MEASURING THE EFFECTIVENESS OF SCIENTIFIC ASSESSMENTS AT THE KNOWLEDGE-POLICY INTERFACE

by

Gregory Oliver Schreiner

(Person number: 1813771)

Thesis

Submitted in fulfilment of the requirements for the degree

Doctor of Philosophy (D.Phil.)

School of Animal, Plant and Environmental Sciences

Faculty of Science, University of the Witwatersrand, Johannesburg, South Africa

Supervisor: Prof Robert John Scholes (Wits)

Co-supervisors: Prof Reinhard Mechler (IIASA) & Dr Luthando Dziba (SANParks)

September 2020

ABSTRACT

‘Scientific assessments’ are elaborate knowledge-policy processes which convene large numbers of experts, policymakers and stakeholders. Their purpose is to surface, deliberate and then organise knowledge relevant to multi-facetted problems of high social importance. Well-known examples include the processes and published reports of the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES). Given the widespread and increasingly frequent use of scientific assessments over the past 30 years at global, regional, national and sub-national scales, it is surprising that few empirically based effectiveness evaluations exist. This research asks two questions: Are scientific assessments effective? And, in the South African context, will they help advance our own knowledge-policy interface? To answer the first question, I apply a case-study mixed methods approach to six scientific assessment cases – two at global scale, two at regional scale and two at national scale. This approach integrates quantitative and qualitative data from: 1.) a systematic review (n = 162); 2.) an online survey (n = 674); 3.) semi-structured interviews (n = 43); and 4.) my own experience from involvement in scientific assessments. Using an evaluation framework based on the dimensions of *credibility*, *relevancy*, and *legitimacy* (CRELE) there is overall good evidence supporting the hypothesis that scientific assessments are effective knowledge-policy processes. With high confidence, based on agreement between multiple lines of enquiry, I conclude that specific areas of strength include their ability to engage multi- and interdisciplinary teams in iterative knowledge production procedures in a transparent way, producing high-quality scientific outputs which policymakers generally find useful; and which garner a high degree of stakeholder trust. There is slightly less agreement between sources regarding the areas which could be improved. Measured against a hypothetical ‘best-case’ (which may be an unrealistic and unnecessarily high target) specific areas in which there is scope for improvement include the adequate planning of financial and human resources, taking note of ‘assessment fatigue’ and the need for future capacity building; the integration of non-academic knowledge systems or ‘transdisciplinarity’; the provision of more co-production opportunities between experts, policymakers and stakeholders; and the need for innovative public communication and media strategies. With respect to the second question, despite the existence in South Africa of a well-established and resilient knowledge-policy infrastructure, there are nevertheless examples of decision-making processes poorly informed by evidence. These practices primarily subscribe to the ‘test’ model of policy generation, where policymakers rely on legislated minimum requirements rather than adopting more sophisticated, open-ended knowledge production approaches. Given that uneven history, there is little doubt that the targeted application of scientific assessments, for problems that call for a complex response, would substantially help to improve decision-making in South Africa.

DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously, in its entirety or in part, been submitted at any university for a degree.

GREGORY OLIVER SCHREINER

Signed by (names in full)

29 September 2020

Signature *Date*

ACKNOWLEDGEMENTS

To my wife Gemma, and daughter Grace, and to my larger family – my father Geoff, my stepfather David, my mother Josephine, and my stepmother Viv – thank you for everything.

To my supervisor Prof Bob Scholes – who I met in 2014 when we both worked at the Council for Scientific and Industrial Research (CSIR) – thank you for teaching me how to conceptualise, design and actually ‘do’ scientific assessments. To my manager at CSIR Paul Lochner, thank you for advising me through my career, personally and professionally. I would also like to thank my PhD co-supervisors: Prof Reinhard Mechler from International Institute for Applied Systems Analysis (IIASA) and Dr Luthando Dziba from SANParks for their time and assistance.

Funds were made available to me by the Global Change Institute (GCI) at Wits University, including the opportunity to attend the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) plenary session in March 2018. I was also a member of the Southern African Systems Analysis Centre (SASAC)[1] second cohort, under the leadership of Prof Mary Scholes. Through SASAC, I received PhD funding, was provided the opportunity to attend multiple research training initiatives (hosted by the African Doctoral Academy at Stellenbosch University), as well visit IIASA in June 2018. In June 2020, I was awarded the Young Researchers Establishment Fund (YREF) grant by the CSIR to publish the outputs from the PhD research in journals and science-policy guideline documents from 2020-2022.

Other important guidance was offered by: Prof Robert Morrell (University of Cape Town) who reviewed early draft chapters; Prof Martin Kidd (University of Stellenbosch) who assisted with statistical analyses; Associate Professor Katharine Mach (University of Miami) and Dr Martin Kowarsch (Mercator Research Institute on Global Commons and Climate Change) who provided important insights into the research design; Luanita Snyman-van der Walt who helped to develop figures; Jolene Lester who assisted with the collection of email addresses; Natasha Ferreira who typed up interview transcripts; Magdel van der Merwe who formatted the manuscript; and Anne-Marie Taylor who copy-edited the thesis.

Finally, I would like to thank the research participants who contributed – the 674 respondents who took the time to respond to the online survey and the 43 participants who agreed to be interviewed by me over the course of 2018 and 2019.

[1] SASAC was a multi-year initiative between the National Research Foundation (NRF), the Department of Science and Technology (DST), a consortium of universities and IIASA to support PhD students at South African universities.

CONTENTS

ACRONYMS AND ABBREVIATIONS

'Africa'	IPBES Regional Assessment Report on Biodiversity and Ecosystem Services for Africa	**LRTAP**	Assessment of Long-Range Transport of Air Pollutants
AR	Assessment Report	**MEA**	Millennium Ecosystem Assessment
ASC	UK Adaptation Sub-Committee	**MEP**	Multidisciplinary Expert Panel
CA	Contributing Author	**MIRs**	Minimum Information Requirements
CBD	Convention on Biological Diversity	**NAP**	National Adaptation Plan
CCC	UK Climate Change Committee	**NCP**	Nature's Contribution to People
CCRA	UK Climate Change Risk Assessment	**PCG**	Process Custodians Group
CCRA2	UK Second Climate Change Risk Assessment	**PEC**	Project Executive Committee
CLA	Coordinating Lead Author	**PEM**	Pragmatic Enlightenment Model
CRELE	Credibility, relevancy, legitimacy	**PR**	Peer Reviewer
CS	IPCC Chapter Scientist	**PredSA**	South African Predators Assessment
CS-MM	Case Study Mixed-Methods	**RE**	Review Editor
DMF	Decision-making Framework	**SAfMA**	Southern African Millennium Ecosystem Assessment
ECA	IPBES Regional Assessment Report on Biodiversity and Ecosystem Services for Europe and Central Asia	**SDG**	Sustainable Development Goals
EIA	Environmental Impact Assessment	**SEA**	Strategic Environmental Assessment
FOD	First Order Draft	**SGD**	Shale gas development
GNI	Gross National Income	**SGSA**	Shale Gas Scientific Assessment
IAC	InterAcademy Council	**SOD**	Second Order Draft
IAM	Integrated Assessment Model	**SPM**	Summary for Policymakers
ICSU	International Science Council	**TSU**	Technical Support Unit
ILK	Indigenous and Local Knowledge	**UNEP**	United Nations Environment Programme
IMoSEB	International Mechanism of Scientific Expertise on Biodiversity	**UNFCCC**	United Nations Framework Convention on Climate Change
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services	**WG**	Working Group
IPCC	Intergovernmental Panel on Climate Change	**WGII AR5**	Working Group II, Assessment Report 5
LA	Lead Author	**WMO**	World Meteorological Organisation
LDR	The IPBES Assessment Report on Land Degradation and Restoration	**ZOD**	Zero Order Draft

FIGURES

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CHAPTER 1. INTRODUCTION

The purpose of this chapter is to present the focus of the research, provide some background context to the problem in question, and introduce the reader to the structure of the thesis.

1.1 The purpose of the research

This research focuses on the social technology known as 'scientific assessment'.

Scientific assessments are elaborate knowledge-policy processes which convene large numbers of experts, policymakers and stakeholders. Their purpose is to surface, deliberate and then organise knowledge relevant to multi-facetted problems of high social importance. Beyond the reports they generate, these highly structured social processes now serve as essential knowledge intermediaries between science and policy (Farrell and Jäger, 2006).

While theoretical evaluation frameworks are presented in the scientific assessment literature, for example, in Cash and Clark (2001), Young *et al*. (2013), Sarkki *et al*. (2014), Kowarsch *et al*. (2016) and Alcamo (2017); very few empirical analyses have been undertaken using these frameworks (Heink *et al*., 2015).

Scientific assessments are highly influential important tools used at the science-policy interface. They have a substantial impact on shaping policy and social behaviour, with a large and incompletely quantified quantity of human and financial resources dedicated toward their execution, year on year. There is thus an urgent need to initiate experimentation with effectiveness evaluations (Corbera *et al*., 2016 – to develop some 'markers in the sand' in order to track the progress of scientific assessments and provide some metrics from which overall progress can be enhanced (Kowarsch *et al*., 2016).

This research intends to test whether scientific assessments are effective or not by evaluating six cases against a set of theoretical 'best-case' indicators. Based on their effectiveness, I then explore the potential for scientific assessment to play a larger, more influential, role in the South African knowledge-policy interface. In summary, the two questions guiding this research are:

1. Are scientific assessments effective?
2. Will they help to advance the South African knowledge-policy interface?

1.2 The methodological approach

To test the first question, I apply a case-study mixed methods approach to six scientific assessment cases – two at global scale, two at regional scale and two at national scale. This approach combines qualitative and quantitative data from: 1.) a systematic review of the literature (n = 162); 2.) an online survey answered by case participants (n = 674); 3.) semi-structured interviews (n = 43); 4.) as well as drawing from my own experiences of managing scientific assessment processes.

To explore the second question, I provide an overview of the literature examining the structure and trends inherent to the current knowledge production and policymaking landscape in South Africa. With this in mind, and considering the results of the first research question, I make some inferences about the usefulness of scientific assessments playing a more substantial role in the South African knowledge-policy interface.

1.3 Background to the problem

The notion of progress has, for the past few hundred years, guided human development. Post the 17th century Enlightenment, major advancements in civil and political rights, healthcare, trade systems, education and infrastructure helped to produce societies where people now live healthier, safer and longer lives than ever before in human history (Pinker, 2018).

Testament to this, a recent evaluation of the Millennium Development Goals (UN, 2015) – which set 18 socio-economic and environmental targets for the period 2000 to 2015 – revealed that five of the socio-economic targets had been achieved, including: halving the share of the world's population living in extreme poverty; decreasing gender disparity in education; reducing the rate of new malaria and tuberculosis infections; and halving the percentage of the global population without access to clean drinking water. For the remaining three socio-economic targets, while they had not quite achieved their targets, substantial advancements were made (Ritchie and Roser, 2018).

In contrast, the world failed *"…most miserably"* in meeting its environmental targets, including those relating to climate change, ocean acidification, nitrogen and phosphorus cycles, biodiversity loss, land-use change and freshwater degradation and depletion (Ritchie and Roser, 2018: 1). The widespread human alteration of natural systems led, in 2019, to the designation of a new geological epoch: the 'Anthropocene' (Subramanian, 2019) – where, for the first time in history, the impact of human activities now match those of the earth's geophysical processes (Steffen *et al.*, 2011).

Human-nature interactions in the Anthropocene are characterised by ‘wicked’ problems. In other words, problems that are partly values-based, frequently characterized by a polarizing stakeholder divergence and are insoluble from a strictly technical perspective[2] (Kowarsch *et al.*, 2016), Characterising and developing solutions to these problems is the highest policy prerogative in most democratic societies. This is formally codified within globally agreed policies like the United Nations’ Sustainable Development Goals.

The once rather separated domains of science and policymaking now find themselves in a burgeoning, co-evolving relationship. At this often *“…messy”* interface (Horton & Brown 2018: 2) where knowledge, society and policymaking coalesce, Van Enst, Driessen and Runhaar (2014) report that the use of science is underexploited. Research has consistently demonstrated that policymakers primarily use experiential knowledge to make decisions, with personalised internet searches cited as the preferred information source globally (Cvitanovic and Hobday, 2018) and within South Africa (Godfrey, Funk and Mbizvo, 2010).

A social technology called scientific assessment[3] emerged in the 1990s to navigate this ‘messy’ interface with the aim of developing the knowledge base required to inform critical policy negotiations. Three decades later, in their continually evolving form, scientific assessments play a pivotal role in shaping global policy and influencing wider social behaviour[4]. In this way, they play *“…a unique and critical role in the contemporary world”* (Oreskes, 2015: 19). Increasingly so, substantial amounts of human and financial resources are dedicated towards their execution, year on year (Kowarsch *et al*., 2016).

While the success factors of scientific assessment are widely reported in the literature[5], very few effectiveness evaluations have been undertaken using these instruments (Heink *et al*., 2015). In the

[2] With ‘wicked’ problems, the ‘facts’ alone don’t provide for optimal or universally accepted solutions – but socially or politically negotiated outcomes are nevertheless possible. Wicked problems differ from complicated and complex problems. Complicated problems are difficult and have many components but are underpinned by deterministic causal theories. Complex problems are also in principle soluble but are less deterministic, due to the presence of feedbacks and non-linearities, which lead to alternate states, tipping points and path-dependencies.

[3] *Scientific* assessments are so named because they embrace the principles of rationality and evidence synthesis. Having said that, while science is core to their philosophical frameworks and processes, other knowledge forms are increasingly welcomed. In this way, the word ‘science’ in scientific assessments must be viewed in the post-normal sense of embracing a wide range of knowledge systems, in order to generate the most complete picture of reality.

[4] Two prominent examples are the Montreal Protocol and the Paris Climate Agreement.

[5] Scientific assessment is underpinned by three principles: *credibility*, *relevance* and *legitimacy* (shortened to “CRELE”). Chapter 3 provides detailed definition of CRELE, but roughly speaking: *Credibility* means meeting

South African context, although scientific assessments have been trialled to good effect on an *ad hoc* project basis on three or four separate occasions, we still know very little about their real impact and even less about what makes them succeed or fail. Part of the reason for this is that they are not formally supported or codified in the national science and research policy in South Africa, as they are, for example, in the United States or the United Kingdom.

1.4 Thesis structure

Following on from the introductory chapter, Chapter 2 traces the co-evolving relationship between knowledge production and policymaking – from their initial 'normal' forms, to their contemporary, 'post-normal' forms. Set within this evolving landscape, I introduce the knowledge-policy interface processes known as 'environmental assessments' paying specific attention to one of their sub-types called 'scientific assessment'. The rest of Chapter 2 focuses exclusively on scientific assessment. It explains their philosophical underpinnings, characteristics, principles, as well as describing their practical purposes, users, stages and methods of knowledge production. Specific reference to the South African knowledge-policy context is provided, along with a brief description of local examples of scientific assessments undertaken in the last 15 years.

Chapter 3 provides an overview of the methods adopted in the research. Since the approach is 'case-study mixed methods' which integrates a diversity of approaches and data sources, I present a framework explaining my own personal philosophical position and the theoretical lens guiding the research. Next, I sketch the research gap, explaining why this project closes important gaps and offers some value to the wider knowledge community interested in this topic. I then present the two research questions, explain the rational for the adoption of the CRELE framework and unpack other important issues such as data integration, reliability, limitations and ethical considerations.

Chapters 4-6 provide the 'within-case' analyses of the six cases. Each case is analysed using nine subcategory constructs: *representation*, *resources*, *drivers*, *trust*, *capacity building*, *adaptability*, *knowledge*, *quality* and *implementability*. Chapter 4 does this for the (i) Working Group's II contribution to the 5th Assessment Report of the IPCC (global). Chapter 5 does the same for three cases from IPBES: (ii) report on Land Degradation and Restoration (global), (iii) report on Biodiversity and Ecosystem Services for Africa (regional) and (iv) report on Biodiversity and Ecosystem Services for Europe and Central Asia (regional). Chapter 6 applies the analysis to two

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the standards of scientific rigor and technical adequacy. *Relevance* means that the outputs are useful for the public and policy-makers. *Legitimacy* means implementing an unbiased process which considers appropriate values, the concerns and perspectives of different actors, and corresponds with political and procedural fairness.

national scientific assessments, one from the United Kingdom, (v) the UK Second Climate Change Risk Assessment Evidence Report; and the other from South Africa, (vi) the Shale Gas Scientific Assessment.

Chapter 7 presents a 'cross-case' analysis. It synthesises the overall similarities and differences between the cases, again using the nine subcategory constructs. From the evidence presented, broader-scale inferences about the overall effectiveness of scientific assessments are made, as well as the identification of areas of performance strength versus those requiring improvement. Chapter 8 provides the conclusions, specifically addressing the two guiding research questions .

CHAPTER 2. THE KNOWLEDGE-POLICY INTERFACE AND ITS PROCESSES

2.1 Introduction

The purpose of this chapter is to trace the co-evolving relationship between knowledge production and policy-making from their initial 'normal' forms, to their contemporary, 'post-normal' forms. Set within this evolving landscape, I introduce the concept of knowledge-policy interface processes known as environmental assessments, paying specific attention to one of their 'sub-types' called scientific assessment. I then focus exclusively on scientific assessment, describing their philosophical underpinnings, characteristics, principles, as well as their practical purposes, users, stages and methods of knowledge production. Specific reference to the South African knowledge-policy context is provided where relevant, and as it relates to both the knowledge-policy interface and its relationship with scientific assessment.

2.2 The different 'modes' of knowledge production

Science[6], dating back to the Enlightenment, is humanity's most organised attempt at understanding the nature of the world. The last 400 years of scientific endeavour have been profoundly influential in the way humans think, behave and live (Pinker, 2018).

Science has permeated human societies in every sense into our everyday lives, from daily interactions with medicines and weather forecasts, to macro decision-making processes in national and international policy arenas (Sarewitz, 2016). It now exists in the hands of governments, the private sector, civil society and individuals as a tool for meeting the wide-ranging expectations of human needs.

Much of early science was an effort to know the universe better in the pursuit of knowledge, driven by an innate human curiosity. Around the 17th to 19th centuries the leading impetus for science was the pursuit of truth (van den Hove, 2007). Gibbons *et al*. (1994) have referred to this as 'Mode 1 knowledge production'. Mode 1 operated primarily within the 'technology transfer model', where

[6] A holistic but precise definition of science is challenging because science is so diverse, so large and so complex (Ziman, 2000). However, in everyday language, it can be thought of as the transparent and systematic pursuit of knowledge which accumulates over time (Feynman, 1998). Most disciplines of science have their criteria for what constitutes good science, however, what all the disciplines have in common is a commitment to an extended period of expert scrutiny undertaken in a transparent manner (Ziman 2000).

science and decision-making were acted out as *"…independent monologues"*, with only the intermittent exchanges between scientists, policymakers and society (van den Hove, 2007: 807).

While Mode 1 knowledge production did drive many aspects of human progress, the manner in which questions were framed excluded the primary funders and users from knowledge production processes. With little reflection of the needs, interests and values of the users, the outputs from Mode 1 were frequently unsuitable for social application and did not reflect social priorities (Ziman, 2000).

During the 20th century, the limitations to Mode 1 inspired the development of a new, context-driven and problem-focused science called Mode 2 knowledge production (Gibbons *et al*. 1994). Where Mode 1 was located primarily in scientific institutions and structured by scientific disciplines, in Mode 2 the knowledge production locations, practices and principles became much more heterogeneous[7] (Table 1).

Table 1: The main differences between Mode 1 ('normal science') and Mode 2 ('post-normal science') [table generated after Frost & Osterloh (2001) and Hessels & van Lente (2008), based on the work of Gibbons *et al*. (1994)].

Elements	Mode 1 ('Normal science')	Mode 2 ('Post-normal science')
Drivers	Curiosity driven; questions posed by the scientific community. Academic context	Issue driven; questions posed by society. Context of application
Focus	Cognitive context, narrow focus, homogenous teams, divided by discipline	Social and economic context, broad focus, transdisciplinary, heterogeneous teams
Production	Single-source knowledge production by scientific community	Joint knowledge production. Knowledge is produced by continuous negotiation with stakeholders and policy-makers
Quality control	Criteria for quality control defined within the scientific community, autonomous peer-to-peer review	Criteria for quality control defined within the user groups, peer-to-peer review plus wider stakeholder review. Reflexive with social accountability
Knowledge distribution	Limited to scientific community and funders	Extended to affected stakeholders, governments and decision-makers
Users	Scientific community. Little dialogue between scientists and knowledge users	Society. Stakeholders active agents in the definition and solution of problems

[7] Through this thesis, I will use the terms 'normal' and 'post-normal science' (Funtowicz *et al*. 1998) synonymously with Mode 1 and Mode 2 knowledge production (Gibbons *et al* 1994).

2.3 The knowledge-policy interface

As normal science has continued to evolve into its contemporary post-normal form, it has come to be characterised by new knowledge production approaches. Those which are able to cope with uncertainty and high decision stakes while promoting a convergence of epistemological diversity, in other words transdisciplinarity[8] (Hessels and van Lente, 2008) and enhancing knowledge co-production[9] interactions (Miller and Wyborn, 2018).

These new knowledge production 'heuristics' (in other words, tools for problem solving and learning) now dedicate themselves toward the generation of solutions and technologies helpful for society. This has come to be realised by governments around the world, who have, for the last 200 years or so, become the dominant funders of science (Gibbons *et al.*, 1994). This has inspired a burgeoning relationship between science and political systems of governance (Morgan, 2014) in which the expectations are high – governments have invested generously in science and they are now looking for meaningful solutions (Gluckman, 2019c).

These expectations exist in opposition to a series of novel challenges at the contemporary knowledge-policy interface. For one, policymakers, like scientists, now operate within new unchartered and chaotic environments but have limited bandwidth to absorb constant flows of information. Policy-makers are sometimes unreceptive to new information – they may choose to ignore inconvenient facts and remain firmly committed to a predefined course of political action (Mitchell *et al.*, 2006). They are also severely constrained by electoral and fiscal impetus; their policy cycles are becoming both faster and more complex; and governments increasingly operate within fragmented departmental silos characterised by 'turf' protection (Gluckman, 2019c).

[8] Klein *et al.* (2001) characterises transdisciplinarity as a process of collaboration between scientists and non-scientists on specific real-world problems. Burton *et al.* (2008) suggests that transdisciplinarity is the highest form of an integrated process, involving not only multiple disciplines, but also multiple participants in a manner that combines scientific interdisciplinarity with participatory stakeholder approaches. Transdisciplinary knowledge production approaches have been formally embraced by the highest levels of the global scientific community (Swilling, 2014), by many national governments, including South Africa (DST, 2018), and by the private funding agencies (Harris and Lyon, 2014).

[9] In a similar way to transdisciplinarity, co-production challenges the assumptions of normal science, especially the 'top-down' information transfer model which separates the generators of knowledge from the users of knowledge and prioritizes the role of academia (Harris and Lyon, 2014). But there also exist some differences. Firstly, where transdisciplinarity is focused on the generation of knowledge from diverse and context relevant knowledge systems between researchers and wider society, co-production is mainly focused on the collaborative relationship between researchers and policy-makers in generating and disseminating socially relevant findings. Secondly, where the central thesis of transdisciplinarity is to produce socially relevant and implementable knowledge from a range of knowledge sources, Cvitanovic (2015) argues that co-production is primarily a knowledge exchange tool, were researchers and policymakers shape research questions, determine methodologies, collect data, develop tools, interpret and disseminate findings (Graham & Tetroe 2009).

On the other hand, scientists have a skewed perception of the policy process, leading them to become frustrated when their evidence is not immediately adopted. They often fail to communicate their theories and evidence effectively to wider audiences. Along with the traditional 'top-down' bias, the hesitancy policymakers experience when considering the inclusion of scientists in policymaking processes is often a result of an overexposure to advocates and lobbyists adopting a 'science mantle' (Gluckman, 2019c).

While policymakers see scientists as good at problem definition, they commonly don't believe them to be sufficiently pragmatic to generate fit-for-purpose solutions. In this context, scientific knowledge production processes struggle to offer policy-acceptable and scalable solutions (Horton and Brown, 2018). Major portions of global science-policy systems continue to fail, according to a recent report by the InterAcademy Council (IAP Workgroup, 2019).

Science, and broader knowledge production practices, also face novel risks in the 21st century. On the *knowledge production* side there is a vast oversupply of journals and publications[10] (Gluckman, 2019b); an increasing number of financially motivated biases (Jeschke *et al.*, 2019); procedural incompetence (Ziman, 2000) leading to issues such as the 'irreproducibility crisis'[11] (Baker and Penny, 2016); and the rise of a new brand of postmodern radicalism which undermines the epistemic fabric of western society[12] (Lindsay, Boghossian and Pluckrose, 2018).

