element: Productive Exchange

The 3rd key element of an effective science-policy interface is the productive exchange of available evidence between actors. In practice, this is not as easy as is often assumed.

Personal contact is the most productive form of exchange of expertise

Over the last few years, evaluators and researchers have conducted a series of interviews with almost 200 actors or potential recipients of information from some of the major science-policy interface organisations: the Intergovernmental Panel on Climate Change, the United Nations Environment Programme assessment process and the International Resource Panel (Rowe and Toikka 2016).

This research identified that the majority of impacts resulting from these organisations' activities were predicated through personal contacts between scientists and decision-makers (Riousset, Flachsland and Kowarsch 2017), or with other actors involved in decision-making processes (like Non-Governmental Organisations), who then engaged others with scientific evidence and reasoning.

From dissemination to facilitating learning

This supports the conclusions of other research which emphasises that, for science and scientific evidence to have an effect on decision-making it must be productively exchanged between scientists and relevant decision-makers (Riousset, Flachsland and Kowarsch 2017). The availability of knowledge alone is not enough – instead, the promotion of productive exchange can be seen as the underlying rationale of science-policy activity, as compared to scientific research, which constitutes a more linear pathway.

The productive exchange of information entails learning. To be utilised, evidence must first be learnt and understood and facilitating this process usually requires activities beyond simply dissemination.

There are two factors required for productive exchange, given existing and future challenges (Kowarsch *et al*. 2017b:

Success factor 1: Dealing with divergent viewpoints

Exploration of solutions requires an investigation into economic and social drivers and outcomes. The assumptions and values behind these social sciences are more contested than those in the natural sciences. Solutions can also imply distributional effects –producing winners and losers.

Thus, science-policy activity has evolved to engage with divergent views. This encourages the key stakeholders to accept and apply the evidence exchanged. Acceptance relies on the credibility of the science, often won through the peer-review processes. It also involves a process for the creation of evidence that engages stakeholders with multiple viewpoints, to establish legitimacy in the eyes of the actors and amongst a wider audience, and to produce changes in the perspectives or mind-sets of stakeholders, not only their information set (Göpel 2016).

Success factor 2: Collaborative exchange processes, and co-creation of knowledge

Science-policy interfaces have put increasing emphasis and resources into appropriate inter-personal processes that facilitate productive exchanges and learning opportunities. There has been movement away from the 'dissemination' or 'communication' of synthesised science, towards an emphasis on the importance of outcomes resulting from collaborative exchanges between key actors (scientists and decision-makers), as well as joint-learning (or co-creation) of the appropriate knowledge.

For more information on this, **see Section 7.**

2.5 Summary: A model science-policy interface organisation

In summary, an effective science-policy interface exists where:
- sufficient information is available, and
- is being productively exchanged between
- capable, motivated individuals, who
- use it to influence specific decisions affecting environmental outcomes.

Based on experience and practice, an ideal or model science-policy interface organisation would possess each of the characteristics listed below.

Available Evidence

- Relevant data on state and regional trends in the environment are available for use at international, national and regional levels.
- Collection and processing of the data meets statistical norms for quality and comparability.

Capabilities

- Each science-policy interface activity has a clearly defined role to fill identified gaps, and this role matches the capabilities and opportunities of the organisation.
- Strategic choices of activities are based on a "Theory of Change" that identifies the key actors and final audiences in achieving predefined outcomes, with a high level of specificity.
- The most relevant actors are engaged in both the supply (science) and demand (policy making) side.
- This selection includes the direct or indirect participation of major influencers in the selected policy decisions that affect the targeted environmental problem.
- Partnerships are made with intermediaries or 'multiplier' organisations' or individuals who can exchange information with wider groups through existing networks (e.g. business groups).
- Evidence exchange processes are shaped to enhance capacity building for all actors.
- Ongoing impact evaluation activities provide feedback on pathways to impacts, which can refine current and future activities for greater impact.
- Additional activities are programmed to tackle newly identified gaps that are barriers to the success of ongoing work - for instance, activities are designed to boost the capacity of officials in key national and regional governance, whilst improving governance mechanisms and structures.

Productive Exchange

- The planning and scope of scientific research is defined by exploring the needs of the relevant policy-making actors.
- The primary forum of exchange of expertise between actors takes place in and around inter-personal processes. Exchanges focus on participant learning rather than dissemination. It works effectively with divergent viewpoints and value sets to reach accepted common understandings.
- Exchanges are based on explorations of alternative futures and their implications, through scenarios, 'serious games' and visualisations.
- Expertise does not only refer to scientific expertise. It includes experience on the use knowledge in decision-making, and lay, local and traditional knowledge. The processes used for exchange allows for effective trans-disciplinary discussion.
- Expertise is exchanged repeatedly, frequently and in both directions, facilitating learning about the form, content and timing needed to deliver on a "Theory of Change", as well as learning about the scientific basis for decisions.

- Expertise and data used and created in the process is transparent and permanently available for use and 'translation' into information relevant for specific audiences.
- Partnerships are forged with third-party organisations able to 'translate' findings for diverse stakeholder groups, or for national and regional application.
- Information is available digitally and constantly updated based on measured changes in the environment or based on results of environmental policy outcomes. Such assessments would be more likely to meet their audience's needs.
- Wider communication strategies are tailored to specific audiences, recognising the role that science can play in political agenda setting.

This list represents the continued evolution of science-policy activities from "synthesis and dissemination" to "outreach" and finally to "stakeholder engagement and productive exchange" in which the uptake of knowledge is nurtured, rather than evidence being released. This evolution is reflected in recent conclusions from expert discussions:

a. *"Science and technology need to work with society in the co-design and co-production of solution-oriented knowledge and in the process of social innovation. In that endeavour, scientists, decision-makers, policy analysts, the private sector and citizens need to work together closely. Each society can benefit from strengthening its science-policy interface and creating what may be termed a "science advisory ecosystem"*, whereby its scientific and technological community can provide input and advice on public policy issues (E/HLPF/2016/6 p. 7).
b. *"Policy relevance and legitimacy need to be embedded into the science-policy interface, with a geographical and expert balance and an inclusive co-design process…*

…joining forces across national boundaries, promoting a closer interaction between disciplines and across different contexts.

…the science-policy interface needs to develop a range of boundary organisations to support cross-linking and communications between the scientific research and the policy communities (United Nations Environment Programme 2016d).

In practice, existing science-policy interface activities have many, and sometimes all, of these characteristics to varying degrees. Box 1 shows how the ongoing Global Environment Outlook-6 process is responding to these new challenges.

BOX 1: Integrated Environmental Assessments developed under the scope of the Global Environment Outlook process

On 23 October 2014 in Berlin, governments and stakeholders set in motion the sixth edition of the United Nations Environment Programme flagship Global Environment Outlook (GEO-6) assessment. The upcoming GEO-6 global report is being built upon regional assessment processes to create a comprehensive picture of the environmental factors contributing to human well-being, accompanied by an analysis of policies leading to greater attainment of global environmental objectives and goals. The GEO is a consultative, participatory process that builds capacity for conducting integrated environmental assessments and reporting on the state, trends and outlooks of the environment. GEO is also a series of products that informs environmental decision-making and aims to facilitate the interaction between science and policy.

GEO-6 will provide the first integrative baseline in light of global megatrends supported by open access to data, with due consideration given to gender, local and traditional knowledge and cultural dimensions. The assessment will lay the foundation for continued socio-environmental assessments across relevant scales, with a thematic as well as an integrated focus, enabling and informing societal transitions and the tracking of SDG targets and goals as well as previously agreed upon internationally environmental goals. The enhanced policy analysis in GEO-6 will be aimed at assisting Member States to position themselves on the most effective pathways to transition towards a sustainable future.

The rigorous assessment process aims to make GEO products scientifically credible and policy relevant, thus providing information to support environmental management and policy development. GEO also supports multi-stakeholder networking and intra and inter-regional cooperation to identify and assess key priority environmental issues at the regional levels. Some of the integral elements of the GEO include a world-wide network of Collaborating Centre partners; a transparent nomination process that allows governments and other stakeholders to nominate experts to the process; advisory groups to provide guidance on scientific and policy issues such as: the High Level Intergovernmental and Stakeholder Advisory Group; the Scientific Advisory Panel and the Assessment Methodologies, Data and Information Group; and a comprehensive peer review processes.

Using the integrated environmental assessment (IEA) methodology, United Nations Environment Programme has produced five GEO reports so far as well as the first edition of regional assessments, which have analysed environmental state and trends at the global and regional scales, described plausible outlooks for various time frames and formulated policy options.

Each GEO report builds on the assessment findings of its predecessor and draws from lessons learnt.

photo credit: ©Lightspring/shutterstock.com

3. FREQUENTLY OBSERVED GAPS AND POSSIBLE SOLUTIONS

3.1 Every science-policy interface has its gaps

3.1.1 Any gap in a science-policy interface is likely to lead to weak outcomes

Gaps in evidence, either between actors or in the productive exchange of a science-policy interface often mean that desired outcomes are unlikely to be achieved.

Various chains of individuals have the ability to affect each environmental issue with their decisions. The gaps between these differ depending on the nature of the problem, the mandate of each institution and the institution's existing practices, for example between the (relatively specific) pollution-oriented Multilateral Environmental Agreements (e.g. the Stockholm Convention on Persistent Organic Pollutants) and the specific thematic campaigns of UN Enviroment (e.g. the Clean Seas Campaign on marine litter).

Ultimately, there is a wide-range of appropriate science-policy practices across contexts and activities as can be seen in the diversity of scientific advisory bodies linked to Multilateral Environmental Agreements, as described in the Annexes.

3.1.2 Identifying specific gaps

To identify the specific gaps standing in the way of the success of the science-policy activities, an assessment needs to ensure that the needed evidence is available, that each link in the chain is strong (each individual has capabilitiy, opportunity and motivation), and that there is a productive exchange of the evidence.

This assessment needs to be based on an accurate view of which policies are relevant, and which individuals are involved in the chain of connections that influence those decisions. One problem facing science-policy organisations is that they possess little information on how their work actually influences decision-making. The "Theory of Change" they employ sometimes does not identify their intended audiences in sufficient detail to allow evaluations to easily analyse any impact made, and evaluation metrics can weakly reflect actual effects.

Several United Nations Agencies and programmes are currently involved in assessing specific gaps:

- An inventory of Multilateral Environmental Agreements is currently being developed within the context of the work that United Nations Environment Programme is undertaking on data availability in relation to the Sustainable Development Goals indicators (Bueno and Graceffa 2015). Within this research, data has been gathered on the implementation of Multilateral Environmental Agreements' commitments which provide an indication of the strength of science-policy capabilities within states. Example include, reporting on

the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) obligation to establish a scientific authority undertaking research into CITES species, or the Ramsar Convention on Wetlands of International Importance especially as Waterfowls Habitat's obligation to maintain a national inventory of wetlands.
- United Nations Environment Programme has conducted work to identify gaps in the available statistics to inform indicators of the Sustainable Development Goals, and to guide ongoing statistical work to fill said gaps (See Annex 4).
- Among the various advisory groups established under the Global Environment Outlook-6 process, the Assessment Methodologies, Data and Information Working Group has formed task forces to examine environmental data and information gaps, as well as innovative methods for improving environmental assessments. Inputs from the group will facilitate the development of a set of revised international integrated assessment guidelines and support the development of the data and information gap analysis report.
- The United Nations Environment Programme Evaluation Office has recently published its latest 'lessons learnt' document, summarising gaps and barriers identified in its activities and programmes (United Nations Environment Programme 2016d).
- The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has started an internal review process to identify lessons learned from its first years of operation, to find where and how it can more effectively fill the gaps.

Recurring gaps and barriers have been observed across a wide range of science-policy work carried out at all levels. Recent evaluations of science-policy work and reflections from those people working within it (e.g. the The future of global environmental assessment-making project) provide indications as to the nature of frequently occuring gaps.

The following section describes what these gaps are and analyses their reasons for these being present.

3.2 Frequently observed gaps in available evidence

3.2.1 Gaps in monitoring data

Gaps persist in the access, availability and quality of environmental data. Insufficient resources are devoted to harmonising the work of different institutions involved in enriching the statistical capacity of countries. An evidence base of verified and commonly accepted knowledge (whether scientific research, practitioners' expertise or lay, local or traditional knowledge) is often incomplete.

This is illustrated by Achim Steiner's statement in Global Environmental Outlook-5. *"Out of 90 goals and objectives assessed, significant progress could only be shown for four. Of equal concern, progress could not be appraised for 14 goals and objectives, simply because data were lacking* (United Nations Environment Programme 2012 xvii).

Data availability varies significantly between issue and areas. Data acquisition and monitoring often face:

a. Limited financial resources for data collection and monitoring programmes. For instance, the first air quality monitoring station in Africa was only set up in 2015 (with United Nations Environment Programme in Nairobi), despite knowledge of the health impacts of air pollution.
b. Fragmentation where good environmental data may technically be available, but is provided by a large number of different scientific actors in different locations and who may use different methodologies. Both of these create a practical challenge for data synthesis.

The solution is greater investment, but cultural and institutional barriers will also need to be overcome.

3.2.2 Gaps in the production of statistics

A related gap in this context is the continued weakness of environmental statistics, and particularly the timely information linking human systems (economic and social development) and the environment. Good statistical work is often hampered by cultural barriers at the national level, and divergent methods and formats, including a lack of clear explanations on how the data has been collected. Results collected by MEASURE Evaluation in 2010 cite how several developing countries *"experienced missed opportunities to use data in decision-making because staff lacked the skills to produce high-quality, reliable data"* (MEASURE Evaluation 2010).

Transforming national statistical systems requires the building of new capacity, investment in statistical infrastructure and adapting the ways in which statistical offices operate. Improving and implementing existing international standards, methodologies, definitions, and ontologies, as well as guidance on compiling and disseminating environmental statistics and Sustainable Development Goals, forms the foundation for building national capacity in this respect.

For instance, in the State of Qatar environment statistics are still in their infancy, even if they have been officially integrated into the National Statistical System. A section on Environment Statistics was included in a report by the Qatar Statistics Authority in May 2012 (Qatar, General Secretariat for Development Planning 2011).

There has been a growing awareness of the need for more holistic national statistical systems, which integrate environmental statistics into the larger sphere of official national statistical reporting and gathering. The adoption of both the System of Environmental-Economic Accounting (SEEA) by the United Nations Statistics Division (UNSD) and the 80 environment-related Sustainable Development Goal indicators set in 2016 (E/CN.3/2016/2/Rev.1) constitute a clear example of this need.

Standardisation can help, and can also apply to data quality protocols. This is particularly important in realising the potential of big data or citizen science. There may be potential for further cooperation among various scientific bodies, such as the Liaison Group of Biodiversity-related Conventions (United Nations Environment Programme 2016f).

3.2.3 Missing lay, local and traditional knowledge

Incorporating societal and cultural issues into scientific and technological research represents another significant gap. The inclusion of non-scientific or unstructured 'informal' expertise and knowledge can account for a large part of the knowledge gap. It often offers a way to address an issue that would otherwise not be feasible within specific societal settings. As a solution, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has designed a process to fill this gap – creating a specific mechanism for inclusion of reliable lay, local and traditional knowledge – called the Indigenous and Local Knowledge Taskforce, which promotes effective engagement with indigenous and local knowledge holders in all aspects of its work.

3.3 Frequently observed gaps in effective exchange of expertise

There are frequently observed gaps or failures in the way knowledge passes between actors in the science-policy interface, particularly with those decision-makers that are not actively involved in environmental issues, but whose decisions have serious effects on the natural environment.
This challenge is reflected in a project investigating effective knowledge exchange, which asks the question related to the use of:

- the right information,
- for the right people,
- in the right form,
- through the right channel and
- at the right moment" (Interact Programme 2016).

Three reported gaps exist in this exchange, all of which relate to how individuals filter and acquire new information

3.3.1 Knowledge is not picked-up – problems with timing and messengers

Knowledge produced and disseminated in science-policy work is often not applied, either because it does not reach its intended audience at the right time, or because is not disseminated through a person or source that they trust. The internet is a vast, labyrinthine repository of all existing published documents; it is understandable that most decision-makers, even those looking for specific information, will not find such information independently. Networks, personal connections and trusted local providers of thematic information bring knowledge to decision-makers' attention. The credibility of this evidence-based information is closely related to the reputation or relationship of the network or connection, as well as the reputation of the scientists or organisation producing that information (Oliver *et al*. 2014).

Yet, all too often the outcomes of international assessment processes (those not linked to specific Multilateral Environmental Agreements) produce assessments that are not appropriately timed to address policy processes, and are sometimes not widely distributed through trusted networks.

Additionally, many assessments are largely based on literature reviews of previous peer-reviewed assessments. At the time of their delivery, the knowledge may already be outdated for application to policy.

3.3.2 Knowledge is not accepted – problems managing divergent viewpoints

The continued rejection of climate science by various communities is a disturbing illustration of how inconvenient knowledge, which does not fit well with s and individual's existing viewpoints, is often not accepted. This is an example of the difficulties faced in dealing effectively with divergent viewpoints.

Science-policy activity now increasingly seeks to present solutions to those policymakers whose decisions affect the environment (e.g. in industry or agriculture ministries) but whose viewpoints do not correspond to this impact. That better presentation of evidence will change these policymakers' decisions is the ultimate objective of environmental science-policy activity.

However, the acceptance of this evidence relies on the effective management of divergent viewpoints, so that knowledge is consistently accepted and applied. Transparent inclusion of a wide-range of viewpoints within the evidence-gathering process is necessary to legitimise the evidence acquired.

One example of an effective process in this respect is the negotiation and agreement of the Summary for Policy Makers of the Intergovernmental Panel on Climate Change's 5th Assessment, where representatives of the many nations involved collaborated in discussing and negotiating the wording of the conclusions. As a result, the Summary for Policy Makers required no further negotiations during the United Nations Framework Convention on Climate Change process.

For more information on strategies for dealing with divergent viewpoints, **see Section 8.**

3.3.3 Knowledge does not fit needs – problems with relevance, content and the form of outputs

International science-policy work very often synthesises science at a global or regional level, which feeds into discussions concerning Multilateral Environmental Agreements (e.g. the Stockholm Convention on Persistent Organic Pollutants). Even if the focus of science-policy activity moves towards presenting solutions and their implications, these global syntheses are often not directly applicable to national or regional decision-making. In addition, the underlying data is often not transparently included in the published outputs.

For those decision makers that possess the capacity to affect environmental outcomes, but who are not primarily invested in environmental issues, the environmental focus and framing of science-policy interface outputs often makes the information less salient, creating a rift between the competing interests of the policy and scientific communities. Additionally, few policy makers have the motivation to interpret information from often esoteric scientific documents. The language of scientific assessments is often criticised for its lack of clarity and the difficulty with which it is understood by those without a scientific background. The form of outputs does not always meet the needs of its intended users and this has led actors in international science-policy interfaces to criticise the assessment reports as an inappropriate tool for this communication (Carraro *et al*. 2015).

There are many examples of the effective presentation of evidence, in ways that captivate decision-makers, and provide their audiences with accessible pieces of information (e.g. infographics or short videos), which they can then pass on to their networks, or use in discussion. For example:

a. The Intergovernmental Panel for Climate Change partners with the European Climate Foundation to acquire strategic excellence in communication strategies. Recognising that impact is related to very diverse political sensitivities (and conditions) in different regions, they use expertise from a network of individuals in key countries who reframe the Intergovernmental Panel on Climate Change's messages for national and regional audiences, and political processes.
b. To enhance the understanding of the North Sea's potential to delivery renewable energy with economic success, the Urban Futures Studio gathered groups of high-level actors – including 28 Ministers, and numerous business Chief Executive Officers around large-scale visualisations of potential developments of the North Sea's energy potential, with the aim of creating coalitions for action around shared visions of the future (Utrecht University 2017).

c. Given the wide diversity in its audience groups, United Nations Environment Programme's Asia Pacific Office produces tailored policy briefs for different, selected audiences on Sustainable Consumption and Production (SCP). It runs a series of 100 tweets, and 20 info-graphics and short videos which are based on an initial report, utilising external expertise (Carbon Visuals 2015).

