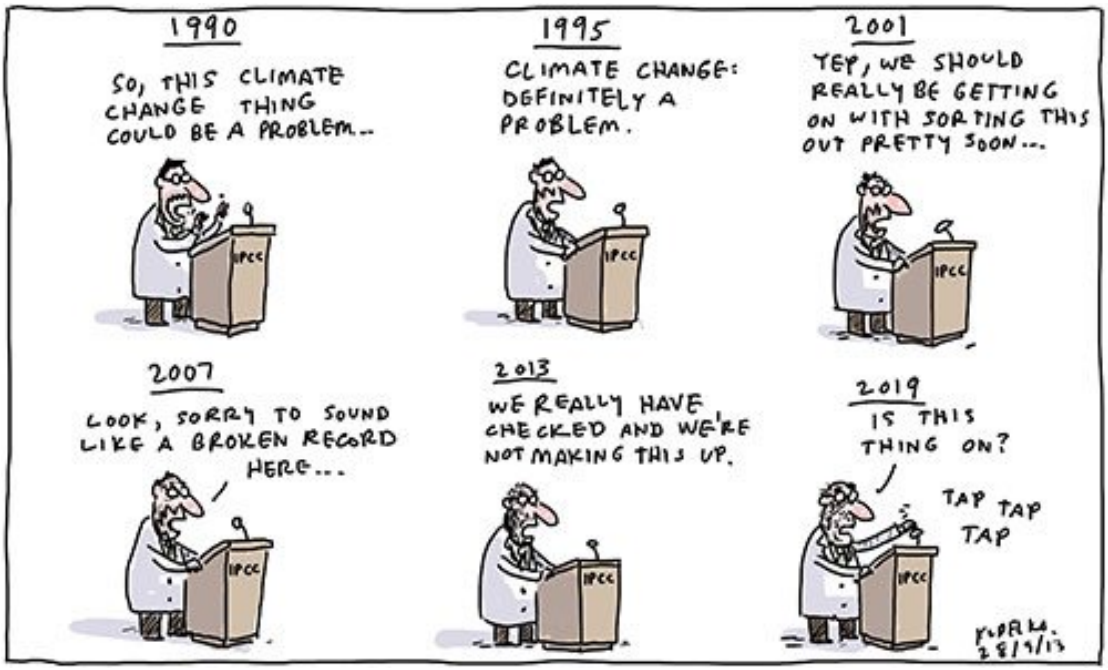
Science Advice to Governments:
Diverse systems, common challenges

A briefing paper for the Auckland conference, 28-29 August 2014



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Foreword by Professor Sir Peter Gluckman

Chief Science Advisor to the Prime Minister of New Zealand

Welcome to Auckland and to the first global conference on Science Advice to Governments. This meeting was initially inspired by a 2012 commentary[1] by James Wilsdon and Robert Doubleday published in *Nature*. It was picked up by Steven Wilson, Executive Director of ICSU who then invited me to assist him, some two years ago, in establishing a planning group to develop the concept further. The intent was to hold a meeting to immediately precede ICSU's General Assembly. In practice, this gathering has taken on a life of its own. It includes over 220 people from more than 45 of world's economies, along with representation from a number of national, subnational and multi-national agencies and organisations.

Intentionally we have crafted the program from the perspective of practitioners of the evolving art and science of science advice. It is also focused deliberately on science advice to governments in relation to policy formation and implementation, rather than on questions of managing the public science system. Many, but not all in attendance will have some responsibility in both of these domains, and it is important to distinguish the two.

Our current model of science advice in New Zealand is still evolving in the five years since it was established. It comprises a science advisor to the Prime Minister and a number of departmental science advisors who include within their terms of reference the ongoing development of departmental capacity to integrate science into the policy process. There is also an active national academy – the Royal Society of New Zealand – which supports the development in-depth policy-relevant studies as well as undertakes various science communication activities.

In New Zealand, the issues we face in enhancing the use of scientific knowledge in policy formation and decision-making require multiple approaches, as is the case I suspect, in most other jurisdictions. Our approaches are influenced not only by the issue at hand, but also by our respective cultures of public reason. Importantly then, this conference brings together not only practitioners, of science advice, members of national academies and other advisory structures, but also scholars of science and technology studies and science communicators.

That this gathering of policy professionals and scholars has also attracted such high public and media interest is an encouraging sign that the worlds of Science and of Policy no longer operate in isolation, nor are they exclusive members-only clubs. The local and global challenges we face demand scientific knowledge that is relevant, timely and accessible to policy-makers and to the public. They also demand systems and mechanisms to put that knowledge into action.

I won't pretend that this is a simple and straight-forward process. Science does not make policy. But scientifically robust knowledge must have a privileged place among

[1] Doubleday, R. and J. Wilsdon, *Science policy: Beyond the great and good.* In Nature vol. 485, pp-301-302. May 17, 2012

the range of inputs that policy- and decision-makers must consider. Jurisdictions in every part of the world are looking at ways to improve both the supply and demand sides for those inputs. It seems appropriate then, that we should pool our efforts in this challenge and learn from each other.

My hope for this two-day meeting of minds is to begin to do just that. Auckland will be an opportunity to share lessons and to listen to each other. We have structured the meeting deliberately to limit formal presentations and instead encourage free and frank discussion among participants.

Developing this conference in collaboration with ICSU and an Advisory Committee comprising some of the world's most reflective practitioners and scholars of science advice has given it an unprecedented reach, and I thank those who have helped the meeting to take off. This is truly a growing global conversation in which we all have a stake.

On a final note, when we scheduled this conference, we did not anticipate that New Zealand would only be one month from a general election. I hope that the inevitable media focus on electioneering does not detract from an enjoyable stay in Auckland as we emerge from Winter into Spring.

With best wishes

PD Gluckman

24 August, 2014
Auckland, New Zealand

1. A rough guide to scientific advice

Scientific advice has never been in greater demand; nor has it been more contested. From climate change to cyber-security, poverty to pandemics, food technologies to fracking, the questions being asked of scientists, engineers and other experts by policymakers, the media and the wider public continue to multiply. At the same time, the authority and legitimacy of these experts is under increasing scrutiny, particularly in areas that often spark intense debate, such as climate change, energy choices and genetically-modified crops.

The Auckland conference on 'Science Advice to Governments' comes at an important time. Across many economies and international institutions, the arrangements and methods for scientific advice and evidence-informed policymaking are being actively debated, and in some cases, new structures are being established. In recent years, New Zealand and the European Commission are among those to have appointed their first chief scientific advisors[2]; at an international level, fresh expert assessments are underway, such as IPBES (the Intergovernmental Platform on Biodiversity and Ecosystem Services)[3]; and new scientific advisory committees have been established, for example within the United Nations system.[4]

These developments reinforce the importance of sharing insights and best practices across different advisory systems. It is to this end that the Auckland conference will bring together participants from over forty-five economies and international organisations – making it the largest ever gathering of scientific advisers, practitioners, policymakers, scholars and experts.

This paper is intended as a brief introduction to the topics that will be discussed at the Auckland conference. The first section outlines some recent developments and debates over the provision of scientific advice. The second section surveys a number of recent sources to suggest some tentative principles for scientific advice that could form the basis for further discussion at the meeting. The third section provides a reading list of key material to assist in further learning and reflection, while an annex contains draft overviews of a range of different scientific advisory systems from economies and international organisations across the globe.

That these case studies are appended rather than integrated into the paper is intended as an indication of their current draft status. The list should not be considered exhaustive, and it is possible that some of the case studies may be incomplete. They were compiled based on material provided in response to a request sent to ICSU member organisations, and have been edited in places for clarity. Any corrections or additions to this information will be most welcome. A more comprehensive report will be produced after the Auckland conference, reflecting the contributions of speakers and participants.

1.1 Diverse models & approaches, reflecting different political cultures

Across different national governments and international bodies, there is a variety of structures and institutions for scientific advice. These reflect distinctive cultures and traditions of decision-making; what Sheila Jasanoff has termed the 'civic epistemology'

[2] See: http://www.pmcsa.org.nz/; http://ec.europa.eu/commission_2010-2014/president/chief-scientific-adviser/index_en.htm
[3] http://www.ipbes.net/
[4] http://www.sab-2014-berlin.de/

through which expert claims are constructed, validated or challenged in a given society.[5] But within this diversity, four structures stand out as most commonly used, often in combination, across particular systems:

- ***Advisory councils:*** many economies have a high-level council for science (or science and innovation) policy. Members typically include senior scientists, alongside representatives of industry, higher education and civil society. Examples include Japan's Council for Science, Technology and Innovation (CSTI) and the US President's Council of Advisors on Science and Technology (PCAST). Another example is Australia, where chief scientist Ian Chubb recently announced that he plans to establish a new science council to advise government on policy.[6] However in most systems, the focus of such entities remains on policy advice in relation to the science system, which is distinct from science advice for public policy.

- ***Advisory committees:*** most governments also rely on an array of specialized scientific and expert committees, which can address detailed technical and regulatory issues in areas such as health, environment and food safety. For example, the US and Japan have hundreds of such committees; the UK has over seventy.

- ***National academies, learned societies and networks:*** A growing number of national academies are active in science policy and/or policy for science. In economies such as Canada, China, Germany, Netherlands, South Africa, US and UK, academies are an important source of scientific advice. Furthermore, networks of national academies such as the International Council for Science, with a membership of 121 national bodies, representing 141 economies, and 31 International Scientific Unions,[7] and the Inter-Academy Panel, the global network of science academies from 107 economies[8] are actively involved in science for policy processes at the international level (see Annex 1).

- ***Chief scientific advisors*****:** the US appointed its first presidential science advisor in 1957, followed seven years later by the appointment of the first cross-government chief scientific advisor (CSA) in the UK. CSAs have also been appointed in Australia, Cuba, Czech Republic, India, Ireland, Malaysia, New Zealand and at the European Commission. In the UK, additional SA roles have been added gradually since 2002, and there is now one in every government department (DSAs). New Zealand is also adopting a DSA model.

None of these structures is perfect, and governments typically rely on two or more of them in combination to create a broad ecosystem of expertise around policy processes. A critical distinction is between processes of formal and informal inputs into policy formation. In a country like the UK, there is a clear hierarchy, with the government chief scientific advisor as the most senior figure. In the US, while the presidential science advisor is also crucial, the system is more decentralized, with multiple points of entry and less attempt at central coordination. Despite the diversity that we see, common challenges persist across all systems: how to protect the independence of advice while ensuring

[5] Jasanoff, S. (2005) *Designs on Nature: Science and Democracy in Europe and the United States*, Princeton University Press
[6] http://www.theguardian.com/science/2014/aug/17/australias-chief-scientist-tells-pms-business-adviser-to-stick-to-economics
[7] http://www.icsu.org/about-icsu/about-us
[8] http://www.interacademies.net/Academies.aspx

that it is listened to; how to develop a trusted relationship with policymakers, while maintaining transparency and accountability in the eyes of the public and the science community alike; and how to undertake appropriate quality assurance. These and other shared challenges will be discussed in depth at the Auckland meeting.

1.2 Meeting the demands and rhythms of the policy process

Debates about scientific advice often focus on the 'supply-side' of the science-policy interface. But the 'demand-side' is equally important: an effective advisor needs a sophisticated understanding of how policymaking processes work, and the pressures and constraints under which ministers, civil servants and decision makers operate.

Policy challenges arise across different time horizons, requiring very different responses. Modes of scientific advice that are most useful in emergency situations will rarely be the same as those required for long-term foresight or horizon scanning. Over the past decade, advisory bodies have had to navigate a number of crises with scientific dimensions. Examples include SARS, bird flu, the Great East Japan earthquake and tsunami, the Christchurch earthquake, hurricanes, flooding and the volcanic ash cloud over Europe. As a result, countries such as Japan, New Zealand and the UK now have improved protocols for scientific advice in emergencies.[9] A key part of this involves communicating to the wider public, where providing clear advice, while acknowledging areas of scientific uncertainty, are the hallmarks of mature crisis management.

Some structures, such as national academies, are better suited to providing formal advice against a longer time horizon, typically by convening expert panels and producing detailed reports. Others, such as chief scientific advisors, nudge the system by informal inputs across the policy process, provide rapid, informal advice in emergencies, gather inputs from a range of sources or form *ad hoc* working groups. Responding to the different rhythms of policymaking, and striking the right balance between formal and informal inputs, are crucial aspects of effective scientific advice.

1.3 Distinguishing between 'science for policy' & 'policy for science'

In many systems, advisors or advisory bodies combine a responsibility for the use of scientific evidence in policymaking ('science for policy') with a role in determining the budgets and structure of the research and innovation system ('policy for science'). The lines between these can easily become blurred, not least because areas of 'science for policy' will have implications for particular research priorities or the funding structure. However, where possible, it is often useful to keep the two roles distinct, to avoid limiting the advisory remit by being seen primarily as a lobbyist for resources for science.

Given their proximity to the scientific community, it can be a challenge for scientific advisors to extend the same commitment to impartial evidence to the management of the research system that they bring to other areas of policy. But it can be done: former US presidential science advisor John Marburger won plaudits for his willingness to ask tough questions about the evidence base for research funding in a 2006 speech, which led to the creation of the National Science Foundation's program on the 'science of

[9] See e.g. https://www.gov.uk/government/groups/scientific-advisory-group-for-emergencies-sage

science and innovation policy'.[10] Such efforts should focus not only on the economic case for research funding, but also on its social and public value, and on opening up debates about research priorities to more diverse perspectives.[11]

1.4 Advice practitioners as intermediaries, brokers and communicators

Scientists are typically appointed as advisors or expert committee members because of their deep expertise and standing in a particular field of research, but (except in technical committees) they may only rarely be asked to provide advice that draws on their narrow area of expertise. More often, their role is to act as intermediaries, able to translate, aggregate and synthesize varied perspectives and sources of evidence.[12]

Roger Pielke Jr. identifies several roles that scientists can play in policymaking, and suggests that the most crucial of these is the 'honest broker', who is able to help decision makers to choose wisely between the available options on a given topic.[13] Ottmar Edenhofer, who recently co-chaired Working Group III of the Intergovernmental Panel on Climate Change, offers a related metaphor of the scientific advisor as a 'cartographer' or 'map maker' of policy paths.[14] It is important for advisors to be clear when they are moving from 'honest broker' mode into more explicit advocacy of a particular policy position (as inevitably happens from time to time), as a failure to do so can undermine trust.

Another aspect of a scientific advisor's intermediary role is to look beyond the scientific content of a particular issue and communicate the broader methodological principles and concepts that underpin scientific evidence. William Sutherland and colleagues suggest twenty key points (such as 'no measurement is exact', 'correlation does not imply causation' and randomization avoids bias') that policymakers and the wider public should bear in mind when interpreting scientific claims.[15]

1.5 You can't resolve value conflicts through appeals to facts

Scientific advisors and advisory bodies spend a lot of their time engaged in debates that reflect what some have dubbed 'post-normal science': where facts are uncertain, values are in dispute, stakes are high and decisions are urgent.[16] Arguments over climate change and GM crops are two obvious examples, but there are many others.

Any issue where science is an important factor, but where values, ethics and politics are also in tension, is unlikely to be resolved through a simple statement of the scientific

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[10] http://www.scienceofsciencepolicy.net/reference/marburger-speech-aaas-forum-science-and-technology-policy

[11] Rafols, I., Ciarli, T., van Zwanenberg, P. and Stirling, A. (2012) 'Towards indicators for "opening up" science and technology policy' http://microsites.oii.ox.ac.uk/ipp2012/sites/microsites.oii.ox.ac.uk.ipp2012/files/Rafols-Ciarli-OpeningUp-FULL.pdf

[12] Mulgan, G. (2013) 'Experts and experimental government' in Doubleday, R. and Wilsdon, J. *Future Directions for Scientific Advice in Whitehall*. London: Alliance for Useful Evidence/CSaP

[13] Pielke, R. Jr. (2007) *The Honest Broker: Making Sense of Science in Policy & Politics*, Cambridge University Press.