On the *knowledge dissemination* side, the ascendency of post-truth politics and rising nationalism (Higgins, 2016) coupled with a mixture of popularity-based online algorithms[13], echo-chambers and click-bait media[14] has metastasised into to a style of information sharing which has left real

[10] In 2018, more than 3 million journal papers were published in 30 000 journals by 7 million authors (Gluckman, 2019b). Of those, in the vicinity of 82% from the humanities, 27% from the natural sciences and 32% from the social sciences papers will not be cited once (Larivière, Gingras and Archambault, 2009).

[11] In a study published by Nature, 1 576 scientists were surveyed. The study found that 70% of respondents had failed to reproduce other researcher experiments and more than half had failed to reproduce their own experiments (Baker and Penny, 2016).

[12] A widely publicised exposé of postmodern grievance studies published in 2018, called the 'Grievance Studies Hoax', suggests that a radicalised brand of postmodernism is spreading rapidly in universities and becoming more prevalent in popular culture (Lindsay, Boghossian and Pluckrose, 2018). Within this ideological framework, knowledge production is reduced to a process of identity-based groups struggling for power ascendency.

[13] The algorithmic patterns running the online search systems, such as Google (which handles at least 63 000 searches per second or 5.5 billion per day), are based solely on popularity and lack fact-checking procedures (Wilber, 2018).

[14] An echo chamber is a social network, usually algorithmically generated, where an individual only encounters beliefs or ideological positions which match their own. Media click-bait is online publications (e.g. news

knowledge in short supply (Jeschke *et al.*, 2019). Inching ever closer to what renowned philosopher Philip Kitcher referred to as 'vulgar democracy' (Gluckman, 2020).

Some scholars have coined the term 'post-truth' to describe the current era of knowledge creation and dissemination. This involves carelessly or strategically inserting lies into the discourse in a way which appeals to personal emotions in order to garner support for an issue (Higgins, 2016). The Oxford English Dictionary named 'post-truth' as the 2016 'Word of the Year' (Lubchenco, 2017). Some consider the post-truth phenomenon to be a pervasive challenge to the very nature of how scientists, citizens, the media, elected officials and interest groups interact (Hawkins, Míriam and Dixon, 2018), and in this way undermine the traditional instruments of democracy and reason (Gluckman 2017a).

2.4 The knowledge-policy interface in South Africa

There is a rich history, extending over a century or more, of knowledge-policy engagement in South Africa (Von Der Heyden *et al.*, 2016). Evidence-based policy is promoted at the highest level of present government, for example, in the vision of the National Development Plan[15]. As such, policy-makers in South Africa are under increasing pressure to demonstrate that they have shown due diligence by considering suitable evidence in the policy cycle (Godfrey, Funk and Mbizvo, 2010).

Several central government ministries have been given a Science, Technology and Innovation (STI) mandate (Marais and Pienaar, 2010). These include the Ministries of Higher Education, Science and Technology; Trade, Industry and Economic Development (Marais and Pienaar, 2010); Environment, Forestry and Fisheries; Performance Monitoring and Evaluation; and Public Service and Administration (Langer and Nduku, 2019).

On the other hand, South Africa is known for transferring research outputs from universities and science councils to the policy environment in a unidirectional and hit-and-miss way, where researchers 'push' information in the hope that policymakers will take up their findings. This has highlighted a fundamental weakness in the South African science-policy model, that there seems to

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articles, opinion pieces etc.) specifically generated to attract online attention. They are designed to incite base human emotions like fear and anger and are commonly presented within false and polarizing narratives.

15 The National Development Plan (NPC, 2012), adopted in 2012 as country's overarching vision for addressing these problems (and 'readopted' under the current political administration). The plan focuses on the key areas of capability within South African society which have some potential to transform the South African economy, society and natural resource base (DPME 2014).

exist a surplus of supply and a deficit in demand in certain areas (Godfrey, Funk and Mbizvo, 2010). The result is an 'implementation chasm' between research and its uptake in technology domains. An analysis of South Africa's knowledge production systems undertaken by Marais & Pienaar (2010) reported that the South African policy landscape has changed substantially since 1994, but that implementation has been poorly executed, especially regarding building domestic innovation systems to promote economic development opportunities. The study suggests that while the South African economy grew rapidly following democratisation in 1994, the STI sector failed to follow suite[16].

Von Der Heyden *et al*. (2016) provide a categorisation of knowledge-policy interactions in South Africa. They contend that the overarching method of engagement adopted is the 'test' model, where policymakers rely on legislated minimum requirements, rather than more sophisticated, open-ended knowledge production practices (Table 2).

Table 2: Categorisation of the different modes of engagement at the South African knowledge-policy interface with the 'test' model most frequently adopted by policymakers (Von Der Heyden *et al*., 2016).

Strategy	**Description**
'Tell'	No debate. Limited scientific and external input. Unlikely to be used, except for policy issues where there is likely to be contestation e.g. e-tolling, sugar tax, nuclear programme.
'Sell'	No debate or external input. Attempts to 'sell' the policy as being in the public 'best interest' e.g. the Department of Mineral Resources promotion of SGD in the Central Karoo.
'Test'	Draft policy released for public comment. Public outrage results in policy disappearing for some time or indefinitely. Public silence taken as tacit agreement e.g. amendments to the mining legislation and beneficiation.
'Consult'	Framework policy shared and discussed with key stakeholders with consultations used to inform the draft policy before it is published for general public comment e.g. public consultations over land redistribution and restitution.
'Co-create'	Broad-based policy issue shared with key stakeholders. Policy development plan is agreed that includes elements of how science will inform policy through focussed new research activities, synthesis and other activities. e.g. South Africa's Climate Change Response Strategy led by the Department of Environmental Affairs.

This systematic lack of co-creation opportunities creates a series of barriers to effective knowledge-policy interaction in South Africa. Based on Von Der Heyden *et al*. (2016); Godfrey, Funk and Mbizvo (2010) and DST (2018), these barriers include:

[16] This has partly been due to latent internal political tension between more technocratic elements in the ruling party and more ideological elements, the negative impact of 2007 economic crisis, and the socio-economic developmental needs of the country receiving highest political priority (Marais and Pienaar, 2010).

1. **Timing, training, data & human capital**: Research can take many years. Policymakers, on the other hand, work on much shorter time scales, sometimes days or weeks. Insufficient opportunities are provided for training and capacity development, making knowledge-policy processes either slow or ineffective. A lack of data accessibility and government capacity to find and evaluate the relevant data also plays a role.
2. **Language, engagement & mutual understanding**: Both scientists and policymakers lack the insights into one another's cognitive and institutional constraints. Poor communication and the lack of a 'language' to bind collaborative efforts means that both problem formulation and the generation of solutions can prove challenging.
3. **Performance metrics**: Success in science is measured by academic impact, while policymakers are appraised based on policy outputs. Different targets mean different aims. Frequently powerful role-players will move a process in a direction which is not necessarily beneficial for all participants. This creates distrust and limits accountability, perceived or otherwise.
4. **Certainty**: Scientists are often unable or unwilling to provide the certainty needed by policymakers. Partly because uncertainty is inherent to most complex issues, but also because of a lack of clear question formulation. In these instances, knowledge can be ignored if policymakers have not been convinced of its importance, significance, relevance or implications for society.

2.5 Knowledge-policy processes

At the messy, post-normal knowledge-policy interface exist procedures called 'knowledge-policy processes'[17]. Van den Hove (2007: 815) conceives of knowledge-policy processes as allowing for *"…exchanges and the joint construction of knowledge with the aim of enriching decision-making*". The literature describes a large variety of different knowledge-policy processes (Kowarsch *et al.*, 2016).

Knowledge-policy processes encompass a range of institutional structures, including mandated projects, expert groups, state agencies and wider stakeholders and include diverse aspects such as knowledge generation, exchange, negotiation and decision-making (Tinch *et al.*, 2016). They can be highly formalised, rule-based structures, such as 'boundary organisations'[18] like the IPCC or IPBES. Alternatively, they can be relatively informal processes undertaken as part of a conventional research programme, such as one-on-one conversations, meetings, workshops and field-trips (Cash *et al.*, 2003) (Table 3).

[17] Also known as science-policy interface processes or 'SPIs'.
[18] For a definition of 'boundary organization', see Table 3, row 4.

Table 3: The diverse types of knowledge-policy processes generated after Van Enst *et al.* (2014) and Gluckman (2018) or otherwise referenced in parentheses.

Knowledge-policy process	Actors	Goal	Strategy	Examples
1) Individual science-policy mediators	Individual, renowned scientist or expert, 'chief scientist', policy-makers	Facilitate the creation, sharing and use of knowledge	Interface between knowledge and decision-making	Knowledge brokers, science arbiters, issue advocates, pure scientists (Pielke Jr, 2007). Also includes aspects like informal meetings, workshops and field trips
2) Processes of knowledge development	Researcher led, scientists, experts, policy-makers, stakeholders	Create common understanding and knowledge in a participatory way	Through participatory gathering with involved stakeholders, exchange of ideas and negotiation	Research programmes, initiatives, peer-reviewed papers. Also includes post-normal hybridisations between different SPI types
3) Processes to inform decision-making	Consultant led, scientists, experts, policy-makers, stakeholders	Inform governmental decision-making on projects, plans, programmes	Undertake participatory, procedurally fair impact assessment processes	Impacts assessments including EIA, SEA, HIA, etc. (Pope *et al.*, 2013)
4) Boundary organisations	Organisations consisting of boards, scientists, stakeholders and policy-makers	Bridge the gap between science and policy, policy-relevant in most cases	Collect and distribute scientific knowledge, translate science for policy-making	Research councils, academies, panels, formalised governmental or intergovernmental structures like IPCC and IPBES
5) Peer-reviewed research papers	Scientific and researcher community	The development of new knowledge in the spirit of normal science	Scientific processes, methods and tools	Studies addressing policy-relevant issues such as meta-analysis, model inter-comparisons and pre-assessments
6) Small-group advice and consultancy	Temporary group of technical experts. Relatively homogeneous intellectually, politically and geographically	Provision of technical advice to policy-makers	Based on existing peer reviewed literature, reports and evidence syntheses	Think tanks, lobby groups, foundations, learned societies, and national research organisations
7) Permanent expert committees	Permanent, usually legislatively mandated group of technical experts. Also, relatively homogeneous intellectually, politically and geographically	Provision of technical advice to policy-makers	Based on existing peer reviewed literature, reports and evidence syntheses	Councils, or panels, or other formalised structures) with formalised procedures which provide direct (e.g., oral) advice to individual policy-makers or parliaments, written policy briefs, or smaller reports

2.6 Environmental assessments as knowledge-policy processes

In the mid-20th century environmental problems came to the forefront of social attention. This became a socially supported movement in the 1960s, particularly in the United States (Brocklehurst, 2004). Scholars have traced the genesis of 'environmental assessment' to shortly after this period when regulations like the US National Environmental Policy Act of 1969 (NEPA) started to mandate environmental assessments (Jay *et al.*, 2007).

The surge of environmental concern driving socio-political movements and regulatory frameworks, like the NEPA, also had wider international ramifications, ultimately leading to the United Nations (UN) Conference on the Environment in Stockholm in 1972 (the 'Stockholm Conference'). At the Conference, Resolution 2997 was passed, which committed UN member states to keeping the environment 'under review' and made specific requirements for environmental assessment to become a more common feature of good governance. This request by the global community for new forms of environmental management led to the many different types of environmental assessment we see in practice today (Ling *et al.*, 2015).

Some environmental assessments emerged from the 'research' community rather than the 'policy' community. An example is Integrated Environmental Assessment[19] (Toth, 2003). Others, such as Impact Assessment[20], emerged from the 'practitioner' community, designed specifically as a tool used for regulatory decision-making (Bond and Pope, 2012) (Figure 1). Some environmental assessments are designed as 'one-off' processes; while others are part of longer-term policy structures or intergovernmental processes and may be periodically repeated. Some environmental assessments involve expertise from many scientific and knowledge disciplines, whilst others are based on contributions from a narrower group of experts. Some environmental assessments are methodologically generic while others are relatively unrestrictive – providing the generators and users with a high degree of creativity in design (Ling *et al.*, 2015).

[19] Toth (2003) defines the main components of Integrated Environmental Assessment as: Integrated Assessment Modelling; Participatory Assessment; and scientific assessments [also called 'Global Environmental Assessments' (Jabbour and Flachsland, 2017); 'Scientific Assessments' (Kowarsch *et al.*, 2016); 'Complex Assessment' (Scholes, Schreiner and Snyman-Van der Walt, 2017); 'Integrative Assessment' (Rothman *et al.*, 2009; Mach and Field, 2017), 'Environmental Assessments' (Heink *et al.*, 2015) and 'Ecosystem Assessments' (Ash *et al.*, 2010)]. Integrated Environmental Assessments are policy relevant, not policy prescriptive.

[20] According to Pope *et al.* (2013), Impact Assessment consists of knowledge-policy processes such as Environmental Impact Assessment (EIA), Strategic Environmental Assessment, Health Impact Assessment, Policy Assessment, Social Impact Assessment and Sustainability Assessment. Impact assessment can be directly traced back to the emergence of the US National Environmental Policy Act and are designed, mostly, to be policy prescriptive.

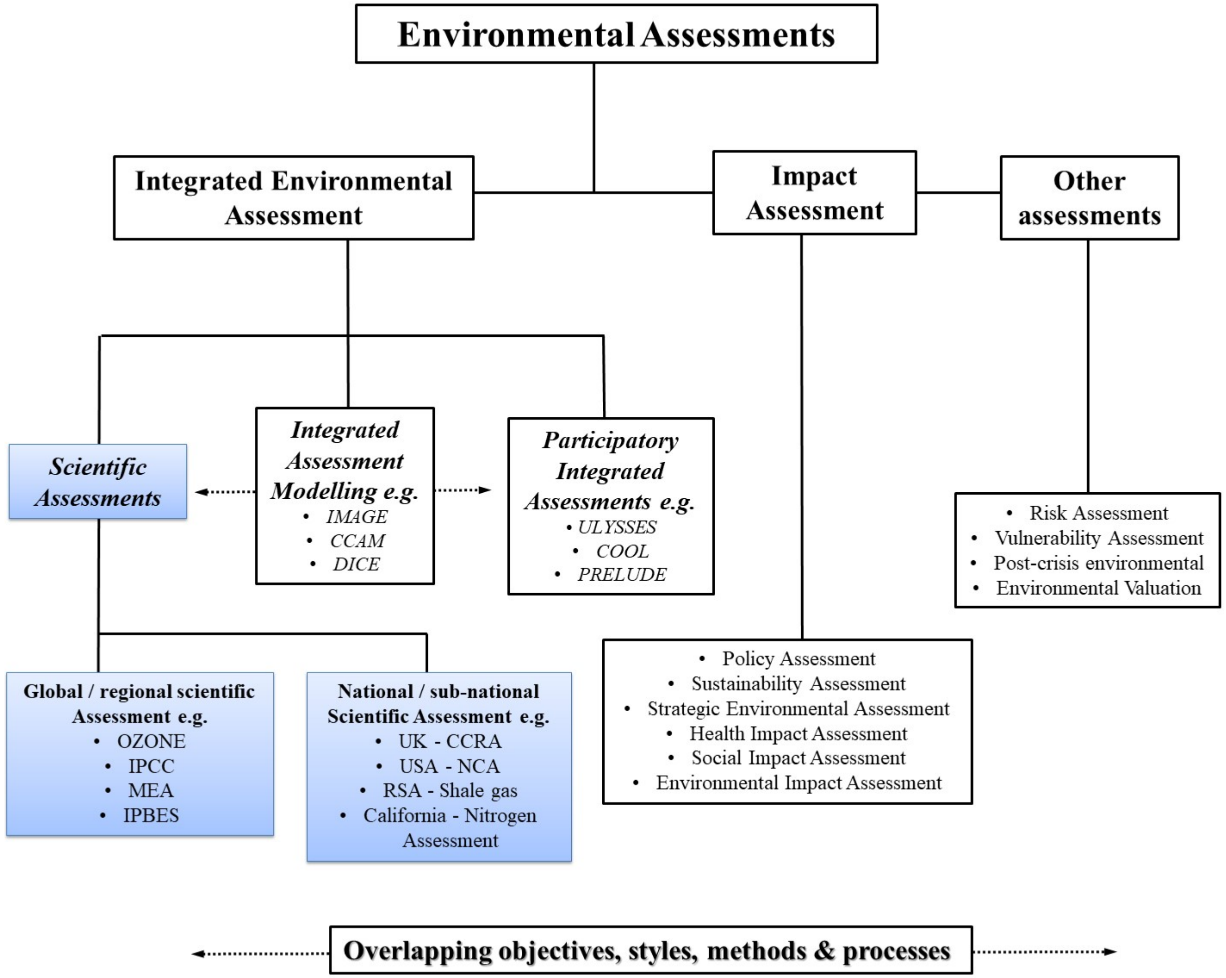

Figure 1: A typology of environmental assessment processes with its two main 'sub-types': Integrated Environmental Assessment (IEA) and Impact Assessment (IA). Note that any one environmental assessment may borrow or adapt a diversity of objectives, styles, methods and processes across the typology. Blue boxes highlight the focus of this research, specifically on scientific assessment.

2.7 The emergence of 'scientific assessment'

Gluckman (2019) suggests three 'eras' of modern 'Mode 2' science and society interaction – each characterised by distinct modes and methods of engagement. Firstly, in the time of global conflict spanning roughly the time of the two world wars from 1900-1950. Secondly, during the time of the Cold War and bipolarity from 1950-1990; and thirdly, the period from 1990-2015[21], during the age of mass globalisation, wicked problems and a global, multi-polar power distribution.

While conventional knowledge-policy processes (Table 3) have existed through all three eras, the period between 1974 and 1984 saw a proliferation of global environmental treaties, regimes, and processes which catalysed, for the first time in human history, a widespread recognition of the need for international scientific cooperation (Jabbour and Flachsland, 2017).

Global environmental assessments emerged on the scene when the Organisation for Economic Cooperation and Development initiated an international investigation into transboundary air pollution which culminated in the assessment of Long-Range Transport of Air Pollutants (LRTAP), which was published in 1977. This form of scientific process was unique for the time and provided a watershed moment for early global science-policy interaction (Jabbour and Flachsland, 2017).

The LRTAP provided the foundation for the first modern scientific assessments, the first one being the assessment of ozone depletion. The ozone assessment led to the adoption of the 'Montreal Protocol on Substances that Deplete the Ozone Layer' in 1987[22] (UNEP, 1987) which aimed to prevent further depletion of stratospheric ozone. In doing so, the Montreal Protocol formalised the establishment of an independent panel of experts which periodically reported to global policy-makers on scientific developments. The success of the Montreal Protocol in mitigating global ozone depletion has been documented (NRC, 2007). This motivated further uptake of scientific assessments as they evolved and became codified as the deliberative, consensus-based approaches they are now known for (Jabbour and Flachsland, 2017).

[21] Gluckman (2019) has not yet described the knowledge-policy era from 2015 onwards. He suggests that this new era – at the intersection of politics, technology, society and science – is evolving at such a speed and intensity, that it makes it difficult, as yet, to frame the phenomena.
[22] The ozone assessments were especially effective for generating relevance by providing highly salient information for decision-making processes (NRC, 2007).

Since that period, *"…global environmental changes and scientific assessments of those changes have become increasingly common elements in international, national, and even local policymaking and decision making"* (Mitchell *et al.*, 2006: 1). Well-known global examples of scientific assessments include the periodic assessments of IPCC, the Global Biodiversity Outlook, the Millennium Ecosystem Assessment[23], the International Assessment of Agricultural Science and Technology for Development and thematic assessments of the International Resource Panel and of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (Kowarsch and Jabbour, 2017). By 2017, 143 global scientific assessment processes had been initiated (Jabbour and Flachsland, 2017), with an unknown number undertaken at regional and national scale.

Prominent national examples in North America include the United States National Climate Assessment (NCA), which has released successive scientific assessments in 2000, 2009 and 2014 (https://nca2014.globalchange.gov). At a state level, the California Nitrogen Assessment was completed in 2016 and provides the first complete review of nitrogen flows, practices, and policies for California (Tomich *et al.*, 2016). In Europe and the United Kingdom, the Climate Change Risk Assessment mandated by the Climate Change Act has completed successive assessments in 2012 and 2017 detailing the risks of climate change (Howarth *et al.*, 2018) (https://www.theccc.org.uk/).

Colloquially, the term 'scientific assessment', can be used to describe a diversity of knowledge-policy processes[24] (Mitchell *et al.*, 2006) – either by being 'scientific' in nature, or 'assessment-like' in procedural orientation, or both. That being said, this research is particularly interested in the highly formalised, 'recipe' of 'scientific assessment' which emerged in the early 1990s. This 'recipe' entails three essential, core elements:

1. The synthesis of evidence (Mach and Field, 2017) using large, balanced, multi-, inter- and increasingly transdisciplinary author teams drawn approximately equally from different

[23] The United Nations Secretariat initiated the Millennium Ecosystem Assessment (MEA) in 2000, which was carried out between 2001 and 2005 at 34 regional, national and local scales (Ash *et al.*, 2010). The success of the MEA led to the formation of a permanent intergovernmental body for assessing biodiversity and ecosystem services, the Intergovernmental science– policy Platform on Biodiversity and Ecosystem Services (IPBES), in 2012.

[24] Some scholars, like Mitchell *et al.* (2006), have left the definition of 'scientific assessment' quite wide, encompassing a broad range of knowledge-policy processes, such as those contemplated in Table 3. For the purposes of this research, I have narrowed the definition to conform with the three criteria listed in the main text.

'sectors' of society (NRC, 2007), offering diverse viewpoints on social problems and their potential solutions (Kowarsch *et al.*, 2016);

2. Double-loop content generation procedures with multiple, iterative (Sarkki *et al.*, 2015) and deliberative (Kowarsch *et al.*, 2016) engagement opportunities with content generators and users; coupled with rigorous and transparent peer/stakeholder review procedures (NRC, 2007); and
3. Integrated, broadly representative, project/platform governance structures are established, responsible for process oversight and product acceptance/approval/adoption (Scholes, Schreiner and Snyman-Van der Walt, 2017).

Even though the criteria for what constitutes a 'scientific assessment' might be rather precise, there is considerable diversity in how they are operationalised at the knowledge-policy interface. For example, some scientific assessments focus on science, others on socio-economics. Some are performed by platforms at specific and ongoing time intervals, others are designed as once-off processes which produce a single report. Some scientific assessments explicitly focus on one scale (e.g. global or national), while others are multi-scale in their focus (Mitchell *et al.*, 2006).

There has been a substantial shift in how scientific assessments, as they are defined in this research, were performed in the late 1980s and early 1990s, to how they are practiced today. They have changed most dramatically in their scope and depth of issue coverage. For example, three volumes of the latest IPCC assessment total over 4 300 pages, 60 chapters, and 16 annexes totalling approximately 3.26 million words (Jabbour and Flachsland, 2017). This can be attributed to increasing levels of knowledge complexity and inclusion, a growing number of scientific publications which need to be assessed and higher levels of public interest and participation – meaning that problem framing is far broader than it was in the past.

In addition, user expectations are much higher than they used to be. The internet has increased connectivity and access to information which has in turn increased the number of people and organisations interested in environmental problems. Social media has played a role in raising awareness of problems, increasing the expectations placed on scientific assessments to deliver workable solutions (Jabbour and Flachsland, 2017), as well as enhancing opportunities for public scrutiny.

Table 4: The main differences between early (1970-1990) and modern (2010-2020) scientific assessments (after Jabbour and Flachsland, 2017).

Features	Pre-sustainable development era (1970-1990)	Modern (2010-2020)
Iconic issues	Waste, water pollution, air pollution, ozone depletion	Climate change, biodiversity loss and management, land degradation, energy production, carbon cycles
Policy instruments	Command and control	Market-based
Users	Policy-makers	Policy-makers and wider societal decision-makers
Knowledge	Multidisciplinary, mainly natural sciences	Inter- and transdisciplinary, many disciplines and knowledge systems
Data management	Limited public access	Open access

Jabbour and Flachsland (2017: 2) describe scientific assessments as being at a *"…crossroads"*, where they could either continue mainly in their function of problem identification and framing, or they can become more solutions oriented.

2.7.1 Definitions and philosophical underpinnings

Since scientific assessment has its roots in the type of co-production theory developed through Harvard's Global Environmental Assessment Project in the early 2000's (Cash and Clark, 2001), most of its definitions emphasise its role as a 'social process'.