3.4 Frequently observed gaps in capacities and motivation

3.4.1 Capabilities, motivations and resources of scientists

Academic incentives are weakly aligned with science-policy interface activity
Leading scientists are essential actors in science-policy activity. The quality, content and uptake of evidence are fully reliant on their input, which is usually given without any direct financial reward.

The remuneration of academic scientists is often aligned with the publication of papers, rather than with participation in science-policy activities. This often limits the resources that are available for engaging with policy makers and other actors in multi-stakeholder processes. The incentive to publish in thematic journals can encourage academic actors to align the outputs of science-policy interface activities with their ongoing research for publication, limiting their motivation to engage in trans-disciplinary multi-stakeholder processes.

One solution is for national and international funders of academic work to increasingly align funding with evaluations of impact on societal goals, rather than publication. The United Kingdom's Research Excellence Framework, which serves as the basis for future research funding has recently included impact as an essential component of excellence in its evaluation (Stevens, Dean and Wykes 2013).

Scientists' capabilities to deal with divergent viewpoints

As science-policy interface activities evolve, the skill set required by scientists is also expanding. There is now a much greater need for scientists to be able to engage with divergent viewpoints—emanating from the range of actors and disciplines present in the interface.

To enable science-policy platforms to deal with these divergent views, greater emphasis has been placed on widening the participation from developing countries, indigenous communities (where possible) and women, in recognition of the different viewpoints they can contribute.

This need is reflected by the capabilities of science advisors identified as beneficial in the Global Network of Science and Technology Advice to Foreign Ministries. This list identifies: a) Science and Technology capacity:

knowledge broker vs advocate, interdisciplinary skills b) diplomatic capacity: communication skills, public understanding and bravery and c) personal capacity: emotional intelligence, good listener and teacher (Arimoto *et al*. 2017).

3.4.2 Motivations, resources and capabilities of policy makers and implementing officials

Policy decision-makers are the essential bridge between research, policy implementation, effective governance, political structures and their outcomes. However, in many countries, organisational cultures or decision-making processes do not value evidence for its contribution to debate. Where policy or implementation decisions are usually made on the basis of informal evidence or opinion, there can be little direct reward for policy makers that try to engage with science and introduce it into decision-making. This acts as a significant barrier to the achievement of positive environmental outcomes.

As policy makers play a front-line role in the integration of evidence into successful policy implementation, they must have the relevant personal expertise and resources. This usually requires them to undertake some scientific training, enabling them to interpret, learn and communicate evidence. Yet in the United States it has been estimated that less than 2% of Congress in 2011 had a professional background in science (Otto 2011).

Equally, it increasingly requires a deep understanding of how to work effectively with the divergent viewpoints of non-environmental policymakers, and expertise in facilitating cross-departmental policy co-operation. This expertise is often not fully present in science-policy work. Personal capabilities of officials including their networks with national scientists and scientific advisors can help to provide access to the interpretation of data that is needed to apply scientific knowledge.

One solution is the designing of a science-policy interface that builds the capacity of actors. The knowledge gained includes the perspectives of other governments, and participation in science-policy work should also generate relevant relationships and access to networks.

Several countries have taken significant steps to support the strengthening of national science-policy interfaces. The Government of Japan recently created the position of Science Adviser to the Minister for Foreign Affairs, whilst China has also initiated major science policy efforts aimed at building the social responsibility of scientists, and a social culture of innovation and experimentation.

In this context, The International Network for Government Science Advice, established in 2014, aims to strengthen the science-policy interface across governments worldwide, through the transformation of exchange and research between these advisors into effective actions to fill identified gaps.

Some countries and regions, and OECD countries in particular, have started to create institutional decision-making processes that promote the use of evidence. This is termed Evidence Informed Policy Making. In some states in the United States, this development has been enshrined in laws as a top down approach to promote evidence-based decision-making, including the ranking of funded programmes by their perceived effectiveness (see Section 5.4.1).

3.4.3 Resources, motivations and capabilities of managers of science-policy interface organisations

Most science-policy work is jointly steered and managed by chairpersons supported by skillful teams within international secretariats. Many of these leaders and staff have proved remarkably successful in their abilities to innovate and adapt science-policy practices to meet the new challenges of their work.

Yet, the adaptation of science-policy interface activities moves at different paces in different organisations. There are several reasons for why existing practices may continue, even where alternative pratices have proven to be more effective.

Inertia in organisational practices is a natural product of existing patterns in respect of mandates, funding structures, participant mix, skill sets, networks and decision-making processes within the platforms and organisations carrying out science-policy activities. For instance:

- Changes in science-policy interfaces often require consensus demanding wide understanding of the challenges facing organisations, and the motivation to change. Often, decisions achieve the 'lowest common denominator' that can be reached – incremental change. For example, in the Multilateral Environmental Agreements, rules of procedure of the Conference of the Parties define the decision-making processes of their bodies, and in some instances, consensus-based decision-making is the rule.
- Staff in science-policy interfaces brings their own professional and personal experiences with their skills and networks often naturally based around existing practices. Staff are usually (more than) fully occupied with existing processes for the production of outputs. Therefore, they may not have the networks, experience or time resources to lead an evolution to new practices. Without access to wider networks (for example in business or lay, local and traditional knowledge) they face significant hurdles, even if possessing the requisite funding and motivation.

Solutions to this gap have been identified in the development of partnerships with external organisations that can provide existing specialist expertise, from which staff can learn as they participate in the processes.

3.5 Why gaps still exist – barriers to evolution in practice

There are several gaps in the operational side of the science-policy interface. In many situations the solutions to fill the gaps have already been identified. However, these gaps are not being filled by changes in the practice of science-policy organisations. Rather, they are being filled by the business side.

This point is illustrated by a document produced by the United Nations Environment Programme Evaluation Office, entitled 'Lessons Learnt' for 2013 and for 2015 (United Nations Environment Programme 2014c; United Nations Environment Programme 2016d). Both summarise the results of evaluations in preceding years. In both, the lessons described are remarkably similar, which may indicate that they have not been yet applied. This is due in part to the efforts required to institute new practices in any organisation.

As it has been recognised, there are strong and varying reasons behind the sometimes slow evolution of effective science-policy interfaces. The steps that have been taken to remove barriers to inhibiting this change (and gap filing) have been increasingly aimed at changing institutions, processes or capabilities, all of which relate to governance challenges.

Integrating a scientific and technical culture into decision-making processes and governance structures is not an easy process. In the case of Morocco, for example, the history of the expansion of a scientific and technical culture is very recent. This is strongly related to a program designed to promote scientific and technical culture introduced in late 2004 by the French Ministry of Foreign and European Affairs (Mikou and Bensalah 2012).

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4. POSSIBLE STEPS TO FILL GAPS

4.1 Practical steps to achieve future goals

4.1.1 Future Goals

To meet the goals and manage the challenges ahead, science-policy interfaces will need to continue to evolve and at a much faster rate.

Achieving the ambitious goals under the 2030 Agenda for Sustainable Development will not be an easy task. Looking at this task from only one angle - United Nations Conference Trade and Development (UNCTAD) has estimated the need to mobilize 3.3-4.5 trillion US dollars a year to achieve the 17 Sustainable Development Goals in developing countries, with a current financing gap estimated at 2.5 trillion US dollars a year (United Nations Conference on Trade and Development 2014). These needs can only be met through the concerted efforts of governments, international organisations and through the establishment of partnerships with the business sector. The science-policy interface has a key role to play in stimulating the release of this extra financing by illustrating feasible alternative scenarios based on improved empirical evidence, its access and use.

4.1.2 Improving governance within the science-policy interface

Filling the gaps will require changes, which put into practice the lessons learnt from past experience. The diffusion of the knowledge of more effective practices is a relatively minor aspect of this challenge.

The current concept of an effective science-policy interface reflects a productive, two-way flow of evidence and expertise along a chain of individuals (within organisations).

These steps are most clearly reflected as improvements in governance, which change the organisation and conditions under which people work. Thus, they also have an effect on the opportunities, resources, incentives and capabilities of individuals. Those who inform these changes can be:
- Funders;
- Chairs and managers of science-policy processes and platforms; and
- Each individual participant in those processes.

There are 10 steps which can be taken to make science-policy interface activities more effective and efficient at achieving outcomes. These entail:
- One step to build your own capacity to identify and fill the gaps
- One step to build the right partnership

- Two steps to increase available evidence
- Three steps to increase capacity, opportunity and motivation of other actors
- Three steps to encourage the productive exchange of evidence and expertise.

These steps are mutually re-enforcing. Taking individual steps may not be sufficient (e.g. a funding allocation for co-creation processes is futile in the absence of a facility to manage it).

4.2 One step to build your own capacity to fill gaps

Step 1. Build your own organisation's capacity and understanding of the science-policy interface

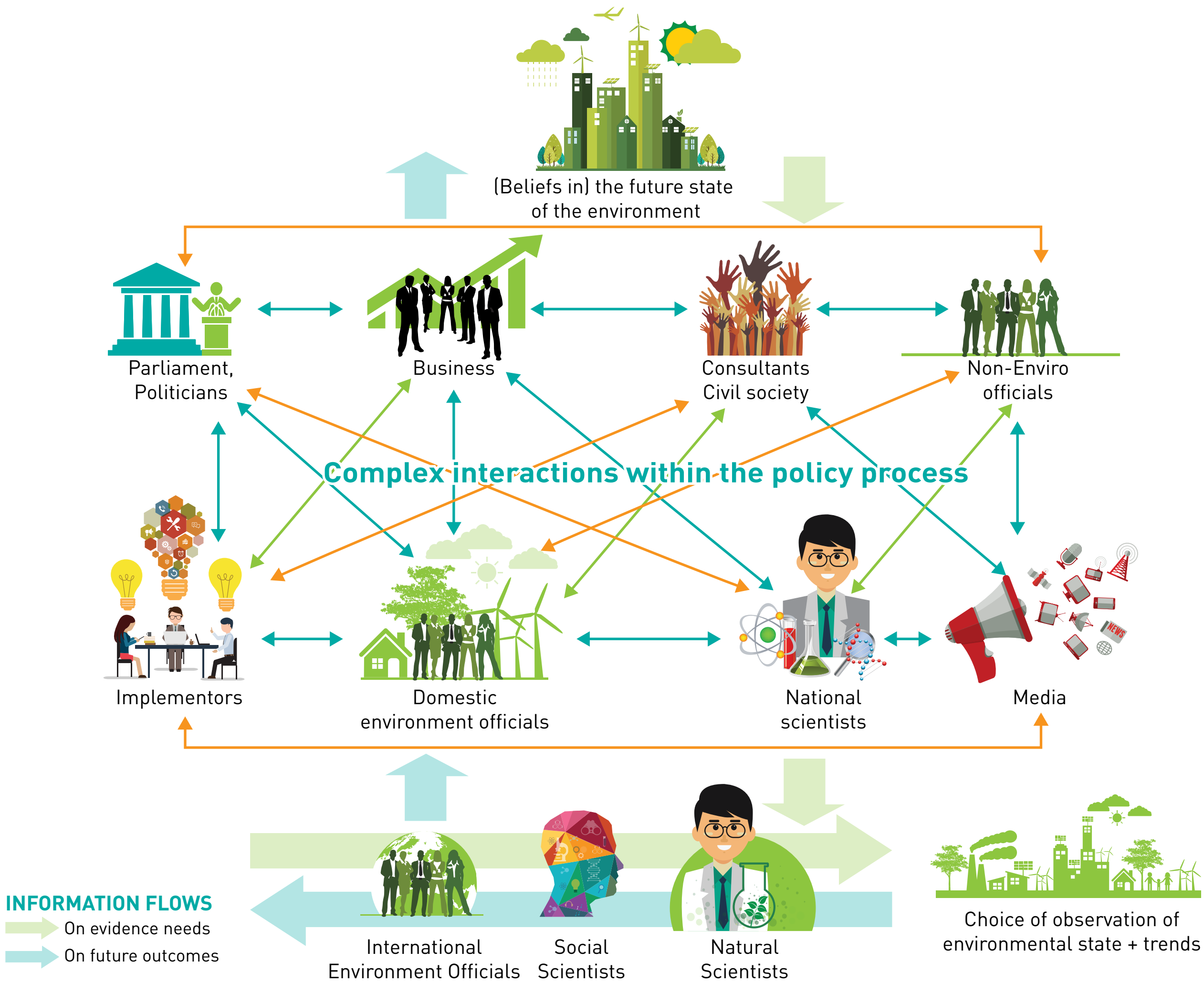
The steps to fill the gaps are based on an understanding or a set of assumptions with respect to the identity of other actors in the chain.

1.1 Understand the key actors in your science-policy interface

To create a sound basis for any decision on science-policy work, begin by increasing your organisation's capacity to think strategically about the key actors in the interface, the gaps and how to fill these. This will determine whether gaps in the interface can be filled effectively.

Your organisation's collective knowledge of decision-making is as important as scientific evidence for achieving outcomes. Similarly shown in **Figure 4** below is a representation of the science-policy interface, but with the 2-way flow of information shown from right-to-left. An effective science-policy interface relies as much on the effective flow of evidence and expertise on decision-makers' needs, as it does on evidence flowing to decision-makers.

Figure 4: The science-policy interface is based on a flow of information on knowledge needs



In practice, the best sources of this information are the policy makers involved in decisions-making processes. This information can be used to build up a "Theory of Change", which involves an iterative exchange with actors in a science-policy interface.

1.2 Check allocation and sufficiency of resources

Pick the gaps your organisation aims to fill and match the capacity of your own organisation with the challenges to fill those gaps.

Few science-policy activities have sufficient resources to tackle all of the global gaps for national or regional decision-making. To be effective with limited resources, science-policy activities must have a clear scope in relation to a predefined set of policy processes.

There is an inevitable trade-off between the volume of evidence-based output produced and the depth of productive exchange around that evidence. This presents a choice that must be made at the start of project planning.

1.3 Dedicate resources to adapting to the new challenges

The pace of learning and improvement in science-policy interfaces is related to the attention and resources given to improving existing practices, which are often difficult to change. This can include steps such as:

i. **Scheduling time and resources for adaptive processes** that pick-up lessons from past evaluations to reshape organisational decision-making processes and resources. Process debates can often draw on extensive expertise from other actors, and may be shaped to give opportunities to learn from actors closer to the final decision-making end of the policy development process.

   For example, to meet upcoming challenges, the International Resource Panel has worked with an external partner, Systemiq, on a new strategy for 2018-2021. The draft strategy under discussion includes: identification of high-impact priority work, changes to Scientific Panel and Steering Committee composition and an external partnership strategy.

   Discussions should contain lessons from the evaluation of the work of other, similar organisations, for example those summarised by the UN Evaluation Office's 'Lessons Learnt' framework, or the United Nations Environment Programme Guidelines for Integrated Environment Assessment (IEA), which build on previous practices to recommend that a high-quality Integrated Environmental Assessment should follow a multi-scalar and multidisciplinary stakeholder assessment process.

ii. **Re-shape project evaluations** to deliver reviews of assumptions about paths to impact outcomes, so that they can be used to develop "Theories of change", and shape future work. This implies shifting the focus of evaluation from metrics that are weakly-related to outcomes (e.g. academic citations or citation in a

policy document) to more direct metrics – particularly interview contact communication with samples of the intended audience. The evaluation exercise then becomes part of the flow of information from decision makers on their information needs and context, and also makes this flow more accessible to decision makers, who are not always well-versed in contemporary theory.
This approach has now been adopted for some international work, and by various countries and regions (e.g. Australia and the European Union).[3]

Regular dialogue between policy makers and scientists during the entire life cycle of the process is a form of evaluation feedback. This is a way to jointly test the assumptions behind the "Theory of Change" used in project planning, and can improve integration between science and policy.

4.3 One step to build the right partnership

Step 2: Build partnership to increase capacity to act

To build your organisation's capacity to expand the number, depth and scope of funded partnerships with external science-policy organisations, the following aspects of partnerships can be useful:

a. Gain immediate access to needed thematic, geographic or sectoral expertise and networks that facilitate connection to relevant actors.
b. Deliver capacity building to other interface actors, including officials, staff and scientists, who can learn new practices whilst working with external expertise.
c. Provide a means by which global science-policy activities such as the International Environmental Assessments, can inform the strategic planning of several countries on specific thematic topics (e.g. energy, water resources, forestry).

Science-policy interface partnerships have already been created with organisations like the national science academies advising government, civil society organisations with similar goals (e.g. European Climate Foundation or New Climate Economy) or think-tanks active on policy agendas (e.g. World Conservation Monitoring Centre, World Resources Institute). The International Resource Panel is currently developing a whole new partnership strategy which prioritises future engagement with external organisations for impact, including: United Nations bodies, other Science-Policy Interface organisations, Regional Political Platforms, Development Banks, Academic Networks and Research Institutions, civil society, the business sector and Economic Political Platforms (e.g. the World Economic Forum).

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3 The European Commissions' scientific advisory body's evaluation framework, used for the first time in 2014, which explicitly asks for the specific policy audiences, the policies on which impact was sought and the way in which the science impacted on the policy. The Australian National Audit office now analyses early planning of policy implementation to consider where data and science have been used to assist the process

4.4 Two steps to fill gaps in available evidence

Step 3: Increased Monitoring and Reporting

3.1 Greater investment in gathering and reporting of data is at the foundation of a better science-policy interface. The value of this data lies not in its use for reporting on Multilateral Environmental Agreements and other internationally agreed goals, but on ways in which it can communicate issues directly affecting key social interests (e.g. the link between air quality and health. First priority could be given to these areas). Collection of gender-disaggregated data is crucial in revealing important information on environmental management and usage, which is especially relevant in policy formulation (United Nations Environment Programme 2016a p. 8).

3.2 Fund long-term environmental monitoring to deliver reliable trend data. This is particularly important to stimulate solutions, particularly for the Sustainable Development Goals. Trend data can help deliver 'evergreen assessments' – the production of frequently updated, in-time data sets for nations and regional levels, which can be used directly by local decision-makers.

Action by international funders is needed to complement national and local resources, particularly in developing countries.

Step 4: Building statistical capacities

4.1 Enhance the pace of increased national and global statistical capacity through increased investment and capacity building in statistical offices and practices. This could facilitate the production of timely country and global statistics that can (like economic statistics) inform and stimulate policy debates on key issues for human and ecological welfare – health, resource availability, productivity and future planning.

4.2 Standardise methodology in data collection and data validation, allowing greater comparability of data across countries or localities in ways that trigger policy debate and greater transparency and trust in data. Comparability can help realise the benefits of online access to other geographic area data.
Implementation of data-validity checks can also help to harvest the benefits of big-data and citizen science. Increased capacity can reduce the fragmentation of practice between agencies and alleviate any concerns about confidentiality.

4.5 Three steps to increase the capacity, opportunity and motivation of other actors

Step 5: Change the conditions and capacities of academic scientific actors

5.1 Increase the professional rewards for scientists working in science-policy fields while helping to align the incentives of academia with the needs of science-policy interface work.
Changes to national and international funding, professional success metrics and peer recognition could

increase the motivation of academics as well as the resources available for two-way exchange of expertise. Options for changes include: explicit funding for participation in exchange processes, or increased impact metrics within funding evaluations (as in the United Kingdom's Research Excellence Framework) linked to research evaluation (Stevens, Dean and Wykes 2013).

5.2 Build the capacity of scientists to engage effectively in trans-disciplinary science-policy processes. This implies developing a multi-faceted skill-set. For example, The American Association for the Advancement of Science (AAAS) is strongly encouraging scientists to engage with policy making through job rotations, dual appointments and liaison units. Additionally, engaging both female and male scientists is crucial in generating more effective policies. Whilst reducing the gender gap in the science-policy interface. "According to the latest U.S. census, only 1 in 7 women with a degree in STEM actually work in that area". Various barriers to women entering STEM jobs were identified including 'information failures' and 'institutional factors' (Munoz-Boudet 2017).

