



The authority of science in sustainability governance: A structured comparison of six science institutions engaged with the Sustainable Development Goals



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ABSTRACT

Over the past decades, numerous science institutions have evolved around issues of global sustainability, aiming to inform and shape societal transformations towards sustainability. While these science-based initiatives seem to take on an ever growing active role in governance for sustainable development, the question arises how they can claim any political authority in the first place. We present here a structured comparison of six international science-based initiatives, all engaged in governance processes related to the recently established Sustainable Development Goals. We focus on the material and rhetorical strategies employed by these science institutions to acquire authority by fostering perceptions of saliency, credibility and legitimacy among governance actors. We distinguish three modes of scientific authority: an *assessment-oriented mode* that combines a strategy of saliency through integration, with credibility by formal mechanisms of review, and legitimacy through representation; an *advice-oriented mode*, which appeals to saliency through the promise of independent and timely science advice, to credibility through the credentials of the scientists involved, and to legitimacy through formal recognition by governance actors; and a *solution-oriented mode*, with science institutions claiming relevance based on the promise to contribute to solutions for global sustainability, while credibility is sought by invoking support of the scientific community, and legitimacy through a strategy of participation. Based on this analysis, we provide a framework for reflection on the claims and strategies of science-based initiatives, and their role and responsibility in governance for sustainable development.

This article is part of a special issue on solution-oriented GEAs.

1. Introduction

Undoubtedly, scientists and science institutions have become highly active participants in global sustainability governance over the past decades. And yet, today's role of scientists and science institutions – notably in the 2012 United Nations Conference on Sustainable Development in Rio de Janeiro and the subsequent intergovernmental negotiations for the Sustainable Development Goals – is bigger in both quality of influence and quantity of representation than ever before (UN DESA, 2014). Numerous science institutions have become actively engaged in formulating the Sustainable Development Goals, and many will have a prominent role in monitoring and measuring the impact of the goals and seek to contribute to their implementation (Griggs et al., 2013; Lu et al., 2015; Lubchenco et al., 2015; Stafford-Smith, 2014; Biermann et al., forthcoming). Overall, many major science institutions seek to turn towards what has been termed “solution-oriented science engagement”, that is, a way of operation that aims to contribute to solutions for global

sustainability (Edenhofer and Kowarsch, 2015; Lee, 2015).

Yet, the current high participation and increasing role of scientists in global sustainability governance is also contested, and has given rise to criticism regarding the usefulness and effectiveness of science institutions. For that reason, science institutions and their managers today seek to carefully construct and safeguard their authority in political processes in order to be able to continue to play an active role in governance for sustainable development. In this paper, we embark from the assumption that to construct and safeguard this authority, science institutions will aim to strengthen the *saliency*, *credibility* and *legitimacy* of their work (drawing on the well-established framework by Cash et al., 2003 and Mitchell et al., 2006). Saliency is here defined as the perceived relevance of science institutions and the knowledge they provide; credibility as the perceived scientific adequacy of scientific products and arguments; and legitimacy as the perceived fairness of knowledge production and assessment, respecting divergent values, interests and beliefs (Cash et al., 2003).

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There are, however, no simple formulas for constructing and safeguarding salience, credibility and legitimacy. Instead, institutions can seek to pursue these qualities in different ways, building on divergent strategies to claim authority in the crowded space of science engagement in governance for sustainable development. The first aim of this paper is hence to *elucidate the variant strategies that science institutions employ to foster perceptions of salience, credibility and legitimacy in governance for sustainability*. The framework that we develop based on this exercise contributes to the second aim of this paper – *to support reflection on the strategies for authority pursued by science institutions engaged in governance for sustainable development*.

For the purpose of this paper, we employ the broad concept of science institutions to include various forms of science-based initiatives operating at the interface between science and governance for sustainable development. This includes Global Environmental Assessments (GEAs) but also advisory bodies and other forms of science networks and platforms. It is important to point out that science institutions are diverse in their institutional design and the context in which they operate, and that these institutions themselves are typically complex, multi-layered entities. Nevertheless, the common focus of science institutions in governance for sustainable development on informing, monitoring and implementing the Sustainable Development Goals warrants a comparison on the ways in which authority is sought in this crowded space of science engagement.

Our paper proceeds as follows. In the next section, we briefly introduce the academic literature on salience, credibility and legitimacy – particularly in relation to the strategies that science institutions may pursue to achieve these attributes – and present our research design, which is based on a structured comparison of six international science-based initiatives engaged in formulating, implementing and monitoring the Sustainable Development Goals. In sections 3 to 5 we discuss the different strategies that science institutions pursue to enhance and safeguard perceptions of salience, credibility and legitimacy among governance actors. We then point out three overarching modes of engagement and conclude by providing a framework to support reflection on the various strategies and their implementation.

2. Understanding authority of science in governance for sustainable development

Over the past decades, global environmental assessments and other science networks and institutions have become an important part of the international governance landscape for sustainable development (Biermann, 2014; Gupta et al., 2012). Indeed, science institutions can be seen as a (potential) source of authority in global politics (Miller and Edwards, 2001). Yet, the authority of science in a dynamic political environment is to a large extent contested and negotiated, and crucially depends on the practical and rhetorical tools that scientists use to establish perceptions of relevance and trustworthiness among governance actors (Kunseler and Tuinstra, 2017; Lidskog and Löfmarck, 2015; Turnhout et al., 2007).