For example; Walt Reid, the director of the Millennium Ecosystem Assessment (MEA) defines scientific assessment as *"…a social process designed to bring the findings of science to bear on the needs of decision-makers"* (MEA, 2005: 2). In another definition offered by Kowarsch and Jabbour (2017: 2), scientific assessments are *"… large-scale social processes where large groups of experts convene to interpret, deliberate and synthesize existing scientific knowledge on complex environmental issues with a view to inform public policy"* (Kowarsch and Jabbour, 2017: 2).

In accordance with this social mandate, Edenhofer and Kowarsch (2012) present the Pragmatic-Enlightened Model (PEM) of scientific assessment based on the work of John Dewey's pragmatist philosophy of ends-means interdependency. The PEM places emphasis on the need for scientific assessments to carefully examine the practical consequences of the different policy pathways ('means') which hold value to different stakeholder constituencies. This requires deep engagement with stakeholders and their values in the knowledge production process – where scientific experts provide the role of 'mapmakers' of policy pathways and their consequences, while policy-makers provide the role of 'navigators' (Kowarsch *et al.*, 2016). According to Vardy *et al.* (2017), the objective of PEM-inspired scientific assessments is to transcend knowledge boundaries to transparently integrate the assessment of human values with scientific facts to arrive at implementable policy solutions.

2.7.2 Defining characteristics

Scientific assessments are commonly applied within the domain of the sustainability sciences, providing a connection between environmental and social issues (Ash *et al.*, 2010). They seek to integrate knowledge from different spatial and temporal scales to meet the needs for decision-makers, from policy-makers in the highest echelons of government, to local communities of people who rely on environmental knowledge such as local people and farmers. In doing so, they provide a summary to stakeholders and policy-makers of the 'state of the knowledge' on a particular issue of societal concern and consequence (Scholes, Schreiner and Snyman-Van der Walt, 2017).

Some scientific assessments involve participants as representatives of governments and NGOs, while others require participants to serve in their individual capacities. The most prominent assessments are a hybrid of the above approaches – participants are nominated by governments, balanced disciplinarily, geographically and in other respects by a political process, but then expected to serve as individuals, while respecting their disciplinary limitations. Some assessment structures are intended to be ongoing whereas others disband after producing a single report. Some explicitly focus on one scale (for example, global), while others focus on multiple scales, either independently or simultaneously, while considering the interactions across levels (Scholes *et al.*, 2013). In spite of scientific assessment playing different roles in society, depending on context and the specific questions being asked, it is generally agreed that scientific assessment will include the following three elements (Kowarsch *et al.*, 2016).

Firstly, they must contain procedures to synthesize large volumes of public-domain scientific information (generally, but not exclusively, in the form of peer-reviewed publications) providing a multidisciplinary interpretation of the state of current knowledge. Information sources can include (in addition to peer-reviewed publications) observations, model-based results and case studies. The technical participants include relevant disciplines in the natural and social sciences, engineering, humanities, law, or medicine (Mach and Field, 2017). During a scientific assessment, experts review a variety of evidence. Their task is to separate for stakeholders, in a comprehensible way, what is known from what is not known, or is imperfectly known (Mach and Field, 2017). Double loop peer review[25] is considered an essential feature of scientific assessments.

Secondly, the knowledge generation processes must include those who it is expected are the users of the knowledge (i.e., in this context, policymakers). Efforts are made to ensure that the knowledge is policy relevant, specifically by engaging with policy-makers in problem framing, assessing scenarios (Mach and Field, 2017), policy goals and objectives and revealing the decision consequences associated with different policy options (Kowarsch *et al.*, 2016).

Thirdly, for most complex issues, following a single line of evidence provides only a partial view of an issue (Mach and Field, 2017). As such, scientific assessments attempt to take into account multiple viewpoints from different actors in a transparent fashion, capitalising on knowledge diversity and encouraging learning amongst participants. The viewpoints are typically somewhat overlapping, but potentially include substantial divergence, including the divergence of legitimate interpretations that often exists within a single discipline.

Scientific assessments have adopted the mantra of '*policy relevant, not policy prescriptive*' and strive to avoid advocacy (Kowarsch *et al.*, 2016). They do require experts to make transparent and traceable judgements based on the evidence (Mach and Field, 2017). This requires reflexive encounters with the multiple contradictions and tensions and that underlie collective judgement exercises (Haas, 2017).

[25] According to Montana (2016), the peer review process operates at two levels. Firstly, through endogenous procedures like establishing scientific consensus on the available evidence in diverse, multi-author teams. And secondly, through independent (exogenous) peer review where First Order Drafts (FODs) of the scientific assessment chapters are made available to appointed peer reviewers – and then in a second round of review the Second Order Drafts (SODs) are returned to the peer reviewers and then made available to the broader stakeholder community for review.

Table 5: Aspects and characteristics of medium- and large-scale scientific assessments compared against those of conventional environmental assessments, such as EIA (after Kowarsch *et al*., 2016).

Aspect	Characteristics	Medium-scale scientific assessment (e.g. national or sub-national scale)	Large-scale scientific assessment (e.g. global to regional scale)	Environmental Impact Assessment
Organisational and procedural setup	Number of experts and disciplines	Very high number (usually 50-100 authors, mostly cross-disciplinary)	Very high number (usually >100) authors, always cross-disciplinary	Often >5 authors, mostly cross-disciplinary
	Author selection process	Formalised process, often many divergent perspectives and regional representation	Highly formalised process, many divergent perspectives and regional representation	Appointed by lead consultancy, not formalised
	Duration of process	Usually around 2 years	Around 4 to 7 years	Often <2 years
	Funding	Multiple funding sources from governments and other donor organisations	Multiple funding sources from governments and other donor organisations	Paid for by private sector development clients
	Social discourse, level of polarisation	High stakes, always controversial	High stakes, always controversial	Commonly controversial
	Formalised governance structure	Highly formalised	Highly formalised e.g. committees, procedures, policies etc.	Mostly informal
Focus & methodology	Spatial scale	Mostly national, sometimes global	Mostly global	Always site specific
	Level of complexity	Moderate to high. Some analysis of interdependencies	High complexity. Extensive analysis of interdependencies	Moderate focus on interdependencies
	Target audience	Governments and policy-makers. Secondary targets are stakeholders	Governments and policy-makers. Secondary targets are stakeholders	Government decision-making at project scale
	Scope of literature	Relatively comprehensive synthesis of the literature	Relatively comprehensive synthesis of the literature	Field work, sample analysis, statistical data. Data mostly quantifiable
	Policy options explored	Exploring several options (if policy analysis done at all)	Many alternative pathway, options, and diverse practical implications	Exploring a few predetermined options
	Transparency in levels of	Moderate to very high	Very high	Very high

Aspect	Characteristics	Medium-scale scientific assessment (e.g. national or sub-national scale)	Large-scale scientific assessment (e.g. global to regional scale)	Environmental Impact Assessment
	confidence			
	Nature of recommendations	Policy-relevant	Policy-relevant	Always policy prescriptive
	Review process	High variation, often a larger group of external reviewers sometimes including policy-makers and stakeholders	Large-scale, formalised, multi-stage review process including policy-makers and other stakeholders	Usually formalised internal peer review, no external peer review
Relationship to stakeholders and political context	Mandate from governing bodies	Nearly always	Nearly always	Always
	Interaction with stakeholders beyond scientists	Very often, and increasingly observed through multiple formats and with many groups	Extensive, and mostly through multiple formats; many diverse groups	Usually formalised interaction with government and stakeholders
	Inclusion of divergent viewpoints	Often, overview and exploration of several divergent viewpoints, sometimes through co-produced scenarios	Often, exploration of many relevant divergent viewpoints, sometimes through co-produced scenarios	Exploration of a few scenarios related to pre-selected policy alternatives
	Outreach and communication	Often extensive efforts	Mostly extensive effort	Moderate
	Outputs	Scientific assessments report chapters, summaries, images, models, scenarios, videos, high accessibility, high exposure	Scientific assessments report chapters, summaries, images, models, scenarios, videos, high accessibility, high exposure	EIA and Environmental Management Plan report by consultants, record of decision by case officers (policy-makers)

2.7.3 Grounding and guiding principles

To give effect to their defining characteristics, scientific assessments are guided, from conceptual design, through to day-to-day operation aspects, by the principles of credibility, relevance and legitimacy ('CRELE') (Cash and Clark, 2001).

2.7.3.1. Credibility

Credibility is the perceived *"…quality, validity and adequacy and reliability of the knowledge, evidence and arguments exchanged at the interface"* (Sarkki *et al.*, 2015: 3). It generally refers to the scientific adequacy of products and arguments (Cash *et al.*, 2003), or more broadly, the quality of the knowledge generated.

Features of a scientific assessment such as the involvement of eminent scientists and leaders (Ash *et al.*, 2010), the traceability of evidence, the defensibility of claims, the consideration of rival data, transparency about uncertainty, the nature of communication methods, the relationship with the media and the rigour of peer review processes all impact the credibility of both the process and the outputs (Sarkki *et al.*, 2015).

Credibility is mainly achieved through three methods: credibility by peer review; credibility by individual credentials; and credibility through community (Hel and Biermann, 2017). Peer review is the well-established strategy that seeks to minimise the impact of bias and also acts to safeguard technical accuracy. The credentials of key individuals can help to bolster trust that content is accurate, while community credibility is developed from over many years following high profile, high quality assessment, for example the IPCC (Hel and Biermann, 2017).

Credibility is enhanced by appointing, in a balanced and transparent way, and with the approval of representative governance structures, a diverse multi-author team of experts with a broad range of disciplinary and geographical experience. Each multi-author team addresses a specific topic or issue in the assessment in an integrated manner, working in collaboration with the teams working on other topics in order to effectively recognise interdisciplinary linkages.

The objective is not to find totally unbiased authors (such a person probably does not exist, although a blatantly biased author is unlikely to pass governance approval), but to include the full range of legitimate expert opinion in the topic team, and trust that debate within the multi-author context balances out individual biases and blind spots, revealing rather than concealing the range of expert opinion and thus giving confidence in the robustness of the findings (Scholes, Schreiner and Snyman-Van der Walt, 2017).

Some have argued that the principle of credibility has been elevated above that of legitimacy, and especially relevance. To the point where salience analysts are dissatisfied because they are not listened to, while policymakers are dissatisfied because they do not hear what they want to listen to (Mitchell *et al.*, 2006). Ironically, Alcamo (2017: 3) argues that relevance is the most essential ingredient for an effective scientific assessment, since *"… the main motivation for performing global environmental assessments is to provide scientific information and knowledge on the global scale relevant to environmental policy"*.

2.7.3.2. *<u>Relevance</u>*

Relevance (in some literature, referred to as 'salience') is the ability to match the knowledge production process and outputs with societal and policy-making needs (Sarkki *et al.*, 2015). It means answering place- and time-specific questions in the way that stakeholders pose them, rather than answering them in the way scientists believe the questions would be asked (Scholes, Schreiner and Snyman-Van der Walt, 2017). In this way, the knowledge becomes useful at multiple scales and within multiple decision-making contexts (Ash *et al.*, 2010).

Relevance is achieved through three key strategies: relevance through integration; relevance through independent advice; and relevance through solutions (Hel and Biermann, 2017). Integration is achieved through surveying large quantities of scientific literature and providing a comprehensive and integrated picture to policy-makers. Relevance through seeking advice from independent experts who are deeply familiar with the topics, the published literature and any relevant policy processes. Relevance is also achieved through assessing the opportunities and constraints of workable policy options[26] (Hel and Biermann, 2017).

[26] Cash and Clark (2001) cite the example of the Global Biodiversity Assessment which was funded by the United Nations Environment Programme (UNEP) and the Global Environment Facility and completed in 1995. It included inputs from more than 1 500 scientists from more than 80 countries but was developed independently of an intended audience (national governments). It failed to assist the political agenda for biodiversity conservation, was not used as a source-book by individual nations and was even viewed with hostility by some countries in the developing world (Cash *et al.*, 2003). Failing to find an authorising environment, the process and products was not welcomed and largely ignored, despite its high technical quality (Raustiala and Victor, 1996).

Relevance is enhanced when the questions pertinent to stakeholders are addressed within the expected breath and scope. Taking in a range of questions, interpretations and framings of the problem, helps to increase the breadth of the usability of the findings and policy options. This is facilitated by iterative steps in a scientific assessment, where there are multiple points for engagement and interaction on assessment content and materials (Sarkki *et al.*, 2015). The 'level of fit' between the knowledge outputs and policy process requirements (in terms of timing, questions and policy options) substantially impacts relevance (Sarkki *et al.*, 2015).

2.7.3.3. Legitimacy

Legitimacy is a perceived fairness, in other words demonstrating respect for divergent values, interest and beliefs (Cash *et al.*, 2003) in the eyes of the users (Ash *et al.*, 2010). Often it is tied to the question of 'was the assessment asked for and endorsed by a legitimate authority'?

Legitimacy is primarily achieved through representation, through formal recognition by the receiving environment and through participatory engagement (Hel and Biermann, 2017). Legitimacy through representation means including a diversity of perspectives, knowledges and stakeholders from different cultures and geographies, including a balance in gender, if necessary.

Legitimacy through formal recognition from the receiving environment means having a mandate – in other words, that the assessment was asked for by the people who are ultimately responsible for making decisions related to the topic. It also stems from being perceived to have implemented an unbiased process which considers actors from different knowledge domains and broadly corresponds with the standards of political and procedural fairness (Scholes, Schreiner and Snyman-Van der Walt, 2017). This is commonly embodied through participation, where a range of non-academic actors, policy-makers, NGOs and interested people have open and transparent access to the process (Hel and Biermann, 2017).

2.7.4 Purpose and users

Environmental problems affect billions of people and require global and national policy responses (Kowarsch, 2016). Policy imperatives such as the SDGs – or in the arena of climate change for example, the Paris Agreement – are built on the evidentiary bases provided by scientific assessments (Jabbour and Flachsland, 2017). For example, the successive IPCC climate assessments undertaken in 1990, 1995, 2001, 2007, 2013 are credited with making possible the historic agreement by 195 countries in Paris in December 2015, to take concerted action on climate change (Scholes, Schreiner and Snyman-Van der Walt, 2017).

There are now more international rules affecting the environment than any other domain of human endeavour, except international trade (Jabbour and Flachsland, 2017). This means that scientific assessments have become permanent features of the political and decision-making landscape with governments, scientists, NGOs and international organisations expending considerable time, effort, and resources supporting them (Mitchell *et al.*, 2006).

The development of overarching target-driven policies like the SDGs or the Paris Agreement are based on scientific assessments (Jabbour and Flachsland, 2017), but the policies themselves provide little guidance regarding the suitability or consequences of the different policy pathways for achieving the stated targets (Kowarsch and Jabbour, 2017). This is where scientific assessments find their greatest utility – by providing insights into technology development, capacity-building, policy integration and by laying the foundations for the establishment of an enabling national policy environment (Kowarsch and Jabbour, 2017).

Scientific assessments positively influence policy learning by bridging the so called 'gap' between scientists, policy-makers and stakeholders (Kowarsch *et al.*, 2016). In doing so, because of their iterative, multi-way dialogues, scientific assessments help to establish collegial relationships between scientists, stakeholders and policy-makers (Scholes, Schreiner and Snyman-Van der Walt, 2017). This is an important element for breaking down disciplinary and institutional silos and enabling higher levels of trust between knowledge co-generators. This, in turn, helps to reduce the risk participant relationship breakdown and ineffective policy options (Tinch *et al.*, 2016).

Policy-makers have traditionally been seen as the primary target audience and their consistent inclusion in iterative scientific assessment processes is seen as essential for successful policy implementation (Mach and Field, 2017). Increasingly, in the last decade, the information generated from scientific assessments has been aimed more toward a broader societal stakeholder community (explicitly and primarily including policy-makers, but not exclusively so), who are interested parties but not necessarily technical experts, and are assumed to have a level of literacy and education that allows them to access the predominantly written outputs, often not in their first language. For this purpose, emphasis is now placed on the use of jargon-free, plain language, summary tables or accessible explanatory diagrams (Scholes *et al.*, 2016).

Since scientific assessments have a wider user audience, the questions they attempt to answer are drawn from a wide community of stakeholders, all of whom make detailed inputs into the process and help shape the assessment from its inception (van den Hove, 2007). The practice of having many derived outputs tailored for particular stakeholder communities, but based on the same core of assessed material, is also quite common – an example is the five summaries that followed from the Millennium Ecosystem Assessment.

2.7.5 Roles and responsibilities

There are three key roles in a scientific assessment process. Firstly, there is the role of the technical experts responsible for content generation. They can be appointed as authors of the assessment, either in a co-opted unpaid capacity (in the case of authors nominated by countries to the assessment process), or by invitation to be 'fellows' or 'volunteer scientists' by the assessment leadership (often used for the engagement and training of early career scientists; they usually end up as authors in some form). The primary role of the authors is to synthesise large bodies of existing knowledge into material useful for decision-making. Authors are drawn from a range of disciplinary backgrounds and represent a diversity of sectoral interest from the private sector, NGOs, the research community and civil service. The authors generally have the ability to call on limited inputs from other experts ('contributing authors') in areas outside of their own direct expertise, but the assessment remains the responsibility of the lead authors.

Table 6: The roles and responsibilities of different technical experts in a scientific assessment.

Technical expert	Roles and responsibilities
Co-chair (s)	Overall responsibility for production of the scientific assessment. Assessments are typically led by two (or three) chairs rather than a single chair, partly for reasons of balance and diversity, but also to provide redundancy. More than one co-chair also serves to manage labour.
Coordinating Lead Authors (CLAs)[27]	Chair the sections/chapter team meetings, allocates writing tasks, ensures they are done on time and to specification, allocates reviewer response tasks and ensures they are done. Experienced expert in own right, part of overall summary/synthesis team. Ensures that any cross-cutting issues are addressed in a complete and coherent manner. Typically, each chapter has two CLAs, sometimes three.
Lead Authors (LAs)	Collates, evaluates and summarises material from the available literature or other fully justified unpublished sources. Lead writer of an allocated section participates in team discussions on entire topic and takes collective responsibility for it. Responds to reviewer comments in allocated section and revises drafts accordingly. Typical numbers of LAs per chapter are three to eight.
Contributing Authors (CAs)	Provides technical information in the form of text, graphs or data usually within narrow or specialised disciplinary domain. May be asked to respond to reviewer comments on the material

[27] According to Griggs (2014: 172) CLAs require some soft skills – requiring them to be *"...diligent, careful, balanced and fair, and able to take criticism while remaining open to changing their views in the face of new evidence. They must be amenable, dedicated enough to tolerate the tortuous process and be able to deliver on time".*

Technical expert	Roles and responsibilities
	provided. CAs do not form part of the citation. There is no in-principle lower or upper limit to their number, but five to ten is typical.
Volunteers (IPCC) & Fellows (IPBES)	Work under the guidance of the CLAs and LAs in the development of the content for the chapters. Typically, they are early-career experts in their own right, and this category is part of assessment capacity development initiatives. One per chapter is typical.
Review Editors	Review editors are technical experts, nominated and approved by the commissioning bodies, not involved in authoring the report or directly reviewing it themselves, but is checking that the review comments provided by external reviewers and stakeholders are handled in a comprehensive and fair way. There are typically hundreds of external reviewers, who in the first iteration are technical experts, but in the second iteration may include any stakeholder.
Peer reviewers	Peer reviewers read first and/or second drafts and provide written, ideally specific and evidence-based, comments in order to correct current content or identify missing knowledge.

Secondly, there are the roles bestowed upon members of commissioning bodies and clients, or governance groups responsible for oversight, such as Plenaries, Bureaus, Boards etc. Commissioning bodies fund the process and have their own representatives participate as authors or peer reviewers. The primary role of governance groups is broad oversight, to ensure that the assessment process produces high quality and salient products. Critically, commissioning bodies and clients are responsible for the approval, adoption or acceptance of SPMs, along with supporting chapters.

Thirdly, there are roles associated with the day-to-day management of the scientific assessment. These include roles, overseen by the co-chairs, including executive officers, secretariats, management committees and technical support units (TSUs) including data-handling experts, language editors, layout editors and illustrators, as well as handling logistical issues such as meeting organisation and communication between participants.

2.7.6 Stages of the scientific assessment process

2.7.6.1. Request and scope

In the case of global scientific assessment platforms such as IPBES and IPCC, governments, stakeholder groups and bodies of the UN propose topics for future assessments in line with agreed procedures. Topics are provisionally 'scoped', which means an investigation into the rationale of the problem is commissioned. This involves determining the need for a scientific assessment; the geographical and thematic coverage; a basic chapter outline and key questions; key data needs; and estimating the costs and duration. The main output from this process is usually a scoping report of some description highlighting these key points. The scoping report is conventionally presented to the governance groups for approval before the expert evaluation component of the assessment is initiated (IPBES, 2018a).

In the case of regional or national processes, scientific assessments may be launched to address a reasonably specific problem. Spatially and thematically constrained assessments may require less elaborately designed processes, with fewer roles, responsibilities and governance group structures.

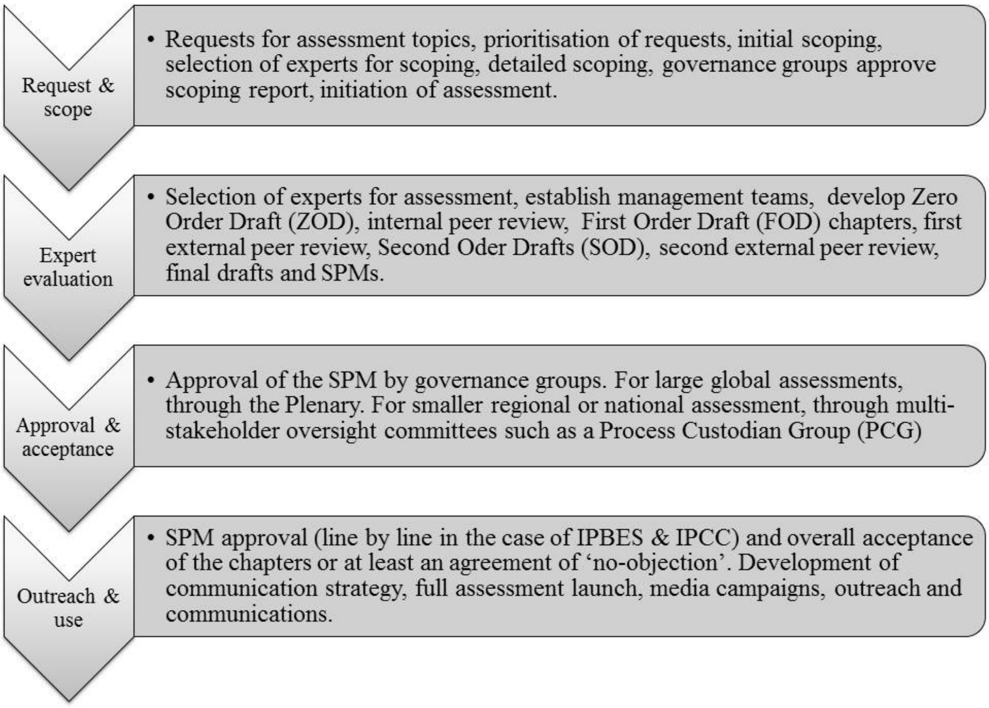

Figure 2: The four stages of a typical scientific assessment commencing with a request from policymakers and ending with the production of outputs for wider stakeholder use (after IPBES, 2018)

2.7.6.2. Selection of technical experts

The first step in the expert evaluation phase is to nominate and appoint technical experts. Governments, stakeholders and governance groups are typically invited to nominate independent experts who have knowledge relevant to the issue in question. Technical experts can be nominated in any author capacity or as a fellow or volunteer. In the case of the IPBES global assessment, the bureau will select co-Chairs and authors from the pool of nominees. CAs do not need to be nominated or attend meetings. They are selected by the CLAs, with the approval of the co-Chairs (IPBES, 2018a).

In the case of national assessments, author nominations are usually made by governance groups and external observers and then captured by the management groups. Selection criteria will be developed by the management committee and vetted by the governance groups to ensure fair selection with due consideration of disciplinary, gender and geographical balance.

In most scientific assessments the stakes are high, so experts are required to complete forms declaring no conflict of interest in instances where affiliation or financial interest in the assessment topic may compromise the integrity of the outputs (IPBES, 2018a). Following expert appointment and declaration of interests the evaluation of the evidence proceeds with the commencement of the assessment.

One of the core features of a scientific assessment is a 'multi-loop' content generation and review system. The multi-loop system is adopted to ensure participants are provided with iterative opportunities for framing questions and developing content (Sarkki *et al.*, 2015). Even though experts are usually intelligent, they may struggle to learn new information. Scientific assessments promote this by enhancing 'double loop learning'[28] (Parrish, 2020).

