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Scientific Advice for Policy Making

THE ROLE AND RESPONSIBILITY OF EXPERT
BODIES AND INDIVIDUAL SCIENTISTS

OECD

Scientific Advice for Policy Making:

The Role and Responsibility of Expert Bodies and Individual Scientists

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FOREWORD

Science advice is playing an increasing role in the formulation of policy and decision-making. Governments require scientific evidence in a wide range of situations, from long-term policy development through to urgent crisis management. The most appropriate source and nature of scientific and technical advice depends upon the purpose for which it is to be used. Consequently, many different approaches and processes have been developed for its production and delivery. This diversity is also a product of the different national and cultural contexts in which advice must operate.

Scientific advice and advisory process has been subject to serious stresses in recent years. In the field of prediction and assessment of risks, a series of legal cases have raised concerns about adverse personal consequences of providing advice to governments – consequences that can extend to civil or even criminal liability. At the same time, the contribution of scientific advice on sensitive issues, relating to people's health and safety or to the environment, has stimulated heated societal debate and confrontation. While many of these issues cross national borders and science itself is an international enterprise, cooperation between countries on scientific advice is inadequate.

The proposal for an OECD – Global Science Forum activity related to scientific advice was raised in October 2012, following a discussion that was triggered by the conviction of Italian scientists in connection with the L'Aquila earthquake. Following initial scoping work, a project was launched by the in April 2013 that focused on two main areas:

- a. The various organisational (and procedural) models that are in use, or being advocated, to provide scientific advice, as well as related key issues at the interface between science and policy; and
- b. The responsibility and/or liability of scientists who provide advice to governments, including issues related to communication.

Findings from an extensive survey carried out among the different stakeholders' communities were discussed during a two-day workshop in Tokyo in October 2013 and further workshop was held in Berlin in February 2014 that focussed on legal liability and responsibility. This was complemented by interviews with key individuals involved in international scientific advisory mechanisms, scientific advice in emergency situations and the use of scientific advice by decision-makers.

The report represents the work of an international expert group, with representation from 14 countries and the European Commission. It was drafted by the co-chairs of the project: Tateo Arimoto (Japan), Mauro Rosi (Italy), Jack Spaapen (The Netherlands) and Jan Wessels (Germany), with support from Yasushi Sato (Japan) and Frédéric Sgard and Carthage Smith of the OECD Secretariat. Telephone interviews were conducted and analysed with the help of a consultant, Ms Pauline Rioussel. The project was overseen by the OECD Global Science Forum, which discussed and commented on the draft and final report.

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EXECUTIVE SUMMARY

Current landscape

The scientific community is increasingly being called upon to provide evidence and advice to government policy-makers across a range of issues, from short-term public health emergencies through to longer-term challenges, such as population ageing or climate change. Such advice can be a valuable, or even essential, input to sound policy-making but its impact depends on how it is formulated and communicated as well as how it is perceived by its target policy audience and by other interested parties. It is rare that scientific evidence is the only consideration in a policy decision and, particularly for complex issues; many interests may have to be balanced in situations where the science itself may be uncertain. The rapid evolution of information and communication technologies and moves towards more participative democratic decision-making have put additional pressure on science to help provide answers and solutions, whilst also opening up the academic enterprise to closer surveillance and criticism. What used to be ‘private’ debates between different scientific viewpoints over areas of uncertainty have now become public disputes that can be exploited by different stakeholders to confirm or deny entrenched positions. Science is truly at the centre of many important policy issues and scientists are increasingly visible and, in many cases, increasingly vulnerable, in policy-making processes.

Advisory processes

In order to meet the increasing policy demands, a large variety of different advisory structures and processes – involving a range of actors - has been established at different scales (local to national to global). National science advisory systems are made up from a variable mix of four components that co-exist in most countries. These are (a) statutory mandated committees to advise governments on policy for science – in some cases coupled with technology and/or innovation.; (b) permanent or *ad hoc* scientific or technical advisory structures that are mandated or commissioned to address specific issues for which scientific input can be helpful; (c) academic institutions that provide policy relevant reports and advice that may or may not have been explicitly requested; and (d) individual advisors or counsellors that may have more or less formalised advisory functions. At the international level, a similar mix of formally mandated (inter-) governmental and independent science advisory structures exists.

The roles of people or institutions that commission advice, those who produce advice, and those who take decisions based on advice differ. Sometimes the boundaries between these different functions are unclear and the roles may overlap or merge. Nevertheless, an understanding of these respective roles is important with respect to issues, such as legal liability and public communication.

There is an important distinction to be made also between the roles of expert bodies or committees and the roles of individual advisors. The current report focuses mainly on the former, which are sometimes described as providing ‘deliberative’ advice as distinct from the advice provided by individual experts or advisors. The importance of such deliberative advice varies in different situations and from one country to another. In many cases, decision-making is informed by both deliberative and individual scientific advice. In such situations, the informal or formal role of individual experts or advisors can be significant and for deliberative advice to have an impact it needs to be recognised and promoted by these individuals.

A number of national authorities have developed general principles and guidelines for the establishment and operation of science advisory structures. These address four key phases in the standard advisory process:

1. *Framing the question*: whilst some issues may be relatively simple, e.g. a technical risk assessment for a single agent, others may be much more complex and can be framed from many different perspectives. In order for science advice to influence policy, the eventual end-users of the advice should ideally be involved together with scientific experts in framing the question(s) at the outset. On complex issues, where multiple stakeholders have an interest, the involvement of all key stakeholders in framing the question(s) may be appropriate.
2. *Selecting the advisors*: involving the right experts and avoiding conflicts of interest is critical for the quality and legitimacy of any science advisory process. As issues become more complex, advice from more diverse fields needs to be integrated. Increasingly this means bringing natural and social scientists together and overcoming the inherent differences in scientific language and terminology. For some issues it means also the inclusion of non-scientific experts and/or lay members. Avoiding conflicts of interest can be a significant challenge as advisory groups become more diverse. Processes for declaring financial or institutional conflicts of interest are becoming routine in many settings but ideological or scientific conflicts of interest can be equally important and less readily identifiable.
3. *Producing the advice*: Once experts have been selected and their task(s) defined, it is important that they are allowed to work independently without any interference from political or other quarters. As the complexity of an issue increases, so in many cases do the scientific uncertainties associated with it. As a general rule, scientific advice should include assessment and clear communication of uncertainties (or probabilities). Where time allows, independent peer-review of scientific advice can help to improve its quality and legitimacy.
4. *Communicating and using the advice*: Premature, inaccurate or biased reporting can undermine the whole advisory process. “Who is responsible for communicating what and to who?” is a critical operational question for any advisory process. The individual and institutional responsibilities and limits with regards to internal and external communication should be fully understood. This understanding should include definition of the advisory and decision-making responsibilities of all the actors in the advisory process; decision making protocols should be established in advance.

Transparency in scientific advisory processes is of the utmost importance. As far as possible, scientific advice and associated evidence should be made publicly available in a timely manner. Policy-makers should be transparent in their use of scientific advice. They should be able to explain how any requested scientific advice has been considered when drawing up policy. In particular they have a duty to explain the rationales when making policy-decisions that are in clear conflict with solicited scientific advice.

There is an additional fifth phase to advisory processes that is often over-looked, i.e. *assessing the impact*. Few advisory structures carry out formal impact evaluation or have a remit to monitor or comment on the implementation of their recommendations. However, there are some noteworthy exceptions and impact assessment is important not only in terms of accountability but also as a way of improving advisory processes.

Responsibility and liability

The scientific advisory and emergency response structures that were in place prior to the L’Aquila earthquake in Italy in 2009 were tried and tested. Nevertheless more than 300 people died in this tragic event, illustrating the inherent limitations of these advisory structures and the uncertainties around the science of seismology. This catastrophic event led also to the criminal prosecution of 7 scientists who served on a scientific commission that was attributed with issuing falsely reassuring public statements in the immediate lead up to the earthquake. The repercussions

for scientists serving on advisory bodies around the world are still being assimilated but in Italy there has been a dramatic increase in legal cases against scientists involved with civil protection processes. The potential legal liability of scientific advisory bodies and the individual scientists who serve on them had - until the L'Aquila earthquake – been given little attention. Now, this is a topic that is high on the agenda for those interested in strengthening the interface between science and policy.

In practice, the potential legal liability is the product of the nature of the advisory structure (e.g. government mandated versus independent), its specific mandate (e.g. science policy versus risk assessment), its role in decision-making (e.g. purely advisory versus policy prescriptive), its role in public communication (if it at all) and the national judiciary system under which it operates (e.g. common law versus civil law). Likewise for individual scientists, their potential liability is similar to that of the advisory body on which they serve but in addition it depends also on their own individual behaviour, particularly with regard to public communication.

There is a danger that, in the light of the L'Aquila case and in the face of growing risks of prosecution (personal prosecution, even if unsuccessful can be personally and professionally crippling), scientists will change their behaviour. They may withdraw from advisory processes altogether or, where they are involved, they may adopt more cautious and/or passive behaviour that will distort the scientific input that informs important decisions. There is some evidence of the latter, in civil protection areas, where an overly precautionary approach can lead to more 'false alarms', increasing the burden on public resources and eventually leading to a loss of public trust in the whole emergency preparedness.

Whilst the risks associated with of civil and criminal liability cannot be eliminated altogether from science advisory processes a number of steps can be taken to reduce these risks. Careful consideration needs to be given to all five of the previously described phases of the advisory process and, in particular the clarification of respective roles and the fourth phase of communication. At the same time, those involved in giving science advice need to embrace their 'ethical' responsibility to perform the task to the best of their ability and in line with agreed procedures and protocols. It is important that the legal liabilities and responsibilities of those involved in advisory processes or serving on advisory bodies are clearly understood.

Large-scale crisis situations

Scientific advice can play an invaluable role in short- and long-term risk assessment for unexpected crisis situations. It can also be essential in informing effective risk management strategies during such crises. When a rare crisis event occurs, which may have impact at regional or global scale, emergency response systems, science advisory structures and policy makers can be confronted with novel complex and rapidly changing challenges. The distinction between advisory and decision-making functions can become blurred, as multiple responses and actions are required within very short time-scales. In such circumstances, existing advisory processes are usually neither entirely appropriate nor entirely adequate.

There are a number of key lessons that can be learned from recent major crises. In common with more routine advisory processes, but to an even greater degree, the issues of maintaining an authoritative scientific voice and being clear where responsibilities lie in a complex and distributed scientific and public discourse are critical. Areas of system vulnerability that require particular consideration in crisis situations include: institutional and procedural preparedness; clarification of reporting procedures and of institutional and individual responsibilities, including for decision-making; internal and external communication strategies; and, international co-ordination.

A check-list for science advice

Drawing on the analysis of different advisory systems, their exposure to legal risks and the particular requirements of crisis situations, it is possible to define three factors that are particularly

important in determining the success or failure of a science advisory process. Attention to these factors will both enhance the efficiency and quality of science advice and help ensure the necessary trust between scientists, policy-makers and the public.

These three factors can be extrapolated to all parts of a system, from the behaviour of individual science advisors through to the functioning of formal advisory committees. They can also be applied across different issues and scales, from local risk assessment to international health crises.

Hence, an effective and trustworthy science advisory process needs to:

1. Have a clear remit, with defined roles and responsibilities for its various actors. This includes having:
 - a. a clear definition and, insofar as is possible, a clear demarcation of advisory versus decision-making functions and roles
 - b. defined roles and responsibilities and the necessary expertise for communication
 - c. an ex ante definition of the legal role and potential liability for all individuals and institutions that are involved
 - d. the necessary institutional, logistical and personnel support relative to its remit.
2. Involve the relevant actors – scientists, policy-makers and other stakeholders, as necessary. This includes:
 - e. using a transparent process for participation and following strict procedures for declaring, verifying and dealing with conflicts of interest
 - f. engaging all the necessary scientific expertise across disciplines to address the issue at hand
 - g. giving explicit consideration to whether and how to engage non-scientific experts and/or civil society stakeholders in framing and/or generating the advice
 - h. having, as necessary, effective procedures for timely exchange of information and co-ordination with different national and international counterparts.
3. Produce advice that is sound, unbiased and legitimate. Such advice should:
 - i. be based on the best available scientific evidence
 - j. explicitly assess and communicate scientific uncertainties
 - k. be preserved from political (and other vested-interest group) interference
 - l. be generated and used in a transparent and accountable manner.

Although careful consideration and attention to these factors cannot guarantee that a particular scientific advisory process or system will be successful, ignoring them increases both the likelihood of failure and the potential exposure to legal pursuit.

These considerations are already reflected in (and are, to some extent, a reflection of) more detailed guidelines and codes of conduct that already exist in some countries and institutions and many of which were considered as part of the present study. It is important, where they do not exist or are incomplete, that such operational guidelines are developed at the appropriate level with the engagement of those who will be involved in the relevant process or system. Language, culture, history, institutional structures and societal attitudes all have an important influence on how any common principles regarding science advice can be translated effectively into local systems and

processes. At the same time, such principles can provide a sound basis for the international exchange that is necessary in many areas of science advice.