Scholars of environmental politics have identified perceived salience, credibility and legitimacy as prerequisites for receptiveness of governance actors for scientific institutions and the knowledge they provide (Cash et al., 2003; Mitchell et al., 2006). In parts of this literature, the term “effectiveness” is used as the dependent variable to assess the eventual influence of science institutions. We rather conceptualize the key impact as authority of science, which we see as fundamental for an effective role of science in governance. The attributes of salience, credibility and legitimacy have been applied to understand the influence of (Global) Environmental Assessments (Cash et al., 2003; Mitchell et al., 2006), as well as other institutions operating at the science-policy interface (e.g. Reinecke, 2015; Sarkki et al., 2014, 2015). In this paper, we assume that science institutions, implicitly or explicitly, will attempt to increase perceptions of salience, credibility and legitimacy in order to establish and maintain their authority among

governance actors.

However, there are no simple avenues for fostering perceptions of salience, credibility and legitimacy (Keller, 2009; Miller and Edwards, 2001; Reinecke, 2015). Reinecke (2015), for instance, lists several rhetoric strategies and institutional mechanisms that are employed to pursue these qualities, including the translation of research findings into policy messages to enhance salience, formal procedures for assuring the quality of knowledge to safeguard credibility, and transparency of the initiative to foster perceptions of legitimacy. Other studies point to formalized rules of engagement as beneficial to salience and credibility (Keller, 2009), emphasize how scientists establish credibility by claiming membership of the broader scientific community (Keller, 2009; Lidskog and Löfmarck, 2015), and identify stakeholder participation as an increasingly popular strategy for generating salient, credible and legitimate science engagement (Kunseler et al., 2015; Sarkki et al., 2015; van Enst et al., 2016).

More broadly, salience, credibility and legitimacy mean different things in different socio-political and cultural contexts, making it difficult to secure these attributes among often highly diverse audiences (Biermann, 2002; Jasanoff, 2005). Moreover, science institutions may place different emphasis on the attributes of salience, credibility and legitimacy (Reinecke, 2015). Several studies have pointed to trade-offs between salience, credibility and legitimacy, and the balancing act for assuring these qualities across different actors (Kunseler et al., 2015; Sarkki et al., 2014). Finally, science institutions have been shown to pursue different strategies across different sites or levels of the institution (Keller, 2009; Kunseler and Tuinstra, 2017).

Our study contributes to this literature by distilling common strategies pursued across different science institutions and by critically reflecting on the related claims for salience, credibility and legitimacy. We use here the broad concept of “strategies”, by which we include organizational strategies and institutional mechanisms – ranging from informal mechanism to formal rules and procedures – as well as rhetorical strategies (Keller, 2009; Reinecke, 2015). As discussed above, science engagement in governance for sustainable development is a complex phenomenon, and science institutions themselves are multi-layered entities. As such, we do not expect to find unequivocal strategies for pursuing perceptions of salience, credibility and legitimacy. Instead, we assume that science institutions apply a multitude of different claims, tools and mechanisms in pursuit of these qualities. These “strategies” might be implicit or explicit, actual or rhetoric, and in various degrees related to the institutional mandate or design. By using the broad concept of “strategy”, we aim to grasp the diversity of institutional, organizational and rhetorical instruments and mechanisms used to pursue authority.

The paper draws on a structured comparison of six science-based initiatives engaged in governance for sustainable development. These six science institutions work according to different logics of operation, yet share the goal of contributing scientific knowledge and expertise to the development and implementation of the Sustainable Development Goals, agreed upon in 2015 by the UN General Assembly. Our six cases include scientific assessments in a more traditional understanding as well as other forms of science institutions, such as scientific advisory boards and international research networks.

Four characteristics are particularly pertinent for understanding how science institutions can foster perceptions of salience, credibility and legitimacy: their structure; their objectives and function; their internal processes; and their intended outcomes (Sarkki et al., 2015). We have hence selected the six cases that we study for their diversity on these four characteristics. We do not claim to have included all relevant institutions. The selected cases rather represent a diverse sample of science institutions engaged with governance for sustainable development, allowing us to investigate different strategies for pursuing salience, credibility and legitimacy. We briefly introduce our cases in Box 1. A more elaborate overview of our cases based on the framework of Sarkki et al. (2015) is provided in the Supplementary Material.

Box 1

Case studies

Scientific and Technological Community Major Group

The Scientific and Technological Major Group is one of nine Major Groups formalized in Agenda 21 as main channel for the participation of stakeholders in UN activities related to sustainable development. The organizing partners of the Scientific and Technological Community Major Group, the International Council for Science (ICSU), the International Social Science Council (ISSC) and the World Federation of Engineering Organizations (WFEO), formally represent the scientific and technological community in UN processes on sustainable development.

Future Earth: Research for Global Sustainability

Future Earth is an international research platform bringing together researchers from various natural and social science disciplines working on issues of sustainability. Future Earth was launched at the 2012 United Nations Conference on Sustainable Development. It aims to inform and guide societal transformations to global sustainability. Several sub-projects focus specifically on the Sustainable Development Goals

Scientific Advisory Board of the UN Secretary-General

The Scientific Advisory Board of the UN Secretary-General was created in 2013 at the request of the UN-Secretary General to ensure “that up-to-date and rigorous science is appropriately reflected in high-level policy discussions within the UN system” (Scientific Advisory Board, 2016, p. 14). The Scientific Advisory Board consists of 26 scientists from around the world and is chaired by Irina Bokova, Director-General of UNESCO.

Global Environmental Outlook

The Global Environmental Outlook is an integrated environmental assessment periodically produced by the United Nations Environment Programme (UNEP). The Global Environmental Outlook was initiated in response to environmental reporting requirements listed in Agenda 21, and five reports have been produced to date. The sixth report, currently in progress, will have a specific focus on the Sustainable Development Goals.

Sustainable Development Solutions Network

The Sustainable Development Solutions Network is a network of experts and institutions from academia, business, civil society, and the public sector, chaired by Professor Jeffrey Sachs. The Network was launched in 2012 by UN Secretary-General Ban Ki-moon, and aims to amplify the voices of science in global debates and contribute to sustainable solutions.