The primary steps in the scientific assessment multi-loop content generation and review system include the following: Firstly, an initial author meeting provides an opportunity to develop comradery and a collegial atmosphere at the outset of a multi-year and potentially challenging project. Participants building trust and networks of cooperation have the potential to provide a more productive work environment that those cauterised by infighting and hostility. At the meetings key problems are framed as succinctly as possible by multiple participants.

The key output generated from this engagement is the so-called 'Zero Order Draft' (ZOD). The ZOD reveals the scope and structure of the scientific assessment in terms of its key questions, its spatial and temporal scale and the most appropriate methods for answering the pertinent questions. The ZOD usually takes the form of a reasonably condensed (down to fourth-level headers) Table of Contents which gives stakeholders a clear indication of the scope and balance of issues to be expected in the First Order Draft (FOD) (Scholes, Schreiner and Snyman-Van der Walt, 2017).

The FOD includes the chapters drafted by the multi-author teams, overseen by the responsible authors and co-Chairs. The FOD is a reasonably complete 'first cut' draft of a chapter, including references, sketches of the intended figures, and draft tables. Each FOD chapter contains an Executive Summary of approximately 300 words, with up to about 10 main findings. Key findings in

[28] Double loop learning is a part of 'action science'. It brings novel evidence or ideas to light which enable new learning. This is especially pertinent for solving complex problems. In the context of a scientific assessment, double loop learning enables knowledge holders to examine their own biases and mental models – thus promoting reflection, creativity and improvement (Parrish, 2020).

the Executive Summary are typically organised into paragraphs each dealing with a topic, headlined with one or two bolded summary sentences, supported by a short paragraph of text that includes pointers by way of heading numbers to the place in the main chapter text where the material is covered. Each key finding is assigned a 'confidence level' (Chapter 3) which subscribes to an agreed, calibrated set of terms based on the availability, quantity and quality of the evidence used, and the degree of agreement on its interpretation by the experts (IPBES, 2018a). The FOD executive summaries form the basis, collectively, for the first draft of a Summary for Policymakers (SPM), an overall executive summary which first appears in conjunction with the Second Order Draft (SOD).

The FOD materials are distributed by the management groups to independent reviewers. The integrity and sufficiency of the review process is under the supervision of the review editors. The review editors are responsible for mediating disagreements between authors and peer reviewers in a transparent and balanced manner. The number of comments pre-chapter of the FOD sometimes reaches thousand, from hundreds of reviewers. They are delivered in a highly structured format, usually in the form of a spreadsheet database, reflecting the page and line number of the content in question. Challenges to content made by the reviewers are expected to be accompanied by supporting evidence validating the alternative position; the presence of such evidence is a key factor in determining how the comments are used.

Responding to the peer review comments on the FOD (both by incorporating changes into the draft, and by informing the reviewer of the action taken) is one of the primary purposes of the second author meeting. This provides an opportunity for the multi-author teams to work through the comments received on the chapters by the peer reviewers, in order to enhance the quality of their work and ensure the technical adequacy of material. This meeting also offers the teams an opportunity to debate and organise how they wish to respond to the reviewers and how they will go about redrafting their text in preparation for the Second Order Draft (SOD) (Figure 3).

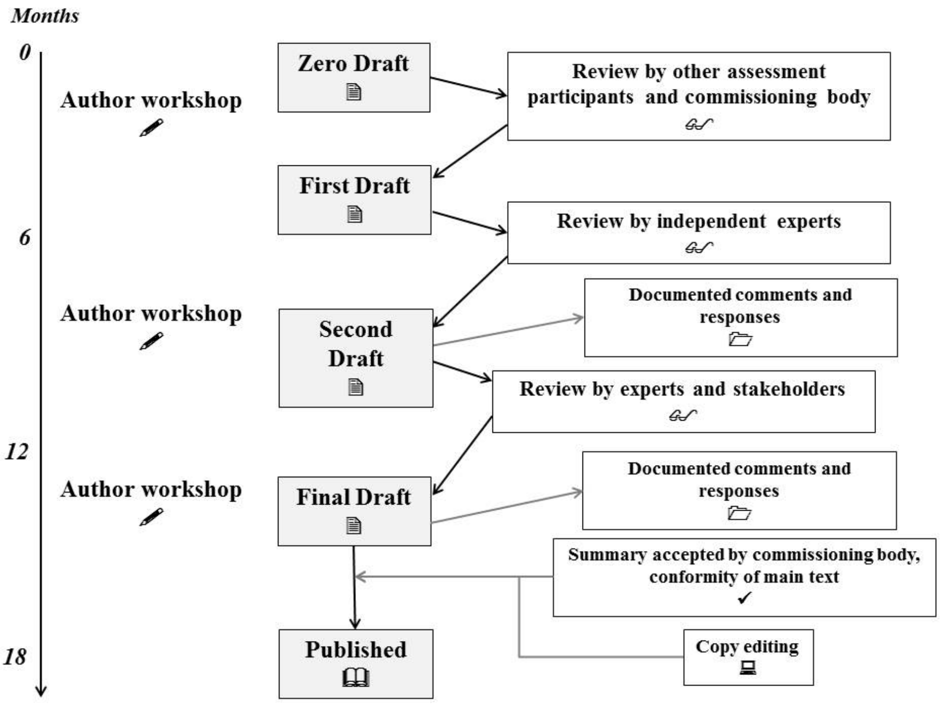

Figure 3: A scientific assessment usually takes in the region of 18-24 months, including three writing workshops (left). Along with the independent peer review (right), these allow for high levels of collaboration and interactivity through ZOD, FOD, SOD and final drafts.

The SOD chapters include content revisions to the FOD, inspired by the reviewer comments. The SOD can therefore differ quite substantially from the FOD, and usually includes new material. The SOD is the draft of the scientific assessment which is released more widely for general stakeholder comment; and subsequent drafts are not expected to include large amounts of new material, just refinements of material already presented in the SOD. This means that the cut-off date for cited literature usually corresponds to the date of finalisation of the SOD. SOD chapters are in the region of 10 000 words each. They tell a nearly complete story about the state of knowledge and reflect the issues raised in the scoping process and include intelligible drafts of the final figures and tables. They are aimed at technical people, but use jargon-free and accessible language. Comments on the SOD follow the same structure as those of the FOD i.e. structured page and line numbered comments, highlighting evidence and data which may be used to enhance the accuracy and quality of the material (IPBES, 2018).

The SOD is accompanied by a Summary for Policy-Makers (SPM), based on the chapter text, and especially their Executive Summaries. The SPM should address the questions raised in the scoping document in a succinct and intelligible way. The SPM provides in the region of fifteen to twenty top key messages and is ideally under 5 000 words. In formal assessment structures, the 'authorising body' (for instance, a Plenary), debates and negotiates the SPM word-by-word, and this places a practical upper limit to how long it can be. The SPM is highly synthesised and tells a condensed, implementation-oriented story of the state of knowledge as it pertains to the issue in question. The messages should ideally aim at conveying striking facts and numbers which the assessment has uncovered, and a limited range of action options with their consequences (IPBES, 2018a).

The third author meeting allows the teams to check the review comments and assign writing and response responsibilities in preparation of the final draft. All comments and responses on the FOD and SOD are captured in a structured online repository and made freely available to all stakeholders so that there is a traceable record of all documents and text changes. At the same time preparation of the final draft SPM commences. This late stage is essential for fine-tuning contents, clearly articulating findings and messages for the final draft, and ensuring internal consistency and cross-referencing. The final draft materials contain the kinds of expressive graphics and striking images which will appeal to users and can be used as supportive material in outreach programmes or media liaison.

2.7.6.3. Approval, adoption and acceptance

The draft SPM and assessment chapters are presented by the management structures to the governance groups for consideration. Traditionally, the governance groups are provided a period to review the SPM and draft chapters and submit written comment (this can also be supplied verbally in meetings or plenary sessions). Because the SPMs are the main items of policy-maker interest, reasonably detailed procedures to review the SPM are implemented over the course of a few days to review and revise (in real time) the contents of the SPM line-by-line before they are approved[29] (IPBES, 2018a).

2.7.6.4. Use of findings

The release of final assessment reports, SPMs and supporting data and information is usually posted onto a user-friendly web portal, where all relevant documentation can be easily downloaded. The launch of the final user materials is generally supported by a comprehensive communication strategy.

[29] *Approval* means the text has been subjected to a detailed line-by-line discussion and analysis. *Adoption* means that text has been endorsed section-by-section. *Acceptance* means that the Panel has agreed that the material presented is comprehensive, balanced and objective (Skodvin and Alfsen, 2010). It is expected that if an SPM is approved, the underlying text is consistent with it. In the event that the underlying text is blatantly contradictory, it must be dropped. This seldom happens.

The aim of the communication strategy is to ensure that the key messages from the assessment are communicated in a clear, comprehensive and technically accurate manner to target audiences. The strategy usually includes media training of experts who will act as spokespersons for the assessment components they contributed to.

In the case of national assessments, other activities may include working closely with the government agencies responsible for commissioning the assessment, in order to tailor the outputs to the needs of policy-makers. Since the material produced out of a scientific assessment is ‘policy relevant’, not ‘policy prescriptive’, and the independent experts commissioned to write the assessment chapters and SPM have no mandate to specify development policy-making content (such as legislations, norms and standards, protocols, data inventories, online GIS platform etc.), this can be undertaken by mandated science councils who report directly to the relevant government departments.

2.7.7 Methods of participation

There are four, generally not completely mutually-exclusive, ‘pathways’ of participation in scientific assessments. Each of the pathways seek to engage the user or participant in a learning and knowledge generation experience beyond the conventional one-way information transfer model associated with the foundations of normal science. The four pathways for participation are through: (i) integrated project governance structures; (ii) the generation of salient questions from stakeholder engagement sessions (i.e. the scoping process); (iii) content development through diverse multi-author teams; and (iv) review of draft and final materials through the various stages of iteration. Of course, reading and using the assessment is also a form of participation, and perhaps the one with the greatest reach.

2.7.7.1. Integrated project governance structures

Governance is how society, or groups within it, organise to make decisions (IOG, 2019). In the context of scientific assessments, good governance depends on building legitimacy in the eyes of the stakeholders.

This is usually achieved by establishing a ‘Board’ of credible people, representative of diverse organisations which represent a plurality of views. These people may be drawn approximately equally from government, the private sector, academia and civil society. Their mandate is to ‘approve’ certain process or content aspects of the scientific assessment[30]. The Board, in

[30] For formal, politically constituted assessment processes such as the IPCC and IPBES, the approval rests with the plenary, which typically contains only national representatives as voting members. Non-governmental

collaboration with the Secretariat, forms a relationship with a wider base of stakeholders from society interested in the issue. The intention is to thus allow for the full expression of stakeholder values within the authorised project governance structures (Scholes, Schreiner and Snyman-Van der Walt, 2017).

The inclusion of decision-makers within governance structures ensures that the scientific assessment questions remain policy relevant and thus of relevance to stakeholders. Commonly, the intended ‘home’ of products from a scientific assessment is within the polity, either domestic or global. Including a broad range of authors who contribute toward the material generated from diverse epistemologies, wide-ranging geographical regions, contextually representative races, sexes and worldviews is common. All of these experts come to form the multi-author teams which are responsible for assessing and drafting the scientific material in their various draft and final formats (Scholes, Schreiner and Snyman-Van der Walt, 2017).

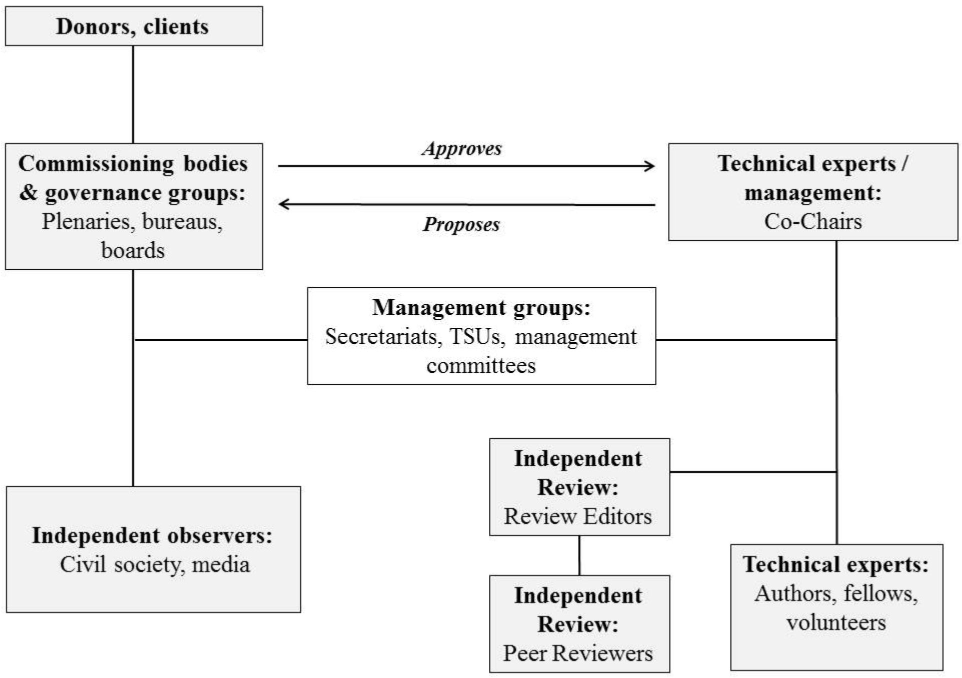

Figure 4: A participant schematic showing the various roles usually adopted within a large scientific assessment project. From a project governance perspective, the commission bodies represented by plenary, boards and bureaus (left) are responsible for overall approval, while the technical experts and management committees (right) are responsible for content generation.

organisations can participate in the discussions. In this case the ‘Board’ equivalent (sometimes called a ‘Bureau’) guides the process between Plenaries.

2.7.7.2. Multi-author teams

Authors comprising the multi-author teams, require acknowledged expertise (though not necessarily as scientists, narrowly defined) and should be drawn from a range of sectors such as research institutions, government, NGOs, universities, a range of geographical regions. Authors are selected according to their formal qualifications, publications and experience, as well as widespread peer-group consensus based on their track record of valuable contributions on the topic. Gender balance is also considered (Schreiner *et al.*, 2018).

The issues to be addressed in scientific assessments are outlined by the stakeholders, through the scoping process. The detailed content of each chapter is developed by large and diverse teams of experts, within the framework of the scoping document, which typically goes at least to sub-chapter level. Subjective judgements regarding the interpretation of the evidence and literature are often required in scientific assessments, but these are made explicit, along with statements of confidence (Mach and Field, 2017). Balance and the elimination of bias is sought as far as possible. The most established means is by establishing broad multi-author teams representing a range of interests and/or positions, coupled with extensive and transparent review (Scholes *et al.*, 2016). The objective is to fairly represent the range of valid (i.e. legitimated by peers and supported by evidence) evaluations, not necessarily to converge on a single consensus outcome. Scientific assessments are independently reviewed by other experts and by stakeholders, often amounting to thousands of documented comments and responses, all of which are available in the public domain.

The experts who participate in scientific assessment processes almost always do so on a *pro bono* basis. Participants are seldom directly paid for their participation. Unless they are self-employed, their salaries are carried by their home institutions, as a donation to the process (sometimes assisted by a special grant from funding agencies or governments). Sometimes out-of-pocket expenses are paid for from secretariat funds, in other instances this option is only extended to participants from developing countries. Using the services of unpaid experts serves two functions. Firstly, it helps to eliminate the accusation that experts may have been 'bought', and secondly, it enables management committees to form very large, diverse multi-author teams[31].

Given that there is no direct financial incentive, why do experts participate in scientific assessments? Firstly, participants generate outputs in the form of citable peer reviewed publications which advance

[31] Some key experts may be self-employed and thus may not be able to donate a large fraction of their time to the 'public good'. Token payments, typically at far below commercial rates, can be made on a case-motivated basis (Scholes, Schreiner and Snyman-Van der Walt, 2017).

the scientific profile and career of participants. In an analysis undertaken by Scholes, Schreiner and Snyman-Van der Walt (2017), it was revealed that researchers who are active in scientific assessments, regardless of whether they are young researchers or established researchers, tend to outperform their non-participating peers on many metrics of impact.

Secondly, participants are exposed to learning environments composed of intricately organised, novel, exciting processes. Thirdly, involvement in scientific assessments tends to stimulate research by revealing important gaps, ideas and opportunities. Fourthly, the assessment process coaches participants in delivering high quality scientific work in brief, within the prescribed methodology, and encourages scientists to engage with other domains and stakeholders, potentially collaborating to generate high-impact publications (Scholes, Schreiner and Snyman-Van der Walt, 2017). Lastly, there may be non-instrumentalist or 'relational' motivations why many people feel the desire to participate in scientific assessments, such as the opportunity to engage in work they feel to be meaningful and impactful.

2.7.7.3. *Stakeholder engagement*

Engagement with a diversity of stakeholders can build bridges between scientific disciplines, establish relationships which transcend political and administrative boundaries and bring together stakeholders to promote a convergence of opinion, rather than the damaging polarisation which characterises many social problems (Garard and Kowarsch, 2017). Engaging with stakeholders successfully, according to Garard and Kowarsch (2017) achieves two-way, iterative dialogues, where stakeholders become information sources. It also helps to build a widespread sense of ownership, which increases the likelihood of policy and behaviour influence.

Research into scientific assessment processes has determined that as the environmental governance and knowledge-policy landscape co-evolve, the nature and methods of stakeholder participation need to evolve in two key, and interrelated areas. Firstly, the evolution so far has entailed a shift toward assessment of solutions, or 'solution-oriented assessments'. Secondly, new actor groups have emerged in the form of local knowledge holders and environmental advocacy groups. The emergence of new groups is in part related to the realigned focus on solutions and a need to develop solution options, which are legitimate and requires scientific assessments to address multiple interests, knowledge systems, geographic contexts, policy relationships, etc. (Garard and Kowarsch, 2017).

2.8 Scientific assessments in South Africa

Building on South Africa's solid STI infrastructure and deep-rooted knowledge production institutions, the country has provided many experts, leaders and policymakers to international scientific assessment activities. The experience gained there has led to the introduction back in South Africa of a number of innovative scientific assessment processes focussing on national issues.

Following on from the regional Southern African Millennium Ecosystem Assessment (SAfMA)[32]– where a number of the scientific assessment features and principles were first tested – scientific assessment (as defined and described in this thesis) has been applied to the topic of elephant management (Scholes and Mennell, 2009), shale gas development (Scholes *et al.*, 2016) and livestock predation ('PredSA') (Kerley, Wilson and Balfour, 2018). The shale gas scientific assessment (SGSA) is discussed in detail in Chapter 7.

2.8.1 <u>The scientific assessment of elephant management</u>

In 2006, the Minister of Environmental Affairs and Tourism in South Africa convened a scientific roundtable to advise him on policies regarding the issue of elephant management, which was controversial, largely because it involved culling, capture and translocation of elephants, in order to protect habitat, lives and livelihoods. The Roundtable concluded that the available scientific information was insufficient to make fully-informed decisions on elephant management (Owen-Smith *et al.*, 2006).

The Minister mandated the Roundtable to propose a research programme that would reduce the uncertainty regarding the consequences of various elephant management strategies (Scholes and Mennell, 2009). The first activity initiated by the research programme was a transdisciplinary scientific assessment of the state of knowledge regarding elephant-ecosystem-society interactions.

The scientific assessment aimed to evaluate the large amount of information regarding savanna elephants, their biology and management in Southern Africa and provide a clear, scientific picture of the state of our current knowledge at multiple scales and within different disciplines, from ethics to

[32] The SAfMA was funded by UNEP and from the government of Norway, with in-kind contributions from various agencies. The SAfMA adopted an experimental approach with the primary aim to assess the consequence of ecosystem change in relationship to human well-being (at basin and local scale) (Biggs *et al.*, 2004) using the then novel conceptual lens of 'ecosystem services'. It was developed through a largely unprecedented degree of collaboration between disciplinary scientists with various institutional affiliations, government and society (Burns, Audouin and Weaver, 2006).

law to economics, within the scope of the 'science' assessment (Scholes, Schreiner and Snyman-Van der Walt, 2017). The specific aims were to (Scholes and Mennell, 2009): mine and summarise the extensive existing information that has not yet contributed to policy; establish an information baseline against which to judge the success of the programme; and identify the critical future research gaps that the programme must address.

Around 62 experts were involved as authors and members of the Review Editor panel. The assessment undertook two rounds of open review, first by experts on the FOD and then stakeholders on the SOD. Reviewers on the FOD were selected to represent a diversity of views on the issue of elephant management, with participants drawn approximately equally from conservations authorities, conservancies, provincial parks, NGOs, welfare groups, academia, consultancies and the private sector (Scholes and Mennell, 2009). The elephant assessment cost in the region of R 500 000 (2008 value), apportioned equally between the Department of Environmental Affairs and Tourism and the Council for Scientific and Industrial Research (CSIR).

The outcome of the scientific assessment was that the contestation around the issue has substantially subsided domestically because of the scientific assessment process itself, as well as the outputs from the process, which included the 'Norms and Standards' for elephant management published in the Government Gazette. Although the issue has not died away completely (Biggs *et al.*, 2017), as can be seen in Figure 5, when comparing online interest in the issue of *elephant culling* between South Africa and the rest of the world, the decreasing ratio shows that South Africa has 'cooled off' more substantially than the rest of the world following about 5 years of high interest from 2004 to 2009[33] (Google, 2019).

[33] The timing of the release of the elephant management scientific assessment and associated Norms and Standards correlates with a decline in online interest in the issue of *elephant culling*. While it is possible to establish a correlation between the two variables, it is not possible to establish causality. Hence the relationship could be random.

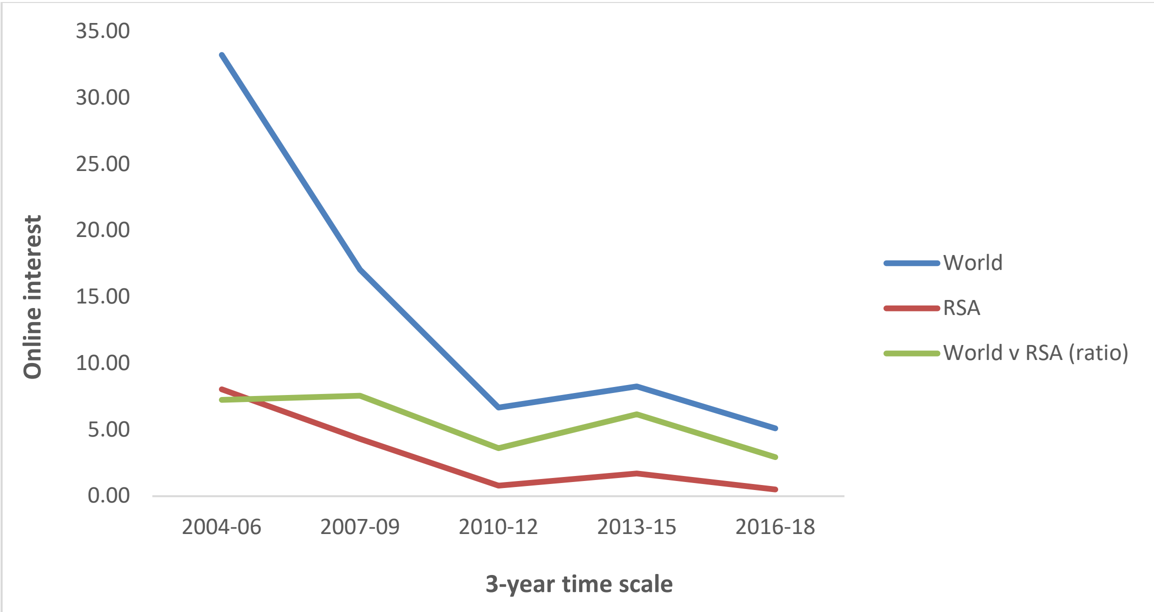

Figure 5: Google Trends data showing online interest in the term *elephant culling* for the World (blue) and South Africa (red) from 2004 to 2018. The ratio between the World and South Africa (green) shows that interest in the topic of elephant culling reduced more in South Africa than that of the rest of the world, following publication of its elephant management scientific assessment and associated Norms and Standards.

2.8.2 The scientific assessment of livestock predation

The Predators Assessment or 'PredSA' was modelled on the elephant assessment and informed by the Shale Gas Scientific Assessment (SGSA) in terms of procedures. It was undertaken as a transdisciplinary and multi-institutional assessment with the TSU based at the Nelson Mandela University.

PredSA was undertaken in partnership with national departments of Environmental Affairs; the Agriculture, Forestry and Fisheries and major industry players such as Cape Wools and the SA Mohair Growers Association. It was launched in 2016 and completed in November 2018. In the region of ZAR 2.5 million was sourced to fund the assessment, coming mainly from government, but including contributions from the livestock industry (Kerley *et al.*, 2017).