Emerging issues

Two issues have come to the fore recurrently throughout the consultations and analysis for this report and also feature strongly in the factors that determine the effectiveness of science advisory processes:

The international dimension of scientific advice can be important when dealing with major acute crisis situations and is essential when dealing with inherently global issues, such as climate change, food, water and energy security or disease pandemics. All of these issues are multi-factorial, many of them are chronic and the science associated with them is complex and continually evolving. In some instances, intergovernmental structures, such as the Intergovernmental Panel on Climate Change (IPCC) have been established to carry out scientific assessments at regular intervals. These scientific assessments then inform policy discussions around international agreements and conventions. Such agreements are difficult to achieve and implement. Moreover, where they do exist, their real influence on regional, national and local policies and strategies is not always evident. The relationship between different science advisory structures addressing similar issues but at different scales and for different groups of decision-makers is often unclear and can be confusing. Most OECD countries have advisory bodies dealing with global societal challenges but best practices and experiences appear to be rarely shared.

The growing interest of civil society in scientific advice is apparent across a whole range of issues from childhood vaccinations to genetically modified foods to climate change. Openness, integrity, transparency and accountability are the critical terms in modern day science advisory structures. Increasingly scientific expertise is being complemented by lay experts on advisory panels; policy questions are being framed in multi-stakeholder settings and policy decisions – even on ‘scientific issues’ are being made in consultation with multiple interested parties. The rapid development of information and communications technologies and social media has opened up exciting new possibilities (and challenges) for soliciting and disseminating scientific views. These changes have occurred, or been adopted, more rapidly in some areas than in others and have taken different forms in different settings. There is an opportunity to exchange experiences and practices across countries in order to improve the trustworthiness and effectiveness of science advisory processes.

Policy Recommendations

This report was drafted at this time of great need and expectations for scientific advice. The following policy recommendations aim to address this:

- **Recommendation 1:** Governments and responsible institutions should define clear and transparent frameworks and rules of procedure for their advisory processes and mechanisms.

The check-list for science advice proposed in this report can provide a basis for the development of such operational guidelines and rules of procedure.

- **Recommendation 2:** Governments should establish effective mechanisms for ensuring appropriate and timely scientific advice in crisis situations.

They should in particular define:

- Institutional and individual roles and responsibilities for crisis preparedness and response at the national level, including procedures that can provide coherent and trustworthy information to the public.

- Mechanisms to facilitate international co-operation between advisory structures and relevant individuals with responsibility for providing science advice in crisis situations. This includes the exchange of data, information and expertise to improve preparedness as well as co-ordination during actual crises.
- **Recommendation 3:** Governments should work with international organisations to ensure coherence between national and international scientific advisory mechanisms related to complex global societal challenges.

They should in particular:

- Facilitate exchange of information, data and good practices between national scientific advisory bodies and relevant international bodies.
- Establish mechanisms, where these do not already exist, to ensure the translation and verification of international advice on global societal challenges into the national and local policy context and vice-versa.
- **Recommendation 4:** Governments and responsible institutions should implement measures that build societal trust in science advice for policy-making.

They should in particular:

- Ensure that advisory processes are as open and inclusive, as necessary.
- Ensure that science advice is considered, communicated and used in a transparent and accountable manner (including training for scientists and policy-makers in the practice and use of science advice).

1. INTRODUCTION

1.1 Scientific advice and policy making

Many of the challenges facing modern societies cannot be adequately addressed by simply using common sense, experience, precedent, ideological principles, or basic analytical methods. Whether it is climate change, renewable energy, natural disasters, food security, or disease pandemics, policy-makers want scientific advice to inform their decisions. Obtaining rigorous and useful science advice in a timely manner is not a trivial matter and taking careful account of such advice in complex policy areas of interest to many different stakeholders is not always straightforward. The interface between science, politics and society at large can be a treacherous area for both policy-makers and scientists.

The pressure on scientists to come up with swift and clear answers for policy-makers can be extreme, particularly in emergency situations. In recent years we have seen the consequences of performing under this pressure in Italy (L'Aquila earthquake of 2009) and in Japan (Fukushima Dai-ichi Nuclear Power Station accident in 2011). In Italy, scientists are involved in a legal battle because of their role in providing contested advice before the earthquake. In Japan, a fierce debate was conducted about the responsibility and liability of those scientists who gave divergent advice on questions that affect the quality of life of hundreds of thousands people. The legal consequences for individual scientists can be severe. In the first round of the legal procedure in Italy, scientists were accused of multiple manslaughters and were convicted to a six year prison sentence and severe financial penalties.

Fortunately, this kind of judicial sentence is rare and, in this particular instance, the sentence was recently over-turned at appeal for all but one of those involved. However, there are at least two important lessons to be learned from these and other recent experiences: (i) scientific evidence is in most cases is associated with uncertainties that are not always clearly communicated; and (ii) scientific evidence often affects lives and those who are affected have a legitimate interest in it. Scientific advice is normally solicited in a context in which many other considerations and interests have to be accommodated. As noted by Daniel Sarewitz, "Science typically lies at the centre of the [political] debate, where those who advocate some line of action are likely to claim a scientific justification for their position, while those opposing the action will either invoke scientific uncertainty or competing scientific results to support their opposition".¹ In policy debates on many issues, a variety of societal stakeholders now play an active role that can be rapidly amplified by the use of the web and social media.

The challenge of providing useful scientific advice to inform policies that address complex societal issues, for which a large amount of variable information is publically available, has multiple implications for the development of effective advisory structures and procedures. In recent years, the active involvement of civil society on many issues has called for a reassessment and re-adjustment of the ways scientists contribute to policy-making. At the same time, the potential adverse personal consequences of providing advice to governments, threaten to undermine efforts to improve the engagement of scientists in advisory processes.

Many important issues cross national borders, but, although science is an international enterprise, collaboration between countries on scientific advice has not yet been developed to its full potential. While there are good examples of collaboration through international science assessment structures, such as the International Panel on Climate Change (IPCC), there is a lack of effective co-ordination in other areas, as illustrated by the 2011 Enterohemorrhagic Escherichia Coli (EHEC) outbreak in Europe or the Fukushima nuclear accident. Some promising initiatives have recently been started including the United Nation's move to establish a Scientific Advisory Board of the Secretary General. Having said that, it is also clear that any form of institutional collaboration in an international context is always contingent on the balancing of national interests, which can affect the framing of questions,

the selection of experts or the provision of funding. The complexities of international bureaucracy can also hinder swift reaction in crisis situations.

1.2 The current OECD project

The proposal for an OECD activity related to scientific advice was triggered by the conviction of scientists in connection with the Aquila earthquake in Italy and concern about the effect that this might have on the participation of scientists in advisory processes, at a time when their input is increasingly required. In order to elucidate the legal liability implications of the Aquila case in other countries, it was recognised that a mapping of national scientific advisory processes was required. The study was expanded also to include other examples, alongside the Aquila event, with a particular focus on trans-national crisis situations. A number of cross-cutting issues - including international co-ordination and civil society engagement - rose to the surface during the workshops and interviews that provided the basis for the final report. The structure of the report has been adapted to reflect this. Whilst the aim at the outset was not to try and develop a set of universal principles for science advice, a number of common lessons-learned came to the fore and these have been consolidated into a 'check list' for science advice.

During the course of this work, a number of other initiatives relating to analysing and improving science advisory processes have got underway. Most notably, an international network of senior science advisors has been established and the first global conference on Science Advice to Governments took place in Auckland, New Zealand in August, 2014 (<http://www.globalscienceadvice.org/>). The preliminary findings from the OECD project were reported at this conference and there has been liaison with this and other international initiatives throughout this work.

2. CURRENT LANDSCAPE

2.1 The overall position of scientific evidence in policy-making

Scientific experts can be involved in either providing advice on Science and Technology policies -“policy for science”- or in providing scientific advice on regulatory or general policies -“science for policy”. The distinction between these two areas is important and the advisory and decision-making requirements and processes are usually different. Unless otherwise specified, the current report focuses on science for policy, although it is recognised that a clear demarcation between the two areas cannot always be made.

Scientific advice plays an important role in the development of policies in most countries. On some issues, well established routines for linking scientific expertise to decision-making processes are in place. This is often the case in regulatory domains. However, many of the problems and challenges facing societies are of a complex nature, and decision makers have to consider many other factors than scientific evidence. Scientists find themselves in a policy arena where the interests of a variety of stakeholders have to be balanced: scientists, policy and law makers, regulators, industry, NGOs, the public at large. Moreover, because of the multifaceted character of many policy issues, scientific advice itself often requires the input of more than one discipline, frequently combining natural sciences and social sciences.

To complicate things even further, many issues are of an international nature, and can only be addressed in a meaningful way through collaboration between countries. Such collaboration can take many different forms, ranging from simply sharing of experiences to the establishment of very large multi-level organisations, such as the Intergovernmental Panel on Climate Change (IPCC).

The policy and societal context for scientific advice is challenging, not only because the stakes are high, but also because the general expectation is that science can provide clear and unambiguous answers. The reality is that the results of scientific research are often provisional and sometimes heavily contested, either inside the research community and/or by other stakeholders. Researchers can find themselves in the centre of political debates for which they are not well-equipped. And the debates in these arenas can be fierce, as is illustrated by public controversies that have arisen in many fields, including genetically modified foods, childhood vaccinations, carbon capture, and shale gas drilling. A neat demarcation between scientific evidence, societal values and beliefs, economic considerations and policy-decisions is not always easy and it is at the boundaries between these domains that strong tensions arise. Individuals, organisations or processes that can effectively bridge these domains are increasingly important.

2.2 Organisation of scientific advisory processes at the national level

There are a great variety of structures and institutions that provide scientific advice to authorities, typically national governments, and which can therefore be considered as scientific advisory bodies. The actual roles and functions of these scientific advisory bodies depend on how the scientific advisory system in which they are embedded works as a whole. The size, power, structure, and legitimacy of national advisory systems differ from country to country,^{2,3} and are subject to temporal changes deriving from political priorities and social dynamics.

Major types of advisory bodies

While a national scientific advisory system usually consists of a large variety of institutions and structures and individuals, four broad categories of actor can be identified.

a. Science policy advisory committee or councils

Many countries have structures (“councils for science and technology” or equivalents) which are dedicated to providing advice on science and technology policies. These are typically deliberative bodies which can be either embedded in the government [e.g. the President’s Council of Advisors on Science and Technology (PCAST) in the United States, the Prime Minister’s Council for Science and Technology (CST) in the United Kingdom, or the Council for Science, Technology and Innovation (CSTI) in Japan] or independent but with a governmental mandate [e.g. the German Commission of Experts for Research and Innovation (EIT) or the Mexican Consultative Forum on Science and Technology]. They usually consist of not just scientists but also representatives of industry and civil society, and sometimes cabinet members. As the highest policy organ in areas related to science, technology, and innovation (STI), this type of structure makes recommendations at a strategic and policy level that respond to government priorities for science technology and innovation. In some instances, such structures may initiate activities at their own initiative but normally keeping within the limits of their STI remit.

b. Permanent or ad hoc scientific/technical advisory structures

Governments rely on scientific/technical advisory structures to provide evidence and advice on a wide variety of policy issues. Such advice may be closely related to regulatory processes in fields like environment or health and safety. Dedicated advisory structures may be established also by governments to deal with specific topics or address more complex issues, such as energy transitions or climate change mitigation. Whilst science advice has a clearly defined role in many routine regulatory processes that most often require quite narrow and specialised skill sets, more complex policy questions require a broader range of scientific inputs and are likely to have multiple ‘customers’.

These advisory structures can either be fully embedded within the government or have an independent status with a governmental mandate. Some may be responsible for research activities in parallel to their advisory role. Members are usually scientific experts in the field; they can be directly employed by the advisory structure or be external experts drawn from various public and private institutions. In most cases, experts are acting in their individual capacity and do not represent the views of their home institution, although this may not be true when the experts are actually employed by the advisory body. In recent years, the membership of a number of these advisory committees has been broadened to include representatives from civil society but such a move remains controversial (see 6.2).

Although most countries rely on these advisory structures to provide scientific evidence and advice to the government or to parliament institutions, their roles and legitimacy vary considerably. For example, the U.S. federal government has about a thousand advisory committees whose operation is regulated by the Federal Advisory Committee Act and other related regulations. Japan also has several thousand government advisory committees, some of which are formal while others are informal and often ad hoc. Indeed, in a number of countries (in some Southern or Eastern European countries for instance), ad hoc/non-permanent advisory structures, which operate outside clearly identified legal frameworks, dominate. This variety in structure and authority results in important variation in the roles that these advisory structures can play in local, national or regional policies and can complicate trans-national collaboration.

When it comes to emergency response situations, which will be covered in more detail in the subsequent chapters, most countries have permanent advisory bodies associated with identified institutions. These bodies usually have a well-defined mandate and procedures and are tightly linked to relevant decision-making and emergency response structures. In major crisis situations, these routine emergency procedures may be supplemented with other ad hoc advisory structures.

c. Academies, professional societies and research organisations

Academies and professional societies are collectives of academic, industrial, and other researchers representing scientific communities. They usually do not have an exclusive or primary focus on providing science advice, but in some instances they can have a significant influence on policy.