Global Sustainable Development Report

The Global Sustainable Development Report is an assessment of assessments led by the United Nations Division for Sustainable Development and responding to the mandate of the High-Level Political Forum (HLPF) to strengthen the science-policy interface on issues of sustainability. Three reports were published to date – a prototype edition in 2014, and full reports in 2015 and 2016.^a

^aAt the 2016 annual meeting of the HLPF, it was decided that the Report will henceforth be published on a quadrennial basis, and drafted by a group of 15 independent scientists (Earth Negotiations Bulletin, 2016). This paper takes into account developments up to the publication of the third Global Sustainable Development Report in 2016.

Our case comparison is based on a structured document analysis. We include both official strategy documents and representations on websites, in interviews, and other informal sources (listed in the Supplementary Material). To elucidate the strategies that science institutions employ to foster salience, credibility and legitimacy we chose an inductive research design, which allowed us to detect patterns and regularities across the six case studies. We coded the selected documents for statements making implicit or explicit claims for salience, credibility and legitimacy. Based on a comparison of these claims, we distinguished common strategies within our selected cases. Our analysis focuses on the rhetorical and institutional strategies of organizations as they are represented in documentary material. We do not offer claims about the actual implementation of these strategies. Instead, we critically reflect on and deconstruct the strategies pursued by our cases, and provide a framework for further reflection on the rationales and implementation of these strategy.

3. Strategies for salience

We distinguish three types of strategies by which science institutions aim to foster perceptions of salience among governance actors. We label these as *salience through integration*, *salience through independent advice* and *salience through solutions*.

3.1. Salience through integration

A first strategy for fostering salience is that of integration. Science institutions that employ this strategy claim salience based on the

comprehensive and integrated nature of their products. They typically survey a large amount of scientific literature with the aim to provide a comprehensive report of the state of science for consideration by governance actors. In that sense, they follow the classical model of global environmental assessments. An example of this strategy is the Global Environmental Outlook, which claims to turn “the best available scientific knowledge into information relevant for decision makers” (UNEP, 2012, p. xix). Similarly, the Global Sustainable Development Report aims to integrate all available scientific knowledge relevant for the High-Level Political Forum, their direct policy audience. The Report takes the form of an “assessment of assessments” that builds on existing assessments and brings together dispersed information in a “comprehensive, authoritative global sustainable development report” (UN DESA, 2014, p. 26).

The question arises, however, what type of knowledge is considered relevant? When does knowledge become “scientific knowledge” worth being integrated in a comprehensive assessment? Traditionally, scientific assessments have relied strongly on peer-reviewed scientific knowledge in established publishing outlets, notably academic journals. However, increasing acknowledgement that knowledge relevant for decision-makers might be found outside of formal scientific disciplines requires science institutions to look beyond the peer-reviewed literature. Indeed, upcoming reports from both the Global Environmental Outlook and the Global Sustainable Development Report are anticipated to draw on a more diverse knowledge base, including along with peer-reviewed scientific literature also grey literature and indigenous and local knowledge. However, to date, although elaborate mechanisms exists for assessing peer-reviewed knowledge, procedures for including local knowledge and grey literature are largely absent.

3.2. Salience through independent advice

Second, some science institutions claim salience based on the promise of providing independent scientific advice. Institutions that follow this strategy are often linked to an ongoing policy process or body and thus have a direct audience to which they address their recommendations. One example is the Scientific Advisory Board that advises the United Nations Secretary-General and the executive heads of UN organizations. Importantly, it was stressed at the inaugural meeting that this Board “should express not only what governments *ask* and *want* to hear but *should* hear, from a scientific perspective” (Scientific Advisory Board, 2014a, p. 3; emphasis in original). A related role for the Scientific Advisory Board is to “elevate the role of science in policy-making” and strengthen the science-policy-society interface (Scientific Advisory Board, 2014a, p. 3).

Another example is the Scientific and Technological Community Major Group, which represents, as part of the UN major group system, the scientific community in UN processes on sustainable development. Members of the group coordinate input from the scientific community “in order to ensure an informed and objective perspective on progress against the achievement of the SDGs” (ICSU et al., 2015, p. 2). For instance, a report by the two core member organizations that reviewed the targets of the Sustainable Development Goals was branded as “the science perspective” and “the first independent scientific review” of the Sustainable Development Goals (ICSU and ISSC, 2015).

And yet, the question arises what can be considered “the science perspective” in the case of complex issues dealt with in governance for sustainable development. Which disciplines, issue areas, theoretical perspectives and methodological approaches should be included? The institutions considered here operate in different ways in developing and communicating their “scientific perspective” on the Sustainable Development Goals. They are both essentially people-driven (as discussed in Section 4), making their input dependent on the qualifications, insights, understanding and possibly also normative preferences of the individual scientists involved.

Central to the advice in both cases is a broader emphasis on the important role of science, in general, in governance for sustainable development. By virtue of its role and institutionalization in the UN system, the Scientific and Technological Community Major Group seeks to represent the entire scientific community as a “stakeholder” in governance for sustainable development. Also the Scientific Advisory Board aims to promote the role of science in the UN system, as reflected in several publications on the science-policy interface and the “crucial role of science” for sustainable development (e.g. Scientific Advisory Board, 2014b). We argue that more reflection is needed on the meaning and potential tensions of this dual role as independent advisor and advocate for science.

3.3. Salience through solutions

A third strategy that some science institutions use to claim salience is the promise of solutions for complex sustainability challenges. Moving away from a focus on assessing the *problems* of environmental change, these institutions aim to contribute to *solutions* for sustainable development.

Table 1
Strategies for salience and case examples.