In a similar approach to the SGSA, the project appointed an independent six person Process Custodian Group (PCG), broadly representative of the societal interest in the issue (Kerley *et al.*, 2017). The role of the PCG was to serve as an independent and trustworthy collective broadly responsible for oversight of the process to ensure that it was implemented in an unbiased and procedurally fair manner (Kerley, Wilson and Balfour, 2018).

Table 7: Basic comparisons between the three large scientific assessments so far undertaken in South Africa.

	Elephants	SGSA	PredSA
Completed	2009	2016	2018
Primary client	Department of Environmental Affairs & Tourism	Department of Environmental Affairs	Department of Environmental Affairs
Thematic focus	Elephant management	Shale gas development	Livestock predation
Budget	~R 500 000	~R 12.5 million	~R 2.5 million
TSU location	Pretoria, CSIR	Stellenbosch, CSIR	Port Elizabeth, NMMU
Final approval	Client, Authorising Body & Guiding Committee	Client, Executive Committee & PCG	Client, content Steering Committee & PCG
Policy use of outputs	'Norms and Standards'	Draft 'Minimum Information Requirements'	Recently completed, uncertain at this stage

The assessment content was iteratively generated through a peer and stakeholder double review loop. It started with a ZOD which provided document structure with some brief details, compiled by the lead authors (Kerley *et al.*, 2019). A FOD was then sent to expert peer reviewers (three expert reviewers per chapter, with one international reviewer per chapter where possible). All comments from expert reviewers were collected and individually responded to during development of the SOD (Kerley, Wilson and Balfour, 2018).

The SOD was then sent back to the peer reviewers with responses to their comments, plus released at the same time for wider public comment (Kerley, Wilson and Balfour, 2018). Stakeholders were provided the opportunity to provide input through various means, the main one being the PredSA website (see https://predsa.mandela.ac.za/). Stakeholder input was captured through the online platform and documented along with the author's responses. The PCG verified that each comment by the reviewers and stakeholders was formally addressed in an appropriate manner (Kerley *et al.*, 2019).

The final output of the assessment was published in November 2018 as a 280-page book consisting of 9 chapters, including an SPM. Forty three authors contributed to the writing of the assessment, drawn from a diversity of disciplinary and institutional backgrounds (Kerley *et al.*, 2019).The assessment highlights the *"…inherent transdisciplinary nature of human–wildlife conflict"* and provides an initial guideline of what best practice management might look like, although it concedes that further research into livestock predation is required[34] (Kerley *et al.*, 2019: 2).

[34] Although PredSA has set a precedent of a scientific assessment commissioning research and already made a considerable contribution toward developing assessment capacity in South Africa, since it was only released in late 2018, its impact on the policy landscape has not yet been determined.

2.9 Research gap

While on the one hand, scientific assessments *"…are widely viewed as powerful, legitimate tools with the potential to catalyse cooperation and arrive at consensual evidence-based knowledge"* (Jabbour and Flachsland, 2017: 1), on the other, scientific assessments face substantial challenges which severely inhibit their effectiveness. For example, Cash and Clark (2001: 6) report a *"…disturbingly high ratio of ineffective to effective assessments in the real world"*.

Numerous CRELE-based evaluation frameworks have been presented, for example, in Cash and Clark (2001), Young *et al*. (2013), Sarkki *et al*. (2014), Kowarsch *et al*. (2016) and Alcamo (2017). However, very few empirically-based effectiveness evaluations have been undertaken using these frameworks (Heink *et al*., 2015). One of the reasons for this has perhaps been that measuring effectiveness based on CRELE indicators has some challenges and limitations (Heink *et al*., 2015).

Notwithstanding these cautions, there is an urgent need to initiate experimentation with effectiveness evaluations (Corbera *et al.*, 2016). Scientific assessments are highly influential important tools used at the science-policy interface. They have a substantial impact on shaping policy and social behaviour, with a large and incompletely quantified quantity of human and financial resources dedicated toward their execution, year on year. It is therefore necessary to develop some 'markers in the sand' in order to track the progress of scientific assessments and provide some metrics from which overall progress can be enhanced (Kowarsch *et al*., 2016).

Scientific assessments are undertaken at different scales, from global to national (and sometimes sub-national) and are executed by different boundary organisations, for example, the IPCC and IPBES. From these different points of departure, scientific assessments are implemented in different shapes and forms in different contexts to satisfy the needs of different users and political regimes. That being said, scientific assessments are all generally based on CRELE principles. Therefore, gaining an understanding of how generic effectiveness across the cases changes, across scales and platforms, can provide insights into the opportunities and constraints encountered by practitioners and users.

In the South African context this has some bearing too. At a policy level, the country is firmly committed to improving its existing knowledge-policy interface, although the practical means for achieving this, in certain areas, are less well established.

CHAPTER 3. RESEARCH METHODS

3.1 Introduction

This chapter provides a description of the methods used to answer the research questions. In it, I present a framework explaining my own personal philosophical position and the theoretical lens through which the data will be analysed. Next, I sketch the research gap, explaining why this project closes important gaps. I then present my research questions, explain the rationale for the development of the evaluation framework and unpack other methodological issues such as data integration, reliability, research limitations and ethical considerations.

3.2 Interpretive framework and theoretical lens

Every researcher brings a set of philosophical assumptions to a research process. These assumptions may apply to their interpretations of the nature of reality (ontology), what counts as knowledge (epistemology), the influence of human values (axiology) or the process of research (methodology). The diversity of researcher worldviews has implications for research practice as researcher assumptions provide a 'lens' through which we gather and interrogate evidence (Creswell and Poth, 2018b).

One mechanism for contextualising worldviews and mitigating the impact of bias is for researchers to present their own 'positionality' in relation to ontology, epistemology, axiology and methodology in their research. Being explicit about positionality makes researcher assumptions transparent and allows the readers of the research to interpret the findings in light of the philosophical assumptions.

Describing positionality is assisted by locating it in a typology of worldviews. I see my own personal worldview as most closely reflecting the post-positivist paradigm but also including elements of pragmatism[35]. The merging of post-positivist and pragmatic worldviews provides a framework of dialectical pluralism which permits balancing differences between worldviews and their *"…intellectual tensions"*, while still producing *"…new workable wholes"* (Burke Johnson, 2017: 156).

[35] Pragmatism contends that a proposition or theory is true if it works satisfactorily in the real world, measured in terms of its effect, outcome and practicality (Creswell and Poth, 2018b). Pragmatism relies on the assumption that truth is a tool of human cognition to solve real world problems, rather than a method of mirroring reality in a perfect way.

Ontologically, this means that I see reality as independent from myself, but that the relationship between myself and reality is mediated through my human 'structures', such as my language, values, theories, biases and limitations. These structures, from a post-positivist perspective, make it possible to know reality in part, but impossible to know it perfectly.

From an epistemological standpoint, because I believe my perception of reality to be imperfect, it is necessary to consider multiple perspectives and knowledge sources when seeking truth (pragmatically defined). This translates, methodologically speaking, into research approaches relying on multiple types and levels of data collection and analyses.

While a worldview provides the philosophical assumptions underpinning the researcher's view of reality, a theoretical lens provides the particular perspective through which the topic is examined. For the purposes of this project, 'evaluation research' provides that lens. Evaluation research is used for the evaluation of social programmes (Powell, 2006). Robson, (2002: 202), in Retief (2007), defines evaluation research as a process *"…to assess the effect or effectiveness of something"*.

Since this research is primarily interested in determining levels of effectiveness of scientific assessment processes and since scientific assessments are defined as 'social processes' (Kowarsch *et al*., 2016; Kowarsch and Jabbour, 2017), it is fitting that they are evaluated within the theoretical lens of evaluation research (Powell, 2006). Methodologically, evaluation research typically relies on a combination of mixed methods and case study research (Robson, 2002), which is elaborated upon in greater detail in the sections which follow.

3.3 Research questions

The research is inductively ('bottom-up') reasoned. It poses two research questions which have guided data collection and analysis. Based on this, the research seeks to identify patterns in order to make some broad generalisations about scientific assessments – about their effectiveness and potential utility in the South African context. This research set out to address two questions:

Question 1: Are scientific assessments effective?

Question 2: Will they help to advance the knowledge-policy interface in South Africa?

3.4 The cases and reasons for their selection

Since the strength of conclusions for single-case studies is not very high, multiple case studies offer more robustness (Rowley, 2002). Typically in the region of six to ten cases are considered sufficient to achieve this (Rowley, 2002).

Case selection was undertaken based on the aims of the research, the research questions, data accessibility, resource availability, timing of assessment completion and the spatial context. These considerations were used to draft the following case selection criteria:

1.) Cases were identified based on their 'bounded characteristics', in other words, a described set of parameters which made them eligible for analysis (Creswell and Poth, 2018a). In this instance, a case was considered to be a 'real' scientific assessment if it generally conformed to the CRELE principles in that it was fully mandated, used diverse multi-author teams and subscribed to the multi-loop peer and stakeholder review mechanism with all comments and responses fully transparent.
2.) The case must have been completed within the time period 2013-2018. This enabled engagement with participants where the scientific assessment process was still relatively 'fresh' in their minds. The older a case gets the more obscure it becomes both in online accessibility and cognitive recall. The trade-off with this decision is that it is less obvious to track outcomes over the medium to long-term (5-30 years).
3.) The case must have the majority of its materials produced in English and the majority of its participants able to read (for survey purposes) and speak (for interview purposes) English.
4.) The case must have good data accessibility. This includes access to working websites, downloadable materials and contactable project managers.
5.) The overall case study design required an even split between different assessment platforms (IPCC and IPBES) and different spatial scales [global (n = 2), regional (n = 2) and national (n = 2)]. This means that cases were selected in terms of their overarching assessment platform and the spatial scale at which they had been implemented.

Following a screening process based on these criteria, the following global, regional and national case studies were selected for analysis:

1. **Global**: IPCC AR5, WG II: Impacts, Adaptation, & Vulnerability (2014) ("WGII AR5")
2. **Global**: IPBES Land Degradation & Restoration Assessment (2018) ("LDR")
3. **Regional**: IPBES Africa Assessment (2018) ("Africa")

4. **Regional**: IPBES Europe & Central Asia Assessment (2018) (“ECA”)
5. **National**: South African Assessment of Shale Gas Development (2016) (“SGSA”)
6. **National**: United Kingdom Climate Change Risk Assessment 2 (2017) (“CCRA2 ER”)

3.5 Methods

3.5.1 Case-study mixed methods

While evaluation research forms the theoretical lens through which this research is structured, case study research and mixed methods form the methodological basis. Case study research is widely used in the social sciences (Rowley, 2002). It involves research processes for analysing a bounded system for single case studies or multiple bounded systems for collective case studies (Creswell and Poth, 2018a).

Collective case study design uses the logic of replication, in which the researcher replicates measurement procedures across each case study. Collective case studies develop themes within the individual cases (called a within-case analysis) and thematic analyses across the case studies (called a cross-case analysis) (Yin, 2009).

Mixed methods research is commonly used for studying complex social phenomena (Guetterman, 2017). At its essence, it seeks to combine the power of qualitative and quantitative methods to integrate data and establish inferences beyond what either can do alone, to provide a more complete understanding of phenomena (Guetterman, 2017).

A case-study mixed method (CS-MM) design allowed for the integration of mixed methods techniques into a research design bounded by an interest in case-study. The cases provide an instrumental, rather than an intrinsic, point of interest. In other words, their purpose is to provide a measure for effectiveness, rather than providing a point of interest in themselves, which is then subjected to various mixed methods approaches (Figure 6).

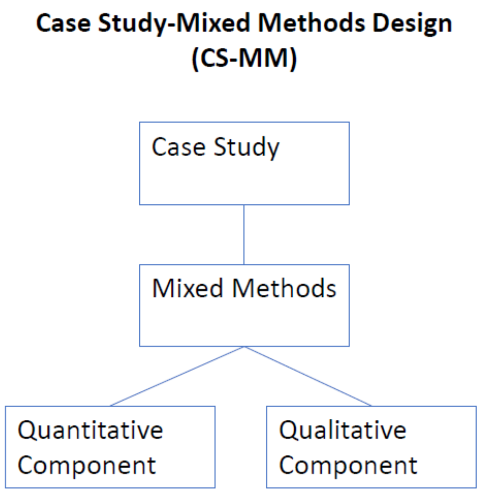

Figure 6: Case-study mixed methods (CS-MM) uses case study to guide the research process and then uses a series mixed method approaches for collecting, analysing and integrating data (Figure after Guetterman, 2017).

Where case study research alone has been criticised for lacking rigour and objectivity (Rowley, 2002), CS-MM design allows the researcher to gain insight into whether the quantitative and qualitative results confirm, contradict, or relate. Mixed methods approaches have been empirically demonstrated to garner more trusted results than singular research methodologies (McKim, 2017).

This research follows a ‘convergent design’, which means that parallel quantitative and qualitative data collection exercises have been undertaken with the intention of merging data in the final analyses. This differs, for example, from the ‘explanatory sequential design’, which uses a quantitative data collection phase to inform the design of the subsequent qualitative data collection phase.

3.5.2 Data collection and analysis

3.5.2.1. Survey

An online survey was built on and distributed through Survey Monkey. Its intention was to measure participant perceptions of the effectiveness of six scientific assessment cases which respondents had been involved in. The survey was distributed following introductory emails sent to respondents outlining the purpose of the research and highlighting ethical considerations in line with the Wits University ethics clearance requirements. Appendix 1 contains the full survey instrument.

No specific sampling frame was adopted as the survey was distributed to all registered participants of all six case studies. Email addresses were obtained from a variety of internet sources obtained between January and July 2018. In spite of requests made to IPCC and IPBES platforms, and following internal legal advice, participant email addresses were not distributed to the researcher for purposes of this research.

Following the introductory email, the survey was distributed to respondents via direct email (gschreiner@csir.co.za), or alternatively, via the Survey Monkey automated tracking response system. In total, ~3 200 emails were distributed, 2 770 of which were successfully delivered and 430 of which were non-delivered. Emails were distributed between end-August to end-September 2018. Based on the received emails, there were 674 respondent responses (~24% response rate) received between 07/09/2018 and 20/12/2018.

The survey was developed based on the CRELE framework (see in sections below). Forty indicators were drawn from the literature and presented as a series of statements. Respondents were then responsible for ranking the extent which they agreed or disagreed with the indicators statements along a Likert-scale were 5 = Strongly Agree, 4 = Agree, 3= Neutral, 2 = Disagree, 1= Strongly Disagree (see Section 3.9.2: Limitations of the survey).

The survey consisted, in total, of 51 questions, structured as follows: Questions 1 – 8 consisted of background questions asking participants which case they had been involved in, their role in the assessment, their knowledge background, their sectors of employment, their age, their nationality and their gender. Questions 9 – 48 were statements reflective of the 40 indicators drawn from the literature (Appendix 1).

Questions 49 – 50 were tailored to gain a sense of respondent's overall impression of the scientific assessments they had been involved in. This was presented in the following statements:

- **Q49** *The process and outputs have made some contribution toward the resolution of the problem in question*.
- **Q50** *You would willingly participate in future assessment processes*.

Question 51 provided an open-ended response opportunity for respondents to make any additional comments about the effectiveness of the scientific assessment process they had participated in.
Respondents answered the survey under anonymity. Data was stored and organised in an encrypted excel spreadsheet.

3.5.2.2. Respondent profile

Forty-two percent of survey respondents participated in WGII AR5. For the remaining cases, survey respondents were split equally between the IPBES cases and SGSA (~15%). The CCRA2 ER, had the least participants at only 4% of the sample.

Ninety-five percent of survey respondents were either reviewers, authors or managers. Only 5% of the respondents classified themselves as part of the 'commissioning body' i.e. the clients (which is a limitation to an effectiveness evaluation).

Seventy percent of respondents were from academia, 14% were from government while the remaining participants were from a combination of the private sector and NGOs.

Sixty percent of respondents were between the ages of 40 and 60. The remaining 40% was split equally between those below 40 years of age (~20%) and those above 60 years of age (~20%).

Sixty-five percent of respondents were male.

See Appendix 1 for a detailed presentation of the demographic distribution.

3.5.2.2.1. Statistical analyses

A combination of one-way, two-way and mixed model ANOVAs were used to compare the subcategory constructs and case studies using R (lmer package). Fisher Least Significant Difference (LSD) was used for post hoc tests, where <0.01 indicated the presence of a significant difference.

Cohen's d was used to calculate effect size between the cases, where a small effect was <0.4, a medium effect was 0.4 – 0.8 and a large effect was >0.8.

For reliability, Cronbach's alphas were calculated where >0.6 was used to indicate acceptable reliability.

In order to test for statistical differences between different groups who answered the survey, one-way t-tests were undertaken.

3.5.2.3. Interviews

Forty-three semi-structured interviews were undertaken with respondents representing four categories of scientific assessment roles:

1. **Authors**: Authors (coordinating, lead, contributing), fellows and volunteers;
2. **Managers**: Commissioning body or governance group (e.g. countries, clients, bureaus, boards, advisers);
3. **Governance**: Assessment chairs, secretariat members, management committees, technical support units and science directors; and
4. **Review**: Independent peer reviewers, review editors, interested stakeholders and external observers.

Table 8: The number of interviews undertaken per case, per scientific assessment role.

	Authors	Managers	Governance	Review	TOTAL
IPCC AR5 WGII	1	2	2	2	**7**
IPBES LDRA	2	3	1	1	**7**
IPBES Africa	2	3	1	2	**8**
IPBES ECA	2	3	2	1	**8**
Shale Gas	2	2	2	2	**8**
UKCCRA2	4	1	0	0	**5**
TOTAL	**13**	**14**	**8**	**8**	**43**

A quota sampling approach was adopted where I sought interviews with ~2 representatives of each of the four participatory categories for each case study. Snowball sampling or chain referral was also used in order to gain access to knowledgeable respondents willing to participate in the research interviews.

Following a brief description of the research and completion of the necessary ethical clearance, the interviews were initiated. Mean duration of interview was 20 minutes. All interviews were semi-structured. This allowed for flexibility to approach different respondents differently, while still covering the same processes of data collection between respondents. The following two questions were used to guide the interviews:

1.) In terms of these CRELE principles, how effective was the scientific assessment process you were involved in?
2.) In order to better achieve these principles, what aspects of the process could be improved and how?

Interviews were digitally recorded to prevent data loss (Noor, 2008) and subsequently transcribed. Interview respondents participated under the security of anonymity. In total 14.3 hours of conversation was collected, amounting to ~83 pages of typed text (11 font, 1.5 spacing).

I had the opportunity to attend the IPBES Plenary session 17 March – 24 March 2018 in Medellin, Columbia, funded by the Global Change Institute at Wits University. The majority of the IPBES interviews were undertaken over the course of this week. The remaining interviews for the other case studies were undertaken between October and November 2018, mainly over Skype, but also including face-to-face interviews, when possible.

I also scheduled interviews with project managers of the scientific assessment case studies (n = 6). These interviews provided me the opportunity to ask reasonably specific questions about the case studies such as those regarding durations, budgets, authors and some information about specific outputs of the assessment (Appendix 3).

All interviews were transcribed and coded using NVivo 12 Pro for Windows. Codes were derived from CRELE effectiveness indicators.

3.5.2.4. Systematic review

A systematic review of the literature on the scientific assessment cases was undertaken between August and September 2019. Where meta-analyses are conducted with statistical methods to aggregate effect sizes, systematic reviews are used to analyse and summarise a range of written evidence for a defined issue. Systemic reviews are transparent and replicable exercises undertaken with clearly defined searches and inclusion/exclusion procedures (Oliver and Cairney, 2019).

The key question guiding the systematic review was: *"What does the published literature say of the relationship between any of the 40 indicators (with 9 subcategories) and the six cases"*?

Google Scholar electronic databases were searched along with selected websites. Terms reflecting the 40 CRELE indicators were used and applied to the different case study platforms. For example, *IPBES knowledge co-production*, *IPBES government involvement*, *IPBES indigenous and local knowledge*, *IPCC knowledge co-production*, *IPCC government involvement*, *IPCC indigenous and local knowledge* and so on.

The systematic review focused on journal and report publications over the last decade from 2009-2019. In total, 161 publications were used for the review. Evidence relating to the 40 CRELE indicators was coded using NVivo 12 Pro for Windows.

While the literature explicitly addressing the specific cases is somewhat limited in the case of the national scientific assessments [SGSA and CCRA2 ER (Table 9 below)], the broader literature contemplating the scientific assessment platforms of the IPCC and IPBES is extensive.

The IPBES and IPCC literature in most instances does not necessarily address the scope of the exact case (i.e. AR5 WGII for IPCC; and LDR, Africa and ECA for IPBES). However, literature relating to the broader assessment platforms can be used as valuable proxy data for the specific cases occurring under those larger platforms.

Table 9: Scientific assessment platforms / case studies in relation to the numbers of literature sources obtained for the systematic review. Of the 162 sources, 85 % of them were published between 2014 and 2018.

Assessment platform / case study	Number of literature sources
IPCC	91
IPBES	57
SGSA	5
CCRA2 ER	9
Total	**162**

Appendix 2 contains a full inventory of the literature supporting the systematic review.

3.5.2.5. <u>Participant observation</u>

I was an observer at the IPBES Plenary in Medellin, Columbia in March 2018, which was attended by >1 000 people, 127 national Governments and >220 inter- and non-governmental organisations. The Plenary adopted five landmark assessment reports, prepared by more than 550 international experts from more than 100 countries. These included four regional assessments for 1) the Americas, 2) Asia and the Pacific, 3) Africa, and 4) Europe and Central Asia and one global assessment of land degradation and restoration.

Attending the IPBES Plenary provided me with the opportunity to actively engage with the scientific assessment processes and observe phenomena as they occurred in their environments. This assisted me in obtaining a better understanding of social processes which are difficult to comprehend only from the literature. Key processes observed included author workshops and discussions, negotiations by member states on final text of the summaries for policymakers, processes associated with capacity development among assessment participants. Diary notes were used to record data of key observations.

I was the project manager of the SGSA from 2015-2017, based at the CSIR in Stellenbosch. During this assessment I had a broad range of responsibilities which included recruiting authors, negotiating with funders, hosting stakeholder meetings, arranging outreach programmes and author meetings, reviewing and drafting scientific content and communicating findings to policy-makers and stakeholders. My experience as an observer of scientific assessment process and knowledge holder in my own right will be infused into the analysis of effectiveness, but I will be explicit about when I am applying this knowledge, since although it is empirically grounded, it could be biased.

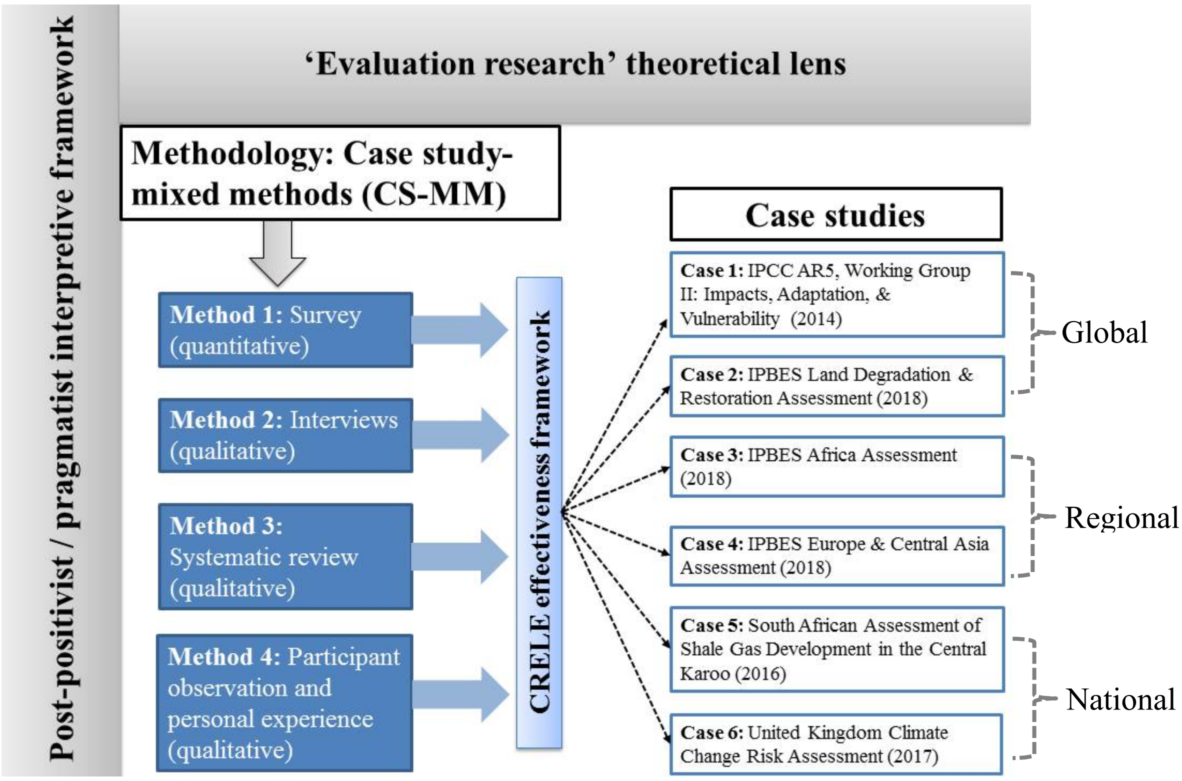

Figure 7: A summary of the research approach. It applies a case-study mixed method (CS-MM) approach to evaluate 40 CRELE-based effectiveness indicators across six cases, two 'boundary organisations' (IPCC & IPBES) and across three different spatial scales.