Step 6: Build capacities and incentives for ministry officials and government agencies

This can be accomplished in several ways, including:

6.1 Promotion of institutional change in Evidence-Based Policy Making in nations and regions, to give more incentive to apply evidence in policy. For instance, exchange on the use of legislation as a top down approach to promote evidence-based decision-making, or ranking funded programmes by their effectiveness (as used in some parts of the United States: see Section 4.3.1).

6.2 Expand the work of exchange and capacity building networks, like the International Network of Government Scientific Advisors, and the Foreign Ministers' Science and Technology Advisor Network, through additional resource mobilisation and participation.

Step 7: Smart design of participatory processes to increase capacity of participants

Design participatory processes in science-policy interfaces in ways that increase the learning opportunities for all actors. This includes, for example, the processes for assessments (such as the Intergovernmental Panel for Climate Change and United Nations Environment Programme's Global Environment Outlook) to increase the benefits of capacity building.

4.6 Three steps to encourage the productive exchange of evidence and expertise

Step 8: Re-designing processes for improved productive exchange

Re-designing the processes for science-policy interfaces can help match activities to the gaps in the productive exchange of evidence. This can match a research focus, for example of Integrated Environmental Assessments (and the science that underpins them) to what will be needed to answer environmental problems.

8.1 Plan activities based around decision-makers' needs at the very beginning of any science-policy work. This must be based on the identification of which policy decisions are intended to be influenced. Relevant decision-makers or (intermediaries) can be identified, and their needs can be explored directly. 'Co-design' is a key manifestation of this, on which there is a significant focus on the practices of many inclusive policy-development arena.

8.2 From 'dissemination' and 'outreach' to resource mobilisation and productive exchange. Focusing on science-policy activities to promote productive exchange and learning, rather than dissemination helps in dealing with challenge of engaging diverse actors with divergent viewpoints. Relevant processes for encapsulating diverging viewpoints can legitimise evidence as a product of multi-stakeholder processes (as seen in the government-negotiated outcomes of the Intergovernmental Panel for Climate Change's Summary for Policy Makers).

Forms of stakeholder engagement that can deal with complexity and cross-cutting issues can promote knowledge uptake on questions that arise when solutions are discussed. Different forms of exchange and learning can be used in different contexts which include scenario creation, serious applied games and visualisations of conceptual models.

Information transfer through these platforms and processes can be tailored so that exchange of key messages takes place at the appropriate time through networks or to individuals whom they trust. This should eventually increase the uptake of expertise.

One example of recent practices in this area includes the first Multi-Stakeholder Forum on Science and Technology for Innovation for the Sustainable Development Goals. Held in May 2016, it had 600+ actors from 81 Governments and more than 350 scientists, innovators, technology specialists, entrepreneurs and civil society representatives. The forum experimented with ways to promote networking and matchmaking.

8.3 Developing written outputs that fit actors' needs (including the intended audiences'). This is likely to imply changes to the form and content of written outputs, based on the needs of decision-making actors. Where evidence is designed to be passed along the chain to decision-makers by intermediaries, the form of output should match this application. Evidence is often more easily understood and passed on to others as visualisations, infographics, slides, short videos and key summarised points.

The content of outputs can be written in less-technical language with key messages linked to the interests of the decision-makers, and can be tailored to specific audience groups, based on their interests and needs.

Step 9. **Ensure secure financial and structural resources for exchange activities**

Key science-policy activities, including assessment processes should be placed on secure financial and structural footing to ensure that they can adapt to meet future challenges. Secure, adequate, long-term funding is needed to allow for proper planning of wider, repeated stakeholder engagement and to meet the increased technical and organisational support needs of these trans-disciplinary processes.

Step 10: **Increasing transparency, open-access and review processes**

To increase the use of evidence, two additional aspects are needed:

10.1 **Increasing the transparency of the data** behind the key messages of evidence can make activities more credible, and further the use of the data gathered, including for national or regional application. This can be useful for Multilateral Environmental Agreements data, which could follow the example of the United Nations Framework Convention on Climate Change and Ozone Secretariat processes that provides open access to their data.

10.2 **Establish transparency and trust through review processes** where needed. This can increase the legitimacy of evidence and reduce the chances of controversy and rejection. Review processes can illuminate potentially controversial value-judgements behind research, or point out methodological weaknesses or gaps before solutions are proposed. This will benefit all science-policy activity, not only the major Integrated Environmental Assessments and Multilateral Environmental Agreements processes.

4.7 Summary

These 10 suggested steps, grouped in five main categories, can be summarized more briefly

Step 1: Build your own understanding of gaps and capacities
• Seek to understand the links in the chains by which evidence could impact chosen environmental outcomes, determining which policy processes are relevant, who are the key players in those policy processes, what are their current viewpoints and their evidence requirements. Build a more specific sketch of the pathways to impact or "Theory of Change" for each intervention. • Understand what information is missing from these pathways to impact and from whom and how it can be obtained. Learn through feedback from existing activities – with improved use of impact evaluation, and from the lessons and examples of other organisations. • Prioritise activities on these understandings. Dedicate resources for capacity building to engage with new challenges (i.e. additional skills, external expertise, developing networks or new decision processes). Build new partnerships to strengthen internal capacity.
Step 2: Build partnerships to grow your capacity to act
• Gain access to specific complementary expertise, sectoral and geographic networks and access to important decision makers by forming partnerships with external organizations with shared interests in improved policy outcomes. • Use ongoing partnership activities to promote learning of new perspectives and process skills in your organization's officials and academic and governmental participants.
Steps 3 and 4: Fill gaps in available evidence
• **3.** Stimulate greater investment in monitoring and reporting of environmental states, particularly in those areas with clear links to welfare – like air quality. Fund long-term environmental monitoring to deliver trend data that can be openly accessed online by decision makers. • **4.** Build statistical capacities, nationally and globally, to deliver reliable and timely statistics that can stimulate and inform policy debates. Promote the standardization of methodologies to allow comparability between countries.
Steps 5, 6 and 7: Build the capacities of other participants (or links in the chain to outcomes)
• **5.** Increase the professional rewards for scientific participants engaging in science-policy activity, through changes to national funding metrics. Build capacities to engage in trans-disciplinary, multi-stakeholder science-policy processes, e.g. placements and skills training. • **6.** Promote changes to decision-making cultures and processes in nations and regions that move towards Evidence Based Policy Making, to give more incentives for individuals to apply evidence in policy. • **7.** Design the participatory processes in science-policy interfaces in ways that increase the learning opportunities of all participants on ways to deliver more effective science-policy activity.

Steps 8, 9, 10: Create practices for the effective exchange of evidence

- **8.** Move away from 'dissemination' and 'outreach' to promoting productive exchange and learning by prioritized participants. Re-design science-policy participatory processes for more productive exchange between individual participants, planning activity around the needs of the relevant decision makers (or intermediaries).
- **9.** Put important assessment processes on a secure financial and structural footing to ensure that they can plan adapt to meet future challenges.
- **10.** Create written outputs that fit participant's needs, tailoring form, frequency and content of outputs to different audiences in different contexts and potential use. Increase transparency of evidence and the processes to agree it, providing open-access to underlying data. Support legitimacy and trust behind evidence with review processes.

PART 2: ADDITIONAL INFORMATION

The second part of this report contains the more detailed information supporting the findings in Part 1. Further information can also be found in the Annexes. Each of the sections below can be accessed through hyperlinks in the text above, or read through as part of the report. Part 2 includes sections on:

5. The evolution of science-policy work - examples of existing solutions to fill gaps
6. How effective exchange of evidence influences decision-making
7. Factors facilitating productive interactions
8. Strategies for dealing with divergent viewpoints

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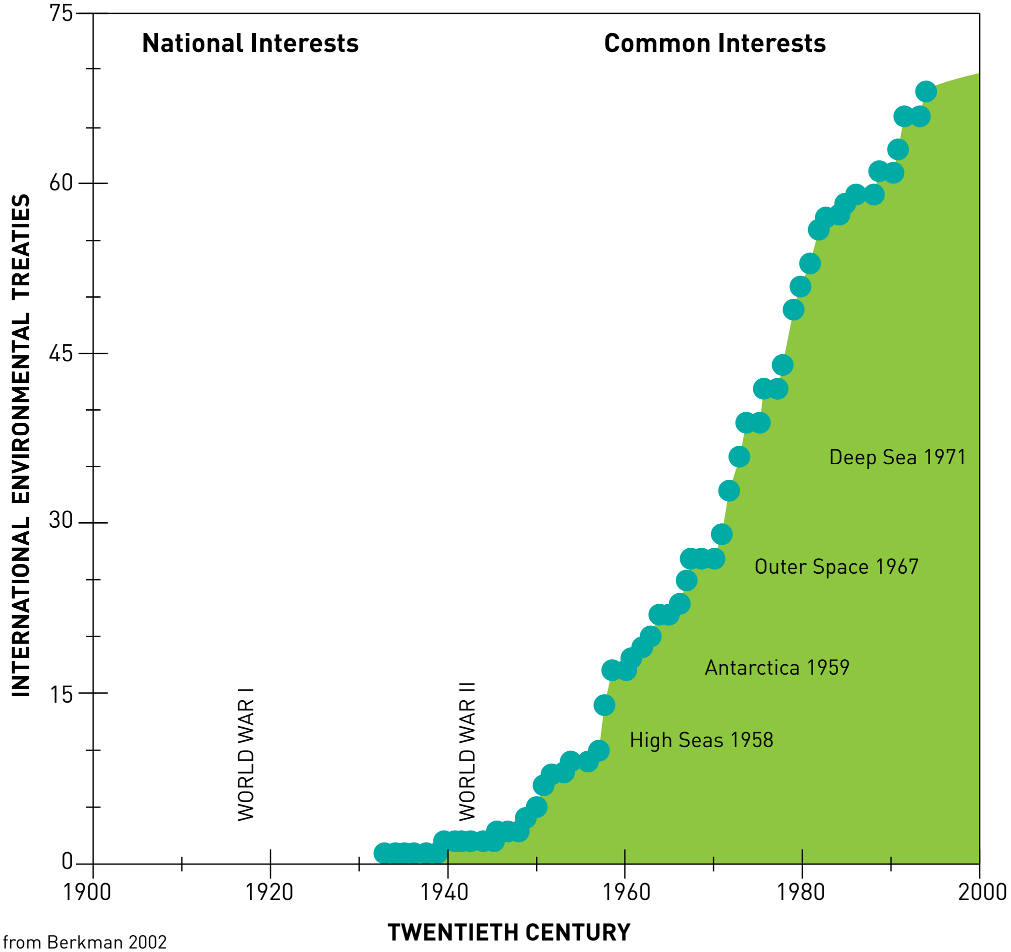
5. THE EVOLUTION OF SCIENCE-POLICY WORK - EXAMPLES OF EXISTING SOLUTIONS TO FILL GAPS

5.1 The expansion of science relating to the environment

From 1974 onwards, an expansion in global environmental treaties stimulated a parallel growth in the number of scientific advisory bodies informing multilateral environment processes. Their role in creating informed collective judgements on the state of environmental problems, and their causes, became a key feature of negotiations on multilateral responses, as shown in **Figure 5**.

Figure 5: The Expansion of International Environmental Agreements



Source: Adapted from Berkman 2002

The 1992 Earth Summit in Rio de Janeiro prompted ten years of fresh expansion of multilateral environmental governance.

The first generation of global environmental assessments – including those on Persistent Organic Pollutants, and the ozone layer depleting substances in the mid-1980s – were usually specific and related closely to international policy institutions for tackling observed problems. They built up the necessary consensual knowledge at times when the underlying problems were still uncertain.

Since then, science-policy interface activity has evolved significantly, to aim at delivering solutions for diverse policy makers, while illustrating their consequences through use of 'soft-technologies' like scenarios.

Recent global science initiatives have made clear that the recommendations from science on global environmental issues cannot be separated from the fundamental issues of fairness, equity and social justice. The deep involvement of lower-income countries and emerging economies in the formulation of the 2030 Agenda and its Sustainable Development Goals have created goals which better reflect the principles of justice and universality.

These changes were widely reflected, including in United Nations Environment Programme's 2011-13 Science Strategy. This aimed to strengthen the scientific base of United Nations Environment Programme and to reinforce its work on the science-policy interface through four overarching goals (1) Anticipating future: emerging issues, (2) Designing Future: sustainability scenarios (3) Catalysing the needed sustainability science, and (4) Bolstering science-policy work.

Evolution has taken place in the roles of science-policy interface activity and in each of the three key areas of effectiveness: Data availability and access; Enhancing the capabilities of the key participants; and Effective exchange of information. Illustrations of the progress delivered in these three areas come from changes in the recent practices of the Global Environment Outlook and the International Resource Panel **(see Box 1 in Part 1 and Box 2 below).**

BOX 2. The International Resource Panel, a Science-Policy Interface for the Sustainable Management of Resources

The International Resource Panel (IRP) was established in 2007 to provide independent and authoritative scientific assessments on the use of natural resources and the resulting environmental impacts. It was conceived as a science-policy platform to allow a dynamic exchange between eminent scientists from around the world and the policy community.

It is an independent panel, funded by member states, with a secretariat hosted in United Nations Environment Programme. To explore the interactions between development, natural resource use and environmental states, the IRP uses nexus and full-life cycle approaches to its assessments.

Its outputs discuss the implications of policy options, without being prescriptive. They provide an overview of trends, identify the drivers behind the trends and explore potential solutions in technological innovation, behavioural change and the policy-options or institutional transformation that would support their diffusion.

Between 2007 and 2016, the IRP produced 21 assessment reports, usually as large scientific reports, with a clear trend towards shorter summary reports and very short 'policy briefs' or articles.

IRP participants see the achievement of impact as the IRP's primary objective. Following the appointment of new Co-chairs in 2015, the IRP has continued trends of increasingly tailoring its audience engagement and written projects to the needs of identified decision-making audiences. For instance, the IRP developed an assessment of synergies and trade-offs in terms of policy coherence between the food, land, energy, climate, water and materials related goals and targets finally proposed as the Sustainable Development Goals. Scientific members of the IRP have also, upon invitation, participated in meetings of the relevant UN Open Working Group, expert consultations, and various events around the Sustainable Development Goals process.

The IRP's strategic goals aim at relevance, legitimacy and credibility. Its work increasingly uses co-design of its assessment work with the final intended audience, to shape that work to be directly policy relevant. For instance, to gain input for the Assessment on Food Systems and Natural Resources report, it held regional workshops in Nairobi, The Hague and Jakarta, in co-operation with the local UN Regional offices. It then engaged with the same audiences with the results of the assessment.

The Panel contributes to the science-policy interface by serving as a platform for exchange between eminent scientists from around the world and the policy community. It brings together the expertise of multiple disciplines through the Panel, and the inputs of a variety of stakeholders through a Steering Committee that includes the involvement of experts and governments from all regions.

The Panel's initial scientist composition was slanted towards the natural sciences. In recent years, this weighting has shifted towards economists, political scientists and social scientists, allowing the political, economic or social aspects of each topic to be considered. Highlighting the role of natural resources in poverty eradication is a repeated aspect of its reports.

To help it increase its impact, the IRP has recently started a strategic partnership with Systemiq, an external organisation with deep experience at engaging high-level policy makers and multinational CEOs around evidence. The partnership aims to build the capacity of the IRP to more effectively engage wider audiences.

The following sub-sections look at examples of evolution in each of the three areas.

5.2 Evolution of scale of science and data

As science-policy work matured, the scale of production of international environment assessments grew. One indication of this is the increasing numbers of experts included within established deliberative processes, most notably within the Intergovernmental Panel on Climate Change.

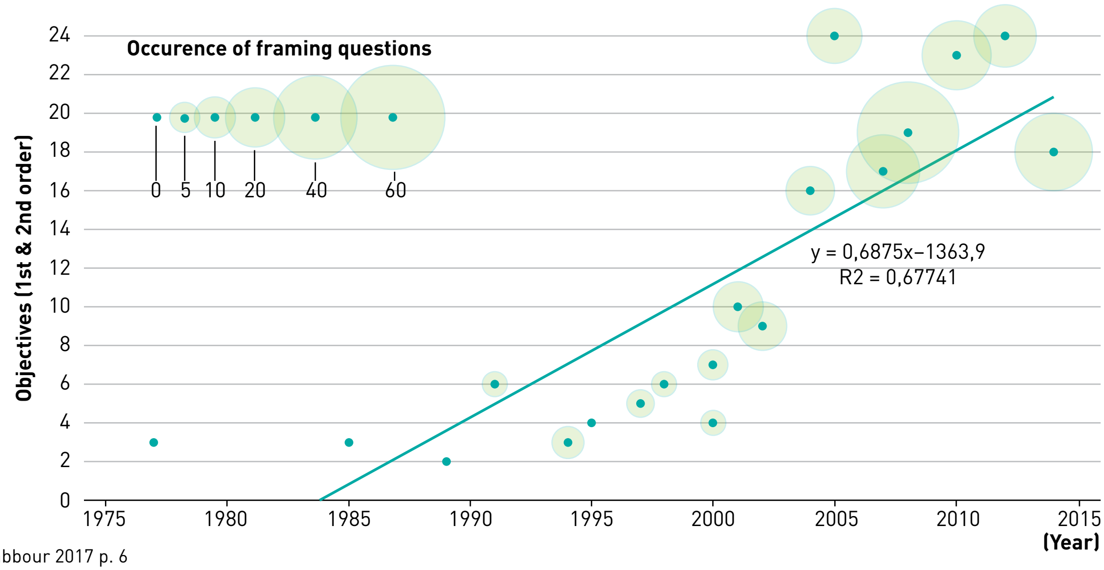
5.2.1 Evolution of participation in international environmental assessments

For the Intergovernmental Panel on Climate Change, 607 authors or contributors worked on the 1st assessment in 1990, and 2330 people working on the 5th Assessment report (2013-2014). Similarly, the number of participants involved in producing content in the series of Global Environment Outlooks has risen from 186 in 1997 to 863 in GEO 5 (2012) and over 1000 for GEO 6 (2019) (Jabbour 2017).

5.2.2 Evolution of Scope of Issues

The width of themes dealt with by recent assessments has greatly increased: **Figure 6** shows the number of "framing questions" that sampled international environmental assessments have addressed in different years.

Figure 6: Number of framing questions in selected IEAs



Source: Jabbour 2017 p. 6

5.2.3 Steps to improve access and transparency in data

Various evolutions have taken place in the efforts to fill gaps in data:

During the 1st Science-Policy Forum in May 2016, United Nations Environment Programme launched the United Nations Environment Programme Live Synergies Portal. This shows synergies existing between the Sustainable Development Goals indicators and the Multilateral Environment Agreements. It aims to facilitate exchange of data among national institutions and coordinate their response to international obligations, avoiding unnecessary overlap between data collection efforts, especially considering the limited resources available in some countries. This was mainly done through a mapping of both Multilateral Environment Agreements and Sustainable Development Goals indicators, which is available and accessible on the Sustainable Development Goals portal (uneplive.unep.org/portal).

Currently, InforMEA Portal on multilateral environmental agreements provides a search facility covering over 10,000 multilateral environmental agreements' governing body decisions, 5,000 national reports and 500 implementation plans, and features news, events, ratification information and information on national focal points. The free and open InforMEA e-learning platform caters to over 2,500 learners from 175 countries, and the LEO-Thesaurus provides definitions of and links between key concepts to help users navigate through the terminology of Multilateral Environmental Agreements. InforMEA will also feature a searchable library of publications and describe how internationally-agreed goals, such as the Sustainable Development Goals, Global Environmental Goals and the Aichi Biodiversity Targets, relate to Multilateral Environment Agreements provisions. The InforMEA Portal is interlinking with the UN Environment Live.

Effectively using information, data and knowledge for interactions, links and synergies between the countries is an irreversible trend. The Multilateral Environmental Agreements Knowledge Management Initiative brings together 53 legally binding instruments on the environment hosted by four UN organisations and the International Union for Conservation of Nature. It is facilitated by United Nations Environment Programme that oversees and steers the InforMEA Project supported by the European Union.