The position of academies and professional societies in the overall scientific advisory system differs from one country to another. For instance, the U.S. National Academy of Sciences (US-NAS) annually publishes hundreds of reports that are used by the federal government to inform policy-making. In contrast, the Science Council of Japan, for example, has only a limited scientific advisory function and influence, although it makes scientific inputs to the Japanese government through published proposals. Similarly, the French Academy of Sciences produces expert reports but these are generally not directed towards specific policy needs.

In contrast to most dedicated scientific/technical advisory structures, academies and professional societies often provide advice to government on issues of their own initiative. They may respond also to specific questions from governments. Bringing-in scientific evidence from respected academic institutions can be used as a way to inform societal debates. Academies have the capacity and status to convene leading experts from a wide diversity of scientific domains. They can also provide input on behalf of the scientific community to science and technology policies, complementing that provided by formally mandated science policy advisory committees or councils.

Academies are usually perceived as being largely independent from governments. Although their funding often comes from Government, their statutes normally guarantee full scientific autonomy. This independence is shared by learned and professional societies. Their scientific advice is often provided at their own initiative, and expected to contain the integrated and independent voice of their member scientists. In the United States, for example, learned and professional societies such as the Institute of Electrical and Electronics Engineers (IEEE), American Physical Society, and American Chemical Society issue numerous reports in diverse policy areas.

In addition to science academies and professional societies, a large variety of other public and private research organisations, institutions and think-tanks, also bring together scientific experts to provide ‘independent’ policy relevant information for policy-makers. On occasion, this may be in response to specific solicitations – for example in Germany and the Netherlands, research institutions that are constituted under the aegis of governmental ministries frequently have important scientific advisory functions. More generally, there is a broad range of policy relevant reports from different scientific groups that feeds into policy processes. In some areas, specialised intermediary bodies or knowledge brokering institutions have developed to try and ensure that this wealth of scientific information is effectively communicated to policy and decision-makers.

d. Individual scientific advisors and counsellors

Governments in many, if not all, countries also rely on scientific advice from individuals, either in an informal way through personal networks, or via formally appointed scientific counsellors. A critical element of the scientific advisory system in some countries is the position of Chief Scientific Advisor (CSA) or its equivalent. The CSA position can be found at a national level and/or at ministerial/departmental levels. The CSA acts as broker and expert navigator between the government and the scientific community. In addition to advising presidents, prime ministers and other ministers, the CSA often fulfils related roles, such as ensuring the proper use of scientific evidence in the government and fostering the professional development of scientists employed by the government. He/she may have a remit that includes both science for policy and policy for science. In some countries, the CSA also has a particular responsibility in relation to emergencies and crises and is expected to act as the government’s science spokesperson.

The Government Chief Scientific Advisor (GCSA) in the United Kingdom is the prototype of this position. There are some other countries that have GCSA-like positions, including the United States, Australia, the Czech Republic, India, Ireland, Malaysia, and New Zealand, although the nature and functions of such positions subtly differ from one country to another. Networks of CSAs are starting to develop around the world. A first global meeting of CSAs and other senior scientific advisers was held in New Zealand in August 2014. Regular Meetings of CSAs and equivalents in the Asia-Pacific Economic Co-operation area began in June 2013 and in the European area in June 2014. Other inter-governmental constellations such as Carnegie and G8 also provide a context for science advisors to come together.

Although the CSA position is widely recognised and referred to as a successful institution for scientific advice, it should not be deemed as universally applicable for all nations. Its acceptance and effectiveness would no doubt be limited in certain political, historical and cultural contexts. Although most countries have a small number of senior scientists who are active at the interface between science and government policy, the identification of a single ‘Chief’ can have its own problems, as illustrated by recent criticisms of the European Science Advisor position^{4,5} (see 6.2).

Whether or not the role of individual advisors is formalised, the role of individual experts in providing direct advice to policy-makers and/or acting as brokers for scientific advice from other sources should not be underestimated. The ideal situation is when advice from deliberative processes and individual experts or advisors is mutually reinforcing, although, inevitably, this is not always the case.

2.3 International advisory mechanisms

Existing intergovernmental organisations, including UN organisations (the World Health Organisation (WHO), the World Meteorological Organisation (WMO) etc.) or the OECD and its related bodies (IEA, NEA) have been providing science policy as well as technical/regulatory advice to governments for many years. However, the role of international advisory bodies is expanding to reflect the growing number of transnational issues, including climate change, energy, food security and disease epidemics, in which science, technology and society are tightly intertwined.

In some cases dedicated intergovernmental structures have been created to provide scientific advice on complex issues that cannot be handled by individual nations. These include the Intergovernmental Panel on Climate Change (IPCC) and the recently established Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES). Political legitimacy for these structures is typically provided by an existing intergovernmental organisation, such as the United Nations. They have clear international mandates to provide scientific assessments, based on the most recent scientific literature, to inform international policy debates. It should be underlined that the formal role of these assessment structures is not that of providing prescriptive policy recommendations to governments, although their outputs are often interpreted as such.

Advisory institutions may also be involved in providing scientific advice at a regional level. This is exemplified in Europe, where many structures, such as the European Commission’s Joint Research Centre (EC-JRC), and various agencies are providing both S&T policy and technical advice to the European Commission, the European Parliament, or to European governments. This is also happening in other regions; for instance, ASEAN’s Committee for Science and Technology sometimes plays an advisory role.

In parallel, international institutions representing the scientific community, such as the Inter-Academy Council (IAC) or the International Council for Science (ICSU) also provide scientific advice for policy-makers using more bottom-up processes. In some cases this is formally linked with the UN system.

The importance of science in international policy can be highlighted by the establishment of a Scientific Advisory Board for the United Nation's Secretary General in October 2013. This new body advises the Secretary General on issues at the interface between science, policy and society, particularly in areas relevant to sustainable development.

2.4 Support and guidelines for providing scientific advice

The role of supporting institution(s) and secretariat(s) is critical for both national and international advisory bodies. As well as providing logistical support, a dedicated secretariat may play a significant role in the collection and analysis of information and evidence as well as co-ordination among stakeholders, including relevant government agencies, industry, and the public.

A secretariat often cooperates with relevant external organisations including academic institutes and think-tanks. Co-operation between diverse organisations can help provide a robust supporting structure for a scientific advisory body. Where public communication is important, having access to 'in house' communications and public relations expertise within the Secretariat can be extremely valuable.

In addition to personnel support, clear guidelines and operating procedures can greatly facilitate and improve the provision of scientific advice (as well as providing some protection against subsequent complaints – see 4.). In a growing number of countries, guidelines for scientific advice are now well-established. These tend to fall into two classes and to focus on either the overall philosophy/principles related to scientific advice or the operation of specific types of advisory bodies. The two types of guidelines are complementary and can be effective in tandem.

A number of countries (Australia, Finland, and the UK, for example) have developed frameworks for the use of scientific information in support of evidence-based government decision-making. For example, the UK has had guidelines for the use of scientific advice by the government since 1997⁶, and also has rules of engagement between the government and independent (i.e. non-government) scientific advisors, as well as guidelines for the operation of governmental advisory committees. The ways in which scientific input is used to inform public policy in Australia was analysed in 2012 (APS200 project)⁷ and a report to support the implementation of the recommendations of this work was published in 2013.⁸ International academic bodies such as Inter-Academy Council and the European Academy Science Advisory Council (EASAC) have also drafted guidelines for scientific advice. Such frameworks can be important instruments for addressing the challenges for science advisory bodies and promoting common understanding and best practices.

3. THE ADVISORY PROCESS

As described in the previous section, a variety of permanent and ad hoc science advisory structures exist at different scales and with different remits. In some situations these structures interact in a more or less co-ordinated way and are frequently complemented by the roles of individual advisors, which adds an additional layer of complexity (and potential confusion). Scientific advisory processes are tailored to different situations with different time scales but there are four distinct phases that are common to the majority of these processes: 1. Framing the question; 2. Selecting the advisors; 3. Producing the advice; and 4. Communicating and using the advice. An additional fifth phase is often over-looked but should take place after the advisory process has been completed – assessing impact.

3.1 Framing of the question (phase 1)

Framing an assignment for scientific advice can be done at different levels of complexity. A new outbreak of ‘mad cow’ disease, for example, leads to relatively straightforward science questions such as what causes it and what we can do about it to prevent spreading. But these primary questions can quickly lead into a set of other issues relating to production processes in the agricultural sector, animal health care, food processing and transport. Policy-makers will, sooner or later, need to consider all of these questions and issues to decide, for example, whether there is a case for changing to a different food production system altogether. While in the first instance it is likely to be the national government that poses the initial risk-assessment questions to scientific experts, the wider set of issues is likely to lead to a societal and policy debate with many stakeholders.

In some circumstances, the framing of an apparently straightforward technical question can become very difficult. A good example is that of risk assessment related to fracking (shale gas drilling). As various case studies from the US and the Netherlands show, different stakeholders frame the questions in different ways, depending on their particular interests and perspectives. These can be wide ranging - from home owners being concerned for their property value, to energy companies worried about their profit, to environmentalists being alarmed about potential water pollution. For science to contribute effectively to this multi-stakeholder debate requires the contribution of multiple disciplines and these need to be brought together early on in framing the questions to be addressed.

In order to procure the best and most appropriate advice, an important requirement is for key customers to be involved early on in the commissioning of the advice. Failure to recognise the full nature of the customer needs, and to ensure the translation of these into appropriate commissioning, can result in ineffective advice and/or poor decision-making. This, in turn, can have negative socio-economic consequences and contributes to a loss of trust in science.

However, the need to involve key customers in framing policy questions should not strictly limit the issues to be considered. In some instances scientists may be better placed than policymakers to identify that an important new question exists. Monitoring of new scientific and technological developments, including via formalised foresight processes, can an effective way to identify new questions that policymakers should be asking.

Some advisory bodies, particularly at international level, have processes through which they ensure policymakers’ buy-in. The questions to be addressed are decided through an active dialogue with the decision-makers. Bodies such as IPCC or the Scientific Advisory Board (SAB) of the UN have initial scoping group meetings with government representatives and the heads of the UN agencies to define the objectives of the advisory body on specific issues. In the IPBES case, experts propose a working agenda to the political representation of the governments, while for the EC-JRC, a formal internal consultation on the work programme and informal discussions help ensure that a common understanding between the scientific experts and the decision makers is found.

3.2 Selecting the advisors (phase 2)

A central element in ensuring the rigour and legitimacy of scientific advice is selecting the “right” experts. On the whole, public trust in science remains high⁹ but engaged citizens must have confidence in the process by which scientific advisers are selected to address issues that concern them, if this trust is to be maintained.

Involving the “right” experts and avoiding conflicts of interest

It is essential that policy-makers ensure the involvement of the appropriate experts when they seek scientific advice either formally or informally. A body of experts involved in providing scientific advice should as a whole have demonstrated capabilities and expertise covering all areas related to the issue at hand. They also should be open to expert opinions coming from outside their selected group, recognising that relevant expertise is often available outside established academic structures.

Selecting the “right” experts for giving scientific advice is becoming a more and more difficult task. As policy issues have become increasingly complex, experts from more diverse fields need to be involved in the process of generating scientific advice. Ensuring “scientific legitimacy” with regards to complex global issues requires particular efforts as the international and interdisciplinary nature of the problems increases the likelihood of divergent opinions. Advisory structures that address these issues need to set up internal procedures that can allow the necessary scientific debate to take place, while at the same time provide integrated assessments and recommendations that can be of use to policy-makers.

As the interaction between scientific research and business and the public sector has grown, concerns about conflicts of interest have come to the fore. In some highly specialised areas this is compounded by the reality that there may be only a small number of individuals with sufficient expertise to provide advice. While it is neither practical nor desirable to prohibit all conceivable conflicts of interest, which would often be to the detriment of the quality of the scientific advice, more openness is required. Transparent procedures for the selection of experts should include specific and clear provisions on declaring and managing potential conflicts of interest. This is particularly the case in a multi-stakeholder context, where ideological and financial conflicts of interest can be even more complicated to deal with (see 6. for further discussion).

In summary, governments and the scientific community need to make sustained efforts both to improve the mechanisms for the selection of experts and to guarantee a level of openness to outside opinions. Lack of attention to this at the outset can ultimately undermine even the best scientific advice.

Ensuring independence of scientific advisers

The independence of academia is a cornerstone of sound and reliable scientific research and thus of scientific advice. Policy-makers invariably understand this and respect the independence of scientific advisers. Nevertheless, the impartiality of scientists can come under pressure in cases where the stakes are high - when there is a divisive political debate or disagreement among stakeholders. In such circumstances, governments may push for clear-cut advice that cannot be scientifically justified. As a general rule, governments should ensure the autonomy of scientific advisers, and experts should not be excluded from advisory processes just because their views are not in accord with government policies. Scientific advice should be based on the best available science.

On the other hand, organisations or institutions that provide scientific advice have to make sure that the scientists they consult will provide policy makers with advice from a fair, objective and apolitical standpoint. Particular vigilance is required when the framing of the question entails a negotiation process between the government and the advisers.