	Salience through integration	Salience through independent advice	Salience through solutions
Main claims	<ul style="list-style-type: none"> Assessing the best available knowledge Integration and comprehensiveness 	<ul style="list-style-type: none"> Providing the/a science perspective in ongoing policy processes Independence of political interests 	<ul style="list-style-type: none"> Contributing to solutions for sustainability challenges
Examples	Global Environmental Outlook; Global Sustainable Development Report	Scientific Advisory Board; Major Group	Sustainable Development Solutions Network; Future Earth

This solution-oriented strategy is strongly reflected in the narrative of both the Sustainable Development Solutions Network and Future Earth. As the name of the first network reflects, providing solutions for sustainability is its main ambition. Core to the strategy of the Sustainable Development Solutions Network are “solution-initiatives” that intend to promote new technologies, models and policies to accelerate progress towards sustainable development. The solution-focus is also central in Future Earth, as reflected in the network’s core mission of “research for global sustainability”. Future Earth sees solution-oriented science as a new type of science which, through integration of multiple disciplinary perspectives and co-production with societal partners, is expected to enable “fundamental societal transitions to global sustainability” (Future Earth, 2013, p. 13).

To a lesser extent, the Global Environmental Outlook and the Global Sustainable Development Report also turn towards solution-orientation. The Global Environmental Outlook provides an analysis of “policy-options” and “priority solutions” in its fifth report, and promises to “[assist] member states to position themselves on the most effective pathways for transitions towards a sustainable future” (UNEP, 2015, p.1). Similarly, the Global Sustainable Development Report brings a solution-oriented focus through its section on “emerging issues”, which aims to inform policy makers of new risks as well as opportunities, policy options and solutions related to sustainable development. Yet, neither institution appears fully comfortable with this approach, using careful wording when it comes to “policy options” and “solutions” with the added qualification that science should point out the costs and benefits of policy options yet cannot make decisions.

In general, it is often unclear what exactly is meant by “solution-orientation”. Future Earth calls for “actionable scientific knowledge” (Future Earth, 2016), whereas the Sustainable Development Solutions Network aims to promote and participate in “practical problem solving for sustainable development” (Sustainable Development Solutions Network, n.d.). Yet, the type and form of solutions coming from science are generally not specified, nor are there many tangible examples of the solutions that these networks bring for sustainable development. More broadly, the fundamental question arises, for *whom* science should provide solutions? Here, we see that the Global Environmental Outlook and the Global Sustainable Development Report primarily speak to governments and intergovernmental organizations, whereas the Sustainable Development Solutions Network and Future Earth also explicitly reach out to the private sector and major corporations (Table 1).

4. Strategies for credibility

We now turn to credibility. We distinguish here three types of strategies by which science institutions aim to foster a perception of credibility among governance actors, which we label as *credibility by peer review*, *credibility by individual credentials* and *credibility by community*.

4.1. Credibility by peer review

The mechanism of peer review is a well-established strategy to provide credibility to scientific knowledge. This strategy is at the heart of scientific assessments such as the Global Environmental Outlook,

which stresses its rigorous and comprehensive review process. Through its nature as an “assessment of assessments”, the Global Sustainable Development Report also appeals to formal mechanisms associated with assessments, including peer review. Indirectly, the other cases considered here also build on peer review as a mechanism upholding the credibility and trustworthiness of the scientific communities they represent (see Section 4.3).

Notwithstanding the prominence of peer review as a strategy for attaining credibility, mechanisms of peer review are not undisputed. Who, for example, are considered credible “peers” for science institutions in governance for sustainable development, and which mechanisms enable the participation of these peers in the review process? Where the review process of the Global Environmental Outlook includes an internal review by UN staff, an external review by scientific experts, and a governmental review, other institutions restrict peer review to the scientific community. The prototype of the Global Sustainable Development Report discusses the option of an open, multi-stakeholder peer review process. Yet, for the three reports published to date, no comprehensive peer review process was developed, with some chapter reviews conducted by a single expert (appealing to credibility by the credentials of this expert, rather than peer review as a mechanism).

4.2. Credibility by individual credentials

A second strategy for establishing credibility is based on the individual credentials of members. The most prominent example is the Scientific Advisory Board, which is composed of 26 “eminent scientists”, whose knowledge and experience form the foundation of its science advice (Scientific Advisory Board, 2016). The Sustainable Development Solutions Network appeals to the credentials of its “remarkable Leadership Council” (Sustainable Development Solutions Network, 2015, p.17). Also Future Earth’s governance structure includes a Science Committee composed of individual scientists who are expected to “ensure scientific quality” (Future Earth, 2013, p. 14). Finally, the Global Environmental Outlook applies this strategy in its selection of “world-renowned experts” as lead authors and members of its Scientific Advisory Panel, tasked with safeguarding the credibility of the assessment (UNEP, 2014, p.1).

We might ask, however, which actors are in fact chosen to uphold the credibility of a scientific institution. Member of the Scientific Advisory Board are described as “leaders in their field, [including] Nobel Prize winners and heads of major national and international science institutions” (Scientific Advisory Board, 2016, p. 13). Yet the processes through which this seniority is established, and the criteria used, remain unclear, and its outcome could hence be questioned. Whereas the Scientific Advisory Board is exclusively composed of scientists, the Leadership Council of the Sustainable Development Solutions Network includes other types of experts from multiple sectors of society, including science, civil society, business, government, and international organizations. Future Earth and the Global Environmental Outlook also include bodies representing societal actors. Yet both organizations rely on an exclusively scientific body (the Science Committee and Scientific Advisory Panel respectively) to uphold the scientific quality and credibility of their work.

Table 2
Strategies for credibility and case examples.