United Nations Environment Programme is also now undertaking extensive work on improving metadata, definitions and other methodological work, including on using big data for monitoring the environment, measuring the environmental dimension of the Sustainable Development Goals and developing an extensive system of Sustainable Development Goal ontologies. A Sustainable Development Goals Interface Ontology was recently launched on UNEP Live as part of the response of the United Nations Secretary-General's Chief Executives Board for Coordination to the data revolution.

To help countries meet reporting obligations, and increase the value of reporting, United Nations Environment Programme launched the Indicator Reporting Information System (IRIS) Tool in 2015. It is currently being tested both in Europe (e.g. Serbia, Montenegro and Bosnia and Herzegovina), and widely across the world. IRIS aims to make it easier for governments to take stock of their environment data and share it across Ministries. Those responsible for collecting data, compiling indicators and ensuring reporting to Multilateral Environment Agreements, to the Sustainable Development Goals and at the national level for State of Environment Reports, should be able to report and easily share data online, create reports and communicate indicator-based information with this tool.

5.3 Enhancing the exchange of evidence and expertise

Several initiatives are indicative of the evolution of science-policy interfaces to include much greater focus on the exchange of evidence and expertise between participants, often based on best-practices in trans-disciplinary research and decision-making.

5.3.1 Illustrations of broader participatory processes

The three Conferences of the Parties of the Basel, Rotterdam and Stockholm Conventions have recently, in May 2017, adopted decisions entitled "From science to action" whereby they emphasized the need to enhance the interaction between scientists, policymakers and other policy actors to promote exchange, development and joint construction of knowledge for more informed decision-making.

The United Nations Convention to Combat Desertification Science-Policy Interface (SPI) was established in 2013 to promote dialog between scientists and policy makers on desertification, land degradation and drought (DLDD). The SPI works to deliver information, knowledge and advice on DLDD needed to develop policies measures that ensure maintenance and enhancement of land resources and ecosystem services that flow from them. Among the SPI members are globally renowned DLDD and political scientists. Engaging a broad range of scientific mechanisms and leveraging synergies with other scientific panels, the SPI identifies knowledge needs, selects means for addressing them and delivers results to policy makers.

The SPI packages its findings into informative and concise products. Among latest SPI publications available on the Knowledge Hub are two science-policy briefs: "Pivotal Soil Carbon" and "Land in Balance," as well as a new report, the "Scientific Conceptual Framework for Land Degradation Neutrality."

The Second session of the United Nations Environment Assembly was preceded by the first Science-Policy Forum, which convened more than 250 representatives from the science and policy-making communities of over 100 countries. For two days, current and emerging issues of human interaction with the environment were discussed, with sessions covering the Sustainable Development Goals, the Global Environment Outlook -6, a range of frontier and merging issues with a series of thematic discussions – all from the perspective of strengthening the science-policy interface (United Nations Environment Programme 2016g).

Research by The Mercator Foundation and United Nations Environment Programme from 2015 show that some of the larger science-policy interfaces already operate as platforms in which divergent viewpoints are reconciled and the capacity and networks of participants are built, through consultative science-based discussion (Kowarsch *et al*. 2017b).

The United Nations Environment Programme Guidelines for Integrated Environment Assessment recommend, regardless of the kind of assessment conducted, that a high-quality Integrated Environmental Assessments should follow a multi-scale and multidisciplinary stakeholder assessment process, which combines all these elements. These examples reflect that there is already a deep body of knowledge and practice on how to run improved learning processes in science-policy work. It includes the "soft" or "social" technologies seen by many as "critical to changing mind-sets, attitudes and behaviour" (E/HLPF/2016/6).

5.3.2 Enhanced Communication

The desire for enhanced environmental outcomes has driven a much greater focus on effective and professional communication. This has involved a shift of resources and of practices. These practices include the shaping of science-policy work to meet communication needs, rather than dissemination and communication occurring after knowledge synthesis.

For example, at a small-group strategy session in the International Resource Panel's 16th Meeting in Hanoi in 2015, the International Resource Panel participants decided that:

"The Secretariat can work with each project on tailored communication (engagement) plans for each report/research area. These should start being shaped at the scoping stage. To help this, the Steering Committee can ask author teams to engage with the intended audience as part of scoping of the proposal."

The Intergovernmental Panel on Climate Change already benefits from a tailored communication strategy relying on external, local expertise to express messages tailored for national debates, recognising the role that science plays in agenda setting, mobilising stakeholders into coalition building and shaping political discourse.

Improved communication strategies and practices are deeply influenced by the lessons on how people learn.

While inter-personal communication delivers the most effective form of learning, for reaching wider audiences, other approaches have been developed. These draw on experience that visualisations and short key messages can be effective, and that repeated, related information creates salience, trust and learning beyond single contact. Onwards, indirect exchange of information through networks or media is promoted by easily shared instantly understandable separate messages like info-graphics.

In addition to the examples in the section above, the online *European State of the Environment Report* contains a section referring to the so-called 'collections' (i.e. all graphs, all maps and all key messages are available, for easy use and reference by other users). A toolkit of information was developed that can be used, adapted and further disseminated by third party individuals or organisations, consultancies, national academies and ministries.

The type of communication methods that are normally developed along with an Integrated Environmental Assessment report now are:

- diversifying the media used to convey the findings of Integrated Environmental Assessments, including short videos, TED talks, social media campaigns and infographics
- developing tailored products for different stakeholders and adapting the findings of the Integrated Environmental assessments to different audiences. These could include a summary for the business sector, summary for youth, improved use of multimedia, improved use of social media as in the example of Europe Office's Friday Fact tweets on the Global Environment Outlook-6 for the Pan-European region
- building media awareness of the Integrated Environmental assessment gradually through briefings, releases and press packs
- sending regular e-mail bulletins on assessment progress
- briefing politicians and decision-makers through regular summaries and providing timely inputs to policy processes
- producing printed materials, including leaflets and posters
- developing a variety of written products within a specific assessment process, including issue briefs and rapid assessments on emerging topics with great transformation potential
- using appropriate events for launching Integrated Environmental assessments.

5.4 Enhancing the capacity of participants

Many different steps have been taken to enhance the capacities, motivation and opportunities for key participants in the science-policy interface, all the way along the chain of connections. This has taken science-policy interface activity into actions strengthening the institutions and processes of decision-making, as well as the opportunities and expertise of individuals working on those processes.

The range of actions is illustrated by the examples below:

5.4.1 Enhancing decision-making processes for national and regional policy

Some governments have recently supported the use of evidence based programmes through enacting laws. In the United States, the use of laws as a top down approach to promote evidence-informed decision-making in federal programs have generated positive effects. They can use different mechanisms. For example, positively incentivizing decision-makers who demonstrate the use of evidence in their programme design; or limiting funding to programmes recognised as not based on ineffective evidence (MacArthur Foundation 2005).

In 2014 the State of Massachusetts created a grant program, through House Bill 4242, to test and expand evidence-informed decision-making to reduce recidivism (Massachusetts House Bill 4242). The only way to access these funds was through the realisation of an inventory of existing programs, classified by evidence of effectiveness, and through the demonstration of efforts supporting quality implementation, independent evaluation and commitment to the enhancement of evidence-informed programs. In 2014 the State of Mississippi, through Law H.B. 677 established ways to evaluate expenditure programmes and score them more positively if they are evidence based. Implementation of this law, supported by a strong mandate assigned to the Legislative Budget Office and the Joint Committee on Performance Evaluation and Expenditure Review, has helped shift the culture toward evidence informed decision-making (Mississippi House Bill 677).

5.4.2 Creating networks to build capacity within policy-making

In addition to the Intergovernmental Network of Government Scientific Advisors, *The Foreign Minister Science and Technology Advisor Network* (FMSTAN) started effectively in February 2016. Its initial meeting involved the four Science and Technology advisors to foreign ministers from Japan, New Zealand, United Kingdom and United States along with diplomats from twelve other nations (i.e. Chile, Ghana, Kazakhstan, Kenya, Malaysia, Oman, Panama, Poland, Senegal, South Africa, Ukraine, and Vietnam). Senegal, Oman and Poland have since joined the network.

The network focuses on:

a. Articulating the benefits of investing in internal Science and Technology advisory capacity within foreign ministries;
b. Sharing best practices and lessons learned in building Science and Technology advisory capacity;
c. Strengthening Science and Technology advisory capacity in foreign ministries; and
d. Coordinating respective Science and Technology diplomacy activities

5.4.3 Building the capacity of the science-policy interface through partnership

Acting to create impact along the wider science-policy interface takes expertise, resources and networks that many of the existing UN-linked science-policy interface organisations still lack.

In response, several of these organisations have created partnerships with organisations that have these capabilities and connections. This fills existing gaps in the science-policy interface more quickly and more completely than could otherwise be achieved.

The partnered, external organisations can already have, or develop, roles within wider networks, which allow them to provide expertise on knowledge needs to scientists, more effectively than otherwise obtainable. They can act as 'two-way knowledge translators' between widely different scientific and social communities. The partner organisations are often philanthropically or project funded.

For example:

a. The Intergovernmental Panel on Climate Change partners with the European Climate Foundation to bring in strategic excellence in communication strategies. Recognising that impact is related to very diverse political sensitivities (and conditions) in different regions, they use a network of individuals in key countries, who will amend the Intergovernmental Panel on Climate Change's messages for national and regional audiences, and political processes.
b. The International Resource Panel has entered into a co-operation with Systemiq, a solution-seeking organisation founded on expertise of partners with deep experience of communicating environmental issues within business and policy circles. Systemiq includes individuals who have shaped the influential non-governmental science-policy interfaces that developed the "New Climate Economy" initiative and the Business Commission on Sustainable Development. The cooperation gives the International Resource Panel the capabilities to learn how to connect more effectively with wider audiences.
c. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services partners with the UNEP-World Conservation Monitoring Centre (UNEP-WCMC), a non-profit consultancy whose expertise lies in effective planning and processes for trans-disciplinary, multi-stakeholder science-policy exchange and use of knowledge. The UNEP-WCMC has deep experience and understanding of the institutional landscape for biodiversity policy and ecosystem management, with insights developed from supporting countries in the implementation of Multilateral Environment Agreements and Agenda 2030.

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6. UNDERSTANDING THE FACTORS BEHIND EFFECTIVE SCIENCE-POLICY INTERFACES

"Quite often, we ask ourselves, why politicians have decided to implement that policy, and not another one, why it has been implemented in that precise way and with these precise resources..." (De Marchi, Lucertini and Tsouki`as 2016 p. 15).

6.1 Mess and complexity

The role of knowledge in policy-making is not linear, or even predictable. Peter Gluckman, Chief Scientific Advisor to the New Zealand Government, and one of the leading voices in the evolution of science-policy interfaces, puts it this way:

"Often forgotten is that policy-making is messy. Although a tidy, analytically driven cycle of policy-making might seem logical to scientists trained in the tradition of hypothesis generation and testing, policy-making is instead a networked process in which scientific evidence is only one of many inputs. The notion of "evidence" comes in multiple forms. Public opinion polls and anecdotes are often considered "evidence" for a certain course of action. Policy decisions involve balancing empirical data with other arguments" and the issues for which scientific input is most needed by policymakers are the very ones for which the science is often the most complex, multidisciplinary, and incomplete" (Gluckman 2016 p. 969).

Policymaking processes are always complex environments. They bring together interconnected decision-making processes based on varied goals and areas of interests, resources, and stakeholders (De Marchi, Lucertini and Tsouki`as 2016). Final outcomes can be the result of decisions at many levels, over long periods, potentially highly influenced by chance or an informal exchange. For example in cabinet-level decision-making, where – again according to Peter Gluckman – evidence is often exchanged as informal conversations and brainstorming at opportune moments, in corridors or over refreshments.

Science is not always used to inform policy decisions in the way we would hope (Spilsbury and Nasi 2006). Surveys have found that existing normative beliefs "shaped by values and moral convictions, religious and cultural identities, and nationalism" act as powerful biases in the selection, acceptance and interpretation of evidence for use in policymaking (Salvatella, Muzio and Sánchez 2000). Decisions are often based on viewpoints that promote the adoption of informal, politically motivated or subjective and anecdotal evidence.

A former Government Minister, and Member of Parliament in the United Kingdom, Vincent Cable has explained some of the challenges facing evidence's use by decision-makers as "Five S's" **(Box 3)**:

Box 3: Pressures affecting the use of evidence in policy-making: The 5 S's.

1. Speed: The time and political pressures that policy makers are subject to mean that they must process information quickly, requiring elements of both compromise and improvisation. This can lead to bad decision-making.
2. Superficiality: policy makers are heavily reliant on the information provided to them by others. Because each policy maker has to cover a vast array of issues they cannot be expected to attain in-depth understanding of all thematic fields. Therefore, they depend on the integrity of the people who inform them — raising questions on who should advise policymakers and how they themselves can judge the information given to them. Different countries experience different issues with regard to their sources of information: in industrialized countries, decision-making processes can become heavily influenced by politically motivated think-tanks; while for developing countries, information and directives provided by the NGO sector can gain greater leverage over other sources of information.
3. Spin: (Public) perception remains an important factor in driving political decisions and can outweigh empirical evidence.
4. Secrecy: Some information or evidence may be deemed as secret, raising the question of how it should be communicated to policymakers as well as on the political implications of who has access to confidential information within decision-making bodies.
5. Scientific ignorance: As in the case of 'spin', suspicion towards science amongst the public can lead to misinformed perceptions that consequently guide government policy (Cable 2004).

Similar pressures acting against the use of evidence have been found in the developing world, with a project in Tanzania finding barriers to evidence-use from:

a. *"Lack of awareness of the value and potential benefits of new knowledge, ideas, discursive and practical tools to solve pressing issues":* This means that new knowledge is available, yet remains inaccessible to those with the power to act upon it. In fact, the biggest single stumbling block in the adoption of scientific research amongst decision-makers was identified as their low scientific understanding, and therefore low trust in the evidence. The impact of this is further magnified by the low capacity of academic institutions to "repackage research findings into user-friendly language for policymakers' consumption".

b. *"Natural predisposition of individuals, community and policymakers to rely on anecdotal evidence even when presented with scientific evidence and its benefits"* (National Institute for Medical Research 2008): An overall lack of incentives to adopt scientific information and limited openness of politicians to ideas was found to be highly counterproductive—once again fortified by the limited dissemination of accessible information (National Institute for Medical Research 2008). This arises out of the dominant set of values in an organisation or society.

6.2 Making sense out of complexity - discourse theory

One of the ways to make sense of the messy, complex decision-making process that science-policy activity engages in is called "discourse theory". Discourse theory provides a helpful conceptualisation of how messy policy decision-making can take place, and so helps guide actions to fill gaps.

Discourses are the grouped collection of ideas and concepts that people use to create meaning and guidance for action. They help us decide when faced with the complex, uncertain, imperfectly known world that we live in. They allow people to understand problems and identify solutions. Policy decisions can be seen to arise out of competition and exchange between discourses.

Evidence feeds particular discourses, often those supporting greater action on the environment, where, in the absence of science and evidence, facts and causalities are unknown or highly contested (Riousset, Flachsland and Kowarsch 2017).

The concurrent existence of multiple parallel discourses or viewpoints and the hope to change them is a core rationale for science-policy work. Policy discussions take place between people with divergent discourses. The discussions help change perceptions of problems, alternatives and their relative importance. Changes in perception open up windows for agreement of policy solutions (Wesselink *et al*. 2013).

6.3 The roles evidence can play

Evidence can be used to support existing prevalent discourses, or challenge them. It can be used to make decisions or to support decisions already made. Both those uses carry risks that sub-optimal outcomes are reached (Tingling and Brydon 2010). More helpfully, it can be used to inform decisions **(See Figure 7).**

Figure 7 Institutional values matter: Decision-based evidence-making vs. evidence-based decision-making

ROLE OF EVIDENCE IN DECISION MAKING	DESCRIPTION	ARCHETYPAL DECISION	RISKS
Make Decision Evidence Decision Process Decision	Evidence forms the basis of the decision	Facilities location	Poor dicisions due to misspecified models
Inform Decision Evidence / Intuition Experience Bargaining etc Decision Process Decision	Evidence is one of several inputs to the decision process	Diagnosis strategic planning	Mismatch between evidence and other inputs requires shift to "make" or "support" roles
Support Decision Intuition Experience Bargaining etc Decision Process Evidence / Decision	Evidence is created to support a decision made using other inputs	New product development, technology adoption	Demoralization of analysts; poor decisions due to decision biases and false consensus

Source: Tingling and Brydon 2010

However, informing decisions is just one of the roles that evidence plays in science-policy interfaces. It has many other, highly important roles within the messy decision-making process. Evidence can:

a. Facilitate discussion and collaboration amongst different stakeholders based on collectively recognized, objective and accurate information;
b. Create interest and salience on an environmental problem or potential solutions – stimulating further discussion and research;
c. Clearly observe the way in which current conditions on the ground interact with previous policies and so better evaluate the likely outcomes of different policy options and assess their impacts (Shaxson 2005);
d. Better understand and analyse complex interactions between different policy objectives that cannot be observed 'by the naked eye' while deepening the understanding of individual issues as well;
e. Stimulate far-reaching 'best-practices' that work with the interrelations between the environment and economy, public health, energy and poverty. Science can describe these interactions and help estimate future impacts from policy change;
f. Create greater accountability within decision-making, increasing scrutiny of decision rational and its evidence base, increasing critical debate and changing power-relationships between stakeholders; and
g. Create increased credibility for the chosen policy solutions, through transparency of a recognised processes of discussion that has fairly involved multiple stakeholders and viewpoints;

h. Generating a rationale for a strategic approach to a long-term problem, that involves the creation and resourcing of institutions and policies that act over the short-, medium and long-term.

There is always a choice as to how science-policy interface will attempt to use evidence, and with which participants. This choice can be made easier – and more likely to be successful – where it is based on a "Theory of Change".

6.4 Using "Theories of Change"

The first step to achieving greater influence on outcomes is setting explicit, well-defined outcome goals. The next step is to consider the routes by which these goals can be achieved.

Creating general rules on the relationship between evidence and policy has proven to be difficult: ground-level data on how decision-making processes operate is often lacking (Broadbent 2012). Therefore, when attempting to translate successful practices from one context to another, considering the diversity of political, cultural, economic and social structures is paramount (Sutcliffe and Court 2005).

Therefore, science-policy interface works in contexts that are uniquely different from one another and from settings where the practice was adopted before it is important that all players (e.g. researchers, policymakers and other stakeholders) understand the decision-making process itself.

6.4.1 Sketching "Theories of change"

Developing this understanding involves sketching out existing assumptions about the pathway of people and organisations that would need to exchange and use evidence in the science-policy interface to lead to outcomes. This sketch is called a "Theory of Change". It illustrates how policy change could be achieved by the science-policy work.

The "Theory of Change" can be used during the scoping of projects to decide which science-policy activity is needed – including which stakeholders need to participate, which evidence and expertise is needed, and the appropriate form and timing of outputs or exchange processes.

The United Nations Environment Programme Evaluation office now bases its evaluation of the success of science-policy projects and programmes on the "Theory of Change" that was used to plan and implement the work. Part of its evaluation work explores whether the assumptions used for that theory were accurate.

Equally, the forthcoming United Nations Environment Programme Integrated Environmental assessments Guidelines outline the main steps to creating an impactful assessment theory as:

"a. Creating the change statement. What should the impact of the assessment be?
b. Relationship management. Identify the key actors that you are seeking to influence, and build connections to them
c. Knowledge management. Gather and analyse the knowledge needed for the assessment."

The extract above highlights that an essential planning activity is the initial identification of the intended audience. Identification of broad categories of audience such as national environmental policy makers, civil society, mining businesses, is easy, but inadequately precise as a basis for intervention planning.