Ensuring the necessary independence and autonomy can be even more complicated in international structures. In the IPCC assessments, hundreds of experts are involved on a voluntary basis, but lead authors are usually nominated from among experts proposed by governments. Similarly, most experts at IPBES are nominated by governments. Although this promotes government buy-in to the final recommendations, it opens the door to accusations of political bias. Procedures for consultation with non-governmental experts and scientific peer-review have been set-up to minimise such criticisms and ensure the independence of the assessments. Conversely, in international structures, when governments do not contribute to nominating experts, advice may be perceived as reflecting the preferences and networks of the scientific institutions producing the reports. For example, advice on complex global issues should ideally have expert input from developing countries. However, finding high-level experts, who have the time and resources to participate in international advisory processes, from some of these countries, can be difficult. This in turn can have a negative impact on the perceived legitimacy and applicability of the advice.

3.3 Producing the advice (phase 3)

It is a challenge to translate research results into advice that is useful for policy makers. There are diverse scientific views on many issues, and if such views are communicated in an unorganised manner, they can be hard to act on. Moreover, scientific evidence is often accompanied by considerable uncertainty that can make it difficult for scientific advisers to communicate clear advice to policy makers. Both the diversity of scientific views and uncertainties need to be properly treated in generating, communicating, and utilising scientific advice.

Accommodating diverse opinions

Individual scientists have diverse views on many issues, depending on their fields, methods, approaches, and subjective judgments. Uncertainties accompanying scientific knowledge may also cause diversity in scientists' views. Such diversity must be properly handled in order for scientific advice to be incorporated into policy making in a sound and effective manner. It is important to acknowledge that scientific judgment itself is made within a value-rich context, and that data-collection depends to a large extent on the way a question is framed. Different frames may lead to different scientific results and opinions.

One way to deal with such diversity is to aim at consensus within the scientific community. In many ways, current incentives in science are leading to more specialised knowledge, which reinforces silos to the detriment of sound integrated advice. Dedicated efforts are needed to build closer consensus across different disciplines, above all between natural and social sciences. Care needs to be taken to involve scientists with a broad approach to facilitate discussions in such a way as to build consensus rather than to entrench differences. Various principles and guidelines exist to promote consensus – while allowing for all opinions to be expressed. Notably, following Japan's experience of the Fukushima nuclear accident, the Science Council of Japan revised its code of conduct in 2013 in favour of consensus advice (see Box 3). However, experience tells us that such agreement will sometimes be hard to achieve. Seeking full consensus as a short-cut to apparent clarity can ultimately undermine the rigour of advice if not handled properly. When legitimate differences in views cannot be resolved, they should be identified and communicated to policy makers.

Managing uncertainties

Scientific advice inevitably incorporates various degrees of uncertainty. In some cases, there might be doubts about the empirical base of scientific knowledge. In others cases, there may be considerable statistical uncertainty with key conclusions being coined in terms of probabilities. There are many cases in which scientific advice has been contested because the evidence is not conclusive enough and does not give a clear answer. The fundamental difference between risk and uncertainty is not always well-understood.

Managing uncertainties, which can become crucial in emergency situations, is a critical issue in science for policy. Some experts turn out to be better than others at assessing uncertainty and approaches such as Structured Expert Judgement¹⁰ can sometimes be used in the assessment of uncertainty. Whether or not such an approach is adopted, being open about uncertainties is important. As a general rule, scientific advisers should explicitly assess uncertainties and communicate and explain them to policy makers. While many believe that policy makers prefer clear-cut scientific views to complicated ones, and don't like or even understand uncertainty, we might want to give them more credit. As one insider writes:

“Politicians are surrounded by and constantly make formal and informal assessments of uncertainty (for example, when considering polling information) and civil servants are expert at drawing up policy options with incomplete information (which is just as well because complete information is a fantasy). It is true to say that policy makers are not fond of information so laden with caveats that it is useless. Better than hazy comments about policy makers not understanding uncertainty, the Sutherland, Spiegelhalter and Burgman list¹¹ is a productive explanation of what knowledge and skills would help policy makers.” (Roland Jackson, Executive Chair of [Sciencewise](#), on Twitter [@Roland Jackson](#)).

Quality assurance

In producing scientific evidence, scientists must take appropriate steps to ensure the reproducibility of their analysis and the quality of their advice. Where time permits, peer review by experts, who are not involved in the immediate advisory process, can provide an important quality control mechanism. Peer-review is integrated into many existing advisory practices, but this is not universal. It can be particularly beneficial when complex, multi-factorial issues are being addressed. In such cases it may be appropriate to include in the review process not only scientific peers, but also experts from other domains, under the condition that they formulate their opinions based on scientifically valid work. It should be recognised also that there are challenges associated with peer review of inter-disciplinary science, and that the nature of scientific evidence and the confidence level in results varies across scientific disciplines.

3.4 Communicating and using the advice (phase 4)

Communicating scientific advice in ways that maximise shared understanding (and minimise misunderstandings) is of key importance for scientific advisory bodies. It is a major factor in determining the impact of the advice. Although some advisory bodies have dedicated communication officers or services, the task of spokesperson is often attributed to the responsible institute or the chair of the expert group in charge of the work. In either case, scientists responsible for communicating advice need to spend time to speak with policy-makers to explain their work and ideally reach mutual understanding of its policy implications.

Most established advisory bodies have informal rules that request experts not to communicate before the advice has been made public, but often there is no real regulation or control in place. Premature communication of partial results and findings may lead to loss of credibility, to misunderstanding and to increased public pressure. An early leak can lead to further questions that distract from the main task and disrupt the whole advisory process.

In some situations – especially concerning the assessment of risks associated with natural disasters or disease epidemics – early communication of initial results and recommendations is necessary, even if this can further complicate the subsequent debate. In these situations, transparency and openness is essential. It should be clear when the advice is based on preliminary results and incomplete data. This can help to ensure that a later change of interpretation of the data or the use of additional data does not lead to public mistrust in the science advisory process.

Advisory bodies normally publish their reports and recommendations on the basis of a group decision - consensus or majority - where individual positions are no longer identifiable (see 3.3). In some cases, minority views are included in the final report or it may be open to members to take individual positions after the publication of the common report. In the latter case, independent experts are usually free to communicate their potential disagreement over the final results although this rarely applies if they are bound by contract, and directly employed by the advisory body. Public dissent among experts may, on the one hand, reduce the authority of the scientific advice. On the other hand, it may also lead to greater credibility because the broader range of interpretation of scientific findings is laid open; the advisory body itself can no longer be accused of being one-sided.

One of the main challenges for the communication of scientific advice is agreeing an appropriate formulation and language. A common mistake is for advice to be written in long, very technical reports. The most effective advice is normally communicated in short readable reports. An advisory report for policy-makers and open publications should be written in a scientifically accurate manner and, at the same time, be understandable to those expected to consider the advice. There is a balance to be achieved between oversimplification and the incomprehensibility of science language. Guidelines for scientific advice already stress this need in referring to an appropriate language vis-à-vis the target group.¹² A dual report process as used by the IPCC (see below) can also help in this regard.

In many situations, scientific advice is both provided to decision-makers and made available to the public. But practices are rather diverse. In some cases, the decision-making 'customer' is consulted over the draft advice, and comments are taken into account in the final document before it is made public; in others, the advisory body is fully independent from the decision-making body, and final advice is made available simultaneously to the public and to the policy side. The IPCC is an interesting example of the former model. The Panel prepares a first order draft including all findings of the different expert groups. After the first order draft has been reviewed, authors prepare a second order draft of the report and a first draft of its Summary for Policymakers (SPM). The second order draft of the report and the first draft of the SPM are subject to simultaneous review by both governments and experts. Authors then prepare final drafts of the report and SPM. These are distributed to governments who provide written comments on the revised draft of the SPM before meeting in plenary to approve the SPM and accept the report.¹³ This dual report process – a scientific report and a summary for policy-makers – has been adopted by a number of scientific advisory bodies at both international and national level.

The communication process does not always end with a final report from the advisory body itself, but can continue with an official reaction from public authorities, sometimes governed by formal regulations or legally binding rules. This response contextualises the scientific findings in a broader political framework. It may also add an interpretation of the advisory report in the light of other scientific findings or the actual stage of the policy making process. The authority of the advisory body and its credibility may be substantially challenged by the way the policy side officially reacts to its advice.

The importance of openness in scientific advisory processes cannot be emphasised enough. This relates directly to communication and the use of scientific advice. Governments must assure timely access for the public to information related to policy decisions based on scientific advice. In many countries this is required by law. At the same time, consideration has to be given to the treatment of sensitive information regarding diplomatic, national security, privacy and other issues. In setting out policies for transparency, both public accountability and the independence of scientific advisers have to be taken into consideration.

It is important to be transparent about how scientific advice has been considered when drawing up policy, especially when making policy decisions that are in conflict with solicited advice. It is understood that policy decisions are based on a number of criteria other than the scientific or factual information provided by advisory bodies. However, it is important that the latter should not be used

selectively in order to justify predetermined positions or as an excuse to avoid political responsibility. Blaming scientific advice, with its inherent uncertainties, can undermine the credibility of the advisory system as well as ruining the development of evidence-based policies.

3.5 Assessing the impact

Although a small number of scientific advisory bodies provide recommendations that have to be enforced by decision-makers (usually in the regulatory domain), most provide advice that is non-binding. Nevertheless, assessing the actual impact of such advice is important given the time and resources that are devoted to generating it. Impact assessment can also feed-back into, and help improve, advisory processes. Few advisory structures carry out formal impact evaluation or have a remit to monitor or comment on the implementation of their recommendations. They usually consider that their role ends when the advice is provided, do not comment on policy decisions and only intervene and communicate when the advice is misinterpreted. There are, however, exceptions; for example, the German Expertkommission Forschung und Innovation (EIT) conducts follow-up surveys and communicates on the take up of its science policy advisory advice, even though EIT itself has no direct role in implementation.

International advisory mechanisms may also find their usefulness and credibility diminished if their advice is perceived as having little impact. These bodies do not usually provide binding advice (one notable exception is advice from some European structures that have a statutory role in regulatory procedures) and their potential policy impacts can be very diverse, depending on the nature of their mandate. Integrated science assessment structures, such as IPCC or IPBES, are mainly focused on providing evidence for international policy agreements and standards, while UN organisations, such as WHO, can produce guidelines and standards that are often of particular interest to developing countries. On the other hand, international risk assessments may aim mainly to raise awareness and help build response capacities in exposed countries. Trying to provide information to a very wide range of recipients can lead to lack of precision and relevance for some international bodies. For instance, while the IPCC is specifically targeted at informing the UNFCCC negotiations, the UN Global Environmental Outlook (GEO) aims at supporting decision-making at all levels and does not have a specific policy forum that it targets on a regular basis. It is a major challenge for GEO to define its impact strategy and find the most suitable channels to inform policy discussions. In general, it can be difficult for national governments to change policies solely on the basis of recommendations provided by an international advisory committee. To really be effective international science advisory mechanisms often need to be complemented by national processes (see 6.1).

4. RESPONSIBILITY AND POTENTIAL LIABILITIES OF ADVISORY BODIES AND EXPERTS

In the light of recent events, there is a danger that the quality of scientific analysis and advice will be negatively affected by concerns about the personal consequences of providing advice to governments. In October 2012, prison sentences were handed to seven Italian scientists because of their role in providing scientific advice prior to the L'Aquila earthquake of 2009. Although the sentences for six of the scientists were eventually overturned after appeal late in 2014, the repercussions of this case for science advisory processes across the world are still being assimilated. It has brought previously neglected issues of institutional and individual responsibilities and liabilities to the centre of the debate on science for policy.

The survey carried out as part of this project indicates that most advisory structures do not have a clear description of their legal status and responsibilities. It seems likely that imprecision or ambiguity in the terms of reference and operating procedures of advisory structures could in some cases be exposing individuals to serious legal liability. How the results of scientific assessments and analysis are communicated, by whom, and to whom, appear to be a critical area of vulnerability. At the same time, establishing universal best practices and guidelines is complicated by the diversity of national legal systems.

4.1 Diversity in advisory structures, responsibilities and liability

As described in section 2, different types of scientific advisory structures coexist and produce different kinds of output. The operational and legal contexts for these structures vary enormously and have direct consequences for the responsibilities and liabilities the experts who serve on them. Standardised rules cannot be applied, although some structures are more vulnerable than others in specific contexts.

- *Science policy advisory structures*
 - Structures such as councils for science and technology are mostly involved in providing non-binding policy advice on national science and innovation policies. Whether these are internal governmental bodies or legally independent structures, they usually have an official mandate from government that accords their members a status similar to that of government officials, within the remit of their advisory activities. This offers them the same legal protection that is accorded to civil administrations. In addition, the general policy nature of their advice makes it unlikely for them or their members to be the subject of successful legal suits.
- *Permanent (or ad hoc) scientific advisory structures*
 - Because of the nature of the advice of these structures, which often involves risk assessments or analysis of new and emerging issues, they, and their experts, are the most likely to be affected by litigation. Their actual susceptibility will vary according to their legal status. Internal bodies of ministries and governments usually enjoy the same protection as the civil administration itself, in which case the structure itself may be exposed to civil liabilities but prosecution of individual experts is only likely in cases of explicit misconduct or negligence. The situation is more uncertain for the many advisory bodies that are not protected by being embedded in state structures or do not benefit from having a clear legal status.