[14] Edenhofer, O & Minx, J. 'Mapmakers and Navigators, Facts and Values' *Science,* 4 July 2014: Vol. 345 no. 6192 pp. 37-38. DOI:10.1126/science.1255998; http://www.sciencemag.org/content/345/6192/37.full?ijkey=Wox6TyUVE94Ts&keytype=ref&siteid=sci

[15] Sutherland, W.J., Spiegelhalter, D. & Burgman, M. 'Twenty tips for interpreting scientific claims', *Nature* 503: 335, 20 November 2013

[16] Funtowicz, S. O., and Ravetz., J. R. "Science for the Post-Normal Age", *Futures,* 25/7 September 1993, p. 739–755.

evidence.[17] To assume a linear relationship between evidence and policymaking is often a mistake, and advisors need to recognize the many ways in which evidence, values and political judgments combine to produce decisions. As Sir Peter Gluckman argues, this is not to deny that science 'should hold a privileged place' among the types of knowledge that may be meaningful to policymakers, but this privilege is fragile and depends on not overstating what is known, and on acknowledging scientific limits and uncertainties.[18]

1.6 Improving quality through multi- & interdisciplinary expertise

There is a growing recognition across advisory systems that identifying solutions to cross-cutting policy problems will require input not only from natural scientists, but also from engineers, social scientists and other experts. For example, in the UK, it is now accepted that social scientists should form part of the network of departmental chief scientific advisors, and the Parliamentary Office for Science and Technology recently established a social science section.[19] Some argue for 'chief social scientists' or 'chief historians' to be appointed alongside chief scientists, but creating separate structures ducks the more important challenge of how to integrate an appropriate mix of advice and evidence from a wide range of disciplines.[20]

In this context, it is helpful to distinguish between *multi*disciplinarity, which is usually about building better links between different disciplines, each of which continues to rely on its usual methods and modes of enquiry, and genuine *inter*disciplinarity which encourages various disciplines to cross subject boundaries, thus enabling , as Andy Stirling argues, 'more radical interactions between different styles of knowledge, fostering potentially transformative solutions.'[21]

Similarly, effective advisory systems now draw their evidence from a wide range of methods, including scientific studies, randomized controlled trials, statistical data, socioeconomic models and forecasts, opinion polls, observational studies, and more qualitative modes of social analysis and public engagement. The growing availability of online 'big data' also has the potential to supplement and enrich existing methods.

Approaches to formal scientific advice that draw on a more diverse range of disciplinary and methodological inputs may in turn lead to less emphasis on reaching a 'consensus', which may obscure legitimate scientific disagreements and uncertainties, in favour of more 'plural and conditional' modes of advice. Andy Stirling points to the way the Bank of England's Monetary Policy Committee reaches decisions on interest rates, with differences of opinion among expert members made public and their rationale openly discussed, and asks why scientific advisory processes can't operate on a similar basis?[22]

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[17] Sarewitz, D. 'How science makes environmental controversies worse' *Environmental Science & Policy,* 7 (2004) 385–403

[18] Gluckman, P. 'The art of science advice to government' *Nature* 507: 163-165, 13 March 2014

[19] http://blogs.lse.ac.uk/impactofsocialsciences/2013/09/09/exclusive-look-post-social-science-section/

[20] Wilsdon, J. 'Too many chiefs? Experts, advisers and the disciplinary mix' *The Guardian*, 15 March 2013 http://www.theguardian.com/science/political-science/2013/mar/15/science-policy

[21] Stirling, A. 'Disciplinary dilemma: working across research silos is harder than it looks' *The Guardian*, 11 June 2014 http://www.theguardian.com/science/political-science/2014/jun/11/science-policy-research-silos-interdisciplinarity

[22] Stirling, A. 'Keep it complex' *Nature* 468: 1029-1031, 23/30 December 2010

1.7 From science advice to evidence-informed policymaking

In a number of economies, governments are showing a renewed enthusiasm for evidence-based policy and more 'experimental' approaches to policymaking, in which scientific methods, such as randomised control trials, are used to inform policy options.[23] Examples include a new program on evidence and policy in the Chinese Academy of Sciences, a new behavioural sciences unit in the US Office of Science and Technology Policy, and a UK government network of 'What Works' evidence centres.[24] A resurgence in the field of intervention research has seen it move beyond health and human services into new areas of policy testing as well.

These efforts are often being driven from the demand side by policymakers and civil servants, and may operate separately from structures for scientific advice. But the synergies between these agendas are obvious, and scientific advisory bodies should position themselves at the forefront of this agenda.

1.8 There is a growing body of research to be linked it to practice.

Geoff Mulgan reminds us that there is 'a science as well as a craft of scientific advice', and argues that advisors need to draw more systematically on research in political science, social psychology, behavioural economics, and science policy which investigates 'why certain kinds of knowledge are acted upon, and others are not.'[25] This requires concerted efforts from both sides – academics and practitioners – to connect the latest scholarship to advisory processes and practices. Building and operationalizing such links is another focus of the Auckland meeting.

In a recent essay, Sheila Jasanoff distils insights that can be drawn from three decades of research in the field of science and technology studies (STS). She acknowledges that the questions raised by STS sometimes can be 'associated with unproductive wheel-spinning and relativism', but insists that 'the wheels, in my view, can spin with traction.' In democracies, no institutions should place themselves beyond critique: 'If judges may not presume to stand above the law, still less should science advisers seek to insulate themselves from the critical gaze of the science of science advice.'[26]

1.9 Exchange & learning across national & international systems

Above all, the aim of the Auckland conference is to improve the exchange of ideas, lessons and best practices across different advisory systems. Other such meetings do take place, including the Carnegie Group of Science Advisors, which was established in 1991 to enable science ministers and advisors from the G8 (now G8+5) nations to meet annually. But the Auckland meeting is an ambitious response to calls for a more open and inclusive global forum for such discussions.[27]

Auckland links to wider agendas around 'science diplomacy' and collaboration in pursuit of shared science policy goals. It also coincides with an ongoing OECD project to examine

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[23] Sabel, C.F. and Zeitlin, J. (2012) 'Experimentalist governance' in Levi-Faur, D. (Ed.) *The Oxford Handbook of Governance*. Oxford: Oxford University Press.

[24] https://www.gov.uk/government/publications/what-works-evidence-centres-for-social-policy

[25] Mulgan, G. 'Experts and experimental government' in Doubleday, R. and Wilsdon, J. *Future Directions for Scientific Advice in Whitehall*. London: Alliance for Useful Evidence/CSaP, April 2013

[26] Jasanoff, S. 'The science of science advice' in Doubleday, R. and Wilsdon, J. *Future Directions for Scientific Advice in Whitehall*. London: Alliance for Useful Evidence/CSaP, April 2013

[27] e.g. Doubleday, R. & Wilsdon, J. 'Beyond the great and good', *Nature* 485 : 301-302, 17 May 2012

and strengthen scientific advisory systems, which will report next year and to which Auckland organisers are continuing to strengthen their links.[28] The Auckland meeting also takes place just weeks after Anne Glover, CSA to the President of the European Commission, launched a new network of scientific advisers from twelve EU member states.[29]

Given the timeliness of these debates, Auckland hopefully represents just the start of a conversation. Every system can benefit from a process that brings together advisors, policymakers, practitioners, experts and others on a regular basis to reflect on progress, share ideas and chart future agendas for the '(art) and science of scientific advice'.

2. Prospects and principles

In an effort to strengthen and systematise scientific advisory processes, various sets of principles and guidelines have been produced by different national systems – from government directives to the codes of national academies.

Among these, the following three sets of guidelines were developed in the context of particular advisory models but also provide a promising basis on which a common set of shared principles may develop:

- The UK GCSA's Guidelines on the Use of Scientific and Engineering Advice in Policy Making. These were first produced in 1997 and have been subsequently revised and improved;[30]
- The Code of Conduct for Scientists published in 2013 by the Science Council of Japan, which draws a clear distinction between brokerage and advocacy;[31]
- A list of 'ten principles' for effective scientific advice, published recently by Sir Peter Gluckman in Nature.[32]

One of the questions for participants at the Auckland conference is whether the meeting could be a first step towards the development of a set of shared international principles, common across a diversity of advisory systems, formal and informal. Any such effort could complement ongoing efforts by the OECD and inter-academy organisations in this area.

As a starting point, Annex 2 cites the above mentioned principles in detail and it is worth considering the key elements of these that reach beyond their jurisdiction or model of origin.

[28] http://www3.grips.ac.jp/~gist/en/events/ws20131022.html
[29] http://www.theguardian.com/science/political-science/2014/jun/23/evidence-based-union-a-new-alliance-for-science-advice-in-europe
[30] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293037/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making.pdf
[31] Science Council of Japan Statement – Code of Conduct for Scientists – Revised Version; SCJ, 2013 http://www.scj.go.jp/en/report/code.html
[32] Gluckman, P. 'The art of science advice to government' Nature 507: 163-165, 13 March 2014 http://www.nature.com/news/policy-the-art-of-science-advice-to-government-1.14838

3. Further reading

Here are a few useful sources for further reading about the issues discussed in this paper:

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Bijker, W.E., Bal, R. & Hendriks, R. (2009) The Paradox of Scientific Authority: the Role of Scientific Advice in Democracies, Boston: MIT Press

Cartwright, N. & Hardie, J. (2012) Evidence-based Policy: A Practical Guide to Doing it Better, Oxford: OUP

DIISRTE/Australian Government (2012) APS200 Project: The Place of Science in Policy Development in the Public Service, Canberra: DIISRTE

Doubleday, R & Wilsdon, J. (2012) 'Beyond the great and good' Nature 485, 301-302, 17 May 2012
Doubleday, R. & Wilsdon, J. (Eds.) (2013) Future Directions for Scientific Advice in Whitehall. London: Institute for Government/CSaP/SPRU/Alliance for Useful Evidence

Ezrahi, Y. (1990) The Descent of Icarus: Science and the Transformation of Contemporary Democracy, Harvard University Press, 1990

Federation of American Scientists (2004) *Flying Blind: The Rise, Fall and Possible Resurrection of Science Policy Advice in the Unites States*
http://fas.org/pubs/_docs/flying_blind.pdf

Glynn, S., Cunningham, P. & Flanagan, K. (2003) Typifying Scientific Advisory Structures and Scientific Advice Production Methodologies, 2003, available as
http://ec.europa.eu/research/sciencesociety/pdf/advice final report en.pdf

Gluckman, PD. (2013) The role of evidence in policy formation and implementation: A report from the Prime Minister's Chief Science Advisor. http://www.pmcsa.org.nz/wp-content/uploads/The-role-of-evidence-in-policy-formation-and-implementation-report.pdf

Hagendijk, R., & Irwin, A. (2006). Public deliberation and governance: engaging with science and technology in contemporary Europe. Minerva, 44(2), 167-184.

Haynes, L., Service, O., Goldacre, B. & Torgeson, D. (2012) Test, Learn, Adapt: Developing Public Policy with Randomised Controlled Trials. London: Cabinet Office

Husbands Fealing, K., Lane, J.,Marburger, J. & Shipp, S. (eds.) The Science of Science Policy – A Handbook (Stanford University Press, 2011).

Jasanoff, S. (2004) States of Knowledge: Co-Production of Science & Social Order. London: Routledge

Jasanoff, S. (2012) Science and Public Reason. London: Routledge

Lentsch, J. & Weingart, P. (Eds.) (2011) The Politics of Scientific Advice, Cambridge: CUP

Millstone, E (2009) 'Science, risk and governance: radical rhetorics and the realities of

reform', Research Policy, Vol 38, No 4, May 2009, pp 624-636

Mulgan, G. (2013) 'Experts and Experimental Government' in Doubleday, R. & Wilsdon, J. (Eds.) Future Directions for Scientific Advice in Whitehall. London: IfG/CSaP/SPRU/A4UE

Pawson, R. (2006) Evidence-based Policy: A Realist Perspective, London: Sage

Pielke, Jr., R (2007) The Honest Broker: Making Sense of Science in Policy & Politics. CUP

Sabel, C. & Zeitlin, J. (2012) 'Experimentalist governance' in Levi-Faur, D. (Ed.) The Oxford Handbook of Governance. Oxford: OUP

Saner, M. (2007) A Map of the Interface Between Science and Policy, Council of Canadian Academies, 2007

Stilgoe, J., Irwin, A., & Jones, K. (2006). The received wisdom. Opening up expert advice. London, Demos

Stirling, A. (2010) 'Keep It Complex' Nature 468, 1029-1031, 22 December 2010

United Nations Secretary-General' High-Level Panel on Global Sustainability (2012) Resilient People, Resilient Planet: A Future Worth Choosing. New York: United Nations

van Zwanenberg, P. & Millstone, E. (2005) BSE: risk, science and governance, Oxford: OUP

Weingart, P. (1999) 'Scientific expertise and political accountability: paradoxes of science in politics', Science and Public Policy, 1999, Vol 26 No 3 pp 151-161

ANNEX 1 Draft case studies from economies and international bodies

The following draft profiles of different advisory systems are based on material provided to organizers ahead of the Auckland meeting. This material was submitted in response to a request to the ICSU membership, which in most cases comprises learned societies. It has been summarised or edited in places for clarity.

Inevitably, these profiles will be incomplete and we welcome broader input toward their continued refinement.

List of contributing organisations:

Australia	Australian Academy of Science
Canada	National Research Council of Canada
China	Chinese Academy of Sciences
Cuba	Office of the Scientific Advisor to the State Council of Cuba
El Salvador	Viceministerio de Ciencia y Tecnología de El Salvador
Finland	The Council of Finnish Academies
France	Ministère de l'Éducation Nationale, de l'Enseignement Supérieur et de la Recherche (MENESR)
Germany	German National Academy of Science Leopoldina and The Deutsche Forschungsgemeinschaft (DFG)
India	Indian National Science Academy
Italy	L'Accademia Nazionale dei Lincei
Japan	Bureau of Science, Technology and Innovation Policy, Cabinet Office, Government of Japan
Mongolia	Mongolian Academy of Sciences
New S. Wales	Office of the Chief Scientist and Engineer, NSW
New Zealand	Royal Society of New Zealand and the Office of the Prime Minister's Science Advisor
Quebec	National Research Council of Canada
Switzerland	The Swiss Academy of Sciences
South Korea	National Academy of Sciences, Republic of Korea
South Africa	National Research Foundation
Taiwan, China	Academia Sinica
UK	The Royal Society

A1.1 Australia

The roles and responsibilities of scientific advisors in the Australian system vary according to a number of factors, including the type of scientific advisor (individual, institution, advisory panel), the type of advice (formal/informal) the topic and audience (health, climate, agriculture), and the policy environment (rapid response, shorter term, longer term). For example, Australia's Chief Scientist provides high-level independent advice to the Prime Minister and other Ministers on matters relating to science, technology and innovation, both directly and through advisory councils and ex-officio roles. Australia's Chief Scientist is also an advocate for Australian science nationally and internationally and a champion of science, research and the role of evidence in the community and in government.

The Chief Scientists at the State level have a similar role (see, for example, a separate summary for New South Wales). The Australian Academy of Science plays a more informal science advisory role, by preparing scientific advice in response to Government and Parliamentary inquiries.

Broadly, scientific advice is provided to the Australian Government in the following four ways:

- In-house capability (science expertise and agencies embedded within departments) provided by:
    - chief scientists and chief economists, across a number of departments, including Health, Agriculture and Defence, and government agencies, like Geoscience Australia;
    - science bureaus, such as the Australian Bureau of Agricultural and Resource Economics and Sciences at the Department of Agriculture; and the Australian Institute of Health and Welfare within the Department of Health;
    - research institutes, such as the Commonwealth Scientific and Industrial Research Organisation, the Australian Institute of Marine Science and a number of Cooperative Research Centres (CRC); such as the Bushfire and Natural Hazards CRC
    - strategic policy units within a number of Government Departments, such as the Department of Immigration's Policy Innovation and Research Unit, which has an evidence-based approach to policy advice and conducts in-house research, commissions external research and engages with other government and research organisations on research and policy development.