3.6 CRELE effectiveness evaluation framework

While there is no formal 'recipe' for scientific assessment (Hel and Biermann, 2017), they rely on the fulfilment of a few requirements (Kowarsch, 2016). In this respect, CRELE offers some well-established guiding principles for practice (Cash and Clark, 2001; Young *et al.*, 2013; Sarkki *et al.*, 2014; Kowarsch *et al.*, 2016; Alcamo, 2017). Sarkki *et al*. (2015), suggest that CRELE also offers a helpful framework from which to evaluate the effectiveness of scientific assessment processes.

However, Dunn and Laing (2017: 146) have criticized CRELE for showing *"…limited empirical verification"*. Heink *et al.* (2015) have suggested that systematic evaluations based on CRELE are subject to two main challenges. Firstly, the definitions of CRELE are ambiguous, leaving them open to different interpretations in different contexts. Secondly, they propose that in the few systematic evaluations undertaken so far, very few have been explicit about how CRELE indicators are selected and why they are relevant within that specific context.

Heink *et al.* (2015) propose that the most effective way of accounting for definitional ambiguity and opaque CRELE criteria selection processes is to explicitly define CRELE at the outset with participants in a co-generative fashion, outlining the specific aims of the project and how these aims interface with CRELE. This includes making trade-off decisions explicit and providing clear rationales for trade-off decisions.

Alcamo (2017) proposes that scientific assessments can be evaluated along two broad lines of interrogation – both of which are valuable. The first is along a common 'generic' set of metrics which apply to all scientific assessments. The second line of evaluation is along the highly specific and individually 'tailored' CRELE metrics which apply on a case-by-case basis – similar to that called for by Heink *et al.* (2015).

The differing lines of effectiveness evaluation (i.e. 'generic' versus 'tailored' evaluations) also give rise to another important question: What do I mean by 'effectiveness'?

Effectiveness defined in the generic sense, could mean that scientific assessments are effective when they *"…facilitate interaction processes between science, policy and stakeholders in such a way as to meet the needs and expectations of participants, foster the integration of science in decision-making, and generally exert an influence on both SPI participants and other target audiences"* (Sarkki *et al*., 2014).

Within a more tailored and context specific evaluation framework, the definition of effectiveness would apply more specifically to the intended objectives of the process in question, along the lines of "…*the degree to which something works well and produces the result that was intended"* (MacMillan, 2019: 1).

Since this research is concerned with measuring the effectiveness of six cases across different platforms, scales, objectives and socio-political contexts, the generic CRELE evaluation framework [and definition of effectiveness consistent with Sarkki *et al.* (2014)] will be applied.

Appendix 4 includes a detailed description of the process undertaken to develop the CRELE evaluation framework.

3.6.1 Dimensions of analysis

Cash and Clark (2001) and Mach and Field (2017) explain that evaluations of effectiveness based solely on outputs are inadequate for analysing the multi-layered nature of scientific assessments – that emphasis on 'process', just as much as 'product', is necessary. This means that multiple 'dimensions of analysis' have to be considered within the CRELE evaluation framework (Cash and Clark, 2001; Young *et al.*, 2013).

There are two main dimensions of analysis. These include the phenomena occurring *endogenous* to the actual scientific assessment and *exogenous* phenomena which are influenced by the broader socio-political context. The relationship between the endogenous and exogenous phenomena is mutually reinforcing, meaning that endogenous phenomena influence exogenous phenomena and *vice versa* (Figure 8).

- **The scientific assessment project (endogenous phenomena)**: The endogenous phenomena occur within the bounds of the actual scientific assessment project. This includes:
    - **Structures:** The institutional arrangements and structural components which have been established in order for the scientific assessment to achieve its stated objectives and functions.
    - **Processes:** The codified procedures of the scientific assessment including its day-to-day processes of content generation, negotiation, outreach, capacity building etc.
    - **Outputs:** Specific tangible products developed from the scientific assessment structures and processes such as reports, publications, events, meetings, models, scenarios, indicators and other tools.

- **The socio-political context (exogenous phenomena)**: The exogenous phenomena occur outside of the bounds of the actual scientific assessment project. This includes:
    - **Users:** The relationship between policy-makers and broader decision-makers in society (such as individuals from academic, NGOs or the private sector) and the scientific assessment project.
    - **Effects:** The processes and outputs of a scientific assessment which have an effect in the real world. Effects can be positive or negative, intended or unintended, short-term (0-5 years) or medium-long-term outcomes (5-30 years). They can also be explicit in some instances (such as direct policy change) or tacit in others (such as changes to cognitive patterns, behaviours or narratives (Mach and Field, 2017).

Effectiveness depends on these dimensions of analysis considered in relationship to the CRELE 'proximate pathways' and the trade-off decisions made about CRELE (Figure 8).

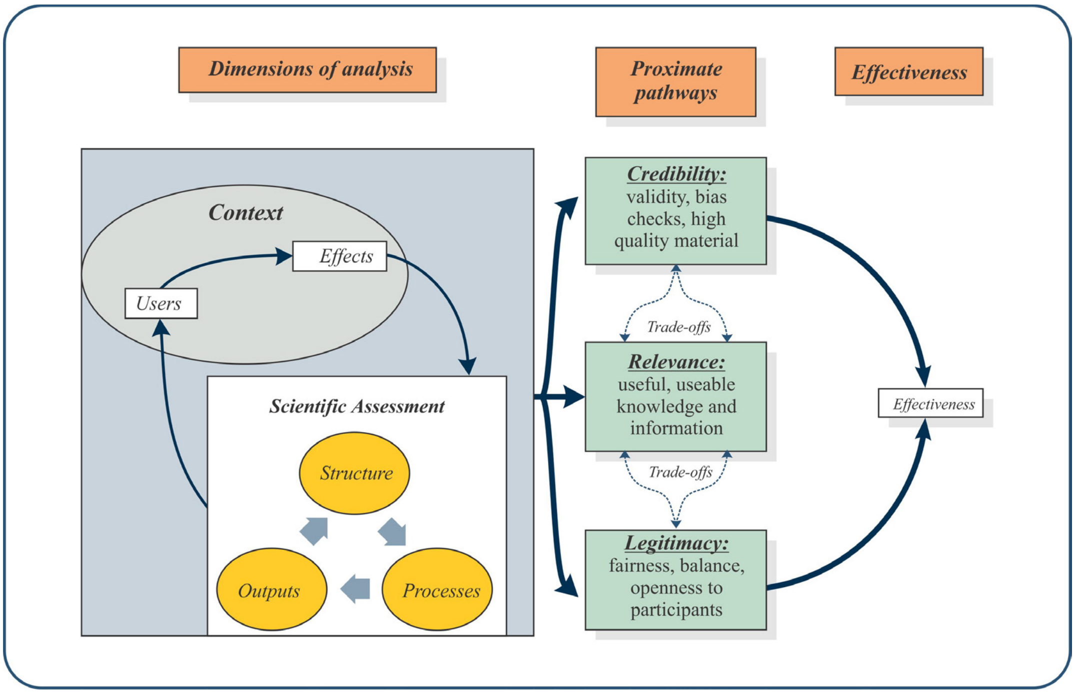

Figure 8: Dimensions of analysis including phenomena both endogenous ("Scientific assessment") and exogenous ("Context") to a case and its context. CRELE principles act as "Proximate pathways" for achieving effectiveness and therefore form the basis of this research evaluation [developed after Cash and Clark (2001) and Young *et al*. (2013)].

3.6.2 The effectiveness framework

This evaluation focuses on generic CRELE indicators, examining endogenous phenomena inherent to the structures, processes and outputs of scientific assessment. While it touches on exogenous phenomena (e.g. examining the impact of a case on policy), it does not consider the broader socio-political context within which the case occurred in time and space.

The scientific assessment dimensions of analyses were subdivided into three categories, which were in turn each subdivided into three *sub-categories constructs*, each with a series of indicators drawn from the literature. *Representation* (*n* = 7), *Resources* (*n* = 5), *Drivers* (*n* = 6), *Trust* (*n* = 8), *Capacity building* (*n* = 3), *Adaptability and uncertainty* (*n* = 3), *Knowledge* (*n* = 3), *Quality* (*n* = 1) and *Implementability* (*n* = 4).

Table 10: CRELE category and subcategory constructs with associated indicators. This framework, drawn widely from the scientific assessment literature, was applied consistently across all six cases in the effectiveness evaluation.

Categories	Sub-categories	Indicators
Structure	Representation	Knowledge co-production, diverse expertise, government involvement, openness to participants, indigenous and local knowledge, embedded social sciences, knowledgeable experts
	Resources	Financial resources, human resources, personnel continuity, information systems, sufficient time
	Drivers	Clear goals and objectives, adaptation to policy changes, different scenarios, mandated process, delineated scope, questions from stakeholders
Processes	Trust	Managed bias, freedom from manipulation, declaration of interests, trust, conflict mediation, transparent procedures, fairness, media relations
	Capacity building	Capacity development, focus on youth development, focus on marginalised groups
	Adaptability	Adaptable, manages uncertainty, iterative processes
Outputs	Knowledge	Enhances debate, covers emerging research areas, delivers on social questions
	Quality	Of sufficient technical quality
	Implementability	Reaches multiple audiences, uses expert judgement, meets practical and policy needs, guides assessments at smaller scale

Indicators were selected following a screening exercise based on Poister's (2010) indicator usefulness test with the following questions applied: Does the indicator reflect what is meant to be measured? Can the indicator be consistently measured? Can the indicator be provided in a timely and cost-effective fashion? The detailed rationale for inclusion of each of the 40 indicators forming this evaluation framework is presented in Appendix 4.

It is very difficult to accurately trace the exact causal relationship between CRELE, subcategories and indicators. This is because virtually all of the subcategories and indicators drawn from literature have a relationship to multiple CRELE principles, at varying intensities. This is demonstrated graphically in Figure 9. This means that it is not possible to causally associate specific indicators with specific CRELE principles, but it is possible to broadly infer that if a scientific assessment meets the majority of indicators (as drawn from the CRELE literature) it can be assumed to have met most of the expectations of the CRELE principles.

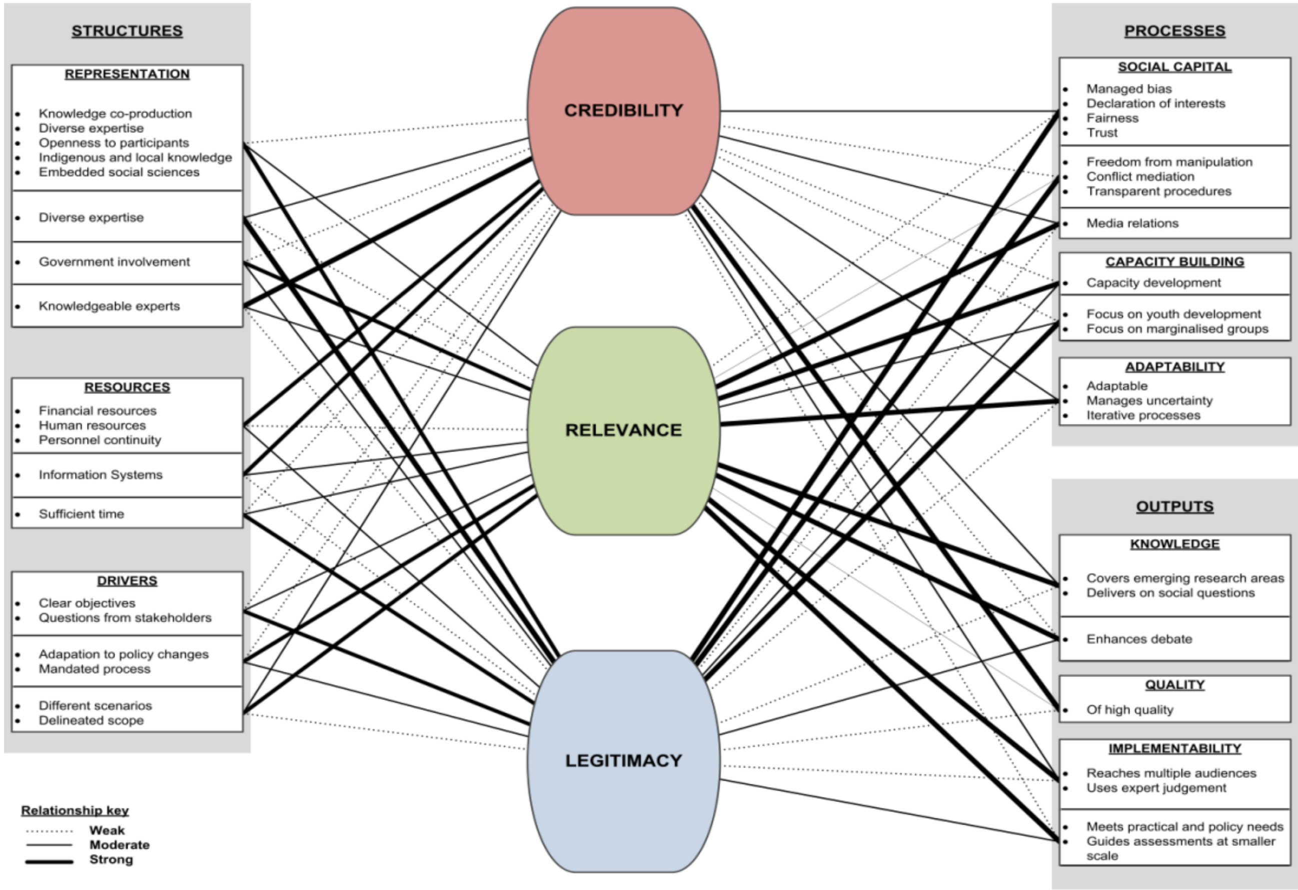

Figure 9: The evaluation framework demonstrating the strength of relationships (defined as either *weak*, *moderate* or *strong*) between CRELE principles, specific categories, sub-categories and indicators of effectiveness. Since the CRELE principles are associated with so many of the indicators, it is not possible to causally associate specific indicators with specific CRELE principles. But it is possible to broadly infer that if a scientific assessment meets the majority of indicators (as drawn from the CRELE literature) it can be assumed to have met most of the expectations of the principles.

3.7 Data integration

Data integration was achieved through 'merging'[36] quantitative data (from surveys) and qualitative data (from interviews, systematic review and participant observation). The primary methods of data analysis and integration were to relate qualitative themes to the quantitative survey scores. In other words, using the qualitative data to explain trends evident in the quantitative data. In order to synthesis the evidence from quantitative and qualitative sources, I applied the IPBES confidence term framework (Figure 10), the results of which are presented in Chapter 7.

Figure 10: Confidence framework reflecting the degree of agreement and quality/quantity of evidence (IPBES, 2018b). In this framework, 'confidence' was seen as a product of expert agreement qualitatively multiplied by the quality and quantity of evidence. High confidence conveyed extensive knowledge and the ability to explain an outcome with high certainty and agreement. Low confidence described a situation of incomplete knowledge, when an outcome cannot be fully explained, or where competing explanations exist

[36] Merging means bringing qualitative and quantitative data together for analysis and comparison, providing *"…a more complete understanding about the topic than the quantitative or the qualitative results would yield alone"* (Guetterman, 2017: 11).

3.8 Validity and reliability of the data

The main concerns regarding the validity and reliability of convergent mixed methods designs are related to: 1.) Whether the qualitative and quantitative methods are sufficiently parallel; 2.) Whether the units under analysis are similar; 3.) Whether the quantitative and qualitative sampling methods are reasonably homogenous; and 4.) Whether any divergent results can be explained backed by an adequate theory (Guetterman, 2017).

The validity and reliability challenge 1 and 2 were mitigated by the consistency provided by the CRELE evaluation framework since it formed the basis upon which the survey was designed, the interview questions were posed and the systematic review was undertaken. In this way, the 40 indicators provide a rigorous method of analysis which guided the integration of quantitative and qualitative data sources and ensured a consistency in analysis. Since there were multiple forms of data collection, these acted upon one another as a means of calibration.

In relation to challenge 3, the stratification of participants into different roles (authors, government, managers and external) was undertaken through the survey and interview processes with the intention of producing homogeneity in sampling methods. In relation to challenge 4, the intention through this integration analysis is to use the qualitative data from the interviews and systematic review to build the theory necessary to explain any inconsistency in the quantitative data.

A large sample of cases was selected in order to provide the best opportunity for replication, since more replication means more validity and reliability; and hence more confidence in the results (Noor, 2008). For this research, if more than three (>3) of the cases replicated, a high degree of reliability was assumed (Rowley, 2002).

3.9 Limitations of the research

3.9.1 Limitations of the framework

The generic CRELE framework is suitable for measuring the effectiveness of endogenous phenomena which occur within the bounds of a ‘project’. Given that a generic framework can be applied across cases, it allows empirically based cross-case comparisons. On the other hand, the value of the tailored line of effectiveness evaluation is that it allows for exploration of both endogenous and exogenous phenomena and can take the rationale and implications of trade-off decisions far better into account.

In accordance with this, the line of evaluation adopted for this research allows for superior within-case comparison, but inferior cross-case comparison. While the tailored line of effectiveness evaluation is theoretically desirable since it has further reach in real-world practice, scientific assessments do not adopt preliminary CRELE framing approaches for indicator identification (potentially due to time and budget constraints). As such, effectiveness evaluations based on highly specific, case-by-case CRELE interpretations are not possible until CRELE framing sessions become a component of scientific assessment project scoping (this was undertaken for the CCRA2 ER only).

This means that the effectiveness evaluation undertaken within this research is limited in its analysis and interpretation of context and effect (since there are no predefined CRELE metrics for the six cases evaluated here). Another reason making it challenging to account for effect is that it is difficult to causally trace effects in the real-world back to the scientific assessment project in a way that demonstrates a direct relationship. Additionally, since this research is based on cases completed between 2013 and 2018, there has not been sufficient time, since their conclusion, to draw any reasonable inferences about medium to long-term effects (5-30 years) at a societal level.

3.9.2 Limitations of the survey

The survey did not include an option to answer "unsure" and all answers were compulsory. This means that there is a possibility that respondent "uncertainty" and respondent "neutrality" may have become conflated in the response patterns. Another potential limitation is that, of the 2 770 email requests, in the region of 24% of respondents actually participated. Being a relatively small percentage of the wider community, this may create the risk of self-selection bias.

3.10 Ethical considerations

Ethical clearance was obtained from the Wits University Human Research Ethics Committee with the code H18/04/18 on 20 April 2018.

CHAPTER 4. CASE FROM THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

4.1 Introduction

In this chapter I first introduce the larger IPCC platform, then specifically the case evaluated in this research: The Fifth Assessment Report of Working Group II on Impacts, Adaptation & Vulnerability (2014). Then, based on the methods proposed in the previous chapter, I use nine subcategory constructs to analyse the case in detail across multiple data sources.

4.2 The genesis, purpose, structure and processes of the IPCC

Human development activities have resulted in increased concentrations of radioactively-active gases such as carbon dioxide in the lower atmosphere. This has a 'greenhouse effect', where visible radiation can penetrate the atmosphere, while deflecting infrared radiation is trapped within the atmospheric 'sheath'. The imbalance created between absorbed sunlight on the surface of the earth and the energy radiated back to space is known as 'radiative forcing'. A series of cascading impacts result from radiative forcing – two of the main concerns being an increase to surface temperatures and increased absorption of carbon into earth's oceans, both of which are associated with major consequences.

Even though the 'greenhouse theory' of global climate equilibrium was first suggested more than 100 years ago, it only became a topic of widespread scientific interest in the 1950s. Growing concerns about atmospheric carbon concentrations were formally recognised by the World Meteorological Organisation (WMO) and the International Council of Scientific Unions (ICSU) when they launched the Global Atmospheric Research Programme in 1967 (Agrawala, 1997).

More international expert panels were established under WMO and UN General Assembly mandates in 1974 and 1975, respectively. However, at the time, there was insufficient evidence to inspire policy interest. Even by the time of the First World Climate Conference in 1979, there was an inadequate understanding of climate change to warrant serious concern (Agrawala, 1997). But by the early 1980s the scientific community started to converge on the theory of climate change and the possibility of human-induced warming. This translated into increased attention in the news media and popular culture which attracted the interests of actors with political mandates (Agrawala, 1997).

Around this period, the United Nations Environment Programme (UNEP), ICSU and WMO hosted three workshops in Villach, Austria, in 1980, 1983 and 1985. The workshops focused on showcasing the increasing evidence for climate change (Skodvin and Alfsen, 2010). Famously, after the 1985 meeting, scientists declared that *"...in the first half of the next century a rise of global mean temperature would occur which is greater than any in man's history"*. Based on this forecast, their recommendations were that *"...scientists and policymakers should begin active collaboration to explore the effectiveness of alternative policies and adjustments"* (Agrawala, 1998: 608).

A year later, in July 1986, at another meeting organised by UNEP, WMO and ICSU, it was decided that an Advisory Group on Greenhouse Gases would be commissioned. Each of the participating bodies nominated two experts to form a prestigious panel[37].

At the same time, UNEP where taking proactive steps to repeat the success of the ozone assessment (Chapter 2) – but this time for climate change. The United States, in particular, started to place increasing pressure on policy-makers to fund an intergovernmental assessment of climate change[38].

With the United States being the largest patron of the UN system, their position was quickly communicated to the WMO Secretariat. At the Tenth WMO Congress which met in May 1987, it was formally recognised that an integrated, multi-actor assessment was required. Resolution 9 from the Congress instructed the Executive Council of WMO *"...to arrange for appropriate mechanisms to undertake further development of scientific and other aspects of greenhouse gases"* (Agrawala, 1997: 5).

The IPCC was formally functional by November 1988. It had intergovernmental status and joint WMO-UNEP sponsorship (Agrawala, 1997). Additionally, through UN General Assembly Resolution 43/53 of 6 December 1988, it had a mandate to undertake scientific assessments of climate change, its impacts and potential response options (Skodvin and Alfsen, 2010).

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[37] The Advisory Group on Greenhouse Gases quickly fell into obscurity as it had insufficient funding and *"...no muscle"* from a policy perspective (Agrawala, 1997: 4)

[38] There are three accepted reasons for the United States interest in climate change. Firstly, the United States had already initiated its own national Climate Impact Assessment Program in 1975 and had the majority of the global climate change expertise. Secondly, it was the largest greenhouse gas emitter of any nation and had substantial economic and policy interest in intergovernmental agreements and treaties. And thirdly, there was a lack of convergence on the issue of climate change internally among the different scientific agencies and there was no coherent view on what adequate policy response mechanisms might look like (Agrawala, 1997).

The early establishment of the IPCC was largely shaped by a small group of individuals from UNEP, WMO and policy-maker agencies from the United States. This led to the development of early assessments which were more like 'expert reports'[39] rather than modern PEM inspired scientific assessments we know in the modern era (Chapter 2).

According to Agrawala (1997: 11), *"Once the IPCC was out of the womb and buffeted by political pressures a somewhat different cast of characters was responsible for its subsequent evolution"*. Over the subsequent years, funding agencies began to play less of a role in the design the IPCC processes. At the same time, new influential individuals chairing the IPCC began shaping the platform along with a plethora of demands from increasingly participating exogenous lobby groups from the private sector and NGOs.

Today, participation in the IPCC is open to all WMO and UN Member countries, plus any other non-state actors[40]. Knowledgeable individuals from these member countries and/or organisations are invited to contribute to the work of the WGs and Task Forces (IPCC, 1998) (Chapter 2). The IPCC does not conduct research but assesses scientific, technical and socio-economic evidence (Skodvin and Alfsen, 2010), although increasingly calls are being made to include more indigenous and local knowledge (ILK)[41].