- *Academies and professional societies*
 - In most countries, academies and professional societies play an important role in the supply of independent scientific expertise. Due to the explicitly independent role of academies and similar bodies, these institutions are normally not part of the political decision-making process itself, but contribute to it with their independent point of view. This clear separation of position-taking and decision-making seems to largely protect academies and other academic institutions from legal prosecution.
- *Individual scientific advisors*
 - Individual scientific advisors (such as Chief Scientists) act as a personalised face of the scientific community towards government and society. They mostly coordinate the scientific advice of other institutions and experts and do not usually play a direct decision-making role. In this function, they seem to be out of danger of legal prosecutions, although their actual status and responsibilities may vary from country to country.
- *International advisory bodies*
 - International laws currently make it difficult to launch lawsuits against international assessment bodies such as the IPCC. Moreover, most of these assessment bodies are clearly distinct from the decision-making processes that they inform. However, as international co-operation in science-based policy advice is becoming more prevalent, the potential responsibilities and juridical status of these structures may also become more important.

The nature and domain of advice also has important implications for issues of responsibility and liability. For example, legal cases relating to science advice in emergencies appear to be more frequent than for issues that have less immediate societal implications. The potential consequences of science advice in terms of physical damage, economic loss, personal injury or death are not surprisingly correlated with potential legal exposure.

4.2 Institutional and personal responsibility and legal liability

Legal cases can be brought against either individual experts or their institutions (or both), and can involve either civil or criminal (penal) liability. Experiences in different national juridical systems suggest that, in general, the Government itself is responsible for decisions based on the findings of Government-appointed expert advisory groups, but this is not universally the case. Moreover, even where it is applicable, governmental-protection does not hold for cases of criminal liability.¹⁴

Legal responsibilities may be difficult to assess for complex situations, when advisory roles are shared. For example, following the 2009 H1N1 “Mexican flu” epidemic that led to widespread and, as things turned out, unnecessary vaccination in many countries, an investigation was conducted in the Netherlands to assess potential responsibilities. No blame was finally attributed to experts and advisory bodies, as responsibility for the decision was shared among many different stakeholders. Indeed, when the role of scientific advisory bodies is clearly separated from decision-making, legal suits are unlikely to succeed as long as advice is provided in good faith and according to professional standards.

Institutions are the primary targets of lawsuits in most countries, as the responsibility of individual experts can be hard to prove. Lawsuits against institutions are seen as more likely to result in financial rewards since institutions are normally in a better position than individuals to pay. Such cases normally concern civil jurisdiction. Civil cases concerning advisory bodies involved in risk assessment are on the increase. This is particularly true for the areas of health and environment. Advisory bodies in these fields are often involved in drafting regulatory processes, the consequences of which can be easily ascribed, in comparison to advice that is only provided in terms of assessments and options.

Institutional responsibility may be invoked when a decision from that institution is considered by a plaintiff as having caused a prejudice. Decisions can be contested in front of administrative jurisdictions when the process itself is contested or in civil or penal jurisdictions if there is a prejudice for the victims. In countries such as Germany, if an advisory body has been established by the state, the state would cover its civil responsibility but not potential personal responsibilities under criminal law.

Experts generally are unlikely to face criminal prosecution for underestimating a risk (but they can face charges for acts of malice aforethought if their advice does not rely on evidence). Collective decision-making within an advisory body means that an individual attribution of responsibility and civil liability may not be possible. In cases of criminal liability however, the potential responsibility or liability of individuals is determined by the judicial system. Scientific experts working for public institutions usually benefit from the legal protection also provided to civil servants. However, this varies from country to country, and even within the same country: for instance, legislation provides civil immunity to public servants from the Queensland state in Australia,¹⁵ but no such legislation exists at federal level. The situation is even less clear for other experts (from private sector or from civil society).

Individual experts may be sued both under civil and criminal law when it can be demonstrated that they did not conduct their activity according to normal professional standards and/or if their behaviour neglected existing guidelines. In the Swiss legal system for instance, civil liability of experts can be engaged as “Any person who unlawfully causes loss or damage to another, whether wilfully or negligently, is obliged to provide compensation”. Moreover, negligence can also be invoked in criminal justice against experts, as the Swiss criminal laws describes an homicide through negligence as “Any person who causes the death of another through negligence or recklessness is liable to a custodial sentence not exceeding three years or to a monetary penalty”.

Individual prosecution of scientific experts has until recently been rather rare, but the first case in a country is particularly important as it can set a precedent and stimulate or discourage further cases. Following the Aquila case, in Italy alone there are now more than 40 legal suits pending concerning the evaluation and management of risk for which the Civil Protection system is competent, with over a hundred experts indicted and now awaiting trial. Typically these cases involve experts and operators of institutions that are charged with failing to perform adequate risk assessments or misinforming plaintiffs of the potential risks associated with natural hazard events.

Box 1. The L'Aquila Case

On 6 April 2009, a major earthquake occurred causing the death of 309 people in the Italian city of L'Aquila, which is situated in the Abruzzi region, an area of high seismic activity. In January 2009, a series of small magnitude earthquakes were felt in the region, and continued in the following months. During this sequence, a technician of the National Institute for Astrophysics issued predictions of impending large earthquakes in the region (the predictions were not backed up by his scientific institution). These unofficial predictions were based on variations of radon concentration measured with gamma-ray detectors. The correlation procedures used were not made openly available, and when later presented to the International Commission on Earthquake Forecasting for Civil Protection¹⁶, after the earthquake, they were found to be without any scientific basis. These predictions generated widespread public concern.

On 31 March 2009, four members of the government-mandated Major Risk Committee (MRC) met in L'Aquila. They were accompanied by the Director of the INGV National Centre of Earthquakes, the Deputy Head of the Department of Civil Protection and the Director of the Seismic Risk Office. The Assessor of Civil Protection of the Abruzzi Region, the L'Aquila Mayor and the Head of the Regional Civil Protection were also present, along with other representatives of different institutions.

The minutes of the meeting were released after the L'Aquila earthquake. They contained three main conclusions: earthquakes are not predictable in a deterministic sense; the seismic hazard of the L'Aquila region is among the highest ones in Italy; the occurrence of a large earthquake in the short term was unlikely.

After the meeting, a press conference took place with the participation of the Deputy President of the MRC, the Deputy Head of the department of Civil Protection, the L'Aquila Mayor and the Assessor of Civil Protection of the Abruzzi Region. Although the recordings of the conference were destroyed by the earthquake, the general message which was taken by the media was that the situation was evolving positively.

On April 1st, the L'Aquila Mayor requested a declaration for a state of emergency. Several schools were temporarily evacuated after tremors were felt. On 6 April 2009, following two small quakes which had occurred a few hours before, an earthquake of MI 5.9 (Mw 6.3) hit the Abruzzi Region at 3:32 AM, causing the death of 309 people.

After the earthquake, the four MRC members and the three other experts who attended the March 31st meeting were charged with manslaughter by the L'Aquila prosecutor. The trial lasted 13 months and ended on 22 October 2012. The seven defendants were found guilty of involuntary multiple manslaughter and causing multiple serious injuries. They were condemned to:

- Six years in prison (suspended until the appeal judgment).
- Perpetual interdiction from public offices and legal interdiction during the enforcement of the sentence (suspended until the final level of judgment).
- A first financial compensation to the families of the victims (" 8 million; immediate).

The more than 900 pages-long justification for this verdict can be summarised into the following points:

- All the seven indicted people were considered members of the Committee (even though only four out of seven actually were).
- The Committee had specific duties with regards to assessment of the risk situation in L'Aquila and providing correct information to the population.
- The Committee failed in its obligations to assess and provide information, and all the MRC members were responsible for the violation of such obligations.
- The fault consisted of an approximate evaluation of the situation and in having contributed to the spread of reassuring messages to the population.
- Because of this, 29 dead people (out of 309 fatalities), who used to run away from their houses when alarmed by small quakes, remained at home in the night of 6 April 2009, and died as a result of the collapse of the buildings in which they had remained.

Following this event, an International Commission on Earthquake Forecasting for Civil Protection was set up, which provided its report to the Italian Department of Civil Protection in 2011 ("Operational earthquake forecasting"). The conclusion stated:

"Despite over a century of scientific effort, the understanding of earthquake predictability remains immature. This lack of understanding is reflected in the inability to predict large earthquakes in the deterministic short-term sense... In well-monitored regions, retrospective analyses of data collected prior to large earthquakes, including the L'Aquila main shock of 6 April 2009, show no convincing evidence of diagnostic precursors".

Note: This case went to appeal in October 2014. In its verdict given on 10 November,¹⁷ the appeal court overturned the initial judgment and six scientists were fully acquitted. However, the former deputy-head of the civil protection agency, who had been in charge of the communication, had his sentence confirmed. The case may still go to the Court of Cassation for a final ruling.

Source: Italian Department of Civil Protection.

As discussed previously, many advisory structures have documents describing their working processes, in which areas such as potential conflicts of interest are usually addressed.¹⁸ The situation is often much less clearly defined for the legal responsibility of advisory bodies and their experts.

Most advisory bodies have no reference to personal or collective responsibility or liability in their statutes or procedures. Indeed, a number of heads of advisory bodies interviewed during the course of this study admitted that they were ignorant concerning the procedures to follow if their organisation or some of their experts were to be sued. For other bodies, the Director or equivalent is the official responsible person providing the advice and would, in all expectation, be the person sued in case of litigation.

4.3 The changing behaviour of scientists

The public debate on examples like the L’Aquila case has highlighted the lack of understanding of the legal responsibility of experts participating on scientific advisory bodies. Even if the vast majority of scientists have not experienced legal action themselves, the potential danger of prosecution may lead to changes in behaviour and a decline in effectiveness of advisory systems in general.

Especially in the area of civil protection and risk assessment, scientists are confronted with a decision making dilemma: false alerts can be costly (e.g. for precautionary measures such as evacuations) and eventually lead to a loss of credibility and confidence in an advisory process, while a failure to alert in situations of real danger can lead to injuries and deaths. This is illustrated in a recent study¹⁹ that revealed a “performance paradox” for hydrogeological risk assessment and risk management in Italy. “Precautionary regions” tend to overestimate potential adverse effects of events in issuing early warning alerts. This overestimation does not completely eliminate missed predictions for serious events (underestimation of events still occurs due to the intrinsic level of uncertainty of numerical weather prediction models), but experts from these regions have a reduced chance of being prosecuted for miscommunicating risk assessments. “High performing regions,” on the other hand, minimise the level of false alerts. However, they display a higher rate of underestimating serious events, which are those likely to lead to judiciary procedures. Indeed these regions have a higher chance of being involved in legal suits than precautionary regions even if their risk assessment systems perform better. The paradox is that the “high performing” (i.e. more accurate) advisory structures and experts are more prone to lawsuits than the “precautionary” ones.

The risk of being personally prosecuted (personal prosecution, even if unsuccessful, can be financially and professionally crippling) may lead to behavioural changes that substantially affect the functioning of science advisory systems. This can affect in particular those scientific experts who are not directly employed by government, and for whom legal liability is unclear. Precautionary or defensive behaviour in recent years includes resignations from office of highly qualified personnel (or refusal to take such responsibility), fragmentation of mandates to dilute responsibilities, suppression of dedicated advisory services to reduce liabilities, and more globally an “advice chill”. With an emphasis on caution, the value of scientific advice, not only in risk assessment but in many other areas, can be seriously weakened.

4.4 Reducing the likelihood of litigation

Faced with an increasing risk of litigation, there are two critical areas for attention with reference to the standard advisory process described previously in section 3.

Clarifying of the roles and responsibilities of experts

As described in section 3, a growing number of advisory structures have clearly defined official statutes and legal or regulatory frameworks which can be of great help in the event of legal disputes. Whilst individual legal liability is often not addressed, there are some interesting descriptions of the legal liability and role of individual experts relative to decision-making in these documents. For example, the Terms of Reference of the Science Advisory Board of Health Canada²⁰ states:

“All members serve on the Science Advisory Board on a volunteer basis. Health Canada undertakes to provide its volunteer advisory body members with protection against civil liability provided the volunteer member acts in good faith, within the scope of their volunteer duties, and does not act against the interests of the Crown.Members act collectively as an advisor to Health Canada with respect to the mandate of their advisory body but they are not final decision-makers. The Department has the ultimate responsibility and accountability for any decision resulting from the advice received from an external advisory body.”

Even where detailed statutes exist, they may not cover all those who might serve on an advisory body. It is important for those who are self-employed, or acting outside the specifications of their employment contract, to be clear on their situation with respect to liability. The position is even more complex for scientists in one country who advise another country or body and who are not employed by a national government to perform an advisory role. In such situations, legal liability can be difficult to strictly evaluate.

While it is important that legal liabilities are defined a priori in so far as this is possible, there is general agreement that experts cannot, and should not, be completely exempted from individual responsibilities in the advisory process. Terms of reference or statutes should make it clear that individuals can be held legally liable for professional negligence, fraud, or concealment of relevant information on risk or uncertainties.