- Advisory bodies (committees, expert groups, review panels and other bodies, both standing and temporary) particular to the science and regulatory needs of each government department and agency. There are a number that are overarching, such as the Commonwealth Science Council or Commonwealth State and Territory Advisory Council on Innovation.

- Commissioned research (science procured through grants or other contracts) particular to the program and policy needs of each government department and agency.

- Consultations, submissions and written reports (both formal and informal, for example seeking submissions to review or enquiry processes) particular to the program, policy and regulatory needs and expertise of each government department and agency.

The science advisory mechanisms of the Australian Government are examined in two recent publications: The Australian Government's report *APS200 Project: The Place of Science in Policy Development in the Public Service* (2012) and the HC Coombs Policy Forum discussion paper *Science for Policy: Mapping Australian Government Investments and Institutions* (2013). The latter is especially useful – using publicly available information, it quantifies the mechanisms employed by Australian Government departments to support the creation and delivery of science for policy.

A Chief Scientist position has been part of the Federal system since 1989. Similarly, Australia has had some form of an overarching science advisory body, reporting to the prime minister, since 1979. The number of chief scientist/economist positions across

government is examined in the recent HC Coombs Policy Forum discussion paper *Science for Policy: Mapping Australian Government Investments and Institutions* (2013).

A strength of the Australian system is the different and complementary ways that science advice is sought and incorporated into government ideas. This tends to complement rather than hinder the bespoke elements of policymaking. Another strength is the diversity of scientific advice and capacity available from the 40+ Commonwealth science departments, agencies and bodies and hundreds of science non-government organisations.

A possible weakness in the system is that the breadth of advisory capacity is not captured comprehensively in any study so it becomes difficult for scientists to engage government—and, vice versa, for government to engage researchers—quickly and widely, with very little effort. A second consideration might be that, while the role of the hard sciences has been well established over time as critical to advice across portfolios (Defence, Health, Agriculture), the potential impact of social sciences advice (economics, psychology, anthropology) is not more broadly acknowledged.

In the context of emergencies and the management of risk, different models and processes are used by different organisations. For example, the regulatory agency National Industrial Chemicals Notification and Assessment Scheme identifies relevant risks and recommends appropriate risk management actions regarding industrial chemicals to the Department of Health. Similarly, the Defence Science and Technology Organisation advises on the technical risks of major Department of Defence acquisitions.

There are a number of considerations for policymakers including those acquired through scientific advice. The incorporation of that advice varies according to some or all of the other policy considerations, which include community views, financial viability, government priority, underlying capability of the system, time, et al. Policies are bespoke. One size does not fit all in the policy world. By and large, policymakers will seek out scientific advice at various points along the policymaking process. Ultimately, however, it is government that determines the policy.

A1.2 Canada

In Canada, demands for scientific advice emanate mostly from science-based departments and agencies or SBDAs (i.e., Agriculture and Agri-Food Canada, Canadian Food Inspection Agency, Canadian Nuclear Safety Commission, Defense Research and Development Canada, Environment Canada, Health Canada, Natural Resources Canada, the National Research Council, Public Health Agency of Canada Aboriginal Affairs and Northern Development Canada). Other users of scientific advice include Industry Canada, Transport Canada, and Public Safety and Emergency Preparedness.

Many scientific experts, working within SBDAs and their 155 research centers, provide advice to policy decision-makers. Details of these scientists and their expertise can be found at: http://www.science.gc.ca/default.asp?lang=En&n=6505F854-1
Some of the scientific advice and expertise comes from organisations like the National Research Council (NRC) and Canada's national research and technology organisation (RTO). Given the international scientific reputation of many of its researchers, the NRC is often called upon to deliver unbiased scientific advice on matters of interest to Parliament. NRC is also asked to provide insights into the needs of Canadian industry given its long history in delivering successful industry support programs.

SBDAs also seek advice from external independent experts, who review the quality of science the Government of Canada performs and provide recommendations on programs and policy that support its regulatory responsibilities in various matters (e.g., safety assessment of various drugs, health and food products, the energy efficiency regulations, management of human pathogens and toxins, etc.).

Federal public servants that provide scientific advice support S&T activities that focus on the collection and integration of data supporting rigorous and timely decisions, policy development, scientific risk assessments, standards development, and regulatory oversight and enforcement. For example experts working at Canada's National Metrology Institute, which is part of the NRC, deliver scientific advice to improve and inform decision-making for commerce, standards development, and regulation and trade agreements. S&T-based observation, monitoring and surveillance play an important role in building Canada's knowledge base in health and the environment, maintaining national security, exercising stewardship and managing resource development.

Federal public servants that provide scientific advice are expected, as all public servants, to conduct themselves in accordance with the values of the public sector and these expected behaviors.[33] Expected behaviors include: carrying out their duties in accordance with legislation, policies and directives in a non-partisan and impartial manner; carrying out the lawful decisions of their leaders and supporting ministers in their accountability to Parliament and Canadians; providing decision makers with all the information, analysis and advice they need, always striving to be open, candid and impartial; acting at all times with integrity and in a manner that will bear the closest public scrutiny; continually improving the quality of policies, programs and services they provide; and fostering a work environment that promotes teamwork, learning and innovation.

In addition, the Federal Government relies on three independent organisations for scientific advice:

1) **The Science, Technology and Innovation Council (STIC)** is an independent advisory body embedded within the Department of Industry, and mandated by the Government of Canada to provide confidential advice on science, technology and innovation (STI) policy issues. This advice helps inform government policy development and decision making. STIC is also mandated to produce biennial, public State of the Nation reports that benchmark Canada's STI performance against international standards of excellence. These reports provide a common evidence base for understanding Canada's STI system The STIC was established in October 2007 as a result of a newly adopted S&T Strategy. (For more information see: http://www.stic-csti.ca/eic/site/stic-csti.nsf/eng/Home).

2) **The Council of Canadian Academies (CCA)** is an external independent, not-for-profit organisation that began operation in 2005. The Council supports independent, authoritative, and evidence-based expert assessments that inform public policy development in Canada.
(For more information see: http://www.scienceadvice.ca/en.aspx).

3) **The Royal Society of Canada (RSC)** is Canada's senior National Academy. It promotes Canadian research and scholarly accomplishment, mentors young scholars and artists, recognizes academic and artistic excellence, and advises

[33] See http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?section=text&id=25049

governments, non-governmental organisations, and Canadians generally on matters of public interest (for more information see https://rsc-src.ca/en).

Scientific advice takes various forms depending on its origin. Most in-house scientific advisors communicate via the regular channels of the governmental apparatus (i.e. written and oral briefings). External advice can be provided via letters addressed to senior public servants or ministers, but it can also be found in public documents (most recent examples of these can be found on the CCA and RSC websites).

The Government of Canada strives to maintain an effective science advisory process. Policy decision makers must exercise their legitimate role to weigh multiple inputs and make choices. The Canadian government is based on a Cabinet system. Cabinet ministers are collectively responsible for all actions taken by the Cabinet and must publicly support all Cabinet decisions. The collective decision-making process has traditionally been protected by the rule of confidentiality, which upholds the principle of collective responsibility and enables ministers to engage in full and frank discussions.

Within the framework of Cabinet confidence, science advice has an important role to play by contributing to government decisions which serve Canada's interests and concerns in areas such as public health and safety, environmental protection, resource exploitation, wealth creation, innovation, and national security. Decision making in the government must consider a wide range of inputs and consult, as appropriate, advisors competent in other non-scientific aspects of public policy (e.g. economics, public administration, social science, international affairs, etc.).

In the context of emergencies and the management of risk, the Centre for Security Science (CSS) (part of Defense Research and Development Canada) leads the Canadian Safety and Security Program, a horizontal effort to strengthen Canada's ability to cope with disasters, whether they are natural, caused by human error or by malicious intent. CSS also manages the Emergency Responder Test and Evaluation Establishment (ERTEE).

CSS leverages expertise from all levels of government, industry, academia and emergency management organisations in areas such as: emergency and security planning, policy and response; public and animal health; food safety; chemical, biological and explosives counter-measures; domestic radiological protection; environmental response; intelligence and law enforcement; and other public safety and security fields. Through this collaborative approach, CSS engages partners in a broad range of activities, including projects, workshops and exercises.

It also manages a vast network of national and international experts who work together through communities of practice. In addition, CSS provides evidence-based advice and guidance to support planning, decision-making, operations and the development of public safety and national security strategies and policies. This is enabled through a network of partners, as well as in-house expertise in capability-based planning, risk assessment, operations research, knowledge management, exercises and support to domestic operations.

CSS also administers a number of international agreements with the United States and the United Kingdom to leverage resources and foster science and technology cooperation between allied nations.[34]

[34] For more information see: http://www.drdc-rddc.gc.ca/en/science-tech/safety-security.page

Other agencies have an important role to play in emergencies and risk management, such as:

- Environment Canada (see http://www.ec.gc.ca/ee-ue/)
- The Public Health Agency of Canada (see http://www.phac-aspc.gc.ca/ep-mu/index-eng.php)
- Transport Canada(see https://www.tc.gc.ca/eng/canutec/menu.htm)

A1.3 China

In China, the State Council/NPC and ministries dealing with economic and social development issues as well as associated funding agencies request scientific advice. Currently, there is no chief scientific advisor in the Chinese government system. Normally, scientific advice to central government, including in the context of emergencies and the management of risk, is provided by the Chinese Academy of Sciences, the Chinese Academy of Social Sciences, and the Chinese Academy of Engineering.

Policymakers request consultations and reviews from natural scientists, engineers, social scientists and other stakeholders during the process of policymaking and implementing policy. The size of their engagements depends on the importance of the policy. The experts are selected according to the needs of policymaking process.

The current model of science advice in China has been in place since 1949 when the Chinese Academy of Sciences was established.

Key strengths of the existing science advisory model include the independence of academies and their equivalent to ministries position.

To provide scientific support to policy-making and emergency response, the international network of senior-level science advisors should be independent and professional.

A1.4 Cuba

In Cuba, the Scientific Advisor's Office facilitates high-level advice on scientific issues of importance and advanced technologies. It provides analysis and independent expertise to the State's Council, and it implements a group of legislative functions as well as some executive governmental ones. It has 31 members and is chaired by the President of the Council of State and Ministers, who at the same time is the Head of the Government.

The Scientific Advisor's Office was founded in 2004, following a deep and detailed analysis of the international experiences and potential of this kind of organisation
From 2008, the Office entered a more mature stage, and from 2012, it was completely integrated into the state reorganisation of the science and innovation system.

Among the functions and responsibilities of the Scientific Advisor Office are:

- To offer advice on scientific advances that could make a contribution to the development of science, technology, and innovation (STI) and to foster, through

the review of national strategies, their coherence and efficiency in correspondence with the national development goals;
- To assist state institutions with STI policies, and the review and upgrade of their strategy over the short, medium and long terms;
- To monitor scientific advances and emerging technologies and to support the introduction of new knowledge and technology areas;
- To provide the general public, with an objective understanding of the scientific basis for an appropriate interpretation of decisions, as well as the enhancement of the country's culture for science and technology;
- To provide the state with complementary scientific information, useful for the handling of environmental crises and natural disasters at national and international levels;
- To propitiate new forms of relationship between university-research-production, expanding cooperation and close coordination among them;
- To offer advice for the preparation of educational projects at different teaching levels, according to the needs of professional formation in the country;
- To promote international links and collaboration, and to encourage the training of human resources.

To perform these functions and guarantee quality, the Advisor's Office is divided in areas that cover key sciences and cutting-edge technologies, such as: new technologies and basic sciences; life sciences, agrotech and biochemistry; security; energy, environment and earth sciences. The Scientific Advisor's activities are supported by temporary Scientific-Technological Commissions and Ad-Hoc Working Groups in different thematic areas. These groups have a multidisciplinary composition, and integrate experts from different entities that provide advice: the Academy of Sciences of Cuba (ACC), the Universities, the Ministries, among others, of Science, Technology, and Environment, Higher Education, Informatics and Communications, and Public Health; as well as the Scientific Societies, and Research Entities, such as the Center for World's Economy Research, the Nuclear and Advanced Technology Agency (AENTA), and the Biotechnical Scientific-Productive Complex, BioCubaFarma.

These temporary groups carry out research and elaborate reports on specific topics, which are presented for discussion and decision making. At the same time, in coordination with the media, a popularization plan through television messages, workshops, seminars, documentaries, and debates is designed and fulfilled for the public understanding and acceptance of science and new technologies.

Among topics on which the office has centered its activity over the past decade are:

1. Advice for the introduction of new innovative industries based on knowledge and modern technology, like the example of nanotechnology;

2. Advice for technical evaluation of new technologies and scientific advances in different areas.

3. Advice to foster new forms of relationship university-research-production.

4. Advice linked to education, for preparation of educational projects for differentundergraduate and postgraduate teaching levels, as well as for transformation of educational institutions.

5. Assessment and elaboration of reports for national strategies, and measures linked to the development of new areas of science and technology.

6. Evaluation of topics that are national priorities and, for their impact and risks, could affect or put in danger the population (climate change, nanotechnologies, nuclear accidents, etc.).

7. Spreading and improving the flow of scientific information through the organisation of workshops, seminars, events, and international conferences.

8. In international affairs, the focus is identifying excellence scientific centers with potential for cooperation in high-priority areas.

It is important to mention the multidisciplinary character of the Office, which is integrated by experts with profound scientific knowledge in different fields. This, with the support of Ad-Hoc groups and interdisciplinary commissions guarantees a wide participation of all science areas. The Scientific Advisor, based on a broad professional career and expertise, provides the State's Council with direct advice characterized by objectivity and impartiality.

A1.5 El Salvador

In El Salvador, several organisations/institutions are involved in providing scientific advice, including the Vice Ministry of Science, Technology and Innovation (STI) (created in 2009), the Interministerial Committee of STI with the Ministers of Education, Finance, Economy, Agriculture, Health, Environment and Natural Resources (created in 2012), institutions of high education, research centers and others. Their roles and responsibilities are diverse ranging from providing guidance on scientific policies and strategies, management, implementation, monitoring and evaluation.

In the context of emergencies and the management of risk, El Salvador is supported by the international organisations of Science and Technology, including CEPAL, WIPO, and such countries as Uruguay, México, India.

In 2013, the Technical Advice Council of Interministerial Committee with representatives from universities, researches centers, industry, trade and social organisations was established to ensure a balanced use of different forms of knowledge and expertise within the policy making process. Furthermore, the Technical Advice Council together with the National Observatory of Politics in STI is responsible for monitoring the effectiveness of science advice use by the government.

The flow of information is organised through various channels, including specialised seminars, congress, networks, publications, and scientific journals.

One of the strengths of the science advisory system is that it is based on the alliance of key actors, including ministries, researches centers, universities, scientific councils, foundations, etc. However, due to the fact that the science advisory system is relatively new, there are not yet enough qualified specialists in the field of STI management.

A1.6 Finland

There is no formalised science advisor system in Finland, but the need for scientific advice has been recognized by the Prime Minister´s office and a planning process is ongoing, with the aim of setting up procedures and structures for science-based advice to government. Some ministries have set up temporary committees for bringing in

scientific knowledge, e.g. a climate panel at the Ministry of the Environment. Most political parties also have their own think tanks that receive support from the state budget, but their impartiality is not guaranteed.

Institutional support is given by a number of state research institutes which function under the guidance and financing of ministries. Their research agendas are variable, with respect to being policy-relevant, and they do not cover the whole breadth of the government. Advisory channels of mainly unofficial, e.g. via universities, and depend on the interest and experience of civil servants to foster them.

In the absence of an organized system of science advice to government, if scientific viewpoints come to play a role in decision-making, it is thanks to competent civil servants who want to find out about the scientific issues and have developed contacts in the scientific community.

In an emergency, advice is usually sought from individuals who are known to be experts in the issue at hand (from universities and research institutes), but this occurs in a fortuitous way. For some emergencies, expert working groups may be set up, but their expertise is usually of the administrative and not scientific sort.

Since the advisory mechanisms in general are undeveloped, practically all fields of science (in the broad sense) are underutilised with the exception of economists, who figure rather prominently in various stages of policymaking.