	Credibility through peer review	Credibility through individual credentials	Credibility through community
Main claims	<ul style="list-style-type: none"> • Building on the combined expertise of peers • Formal procedures to ensure scientific quality 	<ul style="list-style-type: none"> • Distinguished individuals uphold scientific credibility 	<ul style="list-style-type: none"> • Speaks on behalf of the scientific community
Examples	Global Environmental Outlook; Global Sustainable Development Report	Scientific Advisory Board; Sustainable Development Solutions Network	Sustainable Development Solutions Network; Future Earth; Major Group

But also here, the criteria for selection and establishing seniority are unclear, and open for debate.

4.3. Credibility by community

Credibility by community is a third strategy for fostering a perception of credibility among governance actors. This strategy is utilized by the Major Group, Future Earth and the Sustainable Development Solutions Network, who all appeal to the combined expertise, trustworthiness and authority of “the scientific community” in their claims for credibility.

The Major Group formally represents the scientific community in UN processes on sustainable development, speaking on behalf of science within this institutional setting. Input from the Major Group is coordinated by ICSU, ISSC and the World Federation of Engineering Organizations, themselves membership organizations representing National Academies of Science and International Scientific Union Members in their respective domain. The Sustainable Development Solutions Network and Future Earth also appeal to the combined strengths of the scientific community. The Solutions Network, as a membership organization, points to the trustworthiness and authority of its members in its claim for credibility; membership is limited to “accredited” universities, research centres, and other knowledge institutions with “a strong track record” working on sustainable development (Sustainable Development Solutions Network, 2013). Future Earth does not have a formal membership structure but claims to represent and coordinate input from a large and interdisciplinary scientific community working on issues of global change and sustainability. Its outreach material points to the 50,000 scientists that have supposedly been mobilized by Future Earth, working across the world as part of more than 20 global research projects (Future Earth, 2015). Yet it is difficult to establish to what extent Future Earth’s own decision-making processes and outcomes really represent the views, insights, and perspectives of 50,000 scientists in the field.

The question arises who those communities are, and whether they feel part of and represented by the science institutions that claim credibility based on their behalf. The Major Group, for example, has been criticized for inadequately representing the scientific community in international governance for sustainable development (e.g. Zondervan, 2015). In the case of the Sustainable Development Solutions Network, the relative visibility of the selective and high-level Leadership Council has spurred critique of the exclusive nature of the network. For Future Earth, finally, recurrent calls for better involvement of relevant disciplines and research groups reflects that parts of the “community” do not feel represented in the network (e.g. Lövbrand et al., 2015) (Table 2).

5. Strategies for legitimacy

Finally, we distinguish three types of strategies by which science institutions aim to foster perceptions of legitimacy among governance actors, which we label as *legitimacy through representation*, *legitimacy through formal recognition* and *legitimacy through participation*.

5.1. Legitimacy through representation

Science institutions claim legitimacy by stressing that they represent a multiplicity of relevant scientific fields. Additionally, geographical and gender balance are pursued as factors that enhance legitimacy.

A key example is the Scientific Advisory Board, whose Board members, although appointed in their personal capacity, are presented as “representing all regions and many scientific disciplines relevant for sustainable development” (UNESCO, n.d.). Likewise, the procedures of the Global Environmental Outlook for selecting experts “aims to identify the best available expertise representing a range of disciplines, and geographical and gender balance, with particular emphasis on ensuring full representation from developing-country experts” (UNEP, 2014, p. 1). The Global Sustainable Development Report also stresses that it takes into account the perspectives of scientific communities across the globe and emphasizes its open, inclusive and geographically balanced structure. Future Earth, in addition to pursuing gender, age and geographical balance among its committee members, is supported by a globally distributed secretariat, combined with a set of regional hubs, which are considered central to ensuring broader geographical representation.

Although the strategy of representation is widespread among science institutions engaged in governance for sustainable development, achieving the objective of disciplinary, geographical and gender balance often proves difficult in practice. Contributors to the fifth Global Environmental Outlook, for example, are predominantly citizens of developed countries. Nevertheless, an external review notes that this might represent a standard that is “as good as it gets” (Rowe et al., 2014, p. 34). Future Earth similarly struggles with achieving an equal representation of geographical regions in its governance and membership structures, with the globally distributed secretariat and regional hubs based mostly in developed countries and the programme criticized for being Northern-oriented (Padma, 2014). Similarly, science institutions experience difficulties in achieving gender balance as well as a balanced representation of different disciplines. Only the Scientific Advisory Board appears to succeed relatively well in a balanced representation by its members. Yet, even when acceptable levels of representation are reached in numerical terms, we must ask to what extent voices from different disciplines, regions and genders are equally heard and able to shape science engagement in governance for sustainable development. All in all, legitimacy through representation, although often claimed, remains a strategy that requires much more careful consideration and targeted action in order to strengthen the practice of science engagement in governance for sustainable development.

5.2. Legitimacy through formal recognition

Second, legitimacy is claimed through formal recognition within the UN system. This is particularly important for the Global Sustainable Development Report, which was requested by governments at the 2012 UN Conference on Sustainable Development and directly responds to the mandate of the High-Level Political Forum to strengthen the

science-policy interface. As such, it creates “an entry point for scientists across the world to be heard at the highest levels of the United Nations” (UN DESA, 2016, p. 1).

Another entry-point for scientists in the UN system is the Scientific and Technological Community Major Group. As one of nine “Major Groups” representing diverse stakeholders, the Scientific and Technological Community Major Group has been granted comprehensive participatory opportunities in UN processes on sustainable development. Members are keen to further extend this authority and argue that the Major Group “should be recognized as the specific consortium in charge of coordinating inputs by the scientific community in HLPF” (ICSU et al., 2015, p. 4).