The need for scientific synthesis in the arena of climate change becomes clear when one considers the surge in evidence availability over the last 25 years. Bibliometric analyses of the term *climate change* reveal that less than 1 000 articles were published between 1970 and 1990. However, between 1990 and 2012, this number had increased to around 165 000 (Scopus and Web of Science)

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[39] Expert reports differ from scientific assessments in that they are aimed at a client, usually governed by a contract. They answer very specific questions and are performed in a few weeks or months, often by a single-author or a small, self-appointed team. Expert report methodologies are often not explicit. They are used for technical, but uncontroversial topics and often make explicit recommendations to policy-makers (Scholes, Schreiner and Snyman-Van der Walt, 2017).

[40] But not necessarily on an equal footing, as only countries have speaking rights.

[41] The terms 'local' and 'indigenous' are mostly used interchangeably in the literature to refer broadly to 'know-how' knowledge systems which *"…have been accumulated across generations"* to guide human-nature interactions (Nakashima, 2015: 15). In the thesis, I have distinguished between 'local' and 'indigenous'. Local relates to knowledge acquired through human exposure to a given environment within a spatial unit, for example a conservation manager or farmer. On the other hand, for indigenous knowledge, I am referring to knowledge passed down through embedded cultural systems. Obviously, there is substantial overlap between the two and one possessing local knowledge will commonly possess indigenous knowledge and vice versa. It is also acknowledged that the lines between what is 'local' versus 'indigenous' overlap substantially.

with a growing number of publications devoted toward different thematic and regional perspectives of climate change[42] (Burkett *et al.*, 2014).

For this reason, the IPCC was established to provide the world with a clear scientific assessment of the current scientific literature about climate change and its potential human and environmental impacts (Burkett *et al.*, 2014). The overarching objective of the IPCC is to (IPCC, 1998: 1): *"…assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation"*.

To achieve this objective, the IPCC has produced scientific assessments since 1990, for almost 30 years, providing an authoritative source of knowledge on global climate change (Watson, 2005), including its causes and risks, and the potential options for response (Mach and Field, 2017). To date, the IPCC has published five assessment reports (ARs), eleven special reports and eleven methodological reports (Devès *et al.*, 2018).

At the national and international scale, the IPCC is widely considered to be an authoritative source of knowledge, used by governments responsible for mitigation and adaptation responses (Mach and Field, 2017). At the global scale, the successive climate assessment cycles which produced reports in 1990, 1995, 2001, 2007 and 2013 are credited with making possible the historic agreement, by 195 countries in Paris in December 2015, to take concerted action on climate change (Schleussner *et al.*, 2016)[43].

Pearce, Mahony and Raman (2018: 127) call the IPCC "… *an extraordinary institution – perhaps the largest exercise in scientific cooperation ever embarked upon"* or as one interview respondent noted [parentheses added] *"[the IPCC]…is the foundation stone for the entire effort made by all of us working on climate"*. For these reasons, the IPCC is considered to be the quintessential scientific assessment platform in operation today (Edenhofer and Kowarsch, 2012) and the archetype process for numerous other global platforms, regional and national platforms.

[42] Priority is given to peer-reviewed scientific, technical, and social-economic literature, but other sources such as reports from government and industry ('grey literature') can be crucial (Burkett *et al*., 2014).
[43] The Paris Agreement allows each country to determine their own mitigation and adaptation strategies but aims to hold the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels (Devès *et al*., 2018).

The IPCC consists of role players operating from four organisational 'tiers' (Figure 11). At the highest tier, the Plenary meets approximately once a year and is attended by hundreds of officials and experts from member countries (IPCC, 2004). Any major decisions by the IPCC are undertaken at plenary meetings such as deciding on procedures, structures, mandates, work plans and budgets for WGs and task forces (IPCC, 1998). The Plenary also decides when and how to prepare new reports, in terms of their scope and outline, and whether to approve, adopt or accept completed reports. In all decisions, the panel seeks consensus, but forgoing this, different views from different members are reflected in the requisite notes, texts and reports (IPCC, 1998).

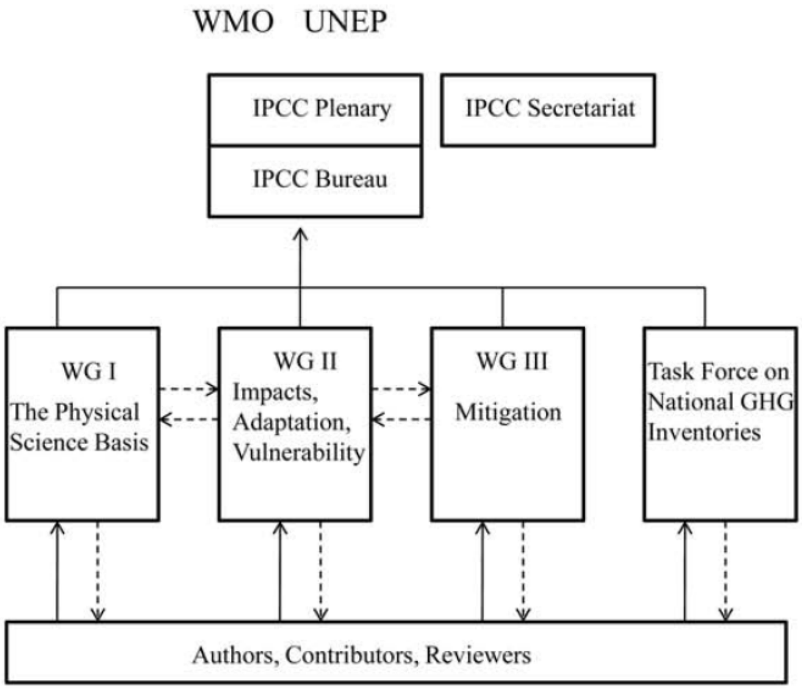


Figure 11: The IPCC consists of role players operating at four organisational 'tiers'. Overarching mandate is provided by the UN Framework Convention on Climate Change to WMO and UNEP (1st tier), which then passes to the IPCC plenary, secretariat and bureau (2nd tier); Working Groups (3rd tier); and technical experts (4th tier).

On the second tier, between the decision-making work of the Plenary and the scientific work of the WGs and task forces, the Bureau oversees administrative functions of each scoping and assessment process. The Bureau is composed of the co-chairs and vice-chairs of the WGs and the task force who are appointed for the duration of the assessment process, usually in the region of 5-6 years. The Bureau is chaired by the Chair of the IPCC and usually has around 30 members from all global regions, all of whom are experts in the field of climate change (IPCC, 2004).

All the activities of the Plenary and Bureau are managed by the Secretariat (hosted by WMO in Geneva) and in-country Technical Support Units (TSU). The Secretariat and TSUs manage the IPCC Trust Fund, manage and coordinate experts and publications, media engagement, public information and outreach, and capacity development activities (IPCC, 2004). The TSUs also play a strong scientific leadership role, ensuring a wide dissemination of findings across a broad range of audiences (IPCC, 2019).

The third tier consists of the WGs and the Task force on national greenhouse gas emissions[44]. The WGs and Task Force have clearly defined mandates and work plans, which are agreed to by the Plenary and Bureau (IPCC, 2004). The WGs and Task Force are led by two co-chairs and are responsible for overall report scoping, generation, adoption and communication (Skodvin and Alfsen, 2010). Each WG has a different assessment scope. WGI assesses the scientific aspects of the climate system and how it is changing. WGII assesses the negative and positive consequences of these changes, as far as they affect ecological systems, socio-economic sectors and human health. Based on this, WGIII assesses the opportunities and constraints associated with different mitigation policies or technologies (IPCC, 2004).

Assessment report	Working group I	Working group II	Working group III
AR1—1990 & 1992	Scientific assessment of climate change	Assessment of impacts of climate change	The IPCC response strategies
AR2—1995	The science of climate change	Impacts, adaptation and mitigation of climate change: scientific-technic analyses	Economic and social dimensions of climate change
AR3—2001	The scientific basis	Impacts, adaptation, and vulnerability	Mitigation
AR4—2007 AR5—2013 & 2014	The physical science basis	Impacts, adaptation and vulnerability	Mitigation of climate change

Figure 12: The scope of issues assessed by IPCC WGs from 1990 to 2014 (Devès *et al*., 2018). Consistently WG I has assessed the physical basis of climate change, WG II the human-ecological impacts and adaptation strategies, and WG III the necessary policy responses for mitigation.

The fourth tier consists of the experts responsible for generating the content of the assessment. This tier involves hundreds of experts from UN member countries who each contribute to reports as authors, contributors or reviewers on a volunteer basis (i.e. they are not remunerated for their time). Experts are selected by the Bureau after receiving nominations from member governments and

[44] The Task Force is mandated to carry out work on the national scale inventory methodologies which are used for calculating the contribution each country makes to global GHG emissions (IPCC, 2004).

participating organisations based on their special expertise relevant to the topic reflected in published work. Their primary responsibility is to review thousands of pieces of scientific literature produced in between assessment cycles in order to establish what is known about the drivers of climate change, its impacts and future risks and how adaptation and mitigation can reduce those risks.

The composition of the WG author teams are selected to represent a range of views, expertise and geographical balance. To best achieve this, author roles are stratified. Coordinating Lead Authors (CLAs) take overall responsibility for coordinating major sections of the report. Lead Authors (LAs) are responsible for the production of designated sections of each report, providing a synthesis of the best available technical and scientific information available in peer reviewed and grey literature (IPCC, 2004). Contributing Authors (CAs) provide remotely based contributions on niche and highly specific topics which are then assimilated in the chapter by the LAs and CLAs (Chapter 2).

IPCC assessment reports are generated by the WGs through a series of meetings, workshops and conferences over a 6-year cycle, with the actual scientific assessment process taking about 3-4 years. After development of draft reports, they are subjected to a rigorous and transparent two-phased review mechanism (Skodvin and Alfsen, 2010) with comments solicited from expert peer reviewers and government representatives at three different points (Chan *et al.*, 2016). Towards the end of the assessment CLAs and Chairs engage in writing a technical summary and a Summary for Policy-makers (SPM) (Chapter 2), with a subset of authors from all WGs convening to draft a Synthesis Report (SYR) and its own SPM (Chan *et al.*, 2016).

4.3 IPCC AR5, Working Group II: Impacts, Adaptation & Vulnerability

The AR5 Working Group II volumes: Impacts, Adaptation, & Vulnerability (‘WGII AR5’), published in 2014, provide one of the cases investigated in this research.

The IPCC platform has included its current subdivisions into Working Groups for close to 25 years. WGII has formed part of Assessment Reports (AR) since AR1 in 1990, including AR2 in 1995, AR3 in 2001, AR4 in 2007 AR5 in 2014 and AR6 currently in progress[45] (IPCC, 2014b). WGII focuses are on evaluating the social and ecological impacts of climate change and describing the opportunities and trade-offs associated with the different policy options for mitigation and adaptation (Figure 13).

[45] AR6 is expected to be completed in 2021, somewhat delayed and modified in process by the intervention of the Covid-19 pandemic. The scoping meeting for AR6 took place in Addis Ababa from 1 to 5 May 2017 where the outlines of chapters were approved by the Panel.

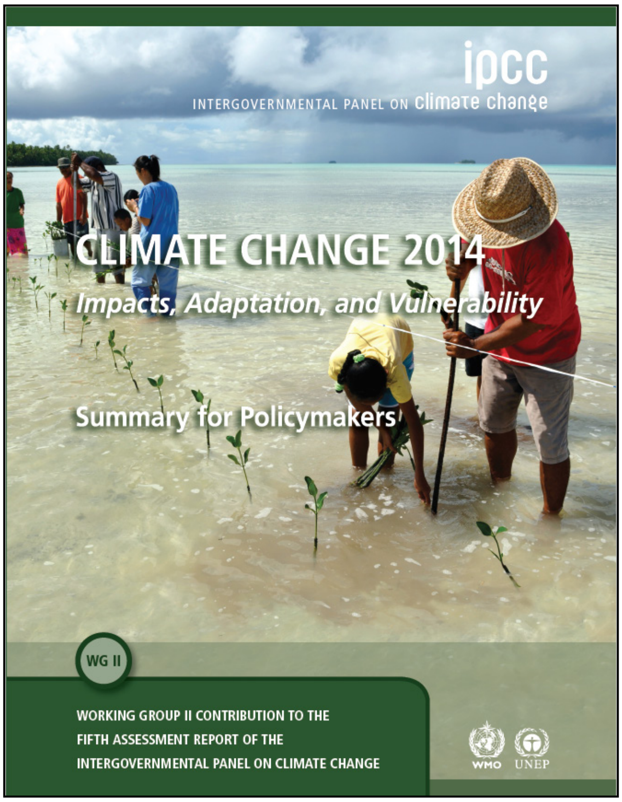


Figure 13: Cover page of the WGII AR5 Summary for Policymakers (SPM): Impacts, Adaptation and Vulnerability, published in 2014.

The contents of WGII AR5 were published in two volumes: Part A – Global and Sectoral Aspects and Part B – Regional Aspects. This allowed for a more thorough regional analysis and expanded coverage of the human dimensions of climate change, such as adaptation (Burkett *et al.*, 2014). The scope of WGII expanded from 7 chapters in the AR1 (1990) to 30 chapters for AR5 (2014) (Ford, Vanderbilt and Berrang-Ford, 2012). Since AR4, 10 new chapters were added to AR5, including a detailed assessment of literature on adaptation, an extensive coverage of oceans, new chapters on livelihoods and poverty, human security, and urban and rural areas (IPCC, 2014c).

Part A of the WGII AR5 covers global and sectoral aspects of climate change including physical, biological, and human systems. It is broken down into the following sections and chapters (IPCC, 2014a) –

1. **Context for the AR5:** (1) Point of departure and (2) Foundations for decision making summarise the conclusions of the AR4 and the WGI contribution to the AR5. They position climate change as a challenge influencing multiple decision-making spheres.

2. **Natural and Managed Resources and Systems, and Their Uses**: (3) Freshwater resources, (4) Terrestrial and inland water systems, (5) Coastal systems and low-lying areas, (6) Ocean systems, and (7) Food security and food production systems, cover diverse sectors, with an emphasis on resource security.
3. **Human Settlements, Industry, and Infrastructure:** (8) Urban areas, (9) Rural areas, and (10) Key economic sectors and services unpack how climate change affects human settlements and economic activities globally.
4. **Human Health, Well-Being, and Security:** (11) Human health: impacts, adaptation, and co-benefits, (12) Human security, and (13) Livelihoods and poverty, increase the focus of the assessment on human well-being.
5. **Adaptation:** (14) Adaptation needs and options, (15) Adaptation planning and implementation, (16) Adaptation opportunities, constraints, and limits, and (17) Economics of adaptation. This coverage reflects a large increase in literature and the emergence of climate change adaptation plans in many countries and concrete action in some.
6. **Multi-Sector Impacts, Risks, Vulnerabilities, and Opportunities:** (18) Detection and attribution of observed impacts, (19) Emergent risks and key vulnerabilities, and (20) Climate-resilient pathways: adaptation, mitigation, and sustainable development, collect material from the chapters in both Parts A and B to provide and integrated examination of impacts to date, future risks and opportunities for response action.

Part B of the report consists of 10 chapters which describe how climate change impacts manifest within different global regions and how these regions are coping with climate change. Each chapter was designed as a consolidated resource for regional stakeholders and explores the issues and themes most relevant to the region (IPCC, 2014a). Part B starts with a chapter explaining the (21) Regional context, structured to help readers understand and use the regional information. This is followed by chapters on different world regions: (22) Africa, (23) Europe, (24) Asia, (25) Australasia, (26) North America, (27) Central and South America, (28) Polar regions, (29) Small islands, and (30) The ocean.

The sections which follow use the CRELE evaluation framework described in Chapter 4 to discuss the effectiveness of WGII AR5 across the nine subcategory constructs. Each of the nine subcategory constructs is briefly defined and introduced prior to evidence evaluation.

4.3.1 Representation

The subcategory construct *representation* refers to harnessing a diversity of knowledge systems and expertise including non-academic knowledge. This allows for the co-production of transdisciplinary knowledge. Within these co-production settings, the intention is that experts leave their 'safe zones' (Kowarsch, 2016) and try to come to terms with complexity, uncertainty and the value-laden contexts which have to characterise wicked problems (Doukas *et al.*, 2018). This relies on an openness to participants across different knowledge domains, sectors, geographies and genders, as well as a continual engagement with policymakers – guiding the process and its outputs (Yamineva, 2017).

The indicators used within the subcategory construct *representation* include knowledge co-production (Scholes, Schreiner and Snyman-Van der Walt, 2017), the involvement of government officials (Rothman *et al.*, 2009), an openness to stakeholders (Rothman *et al.*, 2009), the inclusion of transdisciplinary knowledge systems (Watson, 2005) and social sciences (van den Hove, 2007); and the appointment of suitably experienced and knowledgeable experts (Cash and Clark, 2001).

To begin, the IPCC has been criticised for not being representative enough. For example, El-Hinnawi (2011) highlighted concerns about the overrepresentation of Northern countries. Gay-Antaki and Liverman (2018) noted gender imbalances in patterns of authorship, while Borie, Mahony and Hulme (2015) discuss what they consider to be the marginalisation of indigenous and local knowledge in favour of a dogmatic positivist epistemology (Hulme and Mahony, 2010) overly reliant on established Northern institutions and networks (Okereke, 2017).

Painter (2015) has suggested that the IPCC needs to invest in more stakeholder outreach to capture relevant views. Victor (2015) has raised concerns about a lack of social science in IPCC reports due to a lack of participating social scientists and experts from the humanities. Regarding stakeholder participation, Yamineva (2017) notes that while the IPCC *"…has gradually been opening up to NGOs, it still appears that the latter are held at bay by governments"* (Yamineva, 2017: 248).

Much of the way *representation* is conceived and attempted within the IPCC structure relies on author selection procedures which promote balance across knowledge domains, geographies and genders. Following on from the InterAcademy Council (IAC) recommendation that the IPCC establish a *"…formal set of criteria and processes"* for author selection (IAC, 2010: 9), AR5 member governments and IPCC observer organisations nominated experts in January 2010. Based on these nominations, the Bureau selected CLAs, LAs and REs from a total of 1 217 nominations, with the slate of final experts finalised in June 2010 (IPCC, 2014c).

Woodward *et al*. (2014) argue that the basis for the WGII AR5 author selection process took into account the necessary institutional and disciplinary perspectives – as well as considering gender and geographical balance. In agreement, Interviewee R1 suggested that [parentheses added]: *"…we put a lot of attention [into] making sure that every individual author was carefully selected to be able to effectively present a viewpoint"*. Interviewee R7, a policy-maker, suggested that [parentheses added]: *"…the [author selection] process, I think, is pretty transparent and a solid process"*.

Even so, the IPCC has been criticized for exhibiting a top-down model of ownership (Hulme, 2010) where *"…opaque"* author selections based more on political orientation and personal connections trump scientific track record (McKitrick, 2011: 4). In agreement, one of the open-ended survey respondents stated [parentheses added]: the *"…[s]election of authors was in some cases poor and based on political considerations and not professional competence"*.

With respect to transdisciplinarity and co-production, Devès *et al.* (2018) and Carey, James and Fuller (2014) suggest that the separation of WGs presents a major challenge to integration when human and natural systems are divided, rather than coupled. While WGI has a mandate to cover the physics and chemistry of climate change, WGIII focuses on the socio-economic and policy implications of climate change (Connell *et al.*, 2018). This concern is empirically demonstrated by Gray *et al.* (2013) who report that since the IPCC inception in 1988, only 7% of authors have participated in more than one WG structure.

On the other hand, WGII represents a somewhat different approach, adopting a hybrid model for dealing with a mixture of social and natural science questions (Devès *et al.*, 2018). WGI AR5 was completed about 6 months before WGII AR5. This allowed time for the incorporation of the scientific and technical findings of WGI within the impacts, vulnerability and adaptation assessments made in WGII (Burkett *et al.*, 2014).

Within this hybrid framework there are concerns about the underrepresentation of the social sciences (Victor, 2015) and within the social sciences which do participate in IPCC assessments, there seems to be an overreliance on economics according to Connell *et al.* (2018). In agreement, Klenk and Meehan (2015: 744) believe the IPCC demonstrates a limited understanding of the *"…human dimensions"* of climate change. Reflecting this, in relation to communication of assessment findings, based on quantitative analyses by Kunelius and Yagodin (2017), the voices of IPCC natural scientists dominate over those of IPCC social scientists and economists in the media.

For example, Borie, Mahony and Hulme (2015) cite the case of the IPCC Second Assessment Report where human lives were valued in economic terms in order to measure the impact of climate change. The authors note that countries such as India strongly objected to this value system at the SPM drafting stage, as it implied that human lives in developed countries were more 'valuable' than those in developing countries.

Ford *et al.* (2016) discuss how WGII AR5 framed its assessment within the overarching narrative of impending catastrophe. This, the authors argue, has led to a homogenising of knowledge where the diversity of human experience is not adequately taken into account. As a result, the views and values of local and indigenous knowledge holders are largely omitted (IAC, 2010). In regard to the latter, indigenous populations of people have been identified as having at the same time both high-levels of vulnerability to climate change and high-levels of useful knowledge, especially for adaptation (Ford, Vanderbilt and Berrang-Ford, 2012).

This type of knowledge is therefore seen as essential for building resilience to climate change, especially as regards adaptation. However, an empirical examination of 309 of the authors and REs who contributed toward WGII AR5 revealed that only 9 of them (2.9%) had published material related to *"...climate change and Indigenous populations"* (Ford, Vanderbilt and Berrang-Ford, 2012: 3). These authors were spread across 6 of the 30 AR5 WGII chapters, meaning that 24 out of 30 chapters did not have any authors with published experience in indigenous knowledge systems.

In a lexical analysis of 382 key words and phrases relating to indigenous knowledge in WGII AR5, Ford *et al.* (2016) determined that coverage of key indigenous knowledge themes had increased 60% since WGII AR4 (2007), however, the authors considered the WGII AR5 still to be limited in its scope and *"...largely overlook"* indigenous experiences (Ford *et al.*, 2016: 2). This is consistent with the findings of the survey used in this research, where in response to S13 "*non-scientific knowledge was adequately considered"*, the mean response was 3.02 (± 0.92) with only 4.38% of the respondents Strongly Agreeing (Table 11).

Table 11: Subcategory construct representation mean and median responses (n = 283)

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
9	Knowledge co-production	3.82 (± 0.96)	4 – Agree	26
10	Diverse expertise	4.16 (± 0.79)	4 – Agree	37
11	Government involvement	3.45 (± 0.98)	4 – Agree	14
12	Openness to participants	3.42 (± 1.07)	4 – Agree	16
13	Transdisciplinarity	3.02 (± 0.92)	3 – Neutral	4
14	Use of social sciences	3.59 (± 0.95)	4 – Agree	14
15	Knowledgeable experts	4.14 (± 0.85)	4 – Agree	37

This issue was also flagged by survey respondents, one of whom suggested that WGII AR5 was *"... heavily weighted to the natural and physical sciences"*. Another claimed that [parentheses added] *"…the discipline of sociology […] was ignored throughout the process"* (S14, Table 11). This point is perhaps best illustrated by a review of citations from IPCC reports undertaken by Vasileiadoua, Heimeriks and Petersen (2011). The authors reviewed IPCC reports published in 1990, 1995, 2001 and 2007 and found that 95% of citations were from the physical sciences with only 5% from the social sciences (2% from economics and 2% from socio-political sciences)

Using quantitative and qualitative approaches to lexical and discourse analysis, Fløttum, Gasper and St. Clair (2016: 24) determined that across AR5, all SPMs paid little attention to the human and social dimension of climate change reflecting , what the authors believe, is an *"…inherited cognitive and epistemic dominance of the natural sciences in the IPCC community"*. Conversely, Spencer and Lane (2017) have cited a lack of physical geographers within natural scientists selected as CLAs and LAs in AR5 WGII, who make-up only 4.9% of participating experts.

An analysis undertaken in this research of the 240 authors CLAs and LAs who made up WGII AR5 revealed that 24 were from the applied sciences (10%), 11 from arts and humanities (5%), 68 from economics and social sciences (28%), 15 from health sciences (6%) and 122 from natural sciences (51%)[46]. This suggests that while authors in WGII AR5 were predominantly from the natural

[46] The analysis used the disciplinary classification system designed and maintained by Science-Metrix (Science-Metrix, 2019). Within this system, the Applied Sciences consist of Agriculture, Fisheries & Forestry, Built Environment & Design, Enabling & Strategic Technologies, Engineering and Information & Communication Technologies. The Arts & Humanities consist of Communication & Textual Studies, Historical Studies, Philosophy & Theology and Visual & Performing Arts. Economics & Social Sciences consisted of Economics & Business and Social Sciences. Health sciences consist of Biomedical Research, Clinical Medicine, Psychology & Cognitive Sciences and Public Health & Health Services. The Natural Sciences

sciences, 49% of the authors were drawn from fields outside of the natural sciences and 28% of authors were drawn from the social sciences, although (based on the available data) it was not possible to determine the relative composition of economists with the social sciences field.