A1.7 France

Scientific advisors are present in the strategic service for research and innovation in the General Direction of Research and Innovation at the French Ministry for Research and High Education. They belong to dedicated departments devoted to the following scientific domains:

- Agronomy, ecology, Earth System Sciences, Universe Sciences
- Biology, Health and Well-being
- Mathematics, Physics, Robotics, Numerical Sciences
- Energy, Chemistry, Sustainable Development
- Social Sciences and Humanities

The roles of the scientific directors of these departments are diverse:

- They contribute strongly to the writing of the National Strategy for research and participate in the writing of national Research calls.
- They control the organisms and institutes of their domain as far as their scientific roadmaps are concerned.
- They give advices on the scientific quality of regional programs, national plans as well as Public-Private partnerships.
- They follow and evaluate the scientific involvement of French teams in European and International Infrastructures and Programs.
- They represent France in European and International Governing boards of such Programs and Infrastructures.
- They also prepare documents, letters, answers and decisions for the cabinet of the Secretary of State and the ministers.

Various institutions may request scientific advice:

- The National Assembly and the senate (questions of the elected representatives)
- the technical ministries,
- the first ministry
- the national department for research infrastructure.

In addition to the scientific advisors cited above, French research is structured through alliances of organisms, institutes and universities. There are five alliances covering the five scientific domains cited above. The alliances may also provide advice through their general secretary and their scientific council. When very precise information is needed, advice is sometimes sought directly from the scientific directors of institutes.

The cabinet of the Ministry is also supported by scientific consultants who may also give advice depending on their proper domain of expertise. The National Funding Agency furnishes statistics on funds and human resources involved in different programs and topics.

These arrangements have been in place for about ten years, with some slight changes to improve the flow of information. For the last three years, the role of alliances in providing advice has been strongly supported by the present General Director for Research and Innovation.

The strength of the existing model is linked to the fact that the scientific directors in the French Ministry are senior scientists, former laboratory or institute directors, strongly involved in research. The weaknesses are due 1) to the too rapid turnover of the scientific directors and 2) to the slowness of the administrative transmission of information within the ministry.

In the context of emergencies and the management of risk, the General Direction for Research and Strategy and the scientific directors are fully mobilized, depending on the domain of risk being considered. Moreover, every director has on-call periods even the weekend.

Policymakers take into account scientific advice, depending on the economic, political or strategic importance of the subject. Due to a strong engagement of French public in the innovation process and the precautionary principle, it is sometimes problematic for policymakers to follow only scientific advice, if cultural and historical factors lead to different ways to consider innovation and progress.

A1.8 Germany

The importance of high-quality science-based policy advice has increased in Germany in the past years. Due to the plethora of institutions and actors giving such advice, it has not been easy for policy makers in the past to differentiate between actors with respect of the quality of the scientific content. Advice given by academies, and particularly by the German National Academy of Sciences, Leopoldina, has gained importance as they bring together the most highly respected researchers nationally and worldwide.

Since 2008, the science advisory model in Germany has changed, with the Leopoldina being made the German National Academy of Sciences. In this capacity, it speaks out on social and political questions, providing a nonpartisan, factual framework for discussion. Under the auspices of the Leopoldina, interdisciplinary groups of experts publish policy-guiding statements on issues of current interest. It also releases joint statements with

other German, European and international academies. It does so on a bilateral basis with partner academies or within various international academy committees. The wide-ranging expertise of its 1,500 members allows the Leopoldina to voice its opinions on significant developments and the most pressing challenges of our time.

The Academy's statements and recommendations provide policymakers with scientific analysis and evaluation on the most urgent issues facing society today. A further key aspect of the Academy's work is early identification of major scientific developments that are likely to become important to society in the future, and providing analysis and recommendations accordingly. In this way, the Leopoldina helps to set policy-making on the right course.

The Leopoldina is free to choose its research themes and does so based on the scope of its scientific work, which is defined by its members, the Presidium and its standing committees. It can also decide to respond to policymakers' requests, and is equally independent in appointing researchers to the working groups that produce the respective statements and recommendations. The working groups are interdisciplinary and the Leopoldina calls on further independent experts for the peer review process.

The guidelines of the Leopoldina for its policy advice are: transparent working methods that are documented in a reproducible way; open and unbiased design of the advisory process through inclusion of different disciplines; statements that are developed independently of any economic and political interests giving recommendations on how to approach specific problems facing society; clear presentation and broad dissemination of recommendations in order to encourage public debate.

Scientific advice is provided to ministries, parliaments, and political foundations. It is also given indirectly, e.g. by public events on relevant topics, or by engagement of top-level scientists in government initiated bodies (such as Sachverständigenräte, Forschungsunion etc.). Discussions are also held with policymakers, research organisations, professional associations, and civil society institutions, such as associations, foundations and churches.

Beyond the Leopoldina, there is a wide variety of research institutions and organisations, most of which are - in one way or another – involved in providing advice to government and its different ministries. The intensity and impacts of these advice functions, however, differ widely and are hard to measure accurately.

Other providers of advice include:

- The Deutsche Forschungsgemeinschaft (DFG) – representing the national membership of Germany in ICSU – is a basic science oriented institution with the mission to promote science and research in Germany. It has 10 so called "senate commissions", e. g. on gen research – oceanography – biodiversity – water research – ecosystem research. These mostly permanent commissions support DFG`s obligatory task to advise policy and politics of providing scientifically sound and comments on socially relevant themes opinions. DFG also maintains a number of additional commissions and task forces, partly in close cooperation with the Federal Ministry of Education and Research (BMBF = Bundesministerium für Bildung und Forschung) such as the National Committees on Global Change Research (NKGCF = Nationales Komitee für Global Change Forschung). This committee now has a new aim and scope as well as a new leadership and functions as "Deutsches Komitee für Nachhaltigkeitsforschung in Future Earth".

- There are a number of important government supported, yet independent research institutions that are engaged in a wide range of basic and applied research fields. They, too, provide – in one way or another – advice to government offices. The most important of these are:

    - Leopoldina: Deutsche Akademie der Naturforscher and since 2008 National Academie of Science (see above)
    - Max-Planck-Gesellschaft zur Förderung der Wissenschaften (MPG):
    - MPG maintains more than 80 research institutes, mainly in fields of basic research (natural sciences – social sciences – humanities), in close cooperation with universities.
    - Fraunhofer-Gesellschaft: the leading organisation for applied research (considers itself as Europe`s largest application – oriented research organisation)
    - Helmholtz-Gemeinschaft Deutscher Forschungszentren / Helmholtz Association of German Research Centers: 18 research centers with focus on Aeronautics – Space and Transport – Earth and Environment – Energy – Health – Key Technologies – Structure of Matter
    - Leibniz-Gemeinschaft: the umbrella organisation of 89 independent research institutions. Its slogan "Theoria cum praxi" (meaning science to the benefit of mankind) indicates its focus on the combination of interdisciplinary and applied research, combining basic research approaches with applicability.

- Federal and State governments maintain their own, mostly thematically scientific advisory bodies with very specific mandates. Some of them do have a certain longevity and explicit advisory functions. An example of this type is:
    - WBGU - Wissenschaftlicher Beirat der Bundesregierung – Globale Umweltveränderungen: It has published more than 10 expert reports on fundamental problems of global environmental change and a number of specific advisory statements for the Chancellor`s office of the federal government of Germany.

- There are also a variable number of ad hoc-committees of science and research which may – upon request – assist decision–making processes by both federal and state/provincial government authorities. Their number, their tasks and their aims and goals, however, are limited in time and themes.

- Finally, other universities, smaller research institutions and private companies are commissioned by governments to engage in tasks of scientific evaluations and expertise, often at local and regional levels.

A great strength of the German academic system is its diverse structure. However, this provides potential weaknesses, including:

- the different organisations sometimes work side by side in similar fields and on similar problems – without coordinating their activities and not knowing to which extend their expertise is being sought by governmental institutions,
- government maintains its own scientific advisory boards which not necessarily cooperate with the above mentioned societies unions.
- This lack of coordination is despite the fact that there is an Alliance of German Scientific Organisations (Allianz der Deutschen Wissenschaftsorganisationen) which brings together the different institutions on a regular basis to discuss issues of joint interest.

Within the German system, cases of emergencies and risk management are often "outsourced" and transferred to NGOs like Red Cross, Technical Aid Work (Technisches Hilfswerk!) and similar organisations for immediate responses. Addressing issues of risk management are also part of medium–to long–term research projects.

In terms of information and resource available to policymakers, the Federal Government of Germany maintains and supports the "*Wissenschaftlicher Beirat*" for all members of parliament (MP) with ten specific sections (e. g. Migration – International Law – Social Issues – foreign Policy etc.). This service is available to all MPs upon request and provides background information on some issues.

A1.9 India

The structure of science advice to the Government of India is multi-pronged. Several departments of the Government deal with Science and Technology (S&T), and have their own mechanisms of acquiring advice both internally as well as from the scientific community through various committees of the respective departments. But there are areas which go beyond individual departments.

Advisory mechanisms do exist for addressing such areas. Important among these is the Office of the Principal Scientific Advisor (PSA) to the Government of India. The PSA chairs the Scientific Advisory Committee of the Cabinet (SAC-C). Also, there is a Scientific Advisory Committee to the Prime Minister of India (SAC-PM). Chairs of both these Committees are eminent Scientists. SAC-C and SAC-PM have been in existence at different stages in post-independent India. Besides the ex-officio membership of the Secretaries to the Science Departments, a cross-section of scientific community is nominated to both these committees. A Member (Science) of the Planning Commission, of which the Prime Minister of India is the Chairman, is also engaged in the Science Advisory role. The PSA and Chairman, SAC-C; Chairman, SAC-PM and Member (Science), Planning Commission directly interact with the Prime Minister of India. Additionally, three Science Academies are also engaged in the advisory mechanisms.

The Office of the PSA was set-up in November 1999 with the wide objective to evolve policies, strategies and missions for the generation of innovations and support systems for multiple applications, generate S&T tasks in critical infrastructure, economics and social sectors in partnership with Government departments, institutions and industry. The office endeavors to bring in synergy among the various scientific departments and other ministries in creating an enabling S&T eco-system that encourages innovations across disciplines. It encourages R&D projects in 'advanced high quality basic research', 'directed basic research', as also 'pre-competitive applied research' through academia-industry interactions.

The PSA is the ex-officio Chairman of the SAC-C. It is the apex advisory body of the Government of India in Science & Technology. It renders advice on relevant issues pertaining to S&T. The committee has representation of leading scientists, technologists, various scientific departments, universities, science academies and industry leaders. Major recommendations of SAC-C, after having wide consultations with all stakeholders, lead to position papers and reports for developing new initiatives, followed by appropriate action.

SAC-PM was reconstituted after a gap of 15 years in 2005. It deliberates on various policy issues, pertaining to S&T and also on the role it can play in uplifting the Indian economy. It advises on generation of S&T tasks in critical infrastructure, economic and social sectors in partnership with Government departments, institutions and

industry. The Committee also looks into critical gaps in national competitiveness, promoting technology cooperation amongst developing economies, emerging changes from international competitiveness in S&T and other international matters. The deliberations of SAC-PM have led to new initiatives with respect to science education.

The Planning Commission of India was set up in March 1950, soon after independence, in pursuit of declared objectives of the Government to promote a rapid rise in the standard of living of the people by efficient exploitation of the resources of the country, increasing production and offering opportunities to all for employment in the service of the community. With the formulation of First Five Year Plan (1951-56), at presently the Commission has playing its role in the Twelfth Five Year Plan (2012-17).

The three Science Academies, namely; The Indian National Science Academy (INSA) located in New Delhi; The Indian Academy of Science (IAS) located in Bangalore; and The National Academy of Sciences (NASI), located in Allahabad have been in existence for over 80 years. NASI was established in 1930, IAS in 1934 and INSA in 1935. The Academies generate advisory information, individually as well as collectively, on various contemporary issues that are of relevance to the Government, either on request by the Government of India or on their own initiatives.

Reports of the braining-storming discussions organized by the Academies are made available to the Government and are also available in public domain. For example, brain-storming meetings concerning animal experimentation and nuclear energy issues resulted in reports that were highly useful. Academies are also adequately represented in the other advisory mechanisms of the Government through their presidents/Fellows.

In order to deal with emergencies and natural disasters, the Government of India established the National Disaster Management Authority (NMA) in 2005, particularly after the disastrous Bhuj earthquake of January 2001. Soon after the 2004 tsunami, India took up the work of establishing a modern tsunami-warning center, and the India Tsunami Early Warning System (ITEWS), established by the Department of Earth Sciences, came into being in August 2007. Disasters of this kind do not recognize national boundaries and it is in such emergency situations that international networks of senior level Science Advisors could add most value.

Policymakers in India do take constant advice of scientists, engineers and maintain other sources of public engagement. Engaging with the general public in India, a developing economy, would be very different from that in an already developed country, as the awareness at the level of general public is still limited. Mechanisms of generating advice to the Government of India are highly dynamic and part of a continuous process.

Advisory channels leading to the Government and the Prime Minister are not isolated from each other, as many of the individuals involved in the advisory process have overlapping roles. Since the structure of advisory mechanisms has evolved over a period of time and does have its strengths and weaknesses, it may be suffice to say that the model is functioning effectively over many years and has contributed immensely to the emerging scientific scenario of the country. The situation will improve further as India continues to move on the path to become a knowledge-driven economy.

A1.10 Italy

Since Italy is a member of the European Union, science advice occurs both at national and at European level. At a national level, the model is extremely variable as it depends on the kind of required expertise, and on which governmental institution requires

science advice. At an EU level, through the Accademia Nazionale dei Lincei, Italy is an active member of the European Academies Science Advisory Council (EASAC), which provides scientific advice to EU policymakers. Examples of advisory bodies and processes at the national level include:

- The National Research Council (CNR) is a public organisation; its duty is to carry out, promote, spread, transfer and improve research activities in the main sectors of knowledge growth and of its applications for the scientific, technological, economic and social development of the country. Its areas of interdisciplinary scientific and technological research cover several sectors: biotechnology, medicine, materials, environment and land, information and communications, advanced systems of production, judicial and socio-economic sciences, classical studies and arts. CNR is distributed all over Italy through a network of institutes, which promote a wide diffusion of its competences and cooperation with local firms and organisations. CNR is under the responsibility of the Ministry of Education, University and Scientific Research. Although its role of science advisor of the government is not clearly stated in the Statutes, CNR can play this role through the Ministry to which it belongs.

- INGV (National Institute for Geophysics and Volcanology) provides constant scientific advice to the Civil Protection authorities. The main mission of INGV is the monitoring of geophysical phenomena in both the solid and fluid components of the Earth. INGV is devoted to 24-hour countrywide seismic surveillance, real-time volcanic monitoring, early warning and forecast activities. State-of-the-art networks of geophysical sensors deliver a continuous flow of observations to the acquisition centers of Rome, Naples and Catania, where the data are analyzed around the clock by specialized personnel. INGV operates in close coordination with the Ministry of University and Research and with Civil Protection authorities, both at national and local level. INGV also cooperates with the Ministry of Environment, the Ministry of Education, the Ministry of Defence and the Ministry of Foreign Affairs in the frame of large research programs of national and international relevance.

- The Accademia Nazionale dei Lincei is the scientific advisor of the President of the Italian Republic. As a member of the European Academies Science Council, it provides independent science advice to European policy-makers.

- ISS (Superior Health Institute) provides scientific support to the National Health Service. It belongs to the Ministry of Health, but has independent structures and is scientifically autonomous. ISS's tasks include: performing scientific research in support of public health, as well as performing analytical tests and enquiries.

The strengths of the Italian system are that the government has access to science advice through ad hoc bodies and scientific organisations. A weakness is that the parliament has no institutionalized access to science advice.

For the management of risks and emergencies, the National Committee for Forecast and Prevention of Great Risks is the structure which connects the Department of Civil Protection to the scientific community. Its main function is to provide technical-scientific advice on request by the head of the Department and suggest how to improve the evaluation, forecast, and prevention of the different risks. The Committee is constituted by the Office of the President and operates across seismic risk; volcanic risk;

meteo-hydrogeological risk; hydraulic and landslide risk; chemical, nuclear, industrial and transportation risk; environmental and forest fire risk.