The Scientific Advisory Board is also a formal component of the UN system, set up by UN Secretary-General Ban Ki-moon and reporting directly to executive heads of UN agencies and the Secretary-General. The Global Environmental Outlook is a formal publication of UNEP, and presented as “the UN’s authoritative assessment of the state, trends and outlook of the global environment” (UNEP, 2012, p. xix). Future Earth and the Sustainable Development Solutions Network, finally, officially operate separately from the UN system. Yet, particularly the Sustainable Development Solutions Network stresses its recognition within the UN system, presenting itself as “a global initiative for the United Nations” (e.g. Sustainable Development Solutions Network, n.d.). Two UN agencies – UNESCO and UNEP – are represented in the Governing Council of Future Earth.

Thus, we find intricate relationships between the science institutions studied here and various UN bodies and agencies. Science institutions tend to emphasize these links in their claims for legitimate engagement in governance for sustainable development. At the same time, all science institutions studied here also recurrently stress their independence. As such, a precarious balance is created between close engagement and distance from political processes.

5.3. Legitimacy through participation

A more recent strategy for ensuring legitimacy in governance is through participation of non-academic actors. We see this strategy reflected in the Sustainable Development Solutions Network, whose Leadership Council consists not only of academics but also includes actors from business, civil society and the public sector. Future Earth institutionalizes the role of extra-scientific actors in its Engagement Committee, which is an advisory body representing different stakeholders. Moreover, a core principle of the platform is that of co-design and co-production, stressing the importance of participatory knowledge production.

The Global Environmental Outlook is presented as a “consultative, participatory process that builds capacity for conducting integrated environmental assessments and reporting”, and lists, in addition to scientific institutions, governments and ministries and international organizations, NGOs, indigenous peoples’ networks and the private sector as important partners (UNEP, n.d.). Likewise, the Global Sustainable Development Report envisions a participatory and multi-stakeholder approach for its future reports. For the three reports published to

Table 3
Strategies for legitimacy and case examples.

	Legitimacy through representation	Legitimacy through formal recognition	Legitimacy through participation
Main claims	<ul style="list-style-type: none"> • Gender balance • Geographical representation • Disciplinary diversity 	<ul style="list-style-type: none"> • Formal relationship with UN agencies • Institutionalized role in governance for sustainable development 	<ul style="list-style-type: none"> • Participation of societal actor in governing bodies, advisory bodies and/or research process
Examples	Global Environmental Outlook; Scientific Advisory Board; Future Earth; Global Sustainable Development Report	Global Environmental Outlook; Scientific Advisory Board; Major Group; Sustainable Development Solutions Network; Future Earth; Global Sustainable Development Report	Global Environmental Outlook; Sustainable Development Solutions Network; Future Earth; Global Sustainable Development Report

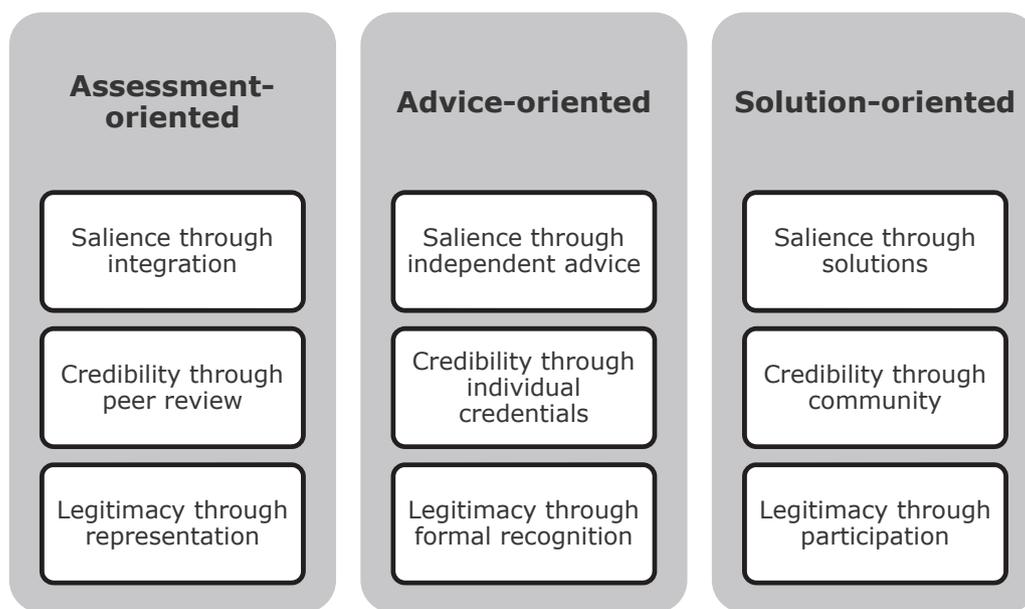


Fig. 1. Modes of authority. Three modes of authority of science institutions in governance for sustainable development, with associated strategies for salience, credibility and legitimacy.

date, input was solicited through an open call for “crowdsourced science briefs”. With the 2016 report going to press, 265 such briefs were received (UN DESA, n.d.).

Yet, realities of participation do not always live up to the claims and expectations of science institutions. Crowdsourced briefs of the Global Sustainable Development Report, for example, were required to be based on peer-reviewed science (as discussed in Section 3.1), thus limiting input beyond established scientific communities. For the fifth Global Environmental Outlook, universities and research centres remained the main contributors, while multilateral organizations and national governments participated as reviewers and members of the advisory group (Rowe et al., 2014). Moreover, we might ask which societal actors are able and willing to participate in science institutions. Although Future Earth has voiced a strong ambition to co-produce knowledge with a diverse group of stakeholders, its governance structure remains dominated by science councils, funding agencies and, to a lesser extent, UN organizations. The Sustainable Development Solutions Network draws strongly on participation from private sector actors in its Leadership Council, but other groups of potential participants appear less strongly represented (Table 3).

6. Three modes of authority

We have presented a comparative case analysis of six science institutions engaged in developing, monitoring and implementing the Sustainable Development Goals, elucidating the strategies pursued by these institutions to enhance and safeguard scientific authority in governance for sustainable development.