The "Theories of change" prove that most useful for improving outcomes are those that identify the specific individuals who will be engaged in the science-policy work (i.e. who may be an intermediary of boundary organisations known to be able to reach the final audiences). This engagement of these participants can then become an extremely valuable source of information for the "Theory of Change" – it is after all about how their own behaviour could be changed.

Box 4. An example of researching evidence needs directly with participants

When the global 'Resource Revolution' report was being initiated by the McKinsey Global Institute, with the goal of informing decision-makers on the benefits of increased resource efficiency policy, the authoring institute defined 200 people that they wanted to support and share their findings. The authors then spent one month engaging with many of these individuals to explore what their information needs would be. This engagement allowed the author team to better shape their science-based work, by testing the assumptions in their "Theory of Change"

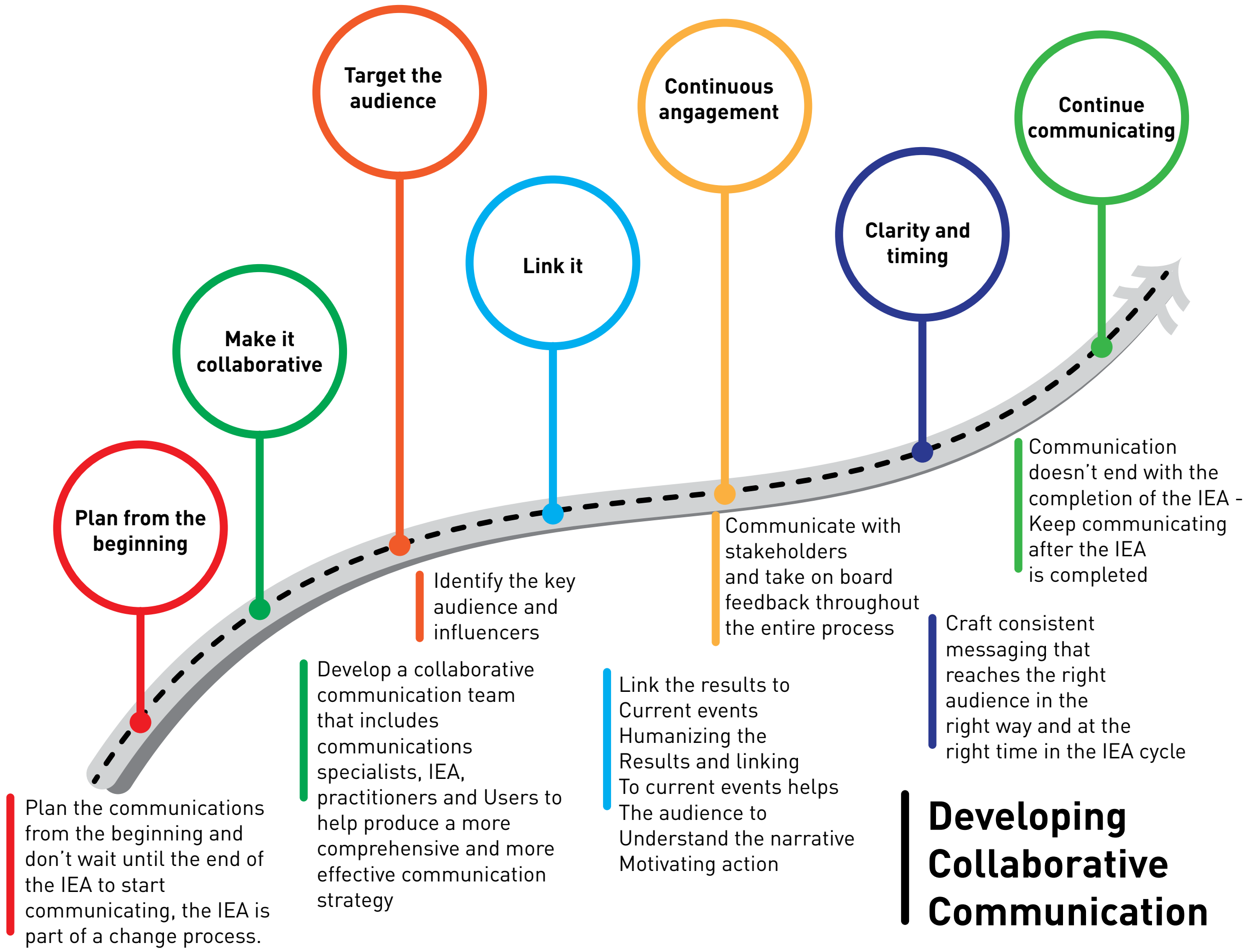
6.4.2 Learning as you go

The audience engagement in the Resource Revolution example reflects a crucial approach used to enhance outcomes when faced with the complexity and uncertainty of policy processes and their outcomes on the environment – learning as you go (Ison 2017).

Early exploration of participants' and final audience needs enables the leading science-policy organisations to engage effectively to define research questions of interest to their intended audience, build relationships that lead to message uptake, and establish routes to refine the content, language and presentation of their research findings to facilitate uptake and use, as the evidence is gathered.

The United Nations Environment Programme Integrated Environmental assessments Guidelines refer to this as "Collaborative Communication", an approach that makes exchange and learning by all participants (especially scientists and organisation staff) integral to the science-policy work, and a constant activity from the start of the work onwards **(Figure 8)**.

Figure 8: Developing Collaborative Communication, for learning as you go



Source: United Nations Environment Programme 2017 fig 2.2.

The current goals of many interdisciplinary scientific assessments and organisations are already close to the goals of continuous learning. Transdisciplinary work is encouraged as a way for scientists to gain a broader understanding of issues across scales, disciplines and sectors – helping them understand the complex routes to environmental outcomes, and allowing them to provide deeper, richer and more useful analyses.

Learning about how to increase the success of outcomes can also take the form of learning from others that have tried similar activities before. These could be lessons from within a particular theme, or more generic lessons from across international science-policy work, where there is ever more knowledge about the activities and conditions that are effective.

For instance, one of the Intergovernmental Panel on Climate Change authors, Carlo Carraro suggests that lessons in productive 2-way interactions might be learned from the Structured Expert Dialogues organized during the United Nations Framework Convention on Climate Change's 2013–2015 review of the 2°C goal. (In these, government representatives held interactive question and- answer sessions with experts from the Intergovernmental Panel on Climate Change and other organisations.)

Return to Part 1.

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7. FACTORS FACILITATING PRODUCTIVE EXCHANGES

7.1 Introduction: Productive interactions

Evidence suggests that decision-makers frequently rely on individual experience or other secondary sources of knowledge in isolation from scientific evidence when formulating decisions which potentially compromises the effectiveness of their decisions (Cvitanovic *et al*. 2015). The goal of science-policy interfaces is to change this reliance.

It is often wrongly assumed that the production and supply of evidence is sufficient to shift this reliance. The continued challenges facing the environment indicate that it is not.

One of the leading researchers into science-policy interfaces has highlighted the issue with this question: *"Why would states and other target audiences willingly defer to the knowledge provided by international scientists?"* (Haas 2017).

The answers to that question have been widely researched, in evaluations, in the academic field of Science Technology Studies and in related fields, like social psychology and behavioural economics. There have been many evaluative focussed studies on this question relating to international environmental science-policy activities, most notably: the Social Learning Group (in 2001), the "Global Environment Assessment Harvard project" (reporting in 2006) and a recent Mercator Climate Centre/UNEP "Future of Global Environmental Assessment" project (2014-16).

These studies found, amongst other things that the most effective channel through which information can be exchanged is through interpersonal interactions.

Interview-based assessments of the International Resource Panel and Global Environment Outlook-5 suggested that personal interactions of the participants in a science-policy interface (e.g. the authors with policy makers) were the most frequent route of impact from science. The reasons for this are explored in this section. The effective exchange of evidence (or the process of its learning) can be seen to be based on 'productive interactions', which – outside of academic study - mostly happen through channels related to past personal contacts (Joly *et al*. 2015).

This finding is one indication of the essentially human factors that promote 'productive exchange' of evidence or expertise. Each of these are described in a sub-section below. A research project investigating effective knowledge-policy transfer (Interact Programme 2016) described the impact of these by asking, "are you providing the right information to the right people in the right form through the right channel at the right moment?"

"Right information" – the relevance and usability

Information that is directly relevant to someone's current decisions is more likely to be used and learnt. This occurs, for instance, where there is a perceived (or unnoticed) information gap within an ongoing decision-making process.

These findings lie behind the shift towards 'solution-oriented' assessments in many international science-policy interfaces, including the Intergovernmental Panel on Climate Change.

The solutions generated for decision-makers can be seen to be much more directly relevant and usable than scientific information about states and drivers, which require further interpretation by policy makers to be used for policy.

The right 'form' of information - ease of understanding – clarity

Evaluation results from the International Resource Panel found that where impact occurred, it came from just one or two messages contained in the International Resource Panel's written or presented outputs, as opposed to the use of the International Resource Panel's data.

The long reports were read only by people who were highly engaged in the issues the International Resource Panel was raising. The presence of too many messages was reported to complicate understanding of a report, and to complicate the learning process for readers. Effective communication tends to convey a very limited number of messages for each audience.

This implies that finding a way to choose the right couple of messages, those that are most relevant to an audience, is a critical part of science-policy work.

"Right channel"

Impact on outcomes has been found to be particularly strong where it used existing relationships. These include networks, for instance within the participant's "home" organisations, (e.g. their governments).

Diffusion of messages through networks occurred most when someone was part of an existing community engaged for common goals. This is called a Community of Practice: a collective of stakeholders that collaborate to discuss issues, share data and information, and generate new knowledge around issues of importance to them. These could be a linked set of Non-Governmental Organisations, consultants or policy makers focussing on one process or topic. Helping the most active and trusted individuals within these communities ("nodes") to learn and exchange information can be a successful strategy.

Some institutions or media organisations can be seen by individuals as part of their community and are more trusted than others. Evidence can travel through social media and word-of-mouth. Each of these have different incentives, governance principles, resources and structures (De Marchi, Lucertini and Tsouki`as 2016). For example:

Around Multilateral Environment Agreements, the formal scientific bodies, are complemented and supported by inputs from other organisations, groups and stakeholders, and wide networks of scientists and technical experts that can provide ad hoc support to their work. One example is the ad hoc group of experts established to develop guidelines on reducing mercury emissions to air from point sources in accordance with Article 8 of the Minamata Convention on Mercury (United Nations Environment Programme 2013). **Annex 1 and 2** give a brief overview of a number of these entities.

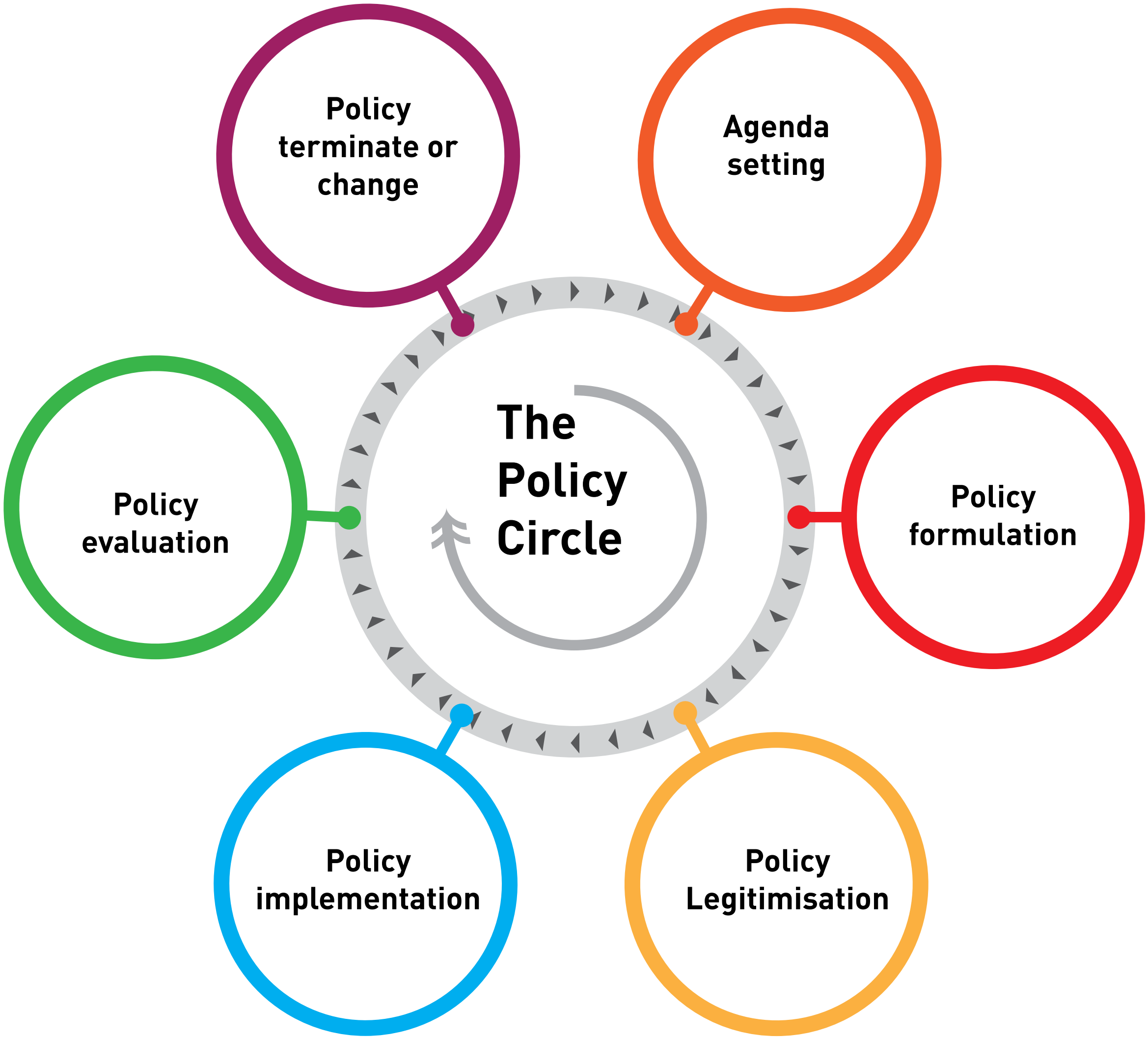
The Global Environment Outlook-6 assessment has developed its own online portal to develop a community of practice working on the Global Environment Outlook-6 assessment. The portal - Healthy Planet, Healthy People - has 1200+ users comprising author groups, advisory bodies and reviewers. The interaction is enhanced by the creation of community blogs and discussions in each community to help users exchange ideas and compare issues in a more social way, while enjoying the privacy needed for a scientific drafting process of Global Environment Outlook's magnitude.

'At the right moment' - Timing

One recurring theme of science-policy gaps is that evidence does not come out at the time that it is useful for a policy process. Policy processes run through distinct timelines, and once the window for evidence to be taken on board has been closed, even the best evidence is unlikely to be relevant.

The cycle of policy decision-making runs from agenda setting to review. At different times, different forms of evidence will be needed. **(Figure 9)** illustrates one simplified view of the major phases of policy.

Figure 9 – An illustration of very varied phases in policy making



Source: United Nations Environment Programme 2017 fig 1.1

Timing is seen as a critical barrier in the science-policy relationship, and a reason why high-quality science-policy work is based around responsiveness - focusing on the punctuality of the answers to participants' questions.

7.2 Acceptance, legitimacy and credibility

The following are further driving factors behind the findings that personal interactions tend to be the most productive forms of evidence exchange and can be useful for guiding all science-policy activity.

7.2.1 Acceptance and legitimacy

As science-policy interfaces have moved towards suggesting solutions in their efforts to gain greater uptake through increased salience, they have necessarily moved into areas where there is increased divergence in the viewpoints of stakeholders.

This has exposed the science-based evidence to be challenged by stakeholders with different viewpoints, who can challenge the underlying assumptions behind the work. Inevitably, as soon as science goes beyond the pure natural science, facts and values are highly intermingled in science-policy interfaces (Dietz 2013). Acceptance involves the belief that assessments are based on appropriate values, interests, concerns, and specific sets of circumstances (Cash *et al*. 2002).

The nature of these challenges was illustrated by the public contestation around the Intergovernmental Panel on Climate Change's 5th Working Group 3 Assessment report (Kowarsch *et al*. 2017a).

Investigations into uptake of science in the field of Science and Technology Studies have found that science-based information is often opposed if diverse stakeholder groups do not agree with the priorities or underlying assumptions of a scientific assessment. Opposition to the content is clearly a block to that person using evidence. Learning , or the uptake of evidence, only takes place where divergent viewpoints are reconciled.

Where there are divergent values, there are always ways that acceptability can be created. It comes where participants have faith in *"an open, transparent system with clearly defined objectives and processes and realistic opportunities for participation by all stakeholders"* (Morrison-Saunders and Bailey 2000).

The perception of Impartiality plays a role. This also requires that key statements considered in the assessment should not be conflicting among each other, guaranteeing the acceptance of final outputs.

When the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services was set up, stakeholder engagement and the inclusion of divergent viewpoints were purposefully prioritised in its processes. There are different approaches for responding to divergent viewpoints **(see section 8)**. They are almost all interactive, involving discussion between people as a way of exploring underlying values and viewpoints.

The weight given to a document by non-participants in its creation comes from the process by which it has been created: the Intergovernmental Panel on Climate Change Summary for Policymakers is the outcome of negotiations between governments and scientists. It is not then re-negotiated during the United Nations Framework Convention on Climate Change process. Therefore, transparency and openness (which require systematic documentation during each step of the assessment and the need for sharing data, results and general information with final users, in respect of confidentiality issues) (European Food Safety Authority 2015) provide proof of process, which can generate acceptance.

7.2.2 Credibility

The other factor is the degree of trust that the audience places in evidence – its credibility. This is a quality that the audience gives itself. It depends on whether the audience members perceive the evidence as meeting standards of scientific plausibility and technical adequacy. Sources of knowledge must be deemed trustworthy and/or believable, along with the facts, theories, and causal explanations evoked by these sources. Key factors are the audience's view of:

- The methodological quality of the process creating evidence, hence generating excellence;
- The reputation, or scientific credentials of the experts involved;
- The reputation of, or relationship with, the messenger who directly passes on the information.

This can be observed amongst policy makers themselves: in some cases they identified legitimacy, integrity and reputation of the institutions producing evidence as the single most important consideration in their selection of evidence; in other cases personal relations among and between experts and policymakers was given more weight (Salvatella, Muzio and Sánchez 2000).

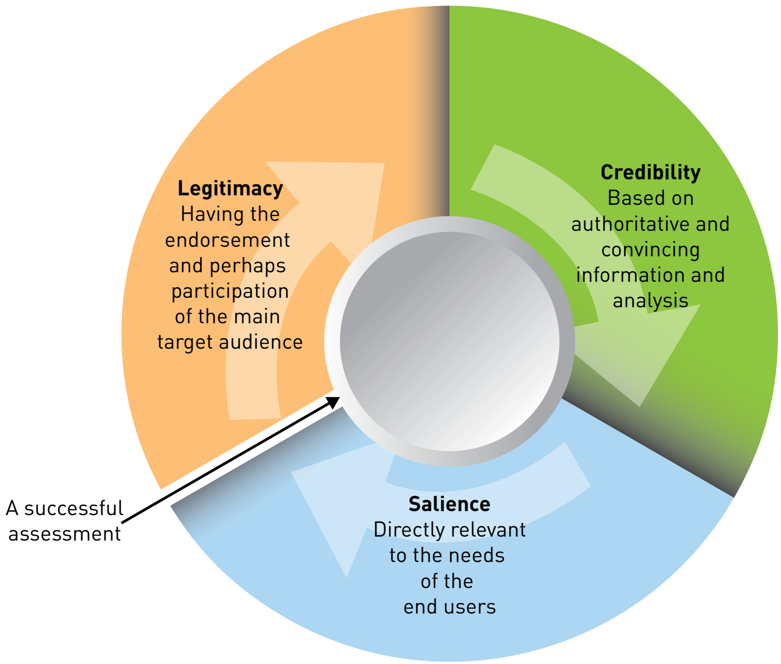
The credibility of science-policy outputs also rests on the credibility of the inputs into that process. Pointers for the uptake of credible information include:

- Is the source reputable (e.g. international organisation or from a recognized research institution)?
- Is the reference list or metadata comprehensive in its coverage?
- Is the research methodology carefully presented to the reader?
- Is the information presented still valid and applicable today?