A1.11 Japan

Whilst the Government of Japan (GOJ) does not have a position specifically assigned as a 'scientific advisor', the Council for Science Technology and Innovation (CSTI), which was just recently renamed from the Council for Science and Technology Policy, provides advice with regards to science, technology and innovation policy.

The Cabinet Office, established under the Prime Minister, provides overall coordination among ministries. Under this structure, the CSTI act as one of the important councils for advice. Chaired by the Prime Minister, and composed of relevant ministers and executive members from academia and industry, CSTI functions as headquarters for STI policy. It has three main functions: (1) formulation of comprehensive STI policy; (2) formulation of resources allocation policy like the STI budget prioritization; and (3) evaluation of important R&D projects.

Concerned ministries promote STI by developing relevant systems and implementing national programs which conform with the basic policy formulated by CSTI. When those ministries make a policy decision which includes scientific and/or technological aspects, they usually turn to their advisory councils or set up ad-hoc expert panels, both consisting of scientists and engineers of relevant areas.

Information is usually gathered by the secretariat (sometimes with the help of think tanks) and provided to the members of CSTI, advisory councils and expert panels. External experts are sometimes requested to attend related meetings to provide scientific opinions.

The current "system" of scientific advice dates back to the post second world war period. CSTI, which started as Council for Science and Technology in 1959, became Council for Science and Technology Policy in 2001. It was renamed the Council of Science, Technology and Innovation in May 2014. This Council has always been chaired by the Prime Minister. The CSTI is a decision-making body, as distinct from advisory councils and expert panels under relevant ministries which are usually advisory bodies. It does not, however, usually provide scientific advice to cope with emergencies or imminent crisis.

The strength of the current "system" is that it is possible to integrate the opinions of many experts. However, some people insist that Japan should set up a position or role in consideration of the roles of GCSA of the UK or the APST of the US. If Japan were to adopt this model, there would need to be clarification of the division of labor with the Minister of State for Science and Technology or the CSTI, as well as the necessity of a secretariat for a new 'scientific advisor' position.

A1.12 Mongolia

In Mongolia, the major responsibilities of science advisors are to work out in timely manner recommendations related to the country's development. They are responsible for the credibility of their recommendations. The advisors can be individuals, legal entities or working group appointed by the authorities.

The Standing Committees of the Parliament, its administration department, or Government Ministries can request recommendations on certain issues. Likewise, science organisations can make recommendations and send these to decision makers.

The role of the sole scientific advisor to the Government of Mongolia is given by law to the Mongolian Academy of Sciences. According to Article Eight of the Legal Status of the Mongolian Academy of Sciences, the President has the responsibility to formulate recommendations on the development of the nation's economic, social and political relations, with respect to science and technology issues.

Under the socialist system from the 1960s until the 1990s, all issues were organized and directed by the Party and the Government, and hence there was no science advice as such. In 1996, after the approval of the Law on the Legal Status of the Mongolian Academy of Sciences, science advice was officially put on the agenda. Nonetheless, expectations that the Government will seek advice remain weak.

The advantage of the science advice model is that it is always open for individuals and scientific organisation to send science advice to the Parliament, Government and the President of the country. A weakness is that it is almost a voluntary matter for policymakers to request science advice and make use of it in their activities, and there is no system of evaluation of its effect. There is also no science advice model and processes of science advice in the context of emergencies and the management of risk in Mongolia.

A1.13 New South Wales, Australia

The NSW Chief Scientist & Engineer (CSE) is a government appointed position reporting to the Deputy Premier. Professor Mary O'Kane was appointed in 2008 as the inaugural NSW Chief Scientist & Engineer. The CSE is responsible for:

- providing the NSW Government with the best quality advice on policy decisions requiring science and engineering input
- seeing that the State's research system operates to maximise its productivity, economic value and social responsibilities
- brokering partnerships and strengthening connections within and between the public and private sectors, particularly with universities and research organisations, to expand the State's research capabilities and networks
- promoting and encouraging high levels of research and development in NSW with global impact – including supporting the growth of vibrant and high impact research institutions and technology companies
- encouraging research excellence, concentration and skills development in areas facing significant challenges including engineering, energy, environment, health
- backing investment in knowledge creation and research in alignment with the needs of the State's future industries

This position is unusual in that it is both Chief Scientist and Chief Engineer. The inclusion of the latter has been particularly valuable and welcomed by engineering-based industries as well as government as much of the work conducted by the CSE, as requested by the Government, pertains to issues of engineering.

Advice on specific science issues for State agencies is also provided to the NSW Government through a number of chief scientific officer positions across government portfolios such as within the Department of Primary Industries and the NSW Food Authority.

The NSW CSE provides independent advice on difficult issues to Government as a whole (generally through the Cabinet) in response to formal requests for information from the Premier and/or portfolio ministers. Examples of recent reviews and studies undertaken include the Independent Review of Coal Seam Gas activities in NSW, Cumulative impacts of activities in the Sydney Water Catchment (as a sub-set of the CSG Review), Review of the Environmental Trust's Environmental Research Program, Thirlmere Lakes Inquiry and Report on Sea Level Rise benchmarks.

These review projects often work as a risk management device and inform significant changes in government policy.

Since her appointment, the NSW Chief Scientist & Engineer has shaped a strategic reengagement between the NSW Government and its universities and the components of the State's innovation system more generally. The universities and other research organisations are now considered central to government policy both in their own right and also as key delivery agents for productivity growth through their vital role in producing value-added labour and as sources of specialist expertise.

To ensure the appropriate rigour is applied to hard policy questions, the CSE commissions advice from a range of external eminent experts in the field of study being reviewed and incorporates this advice into the reports provided to government. This process often includes triangulation or peer review of expert advice.

The NSW CSE also provides advice to the NSW Government on research, science and engineering issues through active involvement in a number of committees. The CSE chairs the Medical Devices Fund Expert Group and the Government's Advisory Committee on Tunnel Air Quality. She is an expert advisor to the NSW Innovation & Productivity Council and a member of Coal Innovation NSW and the NSW Spatial Council.

A1.14 New Zealand

New Zealand appointed a Chief Science Advisor to the Prime Minister (PMCSA) in 2009. The Science Advisor is seconded part-time from a university appointment. This administrative arrangement ensures that the role's independence from both the public service and Cabinet is protected, and that the advisor's scientific integrity as a member of the science community is demonstrably upheld.

The primary purpose of the PMCSA Office is to provide advice on using science to the Prime Minister, Ministers and government agencies, both pro-actively and on request, and both individually and through *ad hoc* expert panels. The PMCSA is also leading New Zealand's efforts to improve the use of scientific evidence in public policy and chairs a growing network of departmental science advisors (DSAs).

Three DSAs have been appointed thus far (Ministry of Primary Industries; Ministry of Business, Innovation and Employment; and the Ministry of Education). Another two ministries are currently in the appointment process and five others under early discussion. Many Ministries have expert committees. The PMCSA and DSAs are charged with establishing protocols for scientific advice to government agencies. The Government's public sector controlling body has asked that this grouping formalize to take on particular functions in coordination of some central needs in relationship to science and policyy.

New Zealand has seven Crown Research Institutes, which also provide technical advice to government. The CRI chief scientists may lead the research planning process for their organisations and serve as principal point of contact for feeding into the government's advisory mechanisms.

There has been increasing interest in developing closer ties between New Zealand's practicing social scientists and ministries with a social policy mandate. The Government has recently established a Social Policy and Evaluation Research Unit. The PMCSA is a member of its Board.

New Zealand also has a Parliamentary Commissioner for the Environment (PCE) with the discretionary powers to develop and release reports on matters of environmental interest. This position serves all of parliament but there is no mechanism for any direct influence on the policy process.

Taken together, these roles represent new and enhanced strengths in the New Zealand Government's engagement with research; however, many of the roles are newly established and are still being incorporated into Government's advice and policy development processes. In addition, a study conducted by the PMCSA showed that parts of government still lack the in-house science literacy and critical appraisal skills to correctly interpret and apply the best evidence. This issue is being addressed first through the DSA network, but also through whole-of-government focus to improve the quality of the public service, as outlined in two recent policy statements.

In addition to these mechanisms, the Royal Society of New Zealand has had the provision of science advice embedded as a statutory role within its Act (i.e., the Royal Society of New Zealand Act 1997; 6. Functions – "For the purpose of the advancement and promotion in New Zealand of science, technology, and the humanities, the functions of the Royal Society of New Zealand are… (e) to provide expert advice on important public issues to the Government and the community").

This statutory role is distinct from that of the PMCSA and the DSAs in that it may deal primarily with the provision of advice on specific technical issues, but not with the systemic issues of strengthening the use of science in policy development process. More recently, the need for technical expertise has been jointly met by the PMCSA working in collaboration with the RSNZ on the development and publication of topic-specific panel reviews.

Other statutory advising roles are those within Ministries with regulatory responsibilities. For instance, the Ministry of health maintains highly specific scientific advisory committees to meet statutory requirements.

Policy advice to Government Ministers is constitutionally protected in New Zealand, in the interests of preserving free and frank advice. In general, there is a growing acceptance of science advice for policy, though robust conduits into the policy process are still being established and the development of a culture of inquiry and evidence is taking hold within the public service. The PMCSA has written extensively about the place of science in the policy process, reiterating that science 'does not make policy' but must be given a privileged place among policy inputs.

A1.15 Quebec, Canada

In the proving of Quebec, the responsibilities of the Chief Scientist include:

- Advising the Minister of Higher Education, Research, Science and Technology on matters pertaining to the future of science and innovation, in order to ensure Quebec's position and influence in Canadian and at international levels;
- Chairing the Board of Directors of each of the three granting funds under the umbrella of the *Fonds de recherche du Quebec*, and coordinating common issues and cross-sectoral research;
- Creating and developing an international strategy for partnerships at the national and international levels; promoting science and innovation culture at the international level by leading official missions and participating at international high-level events;
- Developing scientific literacy.

Quebec created the position of a Chief Scientist in 2011 – a first for any Canadian province. In addition to advising the Minister, the Chief Scientist is regularly solicited for advice to university officials, research associations, researchers from communities, industry at the national and international level. Recently, an inter-ministerial round-table, on major societal issues, was created. At this roundtable, co-chaired by the Chief Scientist, this role is to advise on the priorities for inter-sectorial research, and to ensure a strong cohesiveness between ministries and organisations working on research and innovation.

Information is channeled to the Minister through different means:

- Face-to-face meetings;
- Working sessions with the Deputy Minister and his team with reports produced;
- Documents prepared by the Office of the Chief Scientist;
- Weekly interaction with Cabinet.

Monitoring the efficiency of science advice is done through:

- Annual Reports;
- Action Plans.

With no Chief Scientist at the Federal level in Canada, we can only assess the model at the provincial level. The innovative situation of having science advice in Quebec creates opportunities for the Chief Scientist to strengthen and develop science and innovation within Quebec, and at the Canadian and international level.

Following a wide and thorough in-person consultation a National Research and Innovation Strategy for Quebec was produced, which stated the establishment of conditions for an ongoing and dynamic relationship between the government and the research community. In addition, the Government of Quebec will foster the creation of regular forums between elected officials and researchers in order to determine ways of ensuring better interaction between these two parties.

From a Chief Scientist's perspective, regular exchanges with international counterparts is a mutual benefit as there is a substantial amount of learning from each other and comparing notes on the many issues each has.

A1.16 Switzerland

Science Advice to government in Switzerland is primarily the task of the Swiss Academy of Sciences. The model that is mainly used in the academy can be summarized in the following Figure (from P. Quevauviller et al., Env. Sci. & Pol. 8 (2005) 203–211):

The Swiss Academy of Sciences has established a number of organisations that focus on the science policy dialogue for certain inter-disciplinary themes of high societal relevance (e.g. climate, biodiversity, genetic engineering). The oldest among these organisations, ProClim- Forum for Climate and Global Change, was established 20 years ago and has become a prototype for other forums of the academy and also for similar organisations abroad. With the help of ProClim- as an example we demonstrate in the following maybe not a best practice, but a very successful practice.

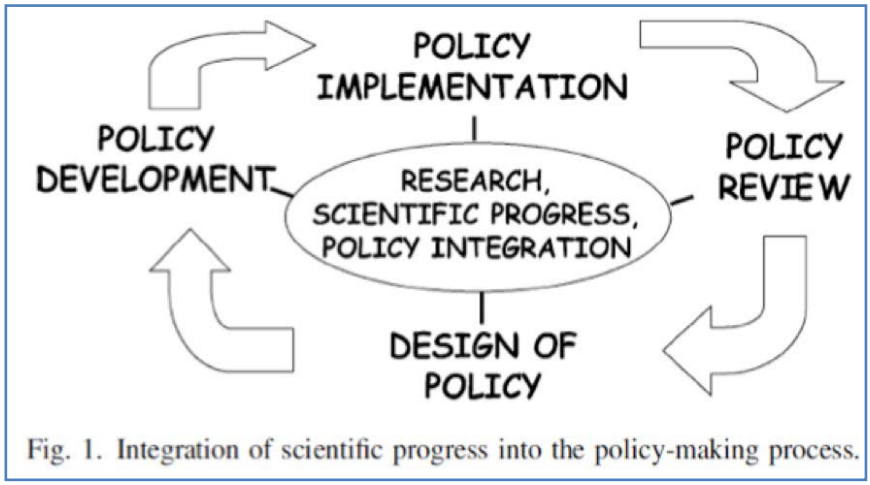
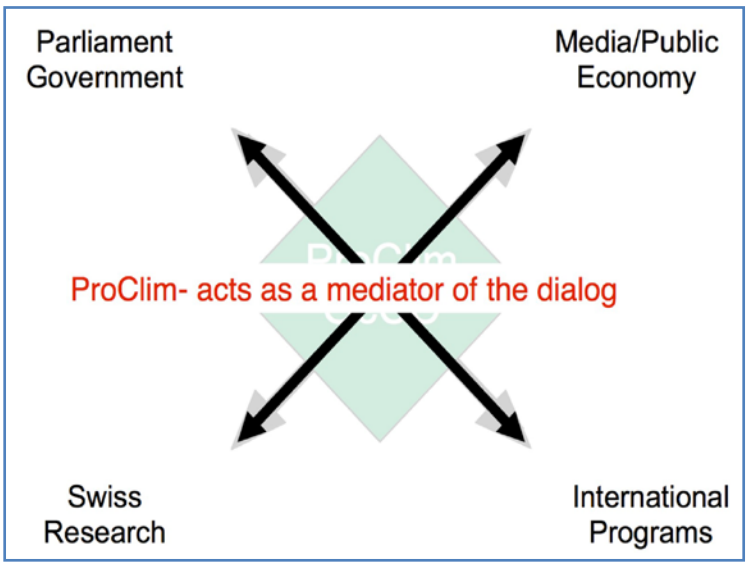


Fig. 1. Integration of scientific progress into the policy-making process.

Example ProClim-:



ProClim- actions are part of an integral strategy and it acts as a mediator of the dialogue

The different target audiences are provided with a number of specific products, such as (i) fact sheets, national assessments etc., (ii) meetings with members of the parliament and/or with stakeholders from economy, (iii) workshops with scientists and communications experts, (iv) delegating scientists to international bodies or research programs, (v) coordinating national authorship in the IPCC, press releases and background information for the media, etc.

Within all these activities, key questions to be considered are: Are the key Swiss experts involved? Which is the key message, is it brought to the point? Is it understandable and interesting and specific for the target audience? Are there benefits for the scientific community?

With its activities over about 20 years, with the organisation of many events and the elaboration of expert's reports on many cross-cutting themes ProClim- has established a broad interdisciplinary community of Swiss researchers dealing with climate and global change which is willing and experienced to contribute to the policy dialogue.