Across the six cases studied here, we find that three sets of strategies are often combined. We see these sets of strategies as the foundation of three different modes of scientific authority in governance for sustainable development (see Fig. 1). These modes of authority reflect different ways in which science institutions pursue salience, credibility and legitimacy, and hence authority, in governance for sustainable development. The first mode, which we call the *assessment-oriented mode*, combines a strategy of salience through integration, claiming relevance based on the comprehensive and integrated nature of scientific output, with credibility by peer review, asserting scientific quality through formal mechanisms of review. Legitimacy is sought here through representation of relevant disciplines, gender and geographical regions. This assessment-oriented mode can be seen as the traditional strategy by which global environmental assessments seek authority in sustain-

ability governance. The Global Environmental Outlook and Global Sustainable Development Report best represent this mode, although they increasingly appeal to additional strategies in order to assure salience, credibility and legitimacy among a diversity of governance actors.

Second, science institutions seek authority based on an *advice-oriented mode* of engagement. This again more traditional mode of science engagement in governance appeals to salience through the promise of independent and timely science advice on ongoing governance processes. Credibility is typically sought based on the individual credentials of scientists engaged in the institution, whereas legitimacy is claimed based on formal recognition by governance actors. The Scientific Advisory Board is a classic example of this mode of science engagement in governance for sustainable development, while the Major Group also appeals to most of these strategies.

Finally, a third *solution-oriented mode* of scientific authority in governance builds on the strategy of salience through solutions, with science institutions claiming relevance among governance actors based on the promise that science can contribute to solutions for global sustainability. Credibility is sought here by appealing to the larger scientific community which is (supposedly) represented by the institution, while legitimacy is claimed based on a strategy of participation, by which extra-scientific actors are invited to participate in the process of knowledge assessment and production. This mode for seeking authority in governance for sustainable development is reflected in the Sustainable Development Solutions Network and Future Earth, although we find other institutions in our sample increasingly appeal to the solution-oriented mode as well.

Thus, we distinguish three modes of engagement by which science institutions seek authority in governance for sustainable development: the assessment-oriented mode, the advice-oriented mode and the solution-oriented mode. Our observations point out that the solution-oriented mode of authority in governance for sustainable development is gaining increasing prominence, with science institutions promising to deliver “actionable scientific knowledge” and contribute to “practical problem solving”. And yet, the type and form of solutions coming from science are generally not specified. Moreover, science institutes differ substantially with respect to the actor groups that they claim to represent and that are able to participate in the search for science-derived solutions for sustainability. Notwithstanding claims of inclusiveness, actors and knowledge from the global South remain under-represented. This is particularly worrisome in the case of the

Table 4
A framework for reflection.

Assessment-oriented mode of authority	Advice-oriented mode of authority	Solution-oriented mode of authority
<p>Salience through integration</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> Why is integration of (scientific) knowledge important? What are possible drawbacks of integration? Which knowledge should be integrated? Why is this knowledge relevant? For what purpose? For whom? <p><i>Implementation</i></p> <ul style="list-style-type: none"> How are different forms and sources of knowledge included in the assessment? What procedures support/inhibit the inclusion of different types of knowledge? Can the promise of comprehensiveness be fulfilled? Are certain perspectives, issue areas or approaches omitted? 	<p>Salience through independent advice</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> What kind of advice is needed from science? Which disciplines, issue areas or approaches should be included in science advice? <p><i>Implementation</i></p> <ul style="list-style-type: none"> Which knowledge is included in the advice? Who speaks on behalf of science? What potential tensions come with the dual role of independent advisor and advocate for the role of science in governance? 	<p>Salience through solutions</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> What kind of solutions can science provide? For whom should solutions be developed? At which level? For which problems? Speaking to which actors? <p><i>Implementation</i></p> <ul style="list-style-type: none"> Which actors are asked to participate in the development of solutions? Which are left out? What kinds of solutions are developed? At which level? For which problems? Who benefits? Who loses?
<p>Credibility through peer review</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> When and how can peer review support the credibility of science institutions? Who is considered a credible peer? <p><i>Implementation</i></p> <ul style="list-style-type: none"> Is the peer review process comprehensive and in-depth? Who is allowed and able to take part in peer review? Whose perspective and expertise are included? Does the peer review process support/inhibit input from particular perspectives? 	<p>Credibility through individual credentials</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> When can someone be considered a credible expert? To what extent can individual experts speak for (a field of) science? <p><i>Implementation</i></p> <ul style="list-style-type: none"> Based on which rationales are certain (groups of) experts selected? What is the role of these individuals within in the institution? Are they active participants or do they have an advisory or symbolic role? 	<p>Credibility through community</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> When and how can a community provide credibility to science institutions? How is the community defined? Who is part of it? Who is not? How should this community be represented? What mechanisms or procedures support community representation? <p><i>Implementation</i></p> <ul style="list-style-type: none"> How are the expertise and perspectives of 'the community' represented? Does the defined community feel part of the initiative? What can be done to better represent the community? Are claims to speak on behalf of the community justifiable? Why (not)?
<p>Legitimacy through representation</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> Who should be represented in order to strengthen the legitimacy of the institution? What form should representation take? <p><i>Implementation</i></p> <ul style="list-style-type: none"> Are different regions, disciplines and genders equally represented in the various dimensions of the institution? Do representatives of different regions, disciplines and genders have equal opportunities and capacity to participate? Why (not)? How can active participation be supported? 	<p>Legitimacy through formal recognition</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> From whom is formal recognition sought? Why is recognition from these actors considered important? <p><i>Implementation</i></p> <ul style="list-style-type: none"> What does formal recognition mean in practice? How is this reflected in formal structures, procedures or mandate of the institution? How to deal with the tension between formal recognition and claims for independence? 	<p>Legitimacy through participation</p> <p><i>Rationale</i></p> <ul style="list-style-type: none"> What is the purpose of participation? What role is there for non-scientific actors in science institutions? <p><i>Implementation</i></p> <ul style="list-style-type: none"> Which actors are able and willing to participate in science institutions? Which actors are encouraged to participate? What procedures and mechanisms exist to support participation? Are participants allowed and able to bring changes to the institution? What is their role? What is their influence?