Improving public communication

Reports from the International Commission on Earthquake Forecasting for Civil Protection on the L'Aquila event,²¹ or of the German Federal Institute for Risk Assessment following the *E. Coli* outbreak in 2011,²² have highlighted the need for appropriate communication procedures regarding scientific advice, particularly when dealing with emergency situations. A number of scientific advisory bodies have specific media communication procedures and protocols with clearly allocated responsibilities. For instance, under Australian law, a government representative (such as a scientific expert from a governmental organisation) could be held personally liable for misrepresenting a situation or for making a statement that was made outside the agreed approval process. Notwithstanding this and other examples of well-defined communication protocols, communication of science advice is often not well organised and can lead to confusion and misunderstanding.

Recent events have shown the difficulty in communicating uncertainties to both decision-makers and the general public. The international report on the L'Aquila event²³ underlined that, in the field of natural hazards, the direct provision of information to the public through various communication mechanisms on a continuous basis (and not only during emergencies) is desirable. Good information keeps the population aware of the current state of hazard risk, decreases the impact of ungrounded information and contributes to improving preparedness.

A major obstacle to effective communication between scientists, between scientists and policy makers, and with the public is different usage and interpretation of language. For example, the

difference between ‘hazard’ and ‘risk’ is often misunderstood. In many case, a common glossary would help all stakeholders to significantly improve communication (see Box 2).

Box 2. Glossary of key terms relating to legal liability, science advice and decision making

This glossary is one outcome of a workshop that was convened as part of the present project (Berlin, February 2014) and which brought together scientists, legal experts and policy-makers. The focus of the workshop was risk assessment and emergency response, including consideration of the L’Aquila case. The glossary has been informed by existing reference works on legal terms but it is not designed to be a complete listing of all terms relevant to science advice, responsibilities and liabilities. Rather, it is illustrative of the terminology needs to be defined early on when different groups work and communicate together.

Advice

Guidance offered by one person or organisation to another as to different options of acting. Advice can be solicited or unsolicited.

Civil Liability

The state of being legally obliged to pay an amount of money as "damages".

Criminal (penal) Law Liability

Criminal (penal) law involves prosecution by the state of a person for an act that has been classified as an offence.

Decision maker (policy)

A person who chooses between options and causes the chosen measures to be taken.

Expert

A person with specific skill or knowledge who may give information, develop options and/or recommendations.

Hard Law

Term used for instruments that are legally binding.

Hazard

A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

Information

Facts not necessarily containing different views or options.

Liability

The legal consequence of an action someone has done, or duty or task she or he has not fulfilled (negligence), that led to damage.

Negligence

A failure to behave with the level of care that someone of ordinary prudence would have exercised under the same circumstances. The behaviour usually consists of actions, but can also consist of omissions when there is some duty to act (e.g. a duty to help victims of one’s previous conduct).

Public Agent

A person appointed to act for the State.

Recommendation

An assessment (weighing of positive and negative aspects) of different options leading to a suggestion about actions to be taken.

Responsibility

A duty or task that one should do because it is morally right, legally required, etc.

Risk

Probability that a hazard will occur and lead to a negative consequence.

Soft Law

Term used for instruments without binding character.

Uncertainty

An expression of the degree to which a value or relationship is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable.

Vicarious Liability

The State’s liability for its agents (vicarious liability) as opposed to the liability of the agent itself (personal liability).

5. PROVIDING SCIENCE ADVICE IN CRISIS SITUATIONS

Scientific advice can play a critical role in both the assessment and management of risks. In the event of emergencies, as referred to in the previous chapter, it is expected to aid government and civil society's responses. Many governments and institutions have set up specific procedures to deal with routine emergencies, but recent cases have highlighted the need for additional advisory processes when such emergencies are linked to unexpected or exceptional events, particularly when these have trans-national repercussions. This can be because of the specific location and nature of the event, its scale, its potential impact or a combination of all of these. For the purposes of this report these major emergency events are referred to as crises.

5.1 Challenges associated with crises

Most emergency advisory processes cater for "normal" events with local impacts. When a rare event occurs, which may have impact at regional or global scale, emergency response systems and national scientific advisory structures are confronted with new, complex and rapidly changing challenges. Addressing these often requires the effective combination of different disciplines or types of knowledge, which are not routinely linked. Recent crises such as the 2010 Deepwater Horizon oil spill, the 2010 Icelandic Eyjafjallajökull volcano eruption, or the 2011 Great East Japan earthquake and tsunami events, have highlighted the difficulty of coordinating and synthesising scientific input from many different fields and institutions and translating these into useful policy advice at very short notice.

Interviews carried out in the course of this activity identified two related areas that require particular attention as regard the role of science advice in crisis situations: authority and responsibility.

Maintaining an authoritative voice

Emergency situations, particularly when they are of an unusual nature and/or affect large populations, are bound to attract a lot of attention from the media. This in turn can encourage alternative sources of scientific or expert information to publicise their own diagnoses or forecasts, which can differ significantly from the views of official/mandated scientific advisory structures. Such alternative sources may not have the same level of competency and legitimacy as mandated structures but, in a context of growing mistrust of governmental or institutional structures, alternative and/or unorthodox views are often showcased by the media. The diversity of solicited and unsolicited advice can be a challenge for decision-makers, as well as create confusion in the public realm. That said, unsolicited information, if used in a properly informed way, can also assist in decision making, particularly for unusual and complex events that require analysis from many different scientific perspectives.

Responsible public communication of scientific advice is very important in crisis situations, as advisory bodies need to be trusted not only by decision-making authorities but also by the general public if their advice is to be useful. As keeping the population informed during crises often falls within their responsibilities, advisory bodies need to be fully aware of the messages that are being disseminated in both mainstream and social media during a crisis.

The challenge of maintaining an authoritative voice is amplified by the trans-national nature of major crises. In the 2011 Fukushima nuclear accident case (see Box 3), confusion in communicating the potential risk to the population led rapidly to a distrust of national official information, and many Japanese people living in the Tokyo area based their decisions on risk assessments from other countries. Unfortunately, differences between assessments from various foreign institutions, and sometimes contradictions between scientific assessments from such institutions and the recommendations issued by the embassy from the same country to their national citizens, did not facilitate effective decision-making.

Clarifying responsibilities

In many countries, scientific advisory bodies that are called upon in emergency situations are embedded into civil protection structures or formally exist under one or several ministries or governmental agencies. Independent science bodies may also be called upon to provide scientific advice during crisis situations. The boundaries between playing an advisory role and direct involvement in decision-making are not always clear for these various structures and this can undermine any advice that is given. For example, in the Fukushima nuclear accident that followed the Great East Japan earthquake in Japan, conflicting assessments from various governmental and private sources and confusion in the decision-making chain led to a sharp decline in the public trust of scientific experts. Although well-established advisory systems often have a clear definition of their role and the roles of their experts, the advisory and decision-making responsibilities in crisis situations can easily be confused.

Box 3. The Fukushima Nuclear Accident

The response to the nuclear crisis in Fukushima has led to a lot of reflection on how the Japanese government and the scientific community did and should have reacted.

On 11 March 2011, a massive tsunami provoked by an exceptionally large earthquake affected a vast area that included the Fukushima Daiichi Nuclear Power Plant. Disruption of the cooling system for the reactors led to nuclear meltdown and hydrogen explosions, which caused a release of radioactivity in the ocean and atmosphere.

After the accident, the Japanese government experienced difficulties in taking wholly consistent action. For instance, a restricted area was set up immediately, but its size was subsequently enlarged several times and evacuation or precautionary safety measures were modified over time without due provision of detailed information to the public. Similarly, information was not communicated to consumers, within and outside Japan, with regard to the safety of agriculture produce, marine products and industrial goods.

In a post-crisis analysis,²⁴ it was found that government officers badly lacked timely access to rigorous scientific information and evidence. Designated advisors to the government, other scientific experts and professional societies were not capable of providing consistent and integrated scientific advice. Instead, many scientists and engineers spontaneously transmitted to the public their various opinions on the risks of radiation exposure, and contamination of food and water. This exacerbated confusion and encouraged the circulation of numerous rumours among citizens. As a result, an important drop in public trust in scientists was noted following the accident.²⁵

In response to the event, the Japanese government and scientific community have made efforts to improve the nation's scientific advisory system. A series of international symposia were organised to discuss the roles and responsibilities of scientists and the government.

Through this process, the need to draft principles or guidelines regarding scientific advice was highlighted.²⁶ Inspired by the crisis response mechanisms put in place by the UK government, the establishment of a Government Chief Science Advisor-like position and supporting functions in Japan has been discussed, although such a position has not yet been established.^{27 28}

Meanwhile, the Science Council of Japan (SCJ) compiled a statement entitled "Recovery from the Great East Japan Earthquake and Responsibilities of Science Council of Japan" in September 2011.²⁹ According to the statement, SCJ charges itself with the mission of integrating advice and recommendations from the scientific community into an effective and appropriate "unique voice" including multiple options for the government. SCJ also revised its "Code of Conduct for Scientists" in January 2013.³⁰ The new version includes a section entitled "Science in Society," in which the need to provide policy makers with appropriate and effective scientific advice is emphasised.

5.2 Lessons learned

Based on experience with recent trans-national crises, a number of governments and independent advisory bodies have introduced new processes to provide scientific advice in crisis situations. A few broadly applicable principles are emerging:

- a. *The need for permanent authoritative structures and/or mechanisms.*

Although it can be difficult to maintain a high level of preparedness for events that may happen very rarely, established processes and ideally some element of permanent structure are important. Such structures can improve preparedness by developing case scenarios for unlikely serious events, establishing procedure testing and validation processes and running simulation exercises. They can

enable the integration of scientific knowledge into risk assessment and policy processes early on, and analyse divergences in scientific opinions not just during emergencies but prior to them. Having pre-established mechanisms to handle conflicting viewpoints and adhering to transparent codes of practice can be important in ensuring public trust in science advice during crises.

Large-scale crises often reveal the limits of even well-established structures and procedures. It is important to have built-in mechanisms to learn lessons from unusual crisis situations. Permanent structures have the advantage of being able to institutionalise their experience in order to improve future responses. By maintaining active links with similar bodies and other relevant groups elsewhere such structures can expand their capabilities beyond their own direct experience and improve their overall flexibility and preparedness.

b. The need for a central contact point.

Crisis situations often lead to a profusion of expert advice. This can lead to confusion and be seriously detrimental in a context where rapid action is required. This can be illustrated if we take the case of the 2011 Enterohaemorrhagic Escherichia Coli (EHEC) outbreak in Germany and Europe. Advice was initially provided at a national scale by several German institutions, including the German Federal Institute for Risk Assessment (BfR), the Federal Office of Consumer Protection and Food Safety and the Robert Koch Institute, as well as additional local institutions, and various origins of the epidemic were proposed. Only then, were additional consultations organised with the European Food Security Agency (EFSA), representatives of EU member states and the World Health Organisation (WHO) to coordinate scientific activities and pool information at the international level³¹, which led to the correct identification of a single source of contamination. In retrospect, the early identification of a central authoritative contact point and coordinating body for scientific advice would surely have helped in this situation.

An appropriate crisis contact point may primarily rely on in-house scientific capacities or act only as a coordinating body - collecting information from external institutions and commissions. The key requirement is to have a structure that is able to coordinate the scientific advice across fields of expertise and internationally and that has direct links to decision-making.³² The early identification of a coordinating person or body, which can rapidly source the most relevant science information, and facilitate delivery of an accepted consensus and authoritative scientific advice to the decision-making authority, is important.

Effective and timely exchange of information and data – both within and across advisory and decision-making bodies – is a critical element during crises. Multiple and divergent sources of scientific advice, with associated uncertainties, can stifle decision-making. The sharing and transmission of information between all responsible actors can be supported by a web-based system like ERMA (Environmental Response Management Application) developed by the US National Oceanic and Atmospheric Administration (NOAA), which provides online up-to-date information about response efforts.

c. The need for clear reporting processes

In crisis situations, the specific role(s) of scientific experts and bodies in the decision-making process can sometimes be blurred. Decision-makers may be tempted to divert some of their responsibilities onto the shoulders of the experts, while scientific experts may feel the need to express their personal views on what action should be taken by authorities, overstepping their scientific advisory role. Such confusion may have serious consequences in terms of maintaining credibility and accountability.

In effective crisis response situations, key elements of the chain leading from the production of scientific information to decision-making and communication are clearly identified. Responsibilities are clearly established in planning documents prior to the crisis. The production of scientific data and information is divided across competent agencies, taskforces and working groups, with a single

identified person or structure in charge of making decisions for each specific setting (e.g. one person in charge of decisions on the site of the accident, one person or body in charge of setting a national strategy and clear communication mechanisms between these geographical levels).

The US National Contingency Plan is a good example of such process. Its initial version was developed after the oil spill resulting from the shipwreck of the oil tanker Torrey Canyon off the South-West coast of the UK in 1967. It specifies the role and responsibilities of each organisation involved in the response to an emergency related to oil or hazardous substances pollution and includes specifications for the scientific support team and its role. It also divides up the roles of the national and the regional response teams (for instance, planning and coordinating responses, guiding the work of the regional teams as well as leading a programme of research to support the response, are all tasks that are appropriate at the national level). Most importantly, in the case of large spills, when many working groups are involved, all information has to roll up to the federal on-scene coordinator, who is the main recipient of the scientific information. He or she belongs to the unit of command that is in charge of the spill and coordinates all types of response activities on site.³³

d. The need for a pre-defined public communication strategy

Public communication is one of the most important aspects of any emergency response situation and, as discussed in previous chapters, scientific advice is often at the centre of this communication.