On the other hand, with its qualified and broad support structure ProClim- has gained confidence and the status of a reliable source in governmental and political institutions as well as for the media. As a result of its reports and comments, ProClim- can e.g. delegate scientists to parliamentary commissions. ProClim- e.g. was involved in

legislation of climate relevant laws, in particular in the establishment of the CO2 law and its recent revision.

From our experience a number of key requirements for scientific policy advice can be derived:

- all activities should be transparent and coherent;
- positions should be clear, evidence-based, consistent and supported by a broad scientific community;
- the representation of individual interests or aspects (e.g. of specific themes) should be avoided;
- messages have to be simplified and understandable for lay people, but nevertheless scientifically correct, which often needs negotiations with experts;
- uncertainties and controversial issues should be clearly communicated;
- provision and communication of relevant and high quality products should be continued over a long time.

These requirements can be supported by:

- elaboration of a draft by an expert team representing the most important fields related to the investigated topic, followed by a broad review in the scientific community;
- a sustained development and maintenance of a scientific network in relevant fields, i.e. support the network with information, opportunities (delegations), workshops, etc. and develop dialogue skills of scientists by including them in policy assessment and discussion activities;
- build up an experienced, skilled and acknowledged staff to organize and support the dialogue (interface);
- establish effective and efficient working schemes in order to be time fair? (to achieve time-readiness).

Example Forum Biodiversity:

The Forum Biodiversity has, similar to ProClim- established over 15 years a broad community of experts and became a reliable and accepted partner of governmental institutions. The Forum was significantly involved in the elaboration of the National Strategy on Biodiversity. Since 2004 it has initiated, fostered and supported the development of a national strategy. It is now engaged in the development of an action plan to implement the strategy.

In the Swiss system, the role of scientific advisors is to provide state of the art scientific knowledge on specific questions relevant for governmental decisions, legislation or any questions relevant for society, and thus provide guidance and orientation in the vast amount of available scientific results by highlighting relevant aspects, robust and broadly accepted knowledge, as well as uncertainties and open questions.

In the fields where the academy is engaged, there are advice facilitators, e.g. the staff of academy organisations such as ProClim-, and expert advisors, which are scientists experienced at least in parts of the field or topic discussed. The academy organizes and coordinates the advice, the scientific experts on the one hand give input into comments, assessments, etc., elaborated by the academy, and on the other hand represent the assessed results in hearings with policy makers or might give lectures. In some fields the government has established commissions consisting of a number of invited scientists to give advice to the government (e.g. the energy research commission).

No formal monitoring procedures have been established. The effects of our reports can only be seen, when the advice is directly implemented and therefore can be attributed to the activities. However, many effects such as the degree of implementation, the influence on the thinking and the argumentation of members of the government etc. are very difficult to measure and analyze.

The strengths of this system are continuity, reliability and trust, and peer competences. Possible weaknesses are: timeliness (due to the time needed to establish reports and comments), to foresee research needs, and to mobilize public awareness. This is mainly due to restricted human and financial resources.

For the (long-term) management of risk, the above described processes are in place. For emergencies there are no established processes to provide scientific advice. Short-term risk and emergency management in fact is the task of the corresponding federal offices (of meteorology, environment, health, etc.).

A1.17 South Korea

In South Korea, the Presidential Advisory Council on Science & Technology (PACST) provides scientific expertise to inquiries of the President regarding:

- S&T development strategies and principal policies to develop S&T, information and human resources and to encourage innovation, and
- Institutional improvement in the field of S&T and issues on S&T policy.

PACST, which consists of no more than 30 S&T experts, provides scientific advice in line with the Constitution and Act on PACST. Currently PACST is constituted of a Vice-Chair, three Committee Chairpersons and 21 members since September, 2013.

PACST listens to various field opinions from on-site visits and workshops, public hearings, special lectures and symposiums, and provides scientific advice to the President. Based on this advice, the President orders necessary measures to the Government.

PACST was established in 1991. From 2008 to 2012, in line with the revision of the Government Organisation Act, it took on the role of providing advice on Education, Science & Technology. From 2013, reverted to its original role in Science & Technology.

PACST gathers strength from the fact that it consists of purely nongovernmental members, who possess high expertise and scholarly attainments or field experiences. They provide high-quality and unconstrained advices, from macroscopic and long-term perspectives. One of the weaknesses of PACST is that its members provide only part-time service, holding full-time positions such as professors, chancellors or CEOs. Therefore, they are very busy and not properly rewarded for the additional advisory service.

On emergency issues, PACST provides advisory meetings or written reports to the President. Before policy advice is delivered to the President, PACST hears the opinions of related Ministries regarding the advices, and accepts reasonable suggestions after modification if necessary, to reduce risk.

A successful case of scientific advice which helps policy-making and emergency response in a country can be a good example to another country. For South Korea,

analysis and dissemination of such examples through an international network would greatly facilitate the use of science in policy-making.

A1.18 South Africa

The South African government generates and obtains scientific advice through a number of statutory and non-statutory institutions. Although there is no office of *Chief Scientific Adviser* to government, the Minister of Science and Technology may appoint personal advisors with specific technical or scientific expertise. A loose and highly elaborated network of centres of scientific advice is available to government, reflecting developments in the period of democracy over the past twenty years as well as incremental scientific development dating back to the last quarter of the 19th century, and in the case of the natural environment, around fifty years before that. 'Scientific adviser' is thus both an individual and a juristic person. Technically the role of *Chief Scientific Adviser* could be regarded as the Minister of Science and Technology (with concomitant advisors in different fields) - however this individual is a political appointee who may or may not have in-depth scientific expertise.

The roles and responsibilities of such statutory entities or juristic persons are laid out in their respective founding legislation. Generally this will include a clause requiring the institution to advise their line Minister on request, and in some cases at their own discretion. The roles and responsibilities of individual advisors are decided upon by the relevant Minister and may include close liaison with the advisory function of statutory entities.

From time to time virtually all government departments request advice. This advice may be sought from other government departments, independently or through the facilitation of the Minister of Science and Technology, direct solicitation from statutory bodies or individual experts, or closed or open tenders.

South Africa, through the White Paper on Science and Technology adopted a holistic model for enabling the national system of innovation. This model sought to inculcate such thinking across government, public research organisations (PROs), universities, industry and civil society. The model emphasizes the importance of linkages, knowledge flows, and technological and policy learning. The Department of Science and Technology (DST) is the custodian of the national system of innovation.

Sector-specific Department-based Research Institutes (DBRIs) are the immediate source of advice, as in the case of Marine and Coastal Management in the Department of Agriculture, Forestry and Fisheries (DAFF).

A second source of advice stems from regulatory bodies spanning health, communications, etc. Key statutory bodies generating scientific advice are PROs – Council for Scientific and Industrial Research (CSIR), National Research Foundation (NRF), South African National Space Agency (SANSA), Agriculture Research Council (ARC), National Health Laboratory Service, Human Sciences Research Council (HSRC), Technology Innovation Agency (TIA), Council for Geosciences, SA Weather Service, Water Research Commission (WRC), Council for Mineral Technology, South African Bureau of Standards (SABS), and the Medical Research Council (MRC).

The National Advisory Council on Innovation (NACI) advises the Minister of Science and Technology. The Academy of Science of South Africa (ASSAf), the Royal Society of South Africa, and the *Academy for Science and the Arts* all offer advice, and in some cases conduct work for DST.

Civil society organisations include the National Science and Technology Forum (NSTF), professional (i.e. SA Institute of Mining and Metallurgy) and trade associations. State-owned enterprises e.g. Eskom, Telkom, Denel, Transnet, and PetroSA are all sources of scientific advice. Business organisations such as Business Leadership South Africa, the Chamber of Mines, and AgriSA will commission scientific research on issues of current interest. The Natural Scientific Professions Act No 106 of 2003 requires professional scientists who offer advice in their field to be registered with the SA Council for Natural Scientific Professions.

The flow of information may be formally structured when advice is requested from an individual or entity on a specific matter, such as strategies in Paleontology or the Bioeconomy. This will also apply in structured processes such as the drafting of legislation, or modifications to existing legislation. On the other hand, various entities may generate comment on matters in a proactive or *ad hoc* manner and then present these for consideration by specific Ministers in Government. Some processes will make all inputs available for public scrutiny; in other cases this does not occur.

The Parliamentary oversight committees will have a role in monitoring the use of such advice since, in most cases, public resources will have been expended to obtain this advice. However, in most cases, advice is presented as a series of recommendations, some of which may be used and implemented while others are rejected. The relevant department will be expected to account for decisions on the use or rejection of such recommendations. In this sense the public is its own watchdog. The establishment of the Ministry for Performance Monitoring and Evaluation in 2009 has a responsibility to scrutinize all aspects of government effectiveness, but this is focused on the performance against extended strategies and annual plans, rather than on specific advice that is given, until the advice is included in these plans and strategies.

This model has a provenance of many decades, and was essentially informed by the approaches prevailing first within the British Empire and then the Commonwealth. Prior to isolation in the 1960s, South Africa was an active member of the world science community and drew on that best practice. During isolation the apartheid government strengthened and diversified the public research organisations, state-owned utilities and industries in its drive for self-sufficiency. Various advisory structures were also put in place. In the 1980s, civil society formations were a central driver of the contestation toward democracy, and brought with them a tradition of consultation and stakeholder participation, strongly informed by Australian, Canadian, German and Scandinavian practices. With the voluntary dissolution of many such formations after 1994 some of this ethos was lost, weakening the popular voice in science discourse. Arguably the activities of the (HIV) *Treatment Action Campaign* re-awakened the power of such movements.

The strength of the present 'model' is its informality and diversity, thereby allowing many voices to be heard. The professions are strong and ensure that integrity and quality of practice are maintained. The main weaknesses are that coordination of effort is difficult, and its informal nature results in a contestation between sources of advice for a share of the limited resources available to advisory entities.

South Africa engaged in five wars over the 20th century. Among the spin-offs from this is considerable expertise in logistics and operations research. The country is subject to regular droughts, occasionally violent weather, and a host of human, plant and animal diseases. Its seaboard is witness to numerous maritime disasters. It has therefore developed a range of early warning and risk management systems generally embedded within line departments that allow for the management of emergencies and risks. These

include the declaration of disaster, quarantine, notification, mass vaccination, etc. South Africa's disaster relief services have also been extended to its less well-equipped neighbors such as Mozambique and Lesotho. This has been codified in the South African Risk and Vulnerability Atlas.

The South African polity is structured through the 1996 Constitution that is premised on the separation of powers, and rule of law enshrined in a Bill of Rights. The Constitution binds the executive to function in an accountable manner, with citizen rights protected via a set of independent institutions including the Office of the Public Protector. An evolving body of law protects Access to Information, Equality, Environment, Health and Safety, administrative excess, etc. A vibrant civil society co-exists alongside government. In the case of natural scientists, engineers, and social scientists these organisations have evolved over the best part of a century. Pre-1994 many reflected ethnic division; this behavior is now proscribed. There are professional learned societies, associations, regulatory bodies and advisory councils that all play their part in advising government on request or in response to government action. Special interest groups also abound. One may estimate a corpus of juristic persons in the hundreds if not thousands.

The precise way in which these independent and quasi-independent organisations interact with government varies according to the issue at hand. In general, except where state security is invoked, policy making in government is performed in an open and consultative manner. The process of soliciting engagement thus takes many forms: a Call for Public Comment regarding a draft bill, new regulations, draft White Papers, intended proclamations in terms of regulations, amendments; Open Calls for Proposals involving tender; closed tenders; public inquiries; Ministerial Committees, Judicial or Ministerial Commissions of Inquiry. In principle a concerned group is free to make a submission on any topic that it regards as important, to any process, and to any forum, including Parliamentary Portfolio and Select Committees. The relevant scientific or professional bodies and entities are specifically and individually invited to participate in and comment on various stages of policy making while these are in progress.

These processes have acquired greater weight in the fourth democratic Administration through the presidential agencies of the National Planning Commission, and the Ministry for Performance Monitoring and Evaluation, both of which have contracted in the advice of scientists and engineers.

Peer networks are an essential element of scientific exchange, and have become even more effective in the Internet age. The extent and nature of this scientific exchange is captured in what Caroline Wagner terms the "New Invisible College of Science". Science policy making turns upon all the processes of learning: theorising and conjecture, collecting data, analysis and synthesis, iteration, revision and learning. No country, organisation, or individual thinker can prosper in isolation.

A1.19 Taiwan, China

Currently, Taiwan has cabinet-level and ministry-level institutions to conduct the systematic and regular collection, implementation and monitoring of scientific advice. As an emerging economy state, the efforts to develop Taiwan's innovation system have received strong endorsement from the President and the Premier of Taiwan.

In the early stage, the foreign science advisors of the Science and Technology Advisory Group (STAG) of the Cabinet serve as advisors for policy planning, inter-agency coordination and program evaluation. In addition to the cabinet-level advisory group, the ministry-level advisory groups have been established, including those for the

Ministries of Science, Education, Health, Agriculture and Economic Affairs, etc. The multiple layers of advisory groups are designed to serve the specific needs of individual ministries and to enable the ministries to flexibly respond to the changing international science landscape, and sometimes bypassing the rigidities of normal procedures.

In 1979, the STAG was launched by Taiwan's Cabinet, the Executive Yuan, to facilitate the implementation of the Science and Technology Development Program as the guideline of science policy. Until 1998, the STAG was composed of the Premier (as Convener), Science Minister without Portfolio (as Vice Convener), and reputable foreign science advisors to advise the Premier and the Cabinet agencies with regard to strategic planning, inter-agency collaboration and coordination, and technology insight to help establish the science and technology policy. The resolutions agreed at the annual conference by the STAG are executed by the government agencies, industries and research institutions under the coordination of Science Minister without Portfolio.

To support the execution of these resolutions, the Technical Review Board (TRB) was subsequently reorganized into the Strategy Review Board (SRB), comprising the local and international experts, and the state-funded corporations and institutes were set up to coordinate, monitor and review the implementation of the S&T programs developed by the inter-agency taskforces. The close interactions, led by the international experts, among the state, academic, and industrial sectors aims to ensure the introduction of new ideas, R&D trends, and the smooth implementation of the scientific advice. In the past several years, the STAG was co-chaired by the President of Academia Sinica and a foreign advisor.

In addition to the STAG, the National Science and Technology Conference organized by the National Science Council (NSC), (subsequently reorganized into Ministry of Science and Technology (MOST) in 2014) was launched in 1996, with the passage of the Science and Technology Basic Law by the congress. According to this bylaw, preparation of the 2 year-cycle White Paper on Science and Technology and the 4 year-cycle National Science and Technology Development Plan is required. The enactment of the Science and Technology Basic Law is to support the transition of science policy from a technology and industry-oriented model to the one with more emphasis on innovation to address the societal needs. Therefore, the 4 year-cycle National Science and Technology Development Plan was developed at the conclusion of National Science and Technology Conference to ensure the balance between technology and humanity. The MOST established the procedures and ad hoc information systems to regularly monitor the proper implementation of science policies in accord with the National Science and Technology Basic Plan.

Compared with the STAG, the advisors involvement in the National Science and Technology Conference was relatively loose with regard to monitoring the implementation of the National Science and Technology Development Plan.

In 2012, after the reorganisation of the National Science Council (NSC) into the Ministry of Science and Technology (MOST), the Science and Technology Advisory Committee comprising the local and international advisors from academic and industrial sectors was established to advise science policy making.

In 2014, the STAG was reorganized into the Board of Science and Technology (BOST), chaired by the Prime Minister and composed of S&T minister without portfolio, minister of Science and Technology (MOST), President of Academia Sinica, and others from domestic and international science-based agencies, institutions and industries. Through this reorganisation, the BOST is responsible for the decision making of science policy,

and the MOST serves as the cabinet-level ministry for science policy planning, evaluation, execution and coordination.

A current weakness is that the National Science and Technology Development Plan is not closely followed by a comprehensive, in-depth foresight process to identify the problems or failures of the innovation system and the priority issues addressed by the National Science and Technology Conference. With regard to the public engagement in the consensus-building and deliberation process of the science conference, the current mechanism remains limited. Moreover, the monitoring of advice concluded in the conference still cannot be adequately executed due to the lack of regular involvement of the advisors in the implementation process. The MOST is aware of these shortcomings and has taken many measures to address the deficiencies. In addition, after reorganisation of the STAG to the BOST, the participation of international experts in the BOST is lacking, and perhaps it is important to consider some adjustment of this deficiency.