7.3 Summary

The findings described above have been described as the categories of 'Saliency, legitimacy and credibility' (Cash *et al*. 2002) after a Harvard based review of practice and success in science-policy interfaces in 2000.

Figure 9: The Legitimacy, Credibility, Saliency model



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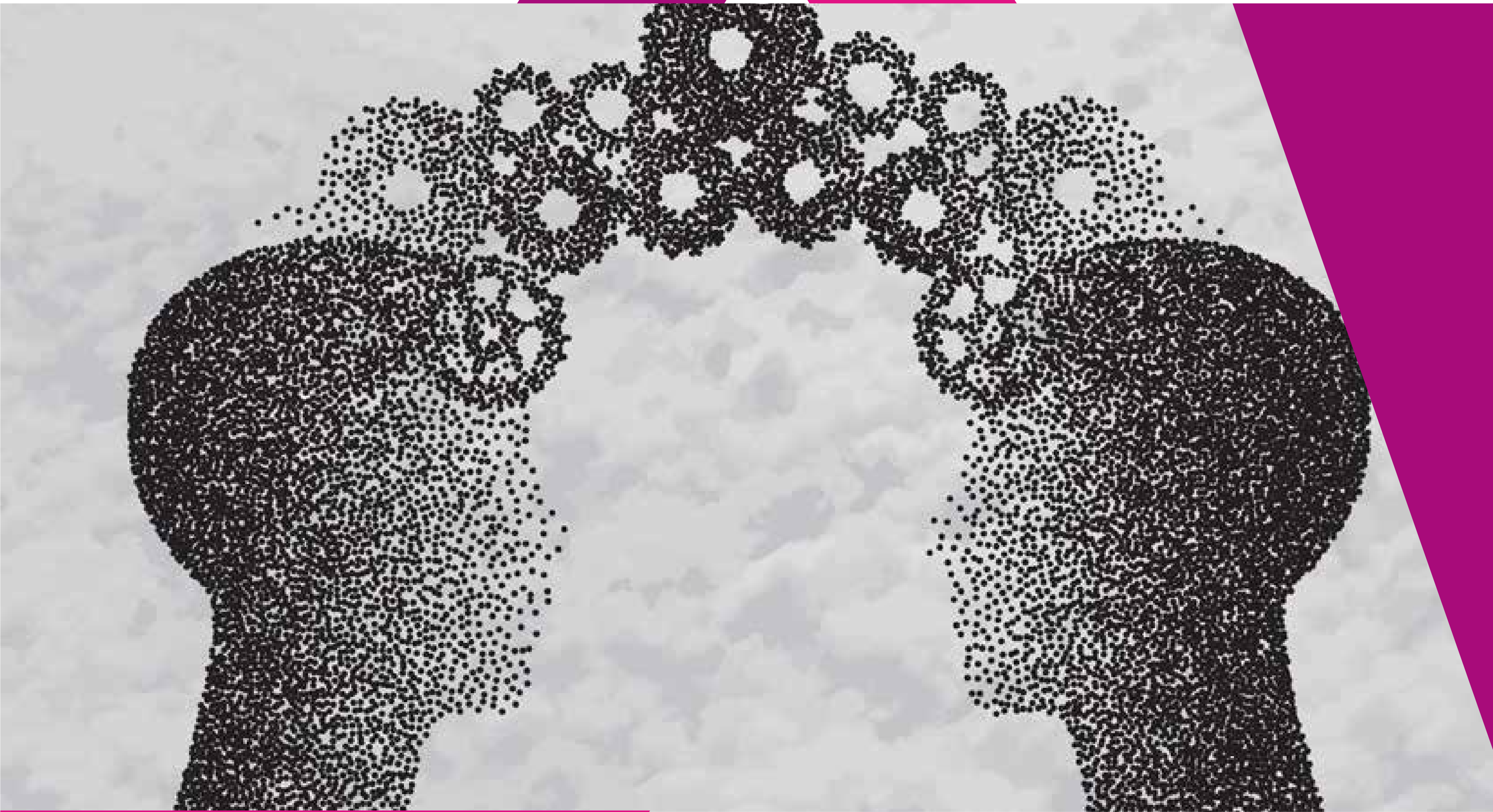

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8. STRATEGIES FOR DEALING WITH DIVERGENT VIEWPOINTS

There are gaps in the exchange of knowledge due to difficulties with the interpretation of internationally gathered data. On several occasions, it has been demonstrated how poor capacity to analyse and interpret data by staff has strongly limited its use in the decision-making process (MEASURE Evaluation 2010).

What seems to be a straightforward scientific finding of, for example, "on average, every square kilometre of the world's oceans has 63,320 microplastic particles floating at the surface" (United Nations Environment Programme 2016h) can have different interpretations and ramifications in different communities, depending on their overall relationship with the oceans (i.e. economic dependence in terms of fisheries and tourism, cultural significance, food security, etc.). For this science to have meaningful policy impact, it should be "localized" with inputs from diverse stakeholders so as to become part of community knowledge that is credible, relevant and legitimate (Armitage *et al*. 2015).

8.1.1 Knowledge can play various roles in stakeholder exchange

The expected and desired role of knowledge is often to 'inform decisions'. More clearly, this implies that it is hoped that it changes the views of decision-makers where needed, to tackle an environmental problem due to a learning process.

This presupposes that the decision-makers have different viewpoints to those in the knowledge being communicated. So much of the activity in science-policy interfaces deals with the way in which divergent viewpoints can be reconciled and learning achieved.

The UNEP-MCC Future of Global Environment Assessment Making project observed and categorised the different roles that science-policy interfaces played to deal with divergent viewpoints (Kowarsch *et al*. 2017a).

a. Provision. One approach is simply the provision of knowledge. This rests on the belief that science-based information, clearly presented from authoritative sources will overcome divergent perspectives. The approach can under-estimate the extent of divergent assumptions and perspectives in its audience. Success depends on the degree of shared perspectives and resulting perception of the authority and acceptability of the evidence.
b. Clarify meaning. This approach makes efforts to avoid misunderstanding (and rejection) by exploring the different understandings of evidence by stakeholders. These misunderstandings frequently come out of the same language or data being understood differently, due to stakeholders' different backgrounds, beliefs and ways of seeing the world.
c. Negotiated compromise. Negotiation of findings (which includes discussion of value judgements and contested assumptions, for example on the value of nature) is frequently used by policy officials in the science-policy interface. Experts still play a significant role in the discussions, to inform these debates. They

can lead to wide acceptance, as in the case of the Intergovernmental Panel on Climate Change Summary for Policy Makers.

d. Expert resolution of revealed controversy. This approach seeks to expose divergent views as part of the knowledge creation process, and create a tailored process by which experts representing the divergent views can discuss and resolve the differences.

For example, the Global Environment Outlook-6 Science and Policy Advisory Board is mandated to 'make the final determination on any science related contentious issues' raised by the lead authors or reviewers. The Board has been filled with people whose reputation should give their role legitimacy, while the existence of the process aims to provide assurance that findings are rigorously discussed, and impartiality challenged – therefore legitimate.

e. Implication mapping. This approach draws participants into explorations of alternative future pathways, under different scenarios, allowing the inclusion of alternative assumptions while allowing people to learn about underlying causal relationships. It facilitates discussions over assumptions and future states of the world, which – as they are all uncertain, and can be shaped by current decisions – are often less contentious.

f. Avoided controversy. This approach removes the contentious issue from discussion, either allowing more than one viewpoint to exist in parallel, perhaps stimulating further research, in both cases, allowing learning on other issues to take place.

The most frequently used approach is to seek expert resolution of revealed controversy. The relative success of each strategy, and the appropriate way to manage the debates, depends on the nature of the divergent viewpoints – particularly the extent to which they are due to complexity, as opposed to deeply different underlying values.

Where no effective approach is used to reconciling divergent viewpoints, the knowledge will not be used or learnt and the science will not affect environmental outcomes through the intended route.

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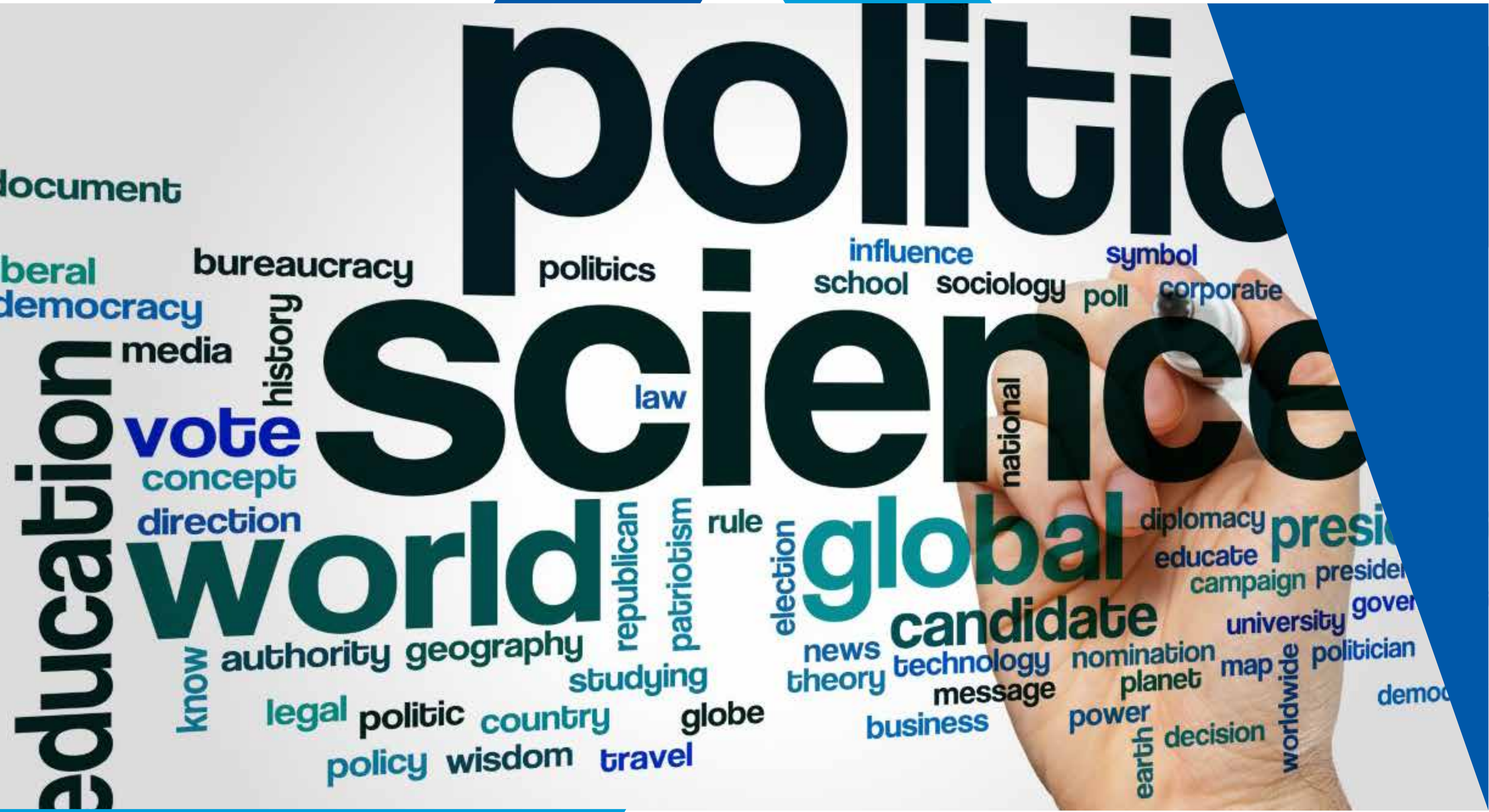

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9. ANNEXES

Annex 1: Multilateral Environmental Agreements (MEAs)

This Annex looks more closely at the scientific bodies serving the different Multilateral Environmental Agreements (MEAs) and will analyse the degree to which they facilitate the scientific uptake into the MEA provisions.

1 The biodiversity-related MEAs

The effectiveness of some of the biodiversity-related MEAs in addressing global threats to biodiversity has been in the recent past called into question given that several of the targets set under some of these MEAs have not been met within the set timeframe. A major example here is the Convention on Biological Diversity's challenge to achieve the 2010 Biodiversity Targets adopted in 2002. Given such experiences, Parties have recognized the need for building strong interlinkages between the adopted policies, decisions, programs and governance/ institutional structures as well as drawing on the existing scientific evidence on how to best address the persistent transboundary and global environmental problems. Such evidence is regularly gathered through the analysis of national reports, independent environmental and scientific monitoring studies, as well as expert inputs. Various biodiversity-related MEAs have repositioned their institutions, mechanisms and approaches to be able to adapt to changes in science and knowledge, and to engage with a wider range of partners.

With a view to strengthen the provision of scientific advice within the biodiversity-related cluster of MEAs, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established in 2012. It is mandated to assess the state of biodiversity and of the ecosystem services and to provide scientific information in in addressing key gaps in data and knowledge. IPBES seeks to strengthen the science-policy interface at all levels, based on requests from policy and decision makers. Almost all biodiversity-related MEAs responded to the establishment of IPBES. MEAs were invited to provide input to the Programme of Work of IPEBS 2014-2018. It is expected that biodiversity-related MEAs will respond to the deliverables of IPBES in a manner they deem appropriate (United Nations Environment Programme 2016b)

Moreover, informal meetings of the Chairs of the Scientific Advisory Bodies of the Biodiversity-related Conventions (CSAB), convened by the Convention on Biological Diversity and supported by UN Environment, were established to discuss the scientific and technical needs for implementing the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets, as well as the contribution of the various scientific advisory bodies to this overarching framework. The body regularly shares experiences and knowledge with the

IPBES with a view to enhancing cooperation on science. Decisions adopted at various Conferences of Parties have called upon scientists to embrace and enhance synergies at all levels.

1.1 The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

For the provision of scientific advice relating to the broad implementation of the Convention, CITES relies on its Animal and Plant Committees, which are instructed by the Conference of the Parties and report to it. This includes scientific advice linked to compliance procedures. The scientific findings used to decide whether trade in CITES-listed species is non-detrimental (i.e. science-based biological sustainability findings that take into account the role of the species in its ecosystem) are made by the Parties themselves, using their designated national Scientific Authorities. CITES has urged its Parties to promote mutual understanding and support across the science-policy interface and ensure that biological and social scientists and policymakers work in a cross-disciplinary manner (United Nations Environment Programme/Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora n.d.) CITES decision 16.14 (revised at the 17th meeting of the Conference of Parties) encourages Parties and Scientific communities to take into account the needs of national scientific and management authorities to foster the use of applied science for the implementation of the Convention.

1.2 The Convention on Migratory Species (CMS)

The Scientific Council of CMS provides scientific advice to the convention on a range of subjects, and in particular on the listing of species in the convention. CMS has recognized the need for regular and thematic assessments of the status of biodiversity to provide decision-makers with the necessary information basis for adaptive management and to promote the necessary political will for action addressing biodiversity loss in general and the loss of migratory species in particular (United Nations Environment Programme/Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals n.d.).

1.3 The Convention on Biological Diversity (CBD)

The Convention on Biological Diversity and its two protocols, the Cartagena Protocol on Biosafety and the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization, are advised by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) on a range of scientific and technical matters pertaining to the work of the convention and protocols, including the provision of biodiversity assessments and impact assessments. In addition, CBD decision XIII/29 on Global Biodiversity Outlook and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services recognizes the role of the scientific community, stakeholders and indigenous peoples and local communities in addressing key science-policy gaps in biodiversity issues. The deliberations of SBSTTA are open to all Parties to the CBD as well as observers. When serving one of the protocols, decisions are taken only by the Parties to that protocol. Often upon recommendation of SBSTTA, the CBD and its Protocols frequently establish Ad Hoc Technical Expert Groups (AHTEGs) which operates under specific terms of reference to assist the Conference of Parties to adopt informed policy decisions based on scientific and technical information.

The Convention, in its Article 18, also provides for technical and scientific cooperation among Parties. Moreover, the CBD and its protocols promote a number of global partnerships and initiatives to help bridge thematic science-policy gaps.

2 The United Nations Convention to Combat Desertification (UNCCD)

The UNCCD relies on the Committee on Science and Technology to provide advice on the science related to desertification and drought, as well as to provide technological advice on how to counter these effects. Moreover, the UNCCD Science-Policy Interface (SPI), established in 2013, provides useful knowledge that is based on a solid scientific basis, influences scientific processes and promotes the involvement of scientists in UNCCD work by promoting dialogue between scientists and policy-makers on desertification, land degradation and drought (United Nations Convention to Combat Desertification 2016). The SPI delivers information, knowledge and advice needed to develop policies measures that ensure maintenance and enhancement of land resources and ecosystem services that flow from them. It also identifies knowledge needs, selects means for addressing them and delivers results to policy-makers.

Among the SPI members are globally renowned DLDD and political scientists. Engaging a broad range of scientific mechanisms and leveraging synergies with other scientific panels, the SPI identifies knowledge needs, selects means for addressing them and delivers results to policy-makers.

The SPI packages its findings into informative and concise products. Among latest SPI publications available on the Knowledge Hub are two science-policy briefs: “Pivotal Soil Carbon” and “Land in Balance,” as well as a new report, the “Scientific Conceptual Framework for Land Degradation Neutrality.”

3 The pollution-related MEAs

The pollution-related MEAs, including the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade and Stockholm Convention on Persistent

Organic Pollutants, the Minamata Convention on Mercury, the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, the Vienna Convention for the Protection of the Ozone Layer and Montreal Protocol on Substances that Deplete the Ozone Layer arguably differ from the biodiversity-related MEAs in that the nature of the environmental issues they seek to address stem from specific types of human activities. In the case of the Montreal Protocol, ozone depletion is caused by the use of a range of niche gases while in the case of the Minamata Convention, the bulk of global anthropogenic mercury pollution is caused by just a handful of economic sectors. In contrast, Basel Convention covers a wide-range of wastes, both those with hazardous characteristics and those from house households. Either way, it is generally possible to identify precisely the specific chemicals of concern to the environment. This, in turn, has an impact on the mandate and operations of the scientific bodies of pollution-related MEAs.

3.1 Basel Convention, Rotterdam Convention and Stockholm Convention

The Basel, Rotterdam and Stockholm Conventions address global pollution issues. The Basel Convention centres around three principal aims: reducing transboundary movements of hazardous and other wastes to a minimum consistent with their environmentally sound management (ESM); regulating the transboundary movements of hazardous and other wastes by reducing the generation of hazardous and other wastes to a minimum and promoting the environmentally sound management of hazardous wastes, wherever the place of disposal. The Rotterdam Convention's objective is to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm; and to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, providing for a national decision-making process on their import and export, and by disseminating these decisions to Parties. The Stockholm Convention aims to protect human health and the environment from Persistent Organic Pollutants (POPs) – chemicals that are highly toxic, remain intact in the environment for long periods, become widely distributed throughout the environment, accumulate in the fatty tissue of living organisms including humans and are found at higher concentrations at higher levels in the food chain. Among other things, it requires Parties to take measures to prohibit, eliminate or restrict the production, use, exports and imports of POPs listed under the Convention.

The Open-ended Working Group (OEWG) of the Basel Convention is composed of representatives of all the Parties to the Convention, and its mandate covers a broad range of issues, including scientific and technical matters pertaining both the further development of the Convention (such as reviewing proposals to amend the lists of wastes covered by the Convention) and to the implementation of the Convention (such as the development of guidance). Any recommendation or draft guidance developed by the OEWG, oftentimes with the support of expert working groups, is put forward to the Conference for its consideration and possible adoption.