There is no standard practice regarding who should communicate scientific advice to the public and media during a crisis. In some cases, governments prefer to keep reports of scientific advisory bodies confidential during crises, and restrict communication to official spokespersons such as Chief Science Advisors, while others allow the publication of such reports. Whatever the final communication outlet, it is important to have an internal clearance mechanism, to ensure the quality and clarity of formally requested science reports and to explain the limits and uncertainties of scientific assessments.

At the same time, it should be recognised that openness and transparency are important elements of maintaining public trust in scientific advice during crises. Major lessons were learned in France after the miscommunications pertaining to the nuclear cloud generated by the Chernobyl accident, which led to an improved culture of openness and continuous communication in this field. Similarly following the *E. Coli* outbreak in 2011, the German Federal Institute for Risk Assessment analysed how the crisis and in particular the recommendations were perceived and understood by the public³⁴.

The combination of different types of formats to communicate important information can improve the public dialogue: dedicated websites such as the NOAA's response and restoration blog³⁵ updated regularly, TV or radio interviews, scientific statements, press releases, press conferences as well as social media such as twitter.³⁶ In some instances, dedicated structures have been established to respond to individual information requests from the public during and after crisis events. Again however, the lack of co-ordination between public information structures in different countries may have a negative impact if conflicting information is disseminated.

e. The need for international co-ordination

Providing scientific advice in crisis situations when an event has trans-national impacts raises special challenges. Responses need to be co-ordinated between multiple players in different countries, in a context where conflicting advice may have serious detrimental consequences (delayed action, confusion in the public etc.). In some instances, international organisations may have a leading role in providing consensus recommendations to governments. WHO, for instance, has played such a role in recent years during epidemics of SARS (*Severe* acute respiratory syndrome) or of H5N1 flu virus. Similarly, the network of regional Volcanic Ash to Advisory Centres (VAAC) have mandated responsibilities from the International Civil Aviation Organisation (a UN agency) to provide advice to the aviation community in a co-ordinated way in case of volcanic eruptions. Nevertheless, in many other areas, no international organisation is in charge of providing integrated scientific advice. In the

case of the Fukushima nuclear accident, information and assessments provided by the International Atomic Energy Agency (*IAEA*) were sometimes in conflict with those from national institutions. Following this event, a number of countries proposed to ask the IAEA to become a hub for the compilation of national nuclear information in the case of trans-boundary nuclear crises, information which could then be shared with all affected countries. However, this proposal was resisted by other countries, which prefer to rely on their own national organisations to provide assessments.

Whether there is a need for international advisory structures to provide advice in particular crisis situations or whether scientific advice should remain the prerogative of national advisory bodies, remain open questions. However, in the absence of mandated and authoritative international bodies, transnational networks of national advisory bodies can play an important role. Such networks already exist in some areas and have defined and validated procedures for exchange of data and information. They can play a dual role in both providing credible and trustworthy advice from different countries to national authorities as well as authoritative information to media and the general public.

6. EMERGING ISSUES

Two cross-cutting issues have appeared recurrently throughout the preparation of this report and are expanded upon in this section.

6.1 Global societal challenges and scientific advice

Scientific advice is increasingly sought to help decision-makers in dealing with complex global issues. As described in section 2, various international science assessment mechanisms have been set up to address issues, such as climate change or biodiversity loss. At the same time many national advisory structures have been established to address these topics and provide advice to governments.

There are specific challenges associated with the effective provision of science advice on global/complex issues:

- *Different scales for assessment and action*

Although some of the international advisory structures addressing global issues may work on questions raised at their own initiative, they usually have to respond also to external requests from governments or intergovernmental structures which are at the origin of their mandate. Due to the nature of the issues and their socio-economic implications, specific national policy-questions cannot be addressed by international assessments alone and need to be considered in a particular national context.

- *Integrating input from many different fields of expertise*

Traditional scientific advice is generated by groups of experts with in-depth knowledge of a specific domain. When addressing global challenges, the legitimacy of narrowly-focused expert groups can be questioned. Input from many different disciplines, including socio-economic disciplines, becomes necessary. National advisory structures are sometimes not well organised to manage and synthesise such a diversity of input. A different type of organisational structure becomes necessary, with the implementation of procedures designed to validate the integration of different types of data and information.

- *How to accommodate many different viewpoints and policy requirements?*

The nature of global/complex issues requires international co-operation, both to develop integrated scientific assessments, and to develop effective international policies. Advisory processes need to have input from a diverse and international community of experts and to respond to conflicting international and national policy demands.

The example of climate change illustrates these challenges. While many national advisory structures are addressing this topic to provide recommendations to their governments, the complexity of the problem requires an international scientific assessment effort to understand the phenomenon in its global dimension. Furthermore, any successful preventive or mitigating policies necessitate international consensus and co-ordinated efforts as well as national and local actions. A dedicated international body, the International Panel on Climate Change (IPCC), had to be created in 1988 to synthesize for decision-makers the vast wealth and diversity of relevant information. Every 5 or 6 years the IPCC publishes scientific climate assessment reports and policy summaries in collaboration with policymakers. Despite very detailed and transparent operating procedures (see 4.4), and despite the fact that it does not, strictly speaking, provide advice but just a summary of the consensus knowledge of the field and scenarios based on this knowledge, the IPCC has been regularly criticized by various stakeholders. Such criticisms include biased interpretation of conflicting evidence and

limits in its model-based scenario. Against this background, the impact of the IPCC on decision-making is difficult to estimate, although the rigour and quality of its scientific assessments are widely accepted by policy-makers.

Different countries have different advisory bodies dealing with global challenges, but good practice for linking international and national assessments and policy-advice are not always shared in a way which can help optimise processes and allow citizens to hold their decision-makers to account against an appropriate standard. The potential for better co-ordination of national and international science advisory structures to respond to crises has been indicated previously (see 5.2). There is related potential for better co-ordination of national and international science advisory structures across different scales (from local via national to global) in order to reinforce policy actions on societal challenges that require a concerted global effort. For example, global health-care challenges, such as anti-microbial resistance, require united, long-term effort by actors at all scales (from individual medication prescribing decisions through to investment in research) which need to be coherent across countries. Such challenges require effective linkage between international frameworks, national strategies and local decision-making and implementation.

6.2 The growing interest of civil society in scientific advice

In recent years, scientific advisory bodies have been increasingly expected to take into account the potential societal impact of their work. This is the result of demands from the decision-making side, which is interested in the potential consequences of its policies, as well as from civil society itself, which is expressing concerns on science and innovation-related decisions. As described in a recent study by the Rathenau Institute of a planned vaccination campaign against cervical cancer in the Netherlands,³⁷ ignoring such societal concerns can lead to public turmoil and undermine evidence-based policy decisions. In this particular case, one person was able to organise a very effective anti-vaccination campaign via the internet. Her campaign was supported by inappropriate references to scientific literature that she had found on the web and interpreted as demonstrating serious side-effects of vaccination. This case highlights the role that (social) media can play in rapidly fermenting public dissent.

As the role of science in issues of interest to all or many sections of civil society grows, so does the impact of any misunderstanding or values-based conflict relating to that science. Civic engagement can reveal conflicting interests between sections of society and lead to polarising controversies. If advisory scientists fail to appreciate the potential ethical, societal, economic or environmental impacts of their recommendations, this can result in their advice being ignored or rejected. On topics on which a strong values-based debate is underway in civil society, scientists who attempt to present what they see as straightforward evidence without acknowledging the values context may be subject to aggressive criticism. In the case of the EHEC bacteria outbreak described earlier (see 5.2) scientists became embroiled in a heated public debate for which they were ill-prepared.

In areas of public interest, a (real or perceived) lack of transparency and accountability are factors confounding the impact of science advice. For example, in July 2014, several environmental NGOs publicly appealed to the new President of the European Commission to disband the position of Chief Scientific Advisor. Much of the substance of the NGO case centred on a perceived lack of transparency and accountability. They cast doubt on the neutrality of the current advisor on specific topics, and called for the position to be replaced by a broader scientific advisory system which would include representatives of NGOs.³⁸ This call triggered a heated debate as other NGOs and representatives from the scientific community came to the defence of the Chief Scientific Advisor office. Finally, the position of EC Chief Scientific Advisor was disbanded in November 2014 and the Bureau of European Policy Advisers transformed into a broader European Political Strategy Centre by the new President of the European Commission.³⁹ The European Commission is currently exploring options for a new independent system for scientific advice, based on the experiences in different

Member States and worldwide. This case illustrates the real challenge in involving representative views and/or expertise from civil society in scientific advisory processes and in decision-making.

Several recent cases, referred to in this report, illustrate the changing relationship between science, government and the broader society. In emergencies or on controversial issues, policy makers and the general public want quick answers from the scientific establishment, and researchers are under pressure to come up with clear-cut advice, even though the uncertainties are often high. Such pressure may be linked to fears (when potential harmful health effects are possible), to economic interests or to ideology. The press and the social media can play an important role in the dissemination of information, true or false, and there can be challenges for international co-ordination and collaboration if trans-boundary effects are expected.

A number of scientific advisory bodies have adopted new procedures and practices, as already mentioned in earlier sections of this report, which can help limit controversies over scientific advice and increase public trust towards advisory systems:

- *Clarified responsibilities*

Many advisory structures have clear mandates and statutes that determine their responsibilities. For some their role is limited to scientific risk assessment. This is often the case for technical advisory bodies. Others have broader mandates that can include combining scientific and societal perspectives. In a recent debate over pre-implantation diagnosis, the German Academy of Sciences discussed whether its scientific advice should be restricted to facts only, or also include ethical consequences. Its final position was that statements must contain the best scientific evidence but may also contain an ethical dimension. This was positively received by decision-makers, but a critical element here is having the capacity to provide such a broad societal, sociological or even ethical impact assessment. If asked to address an issue, advisory bodies need to ensure that such a task is compatible with their mandate and expertise.

- *Increased transparency*

Potential or substantiated conflicts of interest have been responsible for much of the diminution of trust among citizens towards established structures and science-based policies. Most advisory structures have established practices concerning the declaration of interests by expert members and procedures for managing conflicts should they occur. However, it should be underlined that, for all bodies surveyed during this study, declarations of conflicts were largely dependent on the goodwill of the experts, and validation procedures were usually non-existent.

Better definitions of “conflict of interest” are needed for specific situations. It is almost impossible, as sometimes requested, to have experts with no vested interests, particularly as the science system fosters relationships between all interested stakeholders (public and private). Competent experts are likely to have had previous contacts, and often contractual relationships, with some of the stakeholders involved in issues they have to examine. Better standardised definitions of “interests” and transparent rules to identify such interests are therefore needed.

There is a positive trend towards increased transparency in advisory processes. Although internal debates among experts are still usually confidential, observers are increasingly invited to attend (although stakeholders with a vested interest may be excluded). In some processes, the personal positions of experts including dissenting/minority opinions, may be recorded in final reports. This can encourage experts to voice their opinion, as they know that dissenting voices will be registered. However, there can also be negative consequences to making processes more transparent. Feedback from the survey conducted in preparation for

this report indicated that an increasing number of experts are abstaining from giving opinions on complex/technical or controversial issues, as they do not wish to have their name associated with a position they could not necessarily rigorously defend. In extreme cases, experts have resigned when confidentiality procedures have been abolished (for instance in a national agency for drug security, where debates are now video-recorded).

- *Stakeholder consultation*

Stakeholders are usually understood as people and organisations likely to be affected by decisions taken as a consequence of scientific advice, which can include those with economic interests as well as civil society groupings (NGOs, trade unions, patient organisations etc.). In order to take into account the potential impact of their advice, an increasing number of advisory bodies are integrating some sort of consultation process with stakeholders alongside their traditional expert assessments. This is often done through formal public hearings or public consultation on internet-based platforms. There is usually no clear and standardised process for such consultations, although some countries have set up defined consultation procedures in specific cases. In Switzerland for instance, such a mechanism is mandatory in the law-making process.⁴⁰ For the recent Swiss law on reproductive medicine, expert scientific consultations were followed by consultations with government agencies, and then with civil society very broadly (including NGOs, professional organisations, hospitals, and experts from civil society).⁴¹

Stakeholder consultation can help in achieving consensus on policy action and buy-in from the relevant communities, but requires a high level of transparency and additional measures to protect against conflicts of interest and to ensure that scientific rigour is not compromised. In both stakeholder consultations and direct civil society involvement (see below), it is important that contested science should be evaluated on the basis of the science rather than the contest.

- *Direct involvement of civil society*

A number of advisory bodies have gone one step further and included within their expert committees some representatives of civil society, including stakeholder groups (industry organisations, consumer associations) and lay persons. A clear distinction should be made between stakeholder groups - including NGOs - which represent specific views from civil society, and laypersons, who are expected to represent the broader public. Stakeholder representatives are often 'experts' in their own right and may also be scientists. They make an important contribution on science policy advisory structures in some countries (such as the Mexican Consultative Forum on Science and Technology) and in areas such as health. In these and other areas they can play a role in providing early warning of the potential socio-economic impacts of policy recommendations.