After the catastrophic Chi-Chi Earthquake in 1999, a resolution made in the National Science and Technology Conference in 2001 to establish the National Science and Technology Center for Disaster Reduction (NCDR) to coordinate the related R&D, monitoring, evaluation, and technical support of disaster. This well-established national disaster response system is composed of the cabinet-level inter-agency taskforce, Central Disaster Prevention and Response Council and the municipal-level disaster response taskforce. In addition, the Advisory Committee for Disaster Prevention and Response was established at different levels to build the national capacity for disaster prevention and response.

Moreover, in response to the resolution made at the National Science and Technology Conference, the MOST in collaboration with experts in the NCDR has organized a National Science and Technology Program for Hazards Mitigation, which is executed by related government agencies to address the pressing societal needs, and to stimulate the application of related research to solve societal problems.

One of the principles required by the Science and Technology Basic Law is a balanced inclusion of technology and humanity in the implementation of the S&T programs by the government agencies. Despite the significant progresses in this direction, more collaborations among experts of different disciplines are needed to improve the innovative planning and execution process suggested by the advisors, state bureaucracy, and stakeholders.

A1.20 United Kingdom

The arrangements for scientific advice to the UK government are complex. The following is an attempt to distill a large amount of information.

The main roles of the Government Chief Scientific Advisor (GCSA) (currently Sir Mark Walport) are to provide scientific advice to the UK Prime Minister and members of Cabinet, to provide advice on aspects of policy on science, engineering and technology and to ensure that effective systems are in place within government for managing and using science. These often require the GCSA to consult departmental Chief Scientific Advisors (CSAs) and other experts in relevant fields.

The core role of departmental CSAs is to ensure that departmental decisions are informed by the best science and engineering advice. They do this both through offering advice directly to Ministers and official colleagues and by oversight of processes for

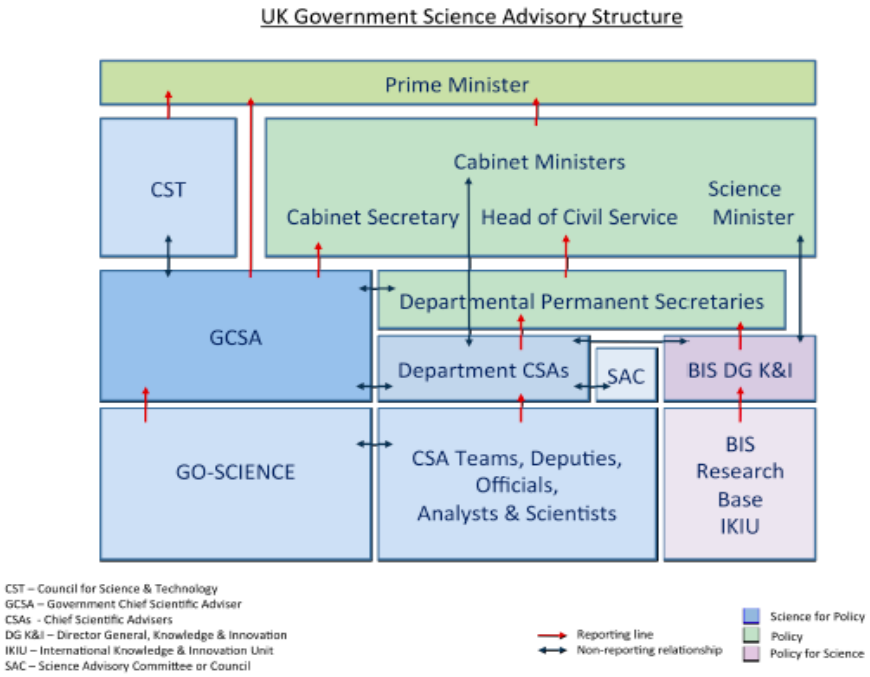
ensuring that departments take account of, and commission where appropriate, relevant scientific and engineering evidence.

Scientific advice is received at multiple levels within government. The Prime Minister receives cross-cutting advice from the Council for Science and Technology, co-chaired by the GCSA. Most government departments have a CSA which can provide advice to the relevant Minister and policy officials.

Government departments draw on analysis and expertise from a wide range of sources, each involving a different level of prescription. These include, but may not be limited to:

- In-house expertise: very closely linked to policy development and the policy priorities of the Government.
- Individually commissioned research projects: each year departments identify priority gaps in the evidence base which could be addressed by commissioning experts to consider specific research questions.
- Funded panels and centres: some departments faced by persistent evidence gaps or where the evidence is particularly contentious may decide to fund research centres. These centres may be tasked to tackle long-term gaps in the evidence base (either through a broad strategic theme or via a set of challenges) or to provide independent analysis to inform policy development.
- Public Sector Research Establishments and Research Councils: build general capability for research that underpins or supports government policy-making and supports excellence across a range of disciplines. It is expected that the Research Councils are best placed to know the most appropriate areas in which to invest, and as such have significant autonomy in setting their research agenda.
- 'What Works Centres' is a new initiative to improve the use of high quality evidence when the government makes decisions about public services. The Network is made up of six evidence centres and synthesises existing evidence and shares findings for local practitioners and policy makers.
- Formal networks: many officials represent the UK on sub-committees or steering groups, for example in the OECD. These are an important source of information and analysis taking place in other economies.
- Informal networks, formed through positive engagement between the academic community, policy officials and government analysts.

It is likely that departments will draw on multiple sources to ensure that the relevant evidence is available.



The GCSA's *Guidelines on the Use of Scientific and Engineering Advice in Policy Making*[35] state that government decision makers should "Adopt an open and transparent approach to the scientific advisory process, publish the evidence and analysis as soon as possible and explain publicly the reasons for policy decisions, particularly when the decision appears to be inconsistent with scientific advice." It adds that "all evidence should be subject to critical evaluation. Departments should ensure appropriate quality assurance and peer review processes are carried out. Scientific Advisory Committees, learned societies, academics and other experts can assist in the peer review process."

The first UK GCSA was introduced in 1964. The Prime Minister's Council for Science and Technology was introduced in 1993, although other bodies served a similar function dating back to 1976. The GCSA first launched the *Guidelines on the Use of Scientific and Engineering Advice in Policy Making* in 1997, and most government departments now have their own departmental CSA.

In emergency situations, COBR, the Government's emergency response committee, can call the Scientific Advisory Group for Emergencies (SAGE) if scientific or technical input is required. SAGE is chaired by the GCSA and consists of experts relevant to the specific emergency. The group acts to review, enrich and agree the scientific advice underpinning policy recommendations and ensure coordinated and consistent advice underpins the central government response. SAGE was activated this year for the flooding emergency, and also during the 2009 H5N1 influenza pandemic, the 2010 volcanic ash disruptions and the Fukushima nuclear incident in 2011.

In the UK, policy making is a long-term, evidence-based process during which public engagement is becoming increasingly core. This process is managed by a cadre of professionals who are experienced at interpreting and contextualising the wide variety of inputs that open policy making promotes. The full range of scientific evidence, from engineering, the natural sciences through to the social sciences, is crucial to this.

[35] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293037/10-669-gcsa-guidelines-scientific-engineering-advice-policy-making.pdf

Science evidence is essential to a wide range of government work, from regulation and policy making through to emergency preparedness and response. A network of senior-level science advisors is demonstrating effectiveness at UK national level, and is already being drawn on to advise across national borders in emergency situations such as the Fukushima incident. It is vital that the best science evidence can continue to inform government decision-making, and that barriers to such advice are addressed.

INTERNATIONAL BODIES

A1.21 UN Scientific Advisory Board

In September 2013, the UN Secretary-General, Ban Ki-moon, announced the creation of the Scientific Advisory Board (SAB) to provide advice to the UN Secretary-General and the Executive Heads of UN organisations. The Board is the first such body set up by the UN Secretary-General to influence and shape action by the international community to advance sustainable development and eradicate poverty. The initiative derives from the report of the UN Secretary-General's High-level Panel on Global Sustainability (GSP) *Resilient People, Resilient Planet: A Future worth choosing* (January, 2012) and specifically from Recommendation 51 thereof which states:

> *"Governments and the scientific community should take practical steps, including through the launching of a major global scientific initiative, to strengthen the interface between policy and science. This should include the preparation of regular assessments and digests of the science around such concepts as "planetary boundaries", "tipping points" and "environmental thresholds" in the context of sustainable development. This would complement other scientific work on the sustainable development agenda, including its economic and social aspects, to improve data and knowledge concerning socio-economic factors such as inequality. In addition, the Secretary-General should consider naming a chief scientific adviser or establishing a scientific advisory board with diverse knowledge and experience to advise him or her and other organs of the United Nations*."

In its report, the GSP also presented recommendations regarding a strengthened interface between science, policy and society. It emphasises that decision-making should be informed by the best available evidence co-designed, co-produced and co-delivered by the relevant stakeholders. Such evidence should be made available not only through the lenses of specific scientific disciplines but also through transdisciplinary approaches.

The Board is composed of twenty-six eminent scientists, representing all regions, as well as the main disciplines, systems and sectors related to the multiple dimensions of science for sustainable development. Board members will act in their personal capacity and will provide advice on a strictly independent basis. They will serve pro bono for two years, with the possibility of renewal for one further two-year term, upon the decision of the Secretary-General. UNESCO will host the Secretariat for the Board.

The central function of the Board will be to provide advice on science, technology and innovation (STI) for sustainable development to the UN Secretary-General and to Executive Heads of UN organisations. The Board will bring together in a coherent manner the collective capacity of all relevant scientific fields, with due regard to social and ethical dimensions of sustainable development. The fields will span a broad spectrum, from the basic sciences, through engineering and technology, social sciences and humanities, ethics, health, economic, behavioral, and agricultural sciences, in

addition to the environmental sciences, which are more commonly associated with sustainability.

The SAB is entrusted, among others, with ensuring that up-to-date and rigorous science is appropriately reflected in high-level policy discussions within the UN system, offering recommendations on priorities related to science for sustainable development that should be supported or encouraged; providing advice on up-to-date scientific issues relevant to sustainable development; identifying knowledge gaps that could be addressed outside the UN system by either national or international research programs (e.g. Future Earth); identifying specific needs that could be addressed by on-going assessments (e.g., IPCC or the IPBES); and advising on issues related to the public visibility and understanding of science.

As a trans-national and trans-disciplinary body, the Board will act as a bridge among the sciences and between science and engineering, as well as at the science-policy-society interface. It will aim to have a transformative impact, not by addressing individual topics but by investigating sustainable development from a perspective that cuts across topics and disciplines, as well as across multiple scales – national, regional and global.

One of the Board's major tasks will be to help elevate the role of science in policy-making and identify concrete modalities to strengthen the science-policy-society interface. The Board will also endeavor for improving communication on science and on the importance of risks related to unsustainable development.

At the first meeting in January 2014, the Board agreed that, in the initial 6-months phase, its work will be structured around four work streams, for each of which a Policy Brief shall be developed. All four Policy Briefs shall be presented to the UN Secretary-General before the UN Climate Summit to be held in September 2014.

> **Work Stream 1**: *What kind of science and what multi-disciplinary approaches are needed for sustainable development*
> The goal of this first work stream is to issue a "defining paper" and identify new approaches needed in science for sustainable development. It will focus on redefining the role and contribution of science for advancing sustainable development, including how science is designed and conducted, scientific gaps to be addressed, and issues related to human capital development for sustainable development.
>
> **Work Stream 2:** *Linkages between science and society and mobilization of all stakeholders for sustainable development*
> The goal of this second work stream is to determine concrete modalities for improving the linkages between science and society and propose solutions to engage better all stakeholders, including the private sector.
>
> **Work Stream 3:** *New approaches, modalities and processes to integrate better science into policy-making*
> The goal of this third work stream is to identify concrete modalities for improving the linkages between science and policy.
>
> **Work Stream 4:** *The relevance of science for the SDGs*
> Board members will comment on the Sustainable Development Goals (SDGs) from the point of view of science, based on the relevant documents related to the deliberations of the post-2015 sustainable development agenda, including the relevance of the eventual targets. Such review will also provide an opportunity to underline the importance of fundamental research, basic and applied sciences,

and the need to invest in science to advance sustainable development. The Board will also engage in proposing strategies for reporting on the SDGs' targets as well as for reviewing and revising them over time.

In the initial phase of its work, the Board will work through Task Groups each dealing with the topical areas related to the Board's main four work streams. The task groups will be open to all interested Board Members and will be coordinated by appointed individuals.

A1.22 The International Council for Science: Science for Policy

The International Council for Science (ICSU) is a non-governmental organisation with a global membership of national scientific bodies (121 Members, representing 141 economies) and International Scientific Unions (31 Members).

To achieve its mission, which is to strengthen international science for the benefit of society, ICSU works at the intersection of science and policy, to ensure that science is integrated into international policy development and that relevant policies take into account both scientific knowledge and the needs of science.

ICSU's work on science for policy focuses on three main areas:

- providing scientific advice and coordinating the participation of scientists in policy processes
- providing advice on how policy processes should be created or modified to best receive and utilise available scientific knowledge
- creating scientific research programs that will improve collaboration between scientists, policy-makers and other stakeholders in the generation of scientific knowledge

Much of ICSU's work on science for policy takes place at the international level, working with the United Nations (UN), predominantly through the 'Major Groups' model of participation, in which ICSU works as co-organising partner for the Scientific and Technological Community Major Group.

In this role, ICSU works to raise the profile of science in intergovernmental processes, especially on environmental and sustainability issues. For instance, ICSU organised a range of activities and meetings in the run up to and during the Rio+20 conference, engaging the wider international scientific community, governments and other stakeholders, in discussions on science for sustainable development.

Following the Rio+20 process and its outcomes, ICSU is working to ensure that the global scientific community provides scientific input and advice to the definition of Sustainable Development Goals (SDGs). ICSU also coordinates input from the international scientific community to the new High-level Political Forum on sustainable development, which is charged to provide political leadership and recommendations for implementing the Rio+20 outcomes and to improve the science-policy interface in this context. ICSU also coordinates scientific inputs into the process to adopt a Post-2015 Framework for Disaster Risk Reduction.

ICSU is also exploring opportunities for collaboration with the UN Scientific Advisory Board (see 2.2.1) to ensure that science has a high profile in the UN system and explore innovative approaches for science to support evidence-based decision-making.

ICSU's Interdisciplinary programs also do work in science for policy area. For instance:

- Future Earth will co-design research with policy-makers and other stakeholders (for more details see 2.2.3).
- DIVERSITAS has supported the establishment of the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES), and is a major contributor for its implementation
- The World Climate Research Program (WCRP) and the International Geosphere-Biosphere Program (IBGP) contribute to the Intergovernmental Panel on Climate Change (IPCC).
- The Global Environmental Change programs are also involved in providing scientific evidence into international conventions such as the United Nations Framework Convention on Climate Change, and the Convention on Biological Diversity through their participation in the Scientific Advisory bodies of these conventions. The GEC programs foster research projects that undertake many science-policy activities at international, regional and national level.
- SCAR provides scientific advice on the role of the Antarctic and associated systems in global climate change to the IPCC and the UN Framework Convention on Climate Change (UNFCCC).

A1.23 Future Earth

Future Earth is a 10-year international research program that aims to provide knowledge required for societies to face the challenges of global environmental change and to help inform the transition to global sustainability.

Launched at Rio+20, Future Earth is being established by a broad Science and Technology Alliance for Global sustainability including the International Council for Science (ICSU), the International Social Science Council (ISSC), the Belmont Forum of global change research funding agencies, the United Nations Educational, Scientific and Cultural Organisation (UNESCO), the United Nations Environment Program (UNEP), the United Nations University (UNU), and the World Meteorological Organisation (WMO) as observer.