The Rotterdam Convention Chemical Review Committee (CRC) is composed of 31 government-designated experts on chemical management from the five UN regions. Following its review of notifications of final regulatory action to ban or severely restrict a particular chemical, received from at least two Prior Informed Consents Regions, or a proposal by a Party for listing a severely hazardous pesticide formulation, the CRC recommends to the Conference of the Parties whether the chemical should be made subject to the PIC procedure and, accordingly, be listed in Annex III to the Convention. For each chemical that the Committee decided to recommend for listing in Annex III, it prepares a draft decision guidance document setting out the scope of the chemical subject to the PIC procedure as well as basic information on the chemical, such as its hazard classification, additional sources of information on the chemical and information on possible alternatives. The Conference of the Parties decides whether the chemical should be listed in Annex III and approves the draft decision guidance document. Although it is not intended as the only source of information, the decision guidance document assists Parties in making decisions on future import of the chemical listed in Annex III.

The Stockholm Convention's Persistent Organic Pollutants Review Committee (POPRC) is composed of 31 government-designated experts in chemical assessment or management from the five UN regions. For each chemical proposed by a Party for listing in Annexes A, B and/or C to the Convention, the Committee, based on the information and comments provided by Parties and others, develops a risk profile and risk management evaluation. The Committee decides whether the chemical is likely as a result of its long-range environmental transport to lead to significant adverse human health or environmental effects such that global action is warranted (i.e. the chemical is a POP), and recommends to the Conference of the Parties whether the chemical should be considered for listing. The Conference of the Parties, taking due account of the recommendations of the POPRC, including any scientific uncertainty, shall decide, in a precautionary manner, whether to list the chemical, and specify its related control measures.

3.2 Minamata Convention on Mercury

The Minamata Convention entered into force on 16 August 2017. The Minamata negotiation process had been informed by a number of scientific assessments produced by the UN Environment Chemicals and Waste Branch. Among these, the Global Mercury Assessments of 2008 and 2013 were seminal publications that served to mobilise global action on mercury pollution. While not formally part of the interim secretariat of the Minamata Convention, the scientific and advisory services provided by the Chemicals and Waste Branch helped to bridge the gap between the science of mercury pollution and the required policy action. The work of the Chemicals and Waste branch has been further enhanced by the work conducted by the Arctic Monitoring and Assessment Programme (AMAP), the Zero Mercury Working Group, as well as other stakeholders.

Moreover, the Global Mercury Partnership (GMP) has provided essential advisory services on how to address mercury pollution in key sectors, such as coal combustion, chlor-alkali facilities, cement production, and artisanal and small-scale gold mining. The GMP has therefore provided yet another mechanism for bridging science into effective policy decision making action and establishment of necessary governance in the context of mercury pollution.

3.3 The Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer

The Vienna Convention and Montreal Protocol have some have some of the strongest links between science and concrete policy decision-making at the international level that then translate into regional and national policies and actions. The three Assessment Panels were established in accordance with the provision in Article 6 of the Montreal Protocol itself, requiring parties to assess the control measures in the Protocol at least every four years, on the basis of available scientific, environmental, technical and economic information. The Article also specifies that appropriate panels of experts qualified in the fields mentioned be convened and terms of reference established for the purpose of the assessments. Scientific Assessment Panel (SAP) provides detailed scientific analyses on the science of ozone depletion and produces highly regarded and exhaustive reports.

The work of the Technology and Economics Assessment Panel (TEAP) focuses on the technological and economic aspects of substituting ozone depleting substances in the relevant industry sectors and also responds annually to the many requests of the parties to provide technical analyses and advise on various aspects of Montreal Protocol implementation, as well as in the discussions on the financial resources required by the Multilateral Fund which provides financial and technical support to developing countries to implement and comply with the Montreal Protocol. Finally, the Environmental Effects Assessment Panel (EEAP) evaluates the environmental effects of ozone layer depletion and increased levels of ultraviolet radiation. World-renowned experts and scientists participate in the Panels and their reports are regarded as the most authoritative, independent, state-of-the-art assessments on the subjects surrounding ozone layer depletion, protection and recovery, contributing to the development of common understanding among the parties. Based on the periodic assessments the Montreal Protocol has been strengthened through six sets of adjustments and four Amendments, to completely phase out almost 100 ozone depleting chemicals substances, from the initial list of eight substances being reduced by just 50%. The latest Kigali Amendment, expected to enter into force in 2019, adds HFCs to the Montreal Protocol to be phased down.

The governance structure of the Montreal Protocol that requires scientific assessments to form an important basis for decision-making has been one of the pillars of the Montreal Protocol success. It may serve as an example to other MEAs on how to effectively inter-link in a coherent way the science based information with governance system and policy decision-making processes, including on the financial mechanisms for implementation.

4 United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol and Paris Agreement

The UN Climate Change, i.e. UNFCCC, the Kyoto Protocol and the Paris Agreement are primarily provided scientific input by the Subsidiary Body for Scientific and Technological Advice (SBSTA). The SBSTA provides scientific and technical advice on matters that relate to the UNFCCC, the Kyoto Protocol and the Paris Agreement. Such advice includes information on the impacts of climate change, emissions from land-use, the development and transfer of environmentally sound technologies, and the provision on guidelines to countries to develop greenhouse gas inventories. The SBSTA also acts as the link between the pure scientific input on climate change provided by the IPCC and the more policy-oriented work of the climate change MEAs.

Moreover, the work conducted on climate change is given overall scientific support by the International Panel of Climate Change (IPCC). This Nobel Prize winning body was established by UN Environment and the World Meteorological Organization in 1998 and authors the seminal assessment reports on climate change.

Annex 2: Overview of the scientific organisations supporting selected MEAs

Table A1: Scientific bodies and related institutions directly supporting MEAs

Convention	Scientific body and related partnerships, institutions and groups	Relevant abstract of functions
Convention on Biological Diversity (CBD), the Cartagena Protocol on Biosafety and the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization.	Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) and Ad Hoc Technical Expert Groups (AHTEGs).	• Provide scientific and technical assessments of the status of biological diversity; • Provide scientific and technical assessments on issues related to biosafety and access and benefit-sharing; • Prepare scientific and technical assessments of the effects of types of measures taken; • Advice on scientific programmes and international cooperation in research and development related to conservation and sustainable use of biological diversity as per Article 25 of the Convention; and • Reports to the Conference of Parties.
Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat.	Scientific and Technical Review Panel.	Provide scientific and technical guidance to the Conference of the Parties, the Standing Committee, and the Ramsar Secretariat.
Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention).	International Scientific Committees of International Council on Monuments and Sites.	Study structural aspects of the world heritage, provide forum for the interchange of knowledge and research among archaeologists, other professionals, and decision makers, and promote conservation and restoration of heritage constructions.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Animal and Plant Committees.	• Providing scientific advice and guidance to the Conference of the Parties, the other committees, working groups and the Secretariat on all matters relevant to trade in animal and plant species included in the Appendices; • Cooperate on work to assist; • Scientific Authorities and provide scientific advice on training materials used in capacity building; • Dealing with nomenclatural issues; • Undertaking periodic reviews of species, in order to ensure appropriate categorization in the CITES Appendices; • Advising when certain species are subject to unsustainable trade and recommending remedial action (through a process known as the 'Review of Significant Trade'); • Advising when the terms of the Convention might not be being applied with respect to specimens declared as captive-produced (through a process known as the "Review of trade in animal specimens reported as produced in captivity species"), which can lead to the Standing Committee taking compliance measures; and • Drafting resolutions on animal and plant matters for consideration by the Conference of the Parties.
Convention on the Conservation of Migratory Species of Wild Animals (CMS).	Scientific Council.	Provide advice on scientific matters, including the inclusion of migratory species in the Appendices, to other CMS bodies (Standing Committee, Conference of Parties, working groups) and CMS Parties as per Article VIII of the Convention.
UN Convention to Combat Desertification (UNCCD).	Committee on Science and Technology.	Provide Conference of the Parties with information and advice on scientific and technological matters relating to combating desertification and mitigating the effects of drought.

International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).	Scientific Advisory Committee.	Facilitate the exchange of information, based on scientific, technical and environmental matters related to plant genetic resources for food and agriculture.
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.	Open-ended Working Group (OEWG).	Consider and advise the Conference of the Parties on issues relating to policy, technical, scientific, legal, institutional, administration, finance, budgetary and other aspects of the implementation of the Convention.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.	Chemicals Review Committee (CRC).	Review notifications of final regulatory action of banned or severely restricted chemicals and proposals for listing severely hazardous pesticide formulations in Annex III submitted by Parties; make recommendations to the Conference of the Parties on listing of such chemicals in Annex III to the Convention; and develop guidance documents for Parties to take decisions on import of those chemicals (decision guidance documents).
Stockholm Convention on Persistent Organic Pollutants.	Persistent Organic Pollutants Review Committee (POPRC).	Review chemicals proposed by Parties for listing in Annex A, B or C to the Convention; develop risk profile and risk management evaluation documents; and make recommendations to the Conference of the Parties regarding such listing.
The Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer.	Scientific Assessment Panel (SAP).	Assesses the state of the ozone layer and relevant atmospheric scientific issues of importance.
	Technology and Economics Assessment Panel (TEAP).	Provides technical and economic information on technological alternatives to current ozone depleting substances, equipment and processes.

	Environmental Effects Assessment Panel (EEAP).	Provides assessments of the environmental effects of ozone layer depletion. All provide independent assessments of the latest available information and analysis, including on the specific questions and requests of the parties and present their reports and advice to the Conference/ Meetings of the Parties.
United Nations Framework Convention on Climate Change, the Kyoto Protocol, Paris Agreement.	Subsidiary Body for Scientific and Technological Advice.	Provide timely information and advice on scientific and technological matters as they relate to the Convention.

Table A2: Other organizations, groups and stakeholders supporting the MEAs scientific bodies

Organization, group or stakeholder	Directly related MEAs	Brief summary of functions
UN Environment Chemicals and Waste Branch.	Minamata Convention on Mercury, Basel, Rotterdam and Stockholm Conventions.	Provides technical expertise and assessments on various chemicals and waste issues.
Intergovernmental Panel on Climate Change.	United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Paris Agreement.	Providing assessments of the science related to climate change.
Global Environment Facility: Scientific and Technical Advisory Panel (STAP).	Multiple: Biodiversity, chemicals and waste, climate change, land degradation, international waters.	Provides scientific and technical advice on multiple environmental issues.
Global Mercury Partnership (GMP).	Minamata Convention on Mercury.	Provides technical expertise on mercury reduction in chosen sectors; maintains expert networks.
Arctic Monitoring and Assessment Programme (AMAP).	Minamata Convention on Mercury, Stockholm Convention on Persistent Organic Pollutants.	Provides assessments of arctic pollution.

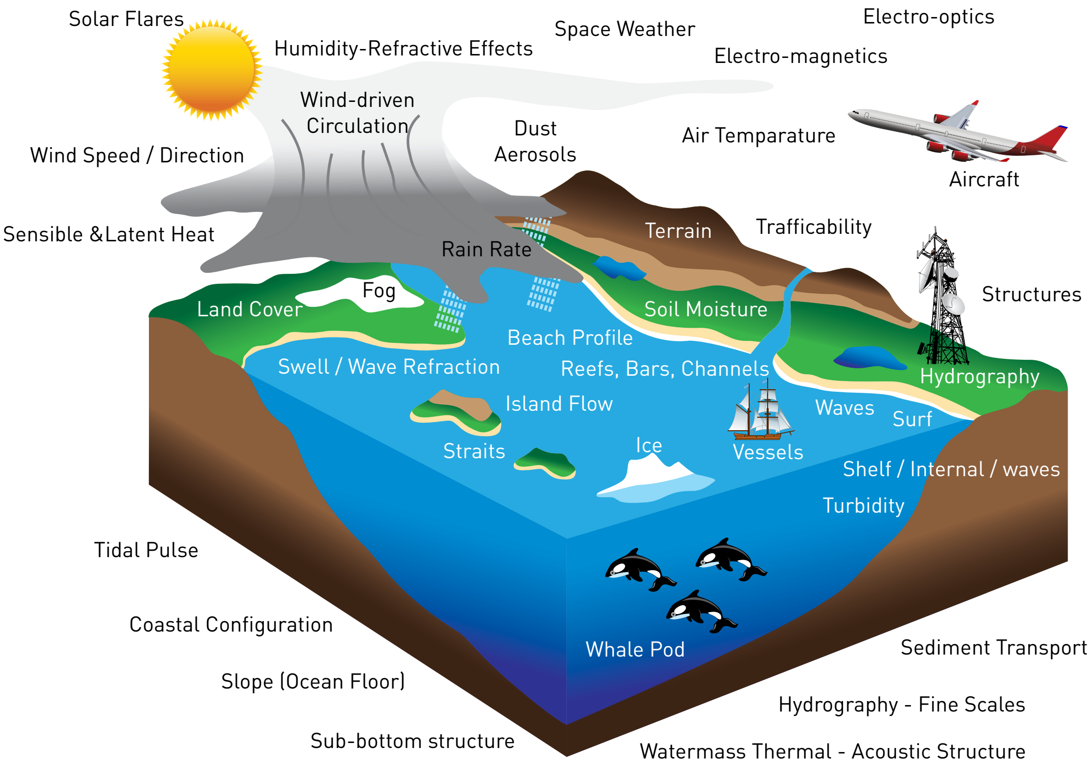
Zero Mercury Working Group.	Minamata Convention on Mercury, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.	Scientific and technical advice on mercury management.
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (United Nations Environment programme 2016b).	Biodiversity-related conventions: • Convention on Biological Diversity; • Convention on International Trade in Endangered Species of Wild Fauna and Flora; • Convention on Migratory Species; • Ramsar Convention on Wetlands; • UNESCO's World Heritage Convention; • International Treaty on Plant Genetic Resources for Food and Agriculture; • International Plant Protection Convention; and • Also provides support to the United Nations Convention to Combat Desertification.	• Increase the capacity of the science policy community to perform and to use assessments and other products of IPBES; • Identify knowledge needs of policymakers, and catalyze efforts to generate new knowledge; • Deliver global, regional and thematic assessments of knowledge regarding biodiversity and ecosystem services; and • Identify policy relevant tools/methodologies, facilitate their use, and promote and catalyze their further development.
Biodiversity Indicators Partnership (BIP).	Biodiversity-related conventions.	Promote and coordinate the development and delivery of biodiversity indicators through partnerships.
Chairs of the Scientific Advisory Bodies of the Biodiversity-related Conventions (CSAB).	Biodiversity-related conventions.	Share information about each Convention's scientific activities and processes.
United Nations Information Portal on Multilateral Environmental Agreements (InforMEA).	53 legally binding instruments on environment.	Brings together Multilateral Environmental Agreements to develop harmonized and interoperable information systems.

Environment Live.	Almost all MEAs.	Collect, process and share the world's best environmental science and research.
Science-Policy Interface (SPI) of the UNCCD.	United Nations Convention to Combat Desertification (UNCCD).	Facilitate a two-way science-policy dialogue and ensure the delivery of policy-relevant information, knowledge and advise on land degradation (scientific conceptual framework for land degradation. Neutrality) desertification and drought (DLDD).

Annex 3: Meaning and Sources of Environmental Data

Environmental data can cover a wide range of statistics and may be presented in different forms. Environmental data are technical, spatial, and temporal data that concern the atmosphere, water and soil including specific topics like waste, noise, dangerous substances, fauna and flora, landscape, nature, and species conservancy **(Figure A1)**.

Figure A1 Environmental data



Source: SEDRIS 2003 p. 24

These data can come from a wide variety of different sources, including data from official statistical collections, from Government administrative sources, from statistical collections managed by Government Ministries, from private sector sources, from academic institutions, from earth observation and from the public (e.g. citizen science). Defining the scope of environmental data and determining which information is of highly enough quality to be used for assessing the environment is a key challenge for filling the remaining data gaps identified by decision makers.

This section outlines some of the sources of data, the type of information available from these sources and the quality assurance issues to keep in mind when using this information.

Official censuses and surveys

The National Statistics Office, in collaboration with other Government Ministries, is typically responsible for the administration of official censuses and surveys. Censuses and surveys are tools that are used to collect periodic demographic and socio-economic information. Censuses aim to collect data from one hundred percent of the population, while official surveys aim to collect data from a representative sample of the population.

Most countries administer two major censuses at a periodicity of 5 or 10 years. These include a (1) population and housing census and (2) an agricultural census. Additionally, many countries administer an economic census of businesses within the economy.

Surveys are typically used to collect information on particular aspects of development and include more detail information than censuses; however, surveys only include a subset of the population and are typically mathematically extrapolated to the whole population. Some common surveys include Demographic and Health Surveys, Household Income and Expenditure Surveys, Labour Force Surveys, Disability Surveys, Agricultural Surveys, and Business Surveys.

Agricultural censuses and surveys typically collect a wealth of environmental information that can be used to assess land use, land ownership, soil quality, fertilizer use, pesticide use, climatic impacts on crop productivity, environmentally sustainable practices and environmental emissions from agriculture.

Although the primary purpose of most censuses and surveys may not be to collect information on the environment, they may have key information that can be used to assess environmental issues such as climate change risk and adaption measures. For example, the census can be used to determine several key environmental aspects:

- The population living in the coastal zone;
- the population living in areas vulnerable to natural disasters and climate change;
- access to clean water, sanitation and electricity;
- the proportion of households using biofuels for cooking and heating;
- types of household waste disposal;
- the population dependent on subsistence agriculture;
- Indicators related to living conditions, slums, household and electrical appliances (including solar panels) and poverty.

This information seems to be, in most of the cases, top quality information, since it is based on standardized survey tools. In several countries a proper Data Quality Assurance (QA) Strategy has been developed in order to:

- provide high quality statistics that meet user needs
- build confidence in the final results
- provide value for money solutions
- protect, and be seen to protect, confidential personal census information (United Kingdom, Office for National Statistics 2009).

Administrative data

Administrative data typically include data derived from information collected for the purpose of implementing administrative regulations (Statistical Data and Metadata eXchange 2009). At the national level, administrative data include a wealth of information that may be relevant to environmental issues, including (Asian Development Bank 2010):

- Records collected at borders, including records of trade and the movement of people;
- Registration of events, including registration of personal property, cars, businesses and registration of life events such as birth, death and marriage;
- Records used in the administration of benefits, including taxation and social services;
- Records from public schools, health facilities and other public institutions;
- Records from government regulations, for example records related to land use, water abstraction, banking, transport, mining, fish catch and other datasets;
- Records from public utilities, including water use, electricity consumption, solid waste generation, sewage treatment, etc.

Even when these data don't specifically refer to the environment, they can contain pieces of information that can be used as a source of environmental data and also for environmental monitoring. A few examples of the linkage between administrative data and environmental monitoring include:

- administrative data on water and electricity provisioning which could support environmental economic accounting;
- administrative data that could support the assessment of the portion of the population with access to environment-related services;
- public health records linking to environmentally-related causes of death;
- car registration information which determines the number and type of cars in the country;
- import and export data that offer key information to determine material footprint;
- records from tertiary institutions that help to (can be used to) determine the percentage of students who pursue different fields of study;
- fish catch monitoring data that could support modelling of fish populations and taxation data which can be used to assess environmental taxes and subsidies.

Government administrations aim to collect data continuously and include near real time data for the complete population covered by the administration collecting the data. However, the quality of administrative data sources may be difficult to determine, the data may not be kept in an easily accessible format or it may only be available as hard-copy records, and can be difficult to gain access to (e.g. due to confidentiality provisions).

Environmental monitoring and research data

In addition to official censuses, surveys and administrative data collection, Ministries of Environment, Agriculture, Lands and other government offices, academic institutions, non-governmental organizations and other institutions collect environmental data through regular environmental monitoring, targeted surveys and projects. Additionally, many institutions also produce estimated or modelled environmental data.