Sustainable Development Goals, as it risks undermining the legitimacy of science institutions operating in a global context. At the same time, although the focus is still predominantly on governmental and inter-governmental organizations, science institutions engaged in governance for sustainable development increasingly seek engagement of local and private sector actors. In several institutions, we see that extra-scientific actors have obtained a formal role. Nevertheless, strategies for credibility remain strongly focused on academic quality assurance through peer review or individual credentials. In general, our analysis reveals that although the solution-oriented mode of authority is increasingly dominant in rhetoric, science institutions continue to rely on more established strategies for acquiring credibility and legitimacy in governance for sustainable development.

Whereas an earlier study found that strategies for legitimacy were underrepresented (Reinecke, 2015), our study shows that strategies for legitimacy, at least in rhetoric, are well-developed across science institutions engaged in governance for sustainable development, with most cases pursuing legitimacy through multiple different strategies, seeking recognition and participation from an increasingly diverse set

of actors. At the same time, science institutions appear to struggle to bring ambitions of representation and participation into practice. We also find, in line with earlier studies (e.g. Sarkki et al., 2014), several potential trade-off between salience, credibility and legitimacy. In particular, our study points out that the specific strategies by which authority is pursued lie at the heart of such trade-offs. For example, credibility when pursued through a strategy of peer review tends to inhibit legitimacy through participation, when the peer review system lacks formal procedures for including extra-scientific knowledge. Another potential tension lies between the strategy of salience through independent advice and legitimacy through formal recognition, as this combination of strategies positions science institutions as both part of and independent from the political system.

The reality of science engagement is clearly more complex than the three ideal typical modes presented here. In fact, most cases included in our analysis combine aspects of more than one mode, building on multiple strategies in seeking authority in governance for sustainable development. Another complicating factor is the interaction between these institutions. Among our sample of cases, ICSU and ISSC, partners

of the Scientific and Technological Community Major Group, are also represented in the Governing Council of Future Earth. Members of Future Earth, in turn, have spoken on behalf of the Major Group in UN meetings on sustainable development. The Sustainable Development Solutions Network is also part of Future Earth's Governing Council, while the two institutions have also recently confirmed their partnership for cooperation on the Sustainable Development Goals (Sustainable Development Solutions Network, 2016). Two other members of the Future Earth Governing Council, UNESCO and UNEP, respectively host the secretariat of the Scientific Advisory Board and publish the Global Environmental Outlook. Finally, the Global Environmental Outlook, Major Group and Future Earth provide input for the Global Sustainable Development Report. Thus, we can see science engagement in the process of designing, implementing and monitoring the Sustainable Development Goals as a complex system of relationships and overlap between institutions. Nevertheless, we find it important and relevant to focus on the individual institutions and their various strategies for ensuring salience, credibility and legitimacy, as this helps to understand and deconstruct the (claims for) authority of science in governance for sustainable development.

7. Conclusion: a framework for reflection

Based on our analysis, we advance a framework that specifies the modes of authority and the strategies for salience, credibility and legitimacy as they are pursued by science institutions in sustainability governance (Fig. 1). We see two complementary uses of this framework. First, as an *analytical framework*, it can serve as a starting point for further empirical analysis of the implementation of particular strategies for pursuing authority of science in governance for sustainable development. Second, the framework can aid science institutions, and the individuals working in the context of these institutions, to reflect on their role and responsibility in governance for sustainable development. To this end, we further developed the framework into a *framework for reflection* (see Table 4).

The main objective of this *framework for reflection* is to support deliberation and contemplation with respect to the strategies for authority pursued by science institutions in governance for sustainable development. The questions that we use in our analysis to deconstruct and reflect on the claims and strategies for salience, credibility and legitimacy are provided in the framework. By posing these questions, we aim, first of all, to support *explicit reflection on the intentions and rationales for pursuing certain strategies* in support of salience, credibility or legitimacy. As our analysis points out, strategies for salience, credibility and legitimacy often remain hidden or implicit; only by explicating these strategies is further reflection on their implementation and effects possible.

Second, questions posed in the framework focus on the *potential discrepancy between the claims of science institutions and their implementation in practice*. Our analysis points out numerous instances in which claims and reality lie far apart. However, also in cases where these discrepancies appear less obvious we contend that reflection on the particular way in which a strategy becomes implemented can yield surprising new insights.

Finally, we aim to support *sensitivity to inequalities and power imbalances* that might inhibit the implementation of strategies, or could, unintendedly, follow from the pursuit of particular strategies. This is particularly important with respect to the emerging mode of solution-oriented science engagement, which is characterized by claims for inclusiveness and participation. Our study as well as other empirical research of inclusiveness and participation point out that the rationales shaping these strategies are diverse, and that their implementation in practice requires further careful scrutiny in order to avoid reproducing dominant structures, and to actually allow for and support inclusive participation in science for sustainability (Esguerra et al., 2017; Lövbrand et al., 2015; van der Hel, 2016).

In conclusion, our framework does not propose a particular “right” way for science-based initiatives to engage in governance for sustainable development. We do not claim to be comprehensive in covering all dimensions of science authority in governance, but hope that our framework will stimulate debate, raise new questions, and support further reflection in order to improve the quality of science engagement in governance for sustainable development.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.envsci.2017.03.008>.

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