Bringing together existing programs on global environmental change (GEC)[36], Future Earth will be an international hub to coordinate new, interdisciplinary approaches to research on three themes: Dynamic Planet, Global Development and Transformations towards Sustainability.

Through its activities, Future Earth aims to support informed policy development. One of the most innovative and challenging aspects of Future Earth is the idea of co-design and co-production of relevant knowledge. This requires an active involvement of researchers and stakeholders, including policy and decision makers, during the entire research process. Through co-design and co-production, Future Earth aims to close the gap between environmental research and current policies and practices. Future Earth invites the broad community of researchers working within the natural and social sciences, engineering and the humanities to engage in developing knowledge that is co-designed with those who use research in governments, business, and civil society. Such co-design means that the overarching research questions are articulated through deliberative dialogues among researchers and other stakeholder groups, including decision makers, to enhance the utility, transparency, and saliency of the research.

[36] DIVERSITAS, the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP).

To better connect science with policy, Future Earth is developing a long-term science-policy strategy. Current science-policy landscape for Future Earth is summarised in the following paragraphs:

- **Future Earth seeks to strengthen links with research initiatives on-going at the international, regional and national level that address policy needs**.
  This includes existing GEC programs and their core projects, as they are often involved in providing advice to policy makers on scientific matters. For instance, the International Global Atmospheric Chemistry project feeds into strategic policy framework on air pollution.

  One of the important outputs of the GEC programs and core projects that Future Earth will continue and strengthen is scoping studies and syntheses of the status of scientific knowledge in specific areas. These activities are distinct from, but often linked to, the formal intergovernmental science assessments, such as IPCC (see below). They are more flexible and rapid than these latter processes and are particularly important in identifying emerging scientific issues and gaps in current knowledge. There is considerable potential for Future Earth to evolve the GEC program scoping and synthesis processes, which have been mainly 'internal' to the scientific community, and to more fully incorporate the concerns and perspectives of other stakeholders. Co-designed and co-produced Future Earth scoping studies and syntheses should be important products of the various themes and the program as a whole.

  While the scope of Future Earth is global, a number of issues require region-specific approaches to provide robust observations and forecasts of regional environmental change, assess potential impacts and vulnerabilities, explore mitigation and adaptation pathways, etc. Regions, as early witnesses of environmental change, have a critical contribution to assess environmental change and to participate in building a global picture for transitioning towards sustainability. Stakeholders in the region also have a fundamental role to play in implementing sustainability research and facilitating its application. This could involve identifying the needs and priorities of researchers and practitioners at national and regional levels and stimulating cooperation and partnerships. Therefore, Future Earth aims to engage at the regional level. This will involve making an inventory of existing regional stakeholders and networks, and establishing a dialogue with them to seek new partnerships and new development models in every region. Regional stakeholders will be involved in developing Future Earth's products that are regionally relevant. They should also actively help Future Earth distribute these products to key audiences, including policy makers.
  To link international research with national research communities and other stakeholders, Future Earth intends to involve the existing national committees that were established by the current GEC programs. New national structures will be established where none currently exist. These committees can help translate international research into products for national audiences, particularly national policy.

- **Supporting intergovernmental assessments:** Future Earth will also respond to the research needs identified by major global and sectoral assessments such as the Intergovernmental Panel on Climate Change, the Millennium Ecosystem Assessment, and the International Assessment of Agricultural Knowledge, Science and Technology for Development. The new Intergovernmental Platform on Biodiversity and Ecosystem Services, the Assessment of Assessments on the oceans provide other important opportunities for researchers to contribute and

collaborate through the mechanisms and networks of Future Earth. The information in assessment reports is widely used to build awareness about global environmental change, to provide future scenarios, to inform negotiations about environment and development, and to guide action on environmental issues.

Future Earth also aims to establish alliances with major international agencies that regularly provide reports on environment and development, such as WMO, UNEP and UNESCO, to ensure that Future Earth research responds to and informs stakeholder needs for up-to-date information and indicators of high scientific quality.

- **Contributing to international policy processes:** Future Earth contributes to the development of sustainable development goals (SDGs) by providing input into the UN Open Working Group tasked with developing a set of proposed SDGs during 2013 and 2014, to be submitted to the UN General Assembly for approval in 2015. The current GEC community is also leading research (e.g. Earth System Governance Project) that contributes to debate on SDGs at national and international levels. Future Earth also aims to play an important role in the implementation and monitoring of the SDGs. Work is already being done by the Science and Technology Alliance for Global sustainability to position Future Earth as a future partner to efforts on the SDGs.

  Another decision made at Rio+20 was to create a 'high-level political forum' (HLPF) that would replace the Commission on Sustainable Development (CSD) as the deliberating body for sustainable development in the UN. Launched in 2014, the HLPF will aim to "strengthen the science-policy interface through review of documentation, bringing together dispersed information and assessments, including in the form of a global sustainable development report, building on existing assessments". A session on Future Earth was held at the second HLPF meeting in July 2014 to encourage the HLPF to make use of the knowledge and expertise that will be available through Future Earth, and to set up mechanisms by which this relationship can be formalised.

  Improving the science-policy interface within UNEP was also a key decision at Rio+20, and this is another key UN process in which Future Earth could be involved. While these improvements still need to be defined, Future Earth could play a key role in providing the interdisciplinary scientific advice that the organisation requires.

  The GEC programs on which Future Earth will build on also contribute to international conventions, such as United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Biodiversity, and UN Convention to Combat Desertification. This contribution involves providing information and advice on scientific matters, organising side events and multi-stakeholder dialogues, and developing summaries for policy-makers.

  Future Earth is also exploring opportunities for collaborating with the UN Scientific Advisory Board, established to advise the UN Secretary-General and Executives of UN agencies on science for sustainable development related matters.

- **Linking with international Observing Systems, GEOSS, government observing and statistical programs:** Because establishing an independent data documentation, preservation, and access system for Future Earth will be costly

and complex, and because there are excellent organisations and institutions that are already committed to these activities, Future Earth plans to work with the existing observing systems and GEO/GEOSS to identify and possibly even calibrate needed data sets for research on global sustainability. Through GEO/GEOSS, Future Earth aims to partner with national data and observing systems where many of the decisions about data collection are actually made. Identifying needed socioeconomic data will also be an important task for Future Earth. Much of the currently available socioeconomic data are now collected by or under the auspices of government statistical agencies and some of this is brought together by UN agencies, national development agencies, or the World Bank. Active partnership with existing multilateral organisations will help in identifying needed data and stimulating the collection of data.

ANNEX 2 Towards principles to strengthen science advisory systems

A2.1 Principles of Science Advice to Government (from UK GO-Science) [37]

Preamble

The Principles of Scientific Advice set out the rules of engagement between Government and those who provide independent scientific and engineering advice. They provide a foundation on which independent scientific advisers and government departments should base their operations and interactions. The Principles apply to Ministers and Government departments, all members of Scientific Advisory Committees and Councils (the membership of which often includes statisticians, social researchers and lay members) and other independent scientific and engineering advice to Government. They do not apply to employed advisers, departmental Chief Scientific Advisers or other civil servants who provide scientific or analytical advice, as other codes of professional conduct apply.

Clear roles and responsibilities

- Government should respect and value the academic freedom, professional status and expertise of its independent scientific advisers.
- Scientific advisers should respect the democratic mandate of the Government to take decisions based on a wide range of factors and recognise that science is only part of the evidence that Government must consider in developing policy.
- Government and its scientific advisers should not act to undermine mutual trust.
- Chairs of Scientific Advisory Committees and Councils have a particular responsibility to maintain open lines of communication with their sponsor department and its Ministers.

Independence

- Scientific advisers should be free from political interference with their work.
- Scientific advisers are free to publish and present their research.
- Scientific advisers are free to communicate publicly their advice to Government, subject to normal confidentiality restrictions, including when it appears to be inconsistent with Government policy.
- Scientific advisers have the right to engage with the media and public independently of the Government and should seek independent media advice on substantive pieces of work.
- Scientific advisers should make clear in what capacity they are communicating.

Transparency and openness

- Scientific advice to Government should be made publicly available unless there are over-riding reasons, such as national security or the facilitation of a crime, for not doing so.
- Any requirement for independent advisers to sign non-disclosure agreements, for example for reasons of national security, should be publicly acknowledged and regularly reviewed.

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37 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/293037/10-669-gcsa-guidelines-scientific-engineering

- The timing of the publication of independent scientific advice is a matter for the advisory body but should be discussed with the Government beforehand.
- Government should not prejudge the advice of independent advisers, nor should it criticise advice or reject it before its publication.
- The timing of the Government's response to scientific advice should demonstrably allow for proper consideration of that advice.
- Government should publicly explain the reasons for policy decisions, particularly when the decision is not consistent with scientific advice and in doing so, should accurately represent the evidence.
- If Government is minded not to accept the advice of a Scientific Advisory Committee or Council the relevant minister should normally meet with the Chair to discuss the issue before a final decision is made, particularly on matters of significant public interest.

Applying the Principles

Scientific Advisory Committees, Councils and government departments should consider the extent to which the Principles in this document are reflected in their operation and to make changes as necessary. Issues relating to the function and working of scientific advisory bodies that are not reflected in these high-level Principles are discussed in more detailed guidance such as the Code of practice for Scientific Advisory Committees or the Guidelines on scientific analysis in policy-making.

Government departments and their independent scientific advisers should raise issues of concern over the application of the Principles, or other guidance, with the relevant departmental Chief Scientific Adviser (CSA). If the matter of concern cannot be effectively resolved or is especially serious CSAs should approach the Government Chief Scientific Adviser (GCSA) and Ministers should approach the GCSA and the Minister for Science. The matter will be examined against a clear set of criteria, which include a breach of the Principles or CoPSAC.

A2.2 The Code of Conduct for Scientists of the Science Council of Japan[38]

1. Responsibilities of Scientists: Scientists shall recognize that they are responsible for assuring the quality of the specialized knowledge and skills that they themselves create, and for using their expert knowledge, skills and experience to contribute to the health and welfare of humankind, the safety and security of society and the sustainability of the global environment.

2. Conduct of Scientists: Scientists shall recognize that scientific autonomy is upheld by public trust and the mandate of the people, and shall always make judgments and act with honesty and integrity. Moreover, scientists shall make the utmost effort to scientifically and objectively demonstrate the accuracy and validity of the knowledge they create through scientific research, and shall actively participate in mutual quality assurance such as peer reviews in the scientific community, especially in their respective fields of expertise.

3. Continuous Professional Development: As well as endeavoring to maintain and improve their own expertise, abilities and skills, scientists shall constantly strive to understand the relationships between science, technology, society and the natural

[38] Extracted from http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-20-s3e-1.pdf

environment from a wide-ranging perspective, and to demonstrate the best judgments and attitudes at all times.

4. Accountability and Disclosure: Scientists shall strive to disclose and actively explain the roles and significance of their own research, evaluate the possible effects of their research on people, society and the environment as well as the changes that their research might engender, neutrally and objectively disclose the results of this evaluation, and build a constructive dialog with society.

5. Research Activities: Scientists shall act with integrity according to the spirit of this Code of Conduct in drafting, planning, applying for, implementing and reporting their own research, ensure that research and survey data are recorded, stored and rigorously handled, and not only refrain themselves from any misconduct such as fabrication, falsification or plagiarism, but also refrain from aiding or abetting such misconduct.

6. Establishing Sound Research Environments: Scientists shall recognize that establishing and maintaining fair research environments where responsible research can be conducted is one of their important duties, and shall actively participate in efforts to improve the quality of research environments in the scientific community and their own institutions. Moreover, they shall also seek the understanding and cooperation of the public in achieving these goals.

7. Compliance with Laws and Regulations: Scientists shall observe all laws, regulations and relevant rules in their activities, including the implementation of research and the use of research funds.

8. Consideration for Research Subjects: Scientists shall respect the dignity and rights of individuals who cooperate with their research, and shall safeguard and give proper consideration to their welfare. They shall also treat animals and other research subjects with all due care and respect.

9. Relations with Others: Scientists shall constructively criticize the results of other scientists' research, humbly listen to the criticism of others, and exchange opinions with an attitude of sincerity. Moreover, they shall properly give credit to other scientists' intellectual findings and achievements, as well as respecting the honor and intellectual property rights of others.

10. Rejection of Discrimination: In their research, education and academic society activities, scientists shall respond to others fairly on a scientific basis, respect individual freedom and character, and not discriminate against individuals based on their race, gender, status, beliefs or religion.

11. Avoiding Conflicts of Interest: In their research, reviews, evaluations, judgments and other scientific activities, scientists shall pay sufficient heed to the presence of conflicts of interest between individuals and organisations, or between different organisations, and shall properly address problems paying all due attention to the public interest.

A2.3 **Principles** suggested **by Sir Peter Gluckman,** CSA-NZ[39]

Maintain the trust of many. The science adviser must sustain in parallel the trust of the public, the media, policy-makers, politicians and the science community. This is especially true in times of crisis and is no small challenge.

Protect the independence of advice. The advisory role should be structured so as to protect its independence from both political interference and premature filtering in the policy process. There is inevitably a tension between such independent advice and departmental policy processes, and it takes considerable diplomacy to create a trusted partnership between an external adviser and departmental officials.

Report to the top. Scientific advice must be available directly — uncensored — to the head of government or the head of the relevant department. Indeed, the questions for which advice is most often sought tend to be politically sensitive and cut across individual portfolios.

Distinguish science for policy from policy for science. Science advising is distinct from the role of administering the system of public funding for science. There is potential for perceived conflict of interest and consequent loss of influence if the science adviser has both roles. There is a risk that the adviser comes to be perceived as a lobbyist for resources, or that the role becomes restricted to the ministry that manages the national research funding. Yes, a science adviser should have input into science policy, but there is a delicate balance to strike.

Expect to inform policy, not make it. Science advice is about presenting a rigorous analysis of what we do and do not know. Alone, it does not make policy. There are many other appropriate inputs to policy, including fiscal considerations and public opinion. Policy-makers and elected officials rightly guard their responsibility to define policy — and this means choosing between options with different trade-offs. This is not the domain of a science adviser. Being explicit about this has eased my capacity to establish and sustain trust broadly across government and the policy community.

Give science privilege as an input into policy. While acknowledging the other relevant inputs into policy formation, we need to demonstrate why science should hold a privileged place among the 'types of knowledge' that may be meaningful to a politician. These include social tradition and popular belief. The privilege of science-derived knowledge comes from its set of standard procedures — for example, replication and peer review — that limit the influence of beliefs and dogma. The other inputs into policy are value-intensive, and rightly so.

Recognize the limits of science. Science can increasingly address complex questions over which policy-makers and elected officials agonize. But scientists must not overstate what is or can be known, even though the shift from a view of science as a source of certainty to a source of probability can frustrate and confuse decision-makers and the public. How many politicians or issues advocates have claimed that they can find a scientist to back any position as, indeed, at least one did in the folate debate? This attitude reflects the dangerous temptation to use science to justify value-based beliefs[6] and a lack of literacy about what science is (a process)[7]. For example, much of the debate

[39] Extracted from the article in Nature http://www.nature.com/news/policy-the-art-of-science-advice-to-government-1.14838

about climate change is not primarily about the data. Rather, it is about intergenerational economic interests.

Act as a broker not an advocate. Trust can be earned and maintained only if the science adviser or advisory committee acts as a knowledge broker, rather than as an advocate[6] — often a subtle distinction. When formal science advice is perceived as advocacy, trust in that advice and in the adviser is undermined, even if the advice is accepted. For example, exaggerated presentations about the causes of storms and floods can erode the credibility of the underlying argument about global warming.

Engage the scientific community. The science adviser must know how to reach out to scientists for the appropriate expertise, and help them to enact their social responsibility in making their knowledge accessible and understandable, and in being more self-aware about when they might be acting as advocates. These issues are encapsulated in the recently updated, groundbreaking Code of Conduct for Scientists[8], which directly implies a distinction between brokerage and advocacy, published by the Japanese Council of Science.

Engage the policy community. The role of the science adviser is often less about providing direct technical expertise than it is about nudging attitudes and practices to enhance both the demand for and the supply of evidence for public policy.