Although there are concerns that involvement of non-scientists in scientific advisory committees may dilute the quality of the science advice, it has been noted that in many cases, these individuals have acquired a level of knowledge in the field sufficient to allow a good understanding of the issues at stake. Nevertheless, where civil society members are involved in the production of science advice, procedural protections may be necessary to preserve rigour. These might include ensuring a numerical majority of scientific experts, and/or a two-stage distinction between the production of scientific advice and of recommendations. In any case, if one accepts that evidence itself should not be tempered by stakeholders' perceptions or public opinion, integrating input from non-scientists into scientific advice is not trivial.

- *Public reporting and open communication*

Communication procedures concerning scientific advice have undergone important changes in response to the demand for more transparency and accountability. Nevertheless, most

advisory bodies still tend to rely on traditional forms of communication, especially those that they are used to in the scientific world, such as printed reports or online editions. Public debate following the publication of scientific advice or even accompanying the work of an advisory body is often of different nature. In addition to traditional media including newspapers and television, it incorporates social media, including You-tube clips, blogs, twitter and Facebook. The character of the discourse may be substantially changed by these different communication formats. The report of the Rathenau Institute on “contested science”⁴² provides six examples of how a counter-discourse may influence the impact of scientific advice once it is published. To communicate scientific advice in a way that more fully engages society, science advisory bodies will need to make more effective use of social media. If assessments and recommendations are challenged by external experts or by civil society, the lack of organised communication may seriously weaken the actual impact of carefully compiled evidence and related conclusions.

7. CONCLUSIONS

Scientific advice plays a critical role in today's society, and all national governments should be aware of the challenges discussed in this report. Approaches to these challenges can vary from country to country and a nation's scientific advisory system will reflect its political and cultural contexts. National scientific advisory systems are necessarily diverse and respond to different needs. For instance, processes for providing scientific advice in emergency situations may be very different from those dealing with long-term risks or policy development. Organisational structures or procedures for scientific advice in one country may not necessarily apply well in another country. It is important to consider at the beginning of any advisory process which model or structure might be the most appropriate to address the particular issue or question at hand.

Nations can learn from each other in designing and refining their scientific advisory systems. For example, several countries are currently contemplating whether they should have a Chief Scientific Advisor and what function that position might have in their particular governmental structure. In other countries, science academies are strengthening their roles in providing formal and informal advice to policy-makers. There are lessons to be learned from experiences in different countries and in different situations. For instance, the conviction of scientific experts in the L'Aquila earthquake case in Italy has highlighted the need to better understand the legal dimensions and respective responsibilities of those involved in scientific advisory processes.

Building on their own and other countries experiences, Governments have an important role to play in developing principles and guidelines for their scientific advisory processes. Some nations have already begun this. However, such principles and guidelines should not be static and need to be responsive to the changing environment for scientific advice, including the growing involvement of civil society and the need to ensure public trust. A preliminary checklist for science advisory processes, which brings together the various lessons learnt that have been described in this report, is proposed in Box 4.

Box 4. A check-list for science advice

An effective and trustworthy science advisory process needs to:

1. **Have a clear remit, with defined roles and responsibilities for its various actors.** *This includes having:*
 - a. *a clear definition and, insofar as is possible, a clear demarcation of advisory versus decision-making functions and roles*
 - b. *defined roles and responsibilities and the necessary expertise for communication*
 - c. *an ex-ante definition of the legal role and potential liability for all individuals and institutions that are involved*
 - d. *the necessary institutional, logistical and personnel support relative to its remit.*
2. **Involve the relevant actors – scientists, policy-makers and other stakeholders, as necessary.** *This includes:*
 - a. *engaging all the necessary scientific expertise across disciplines to address the issue at hand*
 - b. *giving explicit consideration to whether and how to engage non-scientific experts and/or civil society stakeholders in framing and/or generating the advice*
 - c. *using a transparent process for participation and following strict procedures for declaring, verifying and dealing with conflicts of interest*
 - d. *having, as necessary, effective procedures for timely exchange of information and co-ordination with different national and international counterparts.*
3. **Produce advice that is sound, unbiased and legitimate.** *Such advice should:*
 - a. *be based on the best available scientific evidence*
 - b. *explicitly assess and communicate scientific uncertainties*
 - c. *be preserved from political (and other vested-interest group) interference*
 - d. *be generated and used in a transparent and accountable manner.*

Science advice is in itself a field of academic study, generating new theories and conceptual models to explain the complex relationships between science and policy making in different situations. At the same time, it is an important and growing area of practice in which the experiences of those engaged are rarely recorded or shared, though this is starting to change. Despite the diversity of institutional structures, processes and issues, many countries have one or a small number of senior science advisors, who may or may not be formally appointed by Government, but who operate at the interface between science and national policy-making. Links between these advisors are beginning to be formed. In a number of regions, networks of practitioners involved in providing science advice have been created. The first global conference on Science Advice to Governments took place in Auckland, New Zealand in August 2014 (see <http://www.globalscienceadvice.org/>). This highlighted the need for increased international collaboration between scientific advisory structures particularly for addressing transnational issues.⁴³ Moreover, during the course of the current work, several countries have expressed a desire to work with others to strengthen their own science advisory systems. There is an opportunity for OECD, working with other global partners, to facilitate such co-operation and support the exchange of information and experiences across countries.

This report has been drafted at a time of great change for the provision of scientific advice. All nations should be attentive to the use of scientific knowledge in developing better policies that respond to changing social needs and expectations. Governments and scientific bodies should strive to improve national and international mechanisms for the provision and communication of scientific advice. The following recommendations address these requirements:

- **Recommendation 1:** Governments and responsible institutions should define clear and transparent guidelines and rules of procedure for their science advisory processes and mechanisms.

The check-list for science advice proposed in this report (Box 4 above) can provide a basis for the development of such operational guidelines and rules of procedure.

- **Recommendation 2:** Governments should establish effective mechanisms for ensuring appropriate and timely scientific advice in crisis situations.

They should in particular define:

- Institutional and individual roles and responsibilities for crisis preparedness and response at the national level, including procedures that can provide coherent and trustworthy information to the public.
- Mechanisms to facilitate international co-operation between advisory structures and individuals with responsibility for providing science advice in crisis situations. This includes the exchange of data, information and expertise to improve preparedness as well as co-ordination during actual crises.
- **Recommendation 3:** Governments should work with international organisations to ensure coherence between national and international scientific advisory mechanisms relating to complex global societal challenges.

They should in particular:

- Facilitate exchange of information, data and good practices between national scientific advisory bodies and relevant international bodies.
- Establish mechanisms, where these do not already exist, to ensure the translation and verification of international advice on global societal challenges into the national and local policy context and vice-versa.
- **Recommendation 4:** Governments and responsible institutions should implement measures that build societal trust in science advice for policy-making.

They should in particular:

- Ensure that advisory processes are as open and inclusive, as necessary.
- Ensure that science advice is considered, communicated and used in a transparent and accountable manner (including training for scientists and policy-makers in the practice and use of science advice).

NOTES

- ¹ D. Sarewitz, "How science makes environmental controversies worse", *Environmental science & policy*, 7, 2004, p.386.
- ² http://ec.europa.eu/research/science-society/pdf/advice_final_report_en.pdf
- ³ <http://ftp.jrc.es/EURdoc/eur19830en.pdf>
- ⁴ <http://corporateeurope.org/power-lobbies/2014/07/position-chief-scientific-advisor-president-european-commission>
- ⁵ <http://www.theguardian.com/science/2014/jul/25/letters-ec-scientific-adviser>
- ⁶ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293037/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making.pdf
- ⁷ <http://www.industry.gov.au/science/Documents/APS200ScienceinPolicyReport.pdf>
- ⁸ https://coombs-forum.crawford.anu.edu.au/sites/default/files/publication/coombs_forum_crawford_anu_edu_au/2013-2/sciencepolicy_18_oct_2013_web.pdf
- ⁹ See for example the 2013 Eurobarometer study on Responsible Research and Innovation (RRI), Science and Technology: http://ec.europa.eu/public_opinion/archives/ebs/ebs_401_en.pdf
- ¹⁰ Aspinall, WP & Cooke, R, 2013, 'Expert Elicitation and Judgement', in: JC Rougier, RSJ Sparks, L Hill (eds) *Risk and Uncertainty assessment in Natural Hazards*. Cambridge University Press, pp. 234-274.
- ¹¹ Sutherland, W.J., David Spiegelhalter, Mark A. Burgman, 2013, "Twenty tips for interpreting scientific claims", *Nature*, 21 November, vol. 503: 335-337. The authors suggest that immediate priority has to be given to the improvement of policy-makers' understanding of the imperfect nature of science.
- ¹² See for example the guidelines of the German academies: http://www.bbaw.de/service/publikationen-bestellen/manifeste-und-leitlinien/BBAW_PolitischeLeitlinien.pdf.
- ¹³ For procedures of IPPC, see: http://www.ipcc.ch/organization/organization_procedures.shtml.
- ¹⁴ The UK has published a summary of the situation with respect to legal advice to UK government, whether or not a person is employed by government: <https://www.gov.uk/government/publications/scientific-advice-to-government-legal-liability>.
- ¹⁵ http://www.ashurst.com/doc.aspx?id_Content=10098
- ¹⁶ <http://www.annalsofgeophysics.eu/index.php/annals/article/view/5350/5371>
- ¹⁷ <http://news.sciencemag.org/earth/2014/11/updated-appeals-court-overturms-manslaughter-convictions-six-earthquake-scientists>
- ¹⁸ <http://www.leopoldina.org/en/publications/detailview/?publication%5Bpublication%5D=582&cHash=ef11b87261dde27711a727da4b2e96f6>
- ¹⁹ Unpublished communication by Davide Miozzo, work conducted by CIMA Research Foundation and the Italian Civil Protection Department and presented at the OECD-GSF Workshop, Berlin, February 2014.
- ²⁰ <http://www.hc-sc.gc.ca/sr-sr/advice-avis/sab-ccs/mandat-eng.php>
- ²¹ http://www.protezionecivile.gov.it/resources/cms/documents/ICEF_FinalReport_enpdf.pdf.
- ²² <http://www.bfr.bund.de/cm/350/ehc-outbreak-2011-investigation-of-the-outbreak-along-the-food-chain.pdf>.
- ²³ <http://www.annalsofgeophysics.eu/index.php/annals/article/view/5350/5371>.

- ²⁴ Ministry of Education, Culture, Sports, Science and Technology, July 2012, "[White Paper on Science and Technology, 2011.](#)"
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- ²⁶ Center for Research and Development Strategy, Japan Science and Technology Agency, "[Toward the Establishment of Principles Regarding the Roles and Responsibilities of Science and Government in Policy Making.](#)" March 2012.
- ²⁷ Grimes, Robin W., Yuki Chamberlain, and Atsushi Oku, "[The UK Response to Fukushima and Anglo-Japanese Relations.](#)" *Science & Diplomacy* (June 2014), AAAS.
- ²⁸ An expert working group set up under the cabinet office compiled a report that recommends a new "control tower" for science policy in Japan to have more effective and comprehensive functions for realising better co-ordination among the different ministries related to science, technology and innovation policy. Final report (in Japanese): <http://www8.cao.go.jp/cstp/stsonota/kenkyukai/houkokusho.pdf>.
- ²⁹ <http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-21-kanji-3.pdf>
- ³⁰ <http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-20-s3e-1.pdf>
- ³¹ <http://www.bfr.bund.de/cm/350/ehc-outbreak-2011-investigation-of-the-outbreak-along-the-food-chain.pdf>
- ³² One notable example of such a structure is the UK Science Advisory Group in Emergencies (SAGE) <https://www.gov.uk/government/groups/scientific-advisory-group-for-emergencies-sag>.
- ³³ Sources: interview and website: <http://www2.epa.gov/emergency-response/national-oil-and-hazardous-substances-pollution-contingency-plan-ncp-overview>
- ³⁴ <http://www.bfr.bund.de/cm/350/ehc-outbreak-2011-investigation-of-the-outbreak-along-the-food-chain.pdf>
- ³⁵ <https://usresponserestoration.wordpress.com/>
- ³⁶ See for instance Doug Helton's account on twitter for the NOAA response to the Deep Water Horizon oil spill.
- ³⁷ http://www.rathenau.nl/uploads/tx_tferathenau/Contested_Science_Rathenau_Instituut_01.pdf
- ³⁸ <http://roadtoparis.info/2014/07/29/european-ngos-fight-future-science-advice-anne-glover/>
- ³⁹ <http://www.theguardian.com/science/political-science/2014/nov/13/juncker-axes-europes-chief-scientific-adviser>
- ⁴⁰ <http://www.admin.ch/ch/f/gg/pc/index.html>
- ⁴¹ <http://www.admin.ch/ch/f/gg/pc/documents/1635/Ergebnis.pdf>
- ⁴² <http://www.rathenau.nl/en/publications/publication/contested-science.html>
- ⁴³ http://www.pmcsa.org.nz/wp-content/uploads/Synthesis-Report_Science-Advice-to-Governments_August-2014.pdf

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