Environmental monitoring data can include data related to air, water and soil quality; temperature, weather and other meteorological trends, seismic and hydrological conditions. Data collected by environmental monitoring stations typically follow strict quality assurance processes; however, the monitoring stations might not provide sufficient national coverage to scale the data up to a national level estimation of the situation and data collected for environmental monitoring are often not linked to a central national data repository. Modelling can be used to improve the coverage and quality of environmental monitoring data; however, there are sometimes inconsistent international guidelines on how to incorporate modelled data into the generation of national level statistics. Research and project data can provide useful environment-related information; however, these data are often not comparable across locations, countries or time points. Data that arise from research and projects are often underutilized and used only a single time and for a single purpose. Identifying appropriate ways to bring research and project-related data into the scope of environmental information used in assessments could help fill information gaps.

Transactional and other sources of “big” data

There is an increasing wealth of data being generated from the use of mobile phones, the Internet, banking transactions, and other forms of so called “Big Data”. These data represent high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision-making. These new sources of data could complement existing environmental data. For example, web analytics data on the number of people searching the web for different environmental topics from different locations provides some insight into public views on a particular topic.

It is important to keep in mind that transactional and other non-traditional data sources often do not include information from the poor persons, persons in remote areas, persons with disabilities and other vulnerable groups. Additionally, the volume of data generated within a country is usually related to the level of development of that country. Therefore these data require some form of authentication and quality assurance in order to be useful for national governments. An encouraging trend concerns the increasing amount of information coming from members of the public who are contributing to citizen science projects, including through recording animal and plant sightings, precipitation types and levels, light pollution and other phenomena. There are many mobile tools and apps aimed at collecting scientific information from the public; however, methods are lacking for the authentication of citizen science data due to the fact that “citizen scientists” (i.e. the public) often do not have any training or commitment to data quality assurance. In order for Governments, policy analysts and researchers to use citizen science data there is a need for guidelines on the validation of citizen science data. Big data also confronts the same dilemma.

Remote sensing and Geographic Information Systems (GIS) data

Geospatial data can be generated by satellite and aircraft imagery, as well as from any of the above data sources for which data can be geo-referenced. In recent years satellite imagery has drastically reduced in cost and improved in resolution. Additionally, the improved computing power that is now available has increased the utility of satellite images for use in environment statistics. For example, hyper spectral satellite imagery can now be used in monitoring plant and animal populations. Geospatial data are particularly important for assessing the environment because ecosystems and habitats do not restrict themselves to accepted political boundaries. Geospatial data provide the spatial component necessary to assess the environmental conditions within particular ecosystem types. Additionally, geospatial data modelling techniques can be used to improve the coverage and accuracy of modelled data.

Annex 4: Assessing Data Gaps and information needs

In order to assess data gaps, it is first necessary first to define a minimum set of information that is needed to assess the environment and to compare data availability with information needs. The UN Environment methodology for integrated environmental assessments typically assesses five environmental themes: (1) atmosphere; (2) land; (3) water; (4) biodiversity; and (5) chemicals and waste[4]. Additionally, the socio-economic aspects of the environment, listed below, are all included within the scope of these integrated environmental assessments:

- the relationship between the environment and human health;
- the link between gender and the environment;
- environmental governance and regulation;
- the use of energy and mineral resources;
- public perception of the environment and;
- the impact of natural disasters on the human system.

The scope of these assessments matches very closely with the environment-relevant statistical priorities set out in the core set of the Framework for the Development of Environment Statistics (FDES 2013) (United Nations 2016b). Thus for the purpose of this report, the FDES, along with the newly adopted SDGs, will be mapped against the coverage of the globally and regionally available indicators.

The FDES 2013, including the Basic Set of Environment Statistics, was endorsed by UN Member States through the intergovernmental United Nations Statistical Commission in 2013 (United Nations 2013). The Basic Set includes three tiers and covers a broad spectrum of environmental issues that have been agreed to be fundamental for policy analysis and decision-making. The three tiers of the Basic Set are (United Nations 2016a):

- Tier 1 (aka. the Core Set of Environment Statistics): 100 statistics of high priority and relevance to most countries and that have a sound methodological foundation.
- Tier 2: 200 environment statistics which are of priority and relevance to most countries but require greater investment of time, resources or methodological development.
- Tier 3: 158 environment statistics which either are of lower priority or require significant methodological development.

For the purpose of this assessment, only Tier 1 and Tier 2 will be evaluated due to the fact that the data collection methodology for Tier 3 is less developed and the availability for these indicators is limited.

4 Even if for GEO-6 chemicals and waste is now being viewed as a cross-cutting issue

The Basic Set of Environment Statistics includes the following broad categories:

a. Environmental Conditions and Quality: Physical Conditions; Land Cover, Ecosystems and Biodiversity; and Environmental Quality
b. Environmental Resources and their Use: Mineral Resources; Energy Resources; Land; Soil Resources; Biological Resources; and Water Resources
c. Residuals: Emissions to Air; Generation and Management of Wastewater; and Generation and Management of Waste
d. Extreme Events and Disasters: Natural Extreme Events and Disasters
e. Human Settlements and Environmental Health: Human Settlements; Environmental Health
f. Environment Protection, Management and Engagement: Environment Protection and Resource Management Expenditure and Environmental Governance and Regulation

In addition to the FDES, the SDGs were adopted by the United Nations General Assembly in 2015. The SDGs represent a global commitment to work toward global sustainable development through the 169 SDG targets. The SDG indicators provide the mechanism for monitoring these 169 targets. The SDGs will likely become a central component of future environmental assessments, thus the data gap assessment included in this report will also assess available indicators vis-à-vis the environment-related SDG indicators which were presented to the United Nations Statistical Commission in 2016 [5].

Table A3 provides some examples of existing gaps in the environmental information related to the SDGs.

Table A3: SDG indicators and reporting available information

sdg_I_num	SDG Indicator	Data Exist	exact_ match	Indicator used for reporting	Source
1.1.1	Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/ rural).	YES.	Yes.	Population living in poverty at $1.25 a day in 2005 PPP.	MDG Indicators Database.
2.4.1	Proportion of agricultural area under productive and sustainable agriculture.	YES.	No.	Fertilizer consumption.	World Development Indicators (WDI).

5 Note that the SDG indicators presented to the United Nations Statistical Commission still included some provisional indicators and thus the indicators presented in this paper do not represent the final version of the SDG indicators. (All provisional indicators in this document will be marked with an *.)

3.7.1	Proportion of women of reproductive age (aged 15-49 years) who have their need for family planning satisfied with modern methods.	YES.	No.	Fertility rate.	World Population Prospects.
6.5.1	Degree of integrated water resources management implementation (0-100).	No.	No.		
14.6.1	Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing.	No.	No.		
17.3.1	Foreign direct investments (FDI), official development assistance and South-South Cooperation as a proportion of total domestic budget.	YES.	Yes.	FDI inflows.	FDI Statistics.

The global database on Environmental statistics elaborated by UN Environment (United Nations Environment Programme 2017b) provides a list of SDGs indicators for which information is available (or not) for reporting purpose. This information is collected from global resources and could be used by Governments to monitor their pathway through the 2030 Agenda for Sustainable Development.

In some cases, information related to a specific SDG indicator is already available and regularly collected by member states (ex. 1.1.1). This is the case for the Tier 1 indicators. In some other situation (ex. 2.4.1), information related to the indicator is also available but it does not match the exact terminology or structure of the SDGs indicator. In this context similar indicators can be used for monitoring and reporting purposes by member states while waiting for agreed international methodologies to be approved. The third option refers to a situation where no information is available for this specific SDG indicator (ex: 6.5.1). This could be the case of Tier 3 indicators where information is not available, because, in most cases, there is not a validated methodology to collect the needed information. Currently, only 49 indicators are available in the database perfectly corresponding with the SDGs indicators.

The process to bridge the gap in environmental statistics related to the SDGs is ongoing and will slowly facilitate member states in responding to their commitments in achieving the 2030 Agenda.

In addition to data mentioned in this section, there is a wealth of global climatic information, which cannot be disaggregated by country, but which is useful for assessing the environment. For example, data on atmospheric composition, artic ice, oceanic characteristics, solar radiation and other solar measurements are available. The Global Climate Observing System (GCOS) has conducted a detailed review on the data gaps in global climate observation. The GCOS noted that

"due to the heritage of many decades of meteorological data collection, atmospheric observation is the best developed, with relatively dense, though far from gap-free, networks, clear observational standards, largely open data exchange and international data centers covering most if not all variables." In terms of ocean observation, the conclusion was that "whilst there are still limitations and some issues with established networks, the overall structures are in place for improvement to continue" (World Meteorological Organization 2016).

Filling data and information gaps

As noted in the UN Secretary General's synthesis report on the post-2015 development agenda, national ownership of monitoring and evaluation processes is essential (A/69/700).

Even if a few exceptions should be taken into consideration (ex. climate related data), in the context of environmental data, the production of data should primarily lie at the national level. While the UN coordinates the development of statistical standards and methodologies supporting statistical capacity development within countries, its responsibilities in the implementation phase at the national level are limited.

The main statistical guidance documents for environment statistics are the Framework for the Development of Environment Statistics (FDES) and the System of Environmental and Economic Accounting (SEEA). The FDES provides detailed explanation of the compilation of basic environmental data and the SEEA is a statistical standard for putting environmental data into an accounting framework.

Through the implementation initiatives of the FDES and the SEEA, there is a great amount of information related to developing and implementing national programmes on environment statistics. The UN Statistic Division conducted a detailed global assessment of environment statistics and environmental-economic accounting (United Nations 2007) and found that, of the countries that responded to the survey, 88 countries have an existing programme on environment statistics and 80 countries provided detailed information on the type of environmental information covered in the programme. Unfortunately, this assessment is only collected infrequently and regular updates on the progress of FDES and SEEA implementation is not readily available.

Table A4: Type of environmental information covered in national programmes

All world			Developed regions			Developing regions		
Area	Number of countries	Percentage of countries	Area	Number of countries	Percentage of countries	Area	Number of countries	Percentage of countries
Total Countries-World	80	100	Total Countries-developed regions	37	100	Total Countries-developing regions	43	100
Water	70	88	Water	29	78	Water	41	95
Air	60	75	Agriculture	25	68	Air	36	84
Forest	58	73	Air	24	65	Land	36	84
Land	55	69	Forest	25	65	Forest	34	79
Energy	53	66	Energy	25	65	Biodiversity	34	79
Agriculture	53	66	Waste	23	62	Energy	29	67
biodiversity	45	56	Land	19	51	Agriculture	28	65
transport	40	50	transport	17	46	Mineral	27	63
Waste	40	50	Environmental protection expenditure	15	41	Transport	23	53
Mineral	36	45	biodiversity	11	30	Waste	17	40
Environmental protection expenditure	20	25	Mineral	9	24	Environmental protection expenditure	5	12
other	34	43	other	14	38	other	20	47

Source: United Nations 2007 p. 6

Additionally, 52 countries provided information on future plans to improve different aspects of environment statistics.

Table A5: Countries having declared the intention to improve environment statistics

All world			**Developed regions**			**Developing regions**		
Subject Area	Number of countries	Percentage of countries	Subject Area	Number of countries	Percentage of countries	Subject Area	Number of countries	Percentage of countries
Total Countries-World	52	100	Total Countries-developed regions	22	100	Total Countries-developing regions	30	100
Air	21	40	Water	7	32	Air	15	50
Water	20	38	Air	6	27	Biodiversity	14	47
Land	18	35	Land	5	23	Energy	14	47
Biodiversity	17	33	Waste	5	23	Water	13	43
Forest	16	31	Forest	4	18	Land	13	43
Energy	15	29	Agriculture	4	18	Forest	12	40
Agriculture	14	27	EPE	3	14	Transport	11	37
Transport	12	23	Biodiversity	3	14	Agriculture	10	33
Mineral	11	21	Energy	1	5	Mineral	10	33
Waste	10	19	Mineral	1	5	Waste	5	17
EPE	7	13	Transport	1	5	EPE	4	13
other	18	35	other	7	32	other	11	37

Source: United Nations 2007 p. 9

These tables demonstrate that there is an interest at the national level in improving environment statistics systems; however, a number of constraints still exist.

Table A6: Impeding factors in the development of environment statistics and environmental-economic accounting programmes

Environmental statistics			Environmental economic accounting		
	Number of Countries	Percentage of countries		Number of Countries	
Total countries	79	100	Total countries	62	
Lack of human resources	57	72	Lack of human resources	43	
Lack of financial resources	47	60	Lack of financial resources	42	
Lack of inst-set-up/ coordination	40	51	Availability of data	38	
Lack of access to training material	25	32	Quality of data	32	
Lack of interest by the users	12	15	Lack of inst-set-up/ coordination	24	
Availability of data			Lack of interest by the users	21	
Quality of data			Lack of access to training material	19	
other	14	18	other	11	

Source: United Nations 2007 p. 11

Table A7: Impeding factors in the compilation of environment statistics and environmental-economic accounts

Environmental statistics			Environmental economic accounting		
	Number of Countries	Percentage of countries		Number of Countries	Percentage of countries
Total countries	78	100	Total countries	42	100
Availability of data	56	72	Availability of data	37	88
Quality of data	49	63	Quality of data	27	64
Lack of human resources	47	60	Lack of human resources	26	62
Lack of financial resources	38	49	Lack of financial resources	23	55
Lack of inst-set-up/ coordination	35	45	Lack of inst-set-up/ coordination	12	29
Lack of access to training material	22	28	Lack of interest by the users	11	26
Lack of interest by the users	10	13	Lack of access to training material	9	21
other	9	12	other	6	14

Source: United Nations 2007 p. 12

Improvement in recent years has been recorded and data related to environmental statistics shown in these tables have slightly changed. In general, countries, particularly developing ones, require support in improving coordination, securing resources for the collection and processing of environment statistics and building expertise in environment statistics. Ministries of Environment, National Statistical Offices and other relevant ministries must work together to building sustainable environmental statistical systems. This requires high-level political support and it also requires promoting the utilization of existing statistics for environmental assessments and decision-making.

Technological advancements provide the basis for accelerating advancements in the production of environment statistics. However, exploitation of data must be coupled with quality assurance and methodological work that ensures that the statistics produced meet quality and international comparability standards.

Annex 5: Networks of Scientific Academies

There is a growing number of networks of scientific academies, both globally and regionally. These offer some opportunities for improving the effectiveness of the science-policy interface **(Table A8)**.

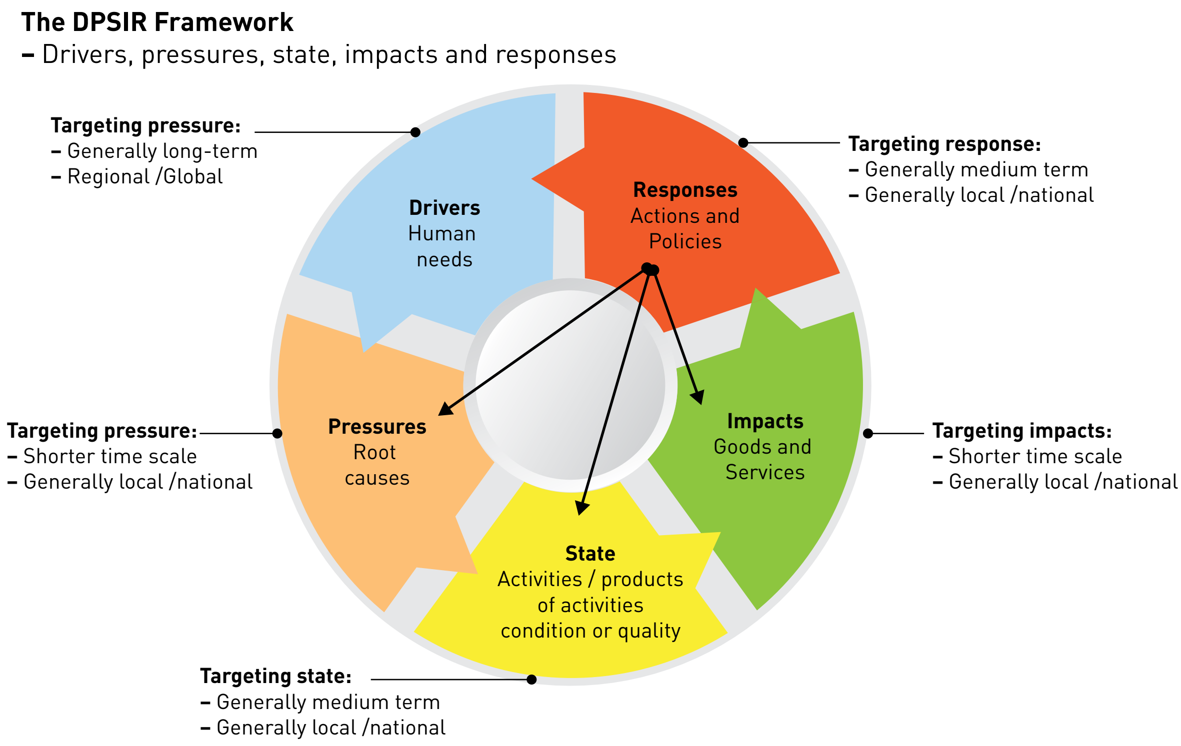
TABLE A8: International Networks of Scientific Academies

Environmental statistics		**Environmental economic accounting**	
Name	Characteristics	Name	Characteristics
The World Academy of Sciences (TWAS)	Global network of scientists among developing nations (launched 1983)	European Academies' Science Advisory Council (EASAC)	National science academies of the EU Member States (launched 2001)
InterAcademy Panel (IAP)	Global network of science academies (launched 1993)	Inter-American Network of Academies of Sciences (IANAS)	Among the countries of the Americas (launched 2004)
InterAcademy Medical Panel (IAMP)	Global network of medical and scientific academies (launched 2000)	Network of African Science Academies (NASAC)	Academies of sciences in Africa (launched 2001)
InterAcademy Council (IAC)	Global network of national scientific academies and corresponding organizations (launched 2000)	Association of Academies and Societies of Sciences in Asia (AASSA)	Academies of sciences in Asia (launched 2012)
Global Young Academy		Global network of young scientists (launched 2010)	
InterAcademy Partnership (IAP)		Global academy network of networks (launched 2016), bringing together the IAP (IAP for Science)	

Annex 6: Drivers, pressures, state, impact and responses (DPSIR) Framework

An important condition for conducting assessments and responding to reporting obligations on the state of the environment and the impacts of human activity is identification of targeted sets of indicators to be surveyed and the adoption of a functional scheme to describe cause-effect relationships across different sectors. A useful framework for the presentation of this evidence is the DPSIR Framework. The UN Environment Guidance on Integrated Environmental assessments refers to the DPSIR framework as the most relevant when developing Integrated Environmental assessments. The DPSIR framework assists the Integrated Environmental assessments practitioners in answering a broad set of policy questions, identified in **Figure A2**.

Figure A2. The DPSIR Framework



Source: United Nations Environment Programme 2017 fig 3.1

The PSR scheme (Pressure – State – Response), adopted by the Organisation for Economic Cooperation and Development (Organisation for Economic Co-operation and Development 2003), and the DSR (Driving force – State – Response) of the UN Commission on Sustainable Development (Pintér, Hardi and Bartelmus 2005) preceded the most recent DPSIR framework (Driver – Pressure – State – Impact– Response). This latest framework has been developed by the National Institute of Public Health and Environment of Bilthoven, Netherlands (Kristensen 2004) and adopted by the European Environmental Agency.
The model takes into considerations the drivers (D) or root causes, which arise from human or societal needs that give rise to pressures (P) which are the human/societal activities that result from fulfilling those needs. These activities generally result in biological, physical, and chemical products that cause changes to the environmental condition, thereby impacting on the state (S) of the environment and affecting its ability to provide services and goods to society (Kelble *et al*. 2013). This, in turn could elicit responses (R), political, or otherwise, designed to mitigate the impacted environmental state, thereby improving the condition of the people. The main purpose of the DPSIR is to reduce complex situations into simpler cause-and -effect situations, leading to better understanding.

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