Since the majority of participating IPCC experts come from formal research systems in academia and government science councils, there is a need for the IPCC to explicitly document a broader range of divergent viewpoints (IAC, 2010). This has prompted calls to increase both the representation of knowledgeable practitioners from the private sector (Howarth *et al.*, 2017), although in the case of WGII AR5, one respondent who answered the open-ended survey response suggested that [parentheses added] *"…very little room [was] made for the practitioner voice"*.

Increased recruitment of practitioners and those working in the private sector in the IPCC assessments will require an expanse of the literature base to include unpublished and non-peer reviewed ('grey') literature (IAC, 2010). In one survey respondents view *"…research documents not published in peer-review-journals should be included e.g. reports from research projects"*. However, in relation to the use of adaptation case studies in the IPCC reports, another respondent complained *"…these sources were completely rejected as they were not peer reviewed articles"*.

Regarding multidisciplinarity, Science-Metrix developed a widget to measure three dimensions of disciplinary diversity in a research team. Based upon a taxonomy which arranges research into domains, fields and subfields, when used in combination with a disciplinary proximity matrix, it is possible to measure the number of different subfields, the relative balance of the subfields and the conceptual 'distance' between the subfields (Struck, 2017).

The Science-Metrix widget was used to assess the team composition as determined by the 61 CLAs from WGII AR5. Scores range from 0 to 1, with 0 being completely monodisciplinary and 1 being maximally diverse. The ranges for scores can be interpreted as follows (Struck, 2017):

- **0.1–0.2:** is a low score, meaning that there is one 'home' discipline with a few 'secondary' areas also included.
- **0.3–0.5:** is a mid-range score, meaning that there is a balance amongst the disciplines represented but that they're all still quite clustered in one intellectual area.

consist of Biology, Chemistry, Earth & Environmental Sciences, Mathematics & Statistics and Physics & Astronomy. The CLAs highest level of education reflected by multiple, freely available internet sources, were used to determine their respective domain, field and subfield.

- **0.6 and above:** is a high score, meaning that several different disciplines are involved, they're relative balanced and they're drawn from a broad intellectual diversity.

The disciplinary diversity score for WGII AR5 was 0.87, which indicates exceptionally high knowledge diversity among CLA leadership. This brings into question the validity of much of the criticism levelled at the IPCC, and in particular WGII AR5, for failing to take into account a diversity of academic knowledge systems (note, this differs from transdisciplinarity, which relies on the inclusion of non-academic knowledge holders within an assessment process).

Regarding representative country participation, during the period 1988 to 2013, 129 countries participated in IPCC processes. However, the relative national contributions are not evenly distributed with five countries – USA, UK, Germany, Canada and Australia – providing over 50% of participating experts (Gray *et al.*, 2013), leading to concerns about an imbalance in geographically determined epistemological diversity (Corbera *et al.*, 2016). Of the 137 developing countries, 75 participated at IPCC-40 (October 2014), 64 at IPCC-41 (February 2015), 85 at IPCC-42 (October 2015) and 78 at IPCC-43 (April 2016) (Yamineva, 2017).

In an analysis of expert author composition across assessment reports in 1990, 1995, 2001 and 2007, Ho-Lem, Zerriffi and Kandlikar (2011) noted an underrepresentation of developing country scientists. They found that European and North American experts made up more than 75% of all authors (n = 4 394), which were mainly influenced by variables such as per capita gross domestic product, population, English-speaking status and levels of tertiary education.

Other factors, cited by Yamineva (2017) include lack of remuneration for IPCC work, weak communication infrastructure in the global South and visa and travel constraints. One interviewee (R1) stated that *"…academic accomplishments, publications, prizes, all that stuff that accrue almost entirely to developed world scientists versus the experience and the perspective of developing world scientists. I think in the IPCC we definitely struggle with that"*.

In addition, bibliometric analyses have revealed that the substantial proportion of climate change publications emanate from Northern countries which may contribute to the increased levels of participation from Northern country representatives (Vardy *et al.*, 2017). Northern countries experts accounted for 88% of all authors in 1990, decreasing to 83% of total authors in 2007. Authors from the global South represented 12% of authors in 1990, growing to 17% of total report authors in 2007 (Ho-Lem, Zerriffi and Kandlikar, 2011) .

With respect to WGII specifically, authors from the global South increased from 19 in 1990 to 119 in 2007, representing a relative increase from 18% to 28% of total WGII authors respectively (Ho-Lem, Zerriffi and Kandlikar, 2011). Importantly, of the review comments received on AR5 WGII, 80% were made by countries from Northern countries (Yamineva, 2017).

One WGII AR5 peer reviewer who answered the open-ended survey question stated that *"…an over dominance of large nations is evident where networks are mutually supportive and outreach to expertise in smaller nations is limited"*. In a similar vein, another author who responded to the open-ended survey question noted that *"…new processes are needed to select qualified authors from the global south and to strengthen capacities for assessments in those regions"*.

Based on the review undertaken in this research[47], of 240 CLAs and LAs undertaken in this research, 160 authors were from high income countries (67%) (e.g. Chile, Hungary, Panama, Poland, Croatia etc.), 47 were from upper-middle income countries (20%) (e.g. Jordan, Samoa, Georgia, Sri Lanka, Algeria and Azerbaijan), 23 were from low-middle income countries (10%) (e.g. Cambodia, Comoros, Myanmar, Kyrgyzstan, Mauritania) and 7 (3%) were from low income countries (e.g. Mozambique, Niger, Malawi, Burundi, Somalia). Of the 240 authors, there was no data available for 3 of them.

Assuming that the World Bank classification system of low, low-middle and upper-middle income countries is roughly analogous with the 'developing' countries referred to in Ho-Lem, Zerriffi and Kandlikar (2011) (which is based on United Nations Framework Convention on Climate Change classification system) then for AR5 WGII, 67% of authors were from Northern countries while 33% of authors were from the global South. This represents a 5% increase on the 28% recorded for AR4 WGII.

As regards gender balance, empirical reviews of research team dynamics has demonstrated that balancing gender diversity leads to increased levels of innovation in solving problems (Nielsen *et al*., 2017). Gay-Antaki and Liverman (2018) found that since 1990, the proportion of female experts involved in IPCC assessments has increased from less than 5% in 1990 to more than 20% in AR5.

[47] For the analysis countries were divided into economic classifications used by the World Bank reflecting Gross National Income (GNI) which is the dollar value of a country's final income in a year, divided by its population, where high income countries have a GNI of ≥ $ 13 800, upper-middle countries have a GNI of between $ 4 000 – $ 13 799, low-middle countries have a GNI of $ 1 190 – $ 3 999 and low-income countries have a GNI of ≤ $ 1 189 (Wikipedia, 2019).

Based on interviews with over 100 women participating in IPCC assessments, Gay-Antaki and Liverman (2018) found *"…that many women report a positive experience in the way in which they are treated and in their ability to influence the report"* (Gay-Antaki and Liverman, 2018: 2060). Specifically, regarding AR5 WG II, of the 240 participating CLAs and LAs, 167 were male (69%) and 67 (31%) were female (while there was no data for 6 authors).

Since 2009, women have earned the majority of doctoral degrees awarded at US universities. In 2017 out of 79 738 doctoral degrees awarded, women earned a majority of 57%. In disciplinary fields such as public administration (76%), the health and medical sciences (70%) and education (69%) women accounted for the majority of doctoral degrees. On the other hand, in fields such as engineering (77%), math and computer science (75%) and physical and earth sciences (66%) men accounted for the largest proportion of doctoral degrees (Okahana and Zhou, 2018).

Assuming PhD graduates in 2017 are a reasonable proxy for gender balance in the current physical and earth sciences knowledge domain, a gender split of 69% male versus 31% female in AR5 WGII is fairly representative of the physical and earth sciences knowledge domain as a whole, which is responsible for around 51% of all participating AR5 WGII experts. Although, since the remaining 49% of WGII AR5 participants are from knowledge disciplines other than the physical and earth sciences, perhaps one might expect to see a higher rate of female participation.

As concerns the competence of experts, governments and participating organisations nominated experts which were selected by the WGII AR5 Bureau and accepted by the IPCC Plenary in May 2010. This established a team of 64 CLAs, 179 LAs and 66 REs from 1 200 nominations (IPCC, 2014c). An additional 436 CAs, who were approved on a need basis by the WGII AR5 co-Chairs, added specialised niche sections to the respective chapters (IPCC, 2014a; 2014c).

Some participants have praised the author selection process, while for others it was sub-standard and resulted in a lack of suitable expertise. For example, one survey respondent notes: "*We were fortunate to have a large range of subject matter experts with whom to collaborate and discuss"*, while another complained that *"…the scientific quality of some participants was below standards"*.

Although expertise or relevant knowledge is difficult to measure, the *h*-index is used as an author-level metric which attempts to measure both the productivity and citation impact of the publications of a scientist or scholar. Based on an analysis undertaken in this research, of 50 CLAs who participated in WGII AR5, the mean *h*-index was 28.86 (± 21.86). For reference, the mean for environmental scientists globally is 22, while the mean for the top 1% of environmental scientists is 32 (Scholes, Schreiner and Snyman-Van der Walt, 2017). It is noted that the high standard deviation suggests a great deal of variation in *h*-indices among participating CLAs.

4.3.2 Resources

Resources refers to the availability of financial and human resources (Sarkki *et al.*, 2015), personnel continuity through an assessment process, sufficient time to complete tasks and adequate information systems for knowledge generation, transferal and communication, such as websites and data platforms (Young *et al.*, 2013: 44).

WGII AR5 initiated with its first author meeting in January 2011 (Ms Katharine Mach, comms, 25/09/18) and concluded when the SPM was accepted line-by-line by the Panel, along with underlying chapters, at the 10th Session of WGII and the 38th Session of the IPCC Panel, held in Yokohama, Japan, from March 25-30, 2014 (IPCC, 2014a). In total, WGII AR5 took just over 3 years from start to finish.

The entire AR5 assessment was supported by a secretariat in Geneva, Switzerland with four TSUs – one for each WG and one for the Task Force on National Greenhouse Gas Inventories, each consisting of about five to seven people (Griggs, 2014). The WGII AR5 TSU was managed out of the Carnegie Institution for Science in Stanford, California, USA (IPCC, 2019).

Co-Director of Science and the lead of the WGII AR5 TSU Ms Katharine Mach (pers comms, 25/09/18) notes that *"...in general the TSU has sufficient human resources with many different people in different roles supporting the process"*.

The entire AR5 cycle including WGI, WGII, WGIII and the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)[48] cost in the region of $12.5 million[49]. It was not possible to determine the relative contribution made toward each assessment in the entire AR5 cycle. WGII AR5 operated within what was described as *"...bare bone*

[48] The SREX focused on the implications of extreme weather and climate events ('climate extremes') for society and sustainable development. The assessment traced the climatic, environmental, and human factors that lead to impacts and disasters and described the best options for managing these risks (IPCC, 2012).
[49] Pers comms with Mr David Dokken (10/15/18), the Executive Director of AR5 WGII. It was not possible to determine the proportional costing of WGII specifically as the entire AR5 cycle was managed as one project.

financing model" where as many as possible in-kind contributions were sought to execute the scope of the work (Ms Katharine Mach, pers comms, 25/09/18).

Table 12: Resources dedicated toward the WGII AR5 work plan.

Resource	Number
Literature sources	~ 12 000
Co-Chairs	2
CLAs	64
LAs	179
CAs	400
REs	66
Chapter Scientists	36
Expert Reviewers	1 729
Budget	~$12.5 million for entire AR5 cycle (see Footnote 46)

All IPCC experts are expected to work unpaid and the majority of them worked unassisted (Stocker and Plattner, 2014). In the account by Carraro *et al.* (2015: 35), this *"...pushed author teams and technical support units (TSUs) to their management limits"*.

Another WGII AR5 peer reviewer noted that the *"...process is very rigorous, but it is a very heavy and patience-requiring process (a real endurance sport) for those who are seriously involved"*. This rigour is known in the scientific community to produce a form of 'assessment fatigue' (Rothman *et al*., 2009), made worse in instances of operational inefficiencies (Chan *et al*., 2016) and laborious and time-consuming procedures, such as consensus, approval sessions, peer review etc. (Kowarsch, 2016).

Stocker and Plattner (2014: 163) [parentheses added] note that *"...working on an assessment for the [IPCC] is utterly exhausting"*, requiring *"...countless hours and late nights of ploughing through the latest research, analysing gigabytes of data and responding to thousands of comments by reviewers"*.

In a slightly dramatic account, Griggs (2014: 171) exclaims that *"...IPCC work can ruin lives",* due to the workload and experts haggling over content in between themselves, peer reviewers and policy-makers.

Carraro *et al.* (2015: 35) suggest that the substantial workload and *"…high costs of time and travel commitments put at risk the participation of the best researchers"*. As one WGII AR5 author noted, *"…much of the effectiveness that matters is not of the actual assessment process, but of the involvement of individual authors. Many authors are in high demand, with many distractions"*.

In relation to the question of whether the IPCC authorship model is working effectively, one of the open-ended survey respondents wrote [parentheses added]: *"…many, if not most, participants from the academic sector are making contributions […] without additional support or time. The work is normally fitted in and around other commitments largely after hours and/or during holidays"*. Another author wrote [parentheses added]: *"…most who participate are unpaid […] meaning that only those that have other avenues of remuneration can participate. Does this create an inherent bias? I'm not sure. Does it result in some scientists not engaging consistently? Absolutely"*.

The issue of financial compensation for authors is consistently questioned in the literature. Stocker and Plattner (2014) ask whether the *pro bono* ('in-kind') model of authorship is sustainable in the future. Griggs (2014) suggests that while authors should not profit from IPCC work, their home institutions should be compensated for their time away. This sentiment was reflected in the findings of the survey. For S16, in response to the statement: *"adequate financial resources were made available"*, the mean response was 2.97 (± 1.00), where only 8 % of the 274 surveyed respondents Strongly Agreed with the statement (Table 13).

Table 13: Subcategory construct resources mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
16	Financial resources	2.97 (± 1.00)	3 – Neutral	8
17	Human resources	3.55 (± 0.94)	4 – Agree	14
18	Personnel continuity	3.76 (± 0.82)	4 – Agree	18
19	Use of information systems	3.84 (± 0.89)	4 – Agree	24
20	Sufficient time	3.56 (± 0.82)	4 – Agree	12

Even though a lack of financing is a concern expressed by participants involved in WGII AR5, as are concerns over capacity constraints to complete the work, in response to the question: "*would you willingly participate in future assessment processes"*, the mean was 4.14 (± 0.91) with 82% of survey respondents (*n* = 274) who either Strongly Agreed (39%) or Agreed (43%) that they would.

This suggests that while participants are subject to high levels of pressure resulting from non-remuneration, the IPCC scientific assessments are still considered a valuable time contribution, even if doing so requires personal and professional sacrifices. This finding is consistent with the findings of a survey conducted of WGI AR5 authors which revealed that more than 80% of the 172 respondents rated their experiences of that process as ‘very good to excellent’ (Stocker and Plattner, 2014).

As regards resource allocation within the WGII AR5 project, some interviewees felt that more support could have been dedicated toward communications and capacity development initiatives. Interviewees suggested that the vast majority of resources are dedicated toward the content development aspects of the scientific assessment. They called for a more evenly distributed flow of resources, balancing the needs to maintain scientific rigour, whilst contemplating the value of participation and communication programmes. In this respect, Interviewee R2 stated [parentheses added]: *“…from a communications point of view there are real weaknesses, or have been in the past […] because it [communications] has been under resourced in its ability to communicate its findings”.*

Regarding resources dedicated toward training, Interviewee R5 noted that: *“…some CLAs get how to run an effective assessment process, others don’t. They are brilliant researchers and scientists, but they don’t quite understand what it means to run a social process”*. Interviewee R5 suggested that further effort is needed to provide experts with sufficient training in science communication and policy processes, as well as capacitation, especially for CLAs, in the art of managing teams of people with potentially disparate viewpoints, in pressurised contexts.

Consistent with Stocker and Plattner (2014), interviewee R5 questioned the *“…real value for the full-blown assessment of every single topic on climate change”*, suggesting that more value might be derived from an assessment cycle every 10 years, with shorter, flexible, intermittent assessments – delivering quicker policy-relevant knowledge (Carraro *et al.*, 2015). The advantage of this is that human resources can be used in a more targeted, less expansive fashion, perhaps via use of “*…remote communication technology”* (Interviewee R4, 2019), which may serve to mitigate the effect of so-called assessment fatigue (Rothman *et al.*, 2009). On the other hand, from a communication perspective, Interviewee R2 noted that the big, well publicised scientific assessments provide *“…the moments where the world sits up and takes notice”.*

4.3.3 Drivers

Drivers refer to an assessment process operating within a mandated structure, where the assessment has been asked for by people authorised to action on the results – this creates what is known as an ‘authorising environment’ (Scholes, Schreiner and Snyman-Van der Walt, 2017). Drivers also refers to having clearly formulated objectives (Sarkki *et al.*, 2015) within a properly delineated scope (Cash and Clark, 2001) which is sensitive and adaptive to policy changes (Young *et al.*, 2013). It includes the assessment of multiple, plausible future scenarios (Mach and Field, 2017) which are informed by questions from the broader stakeholder community (Scholes, Schreiner and Snyman-Van der Walt, 2017).

Building upon the foundations of WGII AR4 (published in 2007) and the SREX (published in 2012) (IPCC, 2014b), WGII AR5 attempted major topic coverage and breadth. It covered a much larger scope, advancing from 20 chapters in AR4 in 2007, to 30 chapters in 2014.

Through the WGII AR5 process, around 12 000 sources of scientific, technical, and socio-economic information from scientific journals, industry journals and reports from governments and international bodies were reviewed (IPCC, 2014c). The decision to initiate the three WG contributions, plus the Synthesis Report, was taken by the member governments of the IPCC at their 28th Session in April 2008 (IPCC, 2014c). In this sense, the process was fully mandated by UN member states tasked with using the findings of the scientific assessment.

Woodward *et al*. (2014) reports that literature search protocols were followed for WGII AR5 to make sure that there were no important omissions and that the literature driving the assessment was salient. To inform the selection of references, authors gave priority to recent studies which added new knowledge to the topic, were geographically relevant, or relevant to a specific region or population (and were judged as being policy relevant). However, according to Minx *et al*. (2017) either in spite of or because of the literature selection protocol adopted in AR5, in the region of 80% of the relevant literature on climate change was excluded from the assessment.

Making decisions about what is included or excluded in an IPCC assessment relies solely on the scrutiny of the collective expert judgement. During AR1, less than 1 500 studies were cited. In the case of WGII AR5, even though it focused on content published after 2007 (Woodward *et al*., 2014), it still ran to about 110 000 citations. Since 2016, about 33 000 new climate change studies are published each year, at an ever-increasing rate.

Based on this, Minx *et al.* (2017) project that 200 000 to 300 000 new publications will need to be assessed within the scope of the AR6 cycle – which may lead to an even smaller fraction of evidence coverage than AR5 achieved. This prompts the need for clear policy questions, which serve to guide the selection of evidence in terms of what is 'in' and what is 'out'. This will avoid cases of 'cherry-picking' to advance a given ideological frame or to promote self-referencing (Minx *et al*., 2017).

However, a clear and succinct set of policy questions are not evident in the WGII AR5 chapters. This is perhaps evidenced by the statement of one participating WGII AR5 author: *"I found my chapter in WGII to be a complete disaster. The main problems were a lack of clarity about goals"*.

The elucidation of clear policy questions may be helpful in future assessments to guide their scope and navigate reference selection processes through the 300 000 plus publications which will be available to AR6 chapter teams. Having said all that, the findings of the participant survey slightly contradict the notion that objectives were not clearly laid out. For S21 (Table 14), the mean response was 4.03 (± 0.83) with 28% of participants Strongly agreeing with the statement.

Table 14: Subcategory construct drivers mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
21	Clear goals and objectives	4.03 (± 0.83)	4 – Agree	28
22	Adaptation to policy changes	3.05 (± 0.78)	3 – Neutral	5
23	Different scenarios assessed	3.71 (± 0.88)	4 – Agree	16
24	Mandated process	3.79 (± 0.97)	4 – Agree	27
25	Delineated scope	4.05 (± 0.78)	4 – Agree	28
26	Stakeholder questions	3.26 (± 0.92)	3 – Neutral	9

This contradiction in data may be due to the fact that the single overarching objective of WGII AR5 (2014) is made clear on the third page of the SPM [parentheses added]: *"…[to] evaluate how patterns of risks and potential benefits are shifting due to climate change […] considers how […] climate change can be reduced and managed through adaptation and mitigation […]assesses needs, options, opportunities, constraints, resilience, limits, and other aspects associated with adaptation"* (IPCC, 2014b: 3).

This, however, is a very broad objective statement. Clearer links with specific policy questions might be necessary for future IPCC assessments. Whereas in previous scientific assessments the co-chairs and the TSU developed the scope of assessments, in the case of AR5, the outline was developed at a scoping meeting in Venice in July 2009 with policymakers (IPCC, 2014c) and experts from across all three WGs (Griggs, 2014). Chapter outlines where approved at the 31st session of the Panel in November 2009, in Bali, Indonesia (IPCC, 2014a). The benefit of this approach meant that there was a single mandated and consistent outline – which all WG teams were working towards. The primary drawback then was a limit to the amount of flexibility the process can cater for.

Even though the scoping process was integrated and diverse, in response to the statement (S26): *"Questions were posed by a diversity of stakeholders"*, the mean response was 3.26 (± 0.92), with only 9 % of the 274 surveyed respondents Strongly Agreeing with the statement (Table 14). This may be due to the fact that the IPCC rules only enable policymaker, scientist and stakeholder engagement right at the beginning of the process and then again right at the end at the scoping stage. For this reason, Carraro *et al.* (2015) calls for more effort to engage with stakeholder questions throughout the process from initiation until conclusion. This might facilitate the [parentheses added]: *"…co-design [of] the scoping, structure and language used throughout the report"* thereby ensuring more alignment with user needs (Painter, 2015: 4).

However, in a scoping process, there is a trade-off between coverage of questions from a wide diversity of stakeholders and policy usability on the one hand, and redundancy on the other hand. Regarding the latter, in the view of Interviewee (R7): *"…there were some redundancies in the AR5 WGII report. I think that often at times it is a testament to the scoping process and the different sort of voices and interests"*.

In addition to being driven by stakeholder questions, scientific assessments are also driven by the scenarios they consider within their scope. Framing the spatial and temporal dynamics of the future as a set of bounded and plausible scenarios can reduce uncertainty to within reasonable limits. In this way, scenarios can act to reduce uncertainty and allow for the assessment of change under different future social and ecological contexts (Schreiner and Snyman-Van der Walt, 2018).

The AR5 assessment used a combination of scenarios. Representative Concentration Pathways (RCPs) were used to estimate GHG emissions and radiative forcing while Shared Socioeconomic Pathways (SSPs) were developed to provide five alternative semi-quantitative trends describing the evolution of society and ecosystems (Forsell, 2016). The RCPs were drawn from the peer reviewed literature to cover a range of possible emission scenarios (Devès *et al.*, 2018) – each with different targets of radiative forcing in the year 2100 (Riede *et al.*, 2016). The results from 1180 scenarios were simulated through Integrated Assessment Models (Chapter 2) to determine the relative impact of the RCPs across societies (Devès *et al.*, 2018) in respect of changes to economics, demographics, energy and climate (Riede *et al.*, 2016).

The SSP scenarios were used to predict changes in society across population, economic growth, education, urbanisation and the rate of technological development. They were narrative-based scenarios (Forsell, 2016), providing a view of how *"…the world might evolve in the absence of climate policy and how different levels of climate change mitigation could be achieved when the mitigation targets of RCPs are combined with the SSPs"* (Hausfather, 2018: 1)[50].

For the first time in IPCC assessments, WGII AR5 featured the systematic employment of the concept of 'risk' to frame, assess and evaluate scenarios and response options (Figure 14). The use of risk as a concept and language was seen as an effective way of engaging audiences (Painter, 2015). The purpose of the risk-based approach used in WGII AR5 was to address climate change from a broad perspective, permitting the engagement, exploration and assessment of complex causal and impact pathways (IPCC, 2014a). The rationale was that since risk is widely understood by decision-makers, it should offer a structured way of framing trade-offs, in the face of uncertainty (Fløttum, Gasper and St. Clair, 2016).

[50] The SSPs were developed relatively late in the AR5 process (Hausfather, 2018), meaning that the there was a stronger focus on the RCP scenarios. Borie, Mahony and Hulme (2015) also argue that this was a result of a bias in favour of natural sciences (who might favour the RCPs) compared to the social sciences (who might favour SSPs).

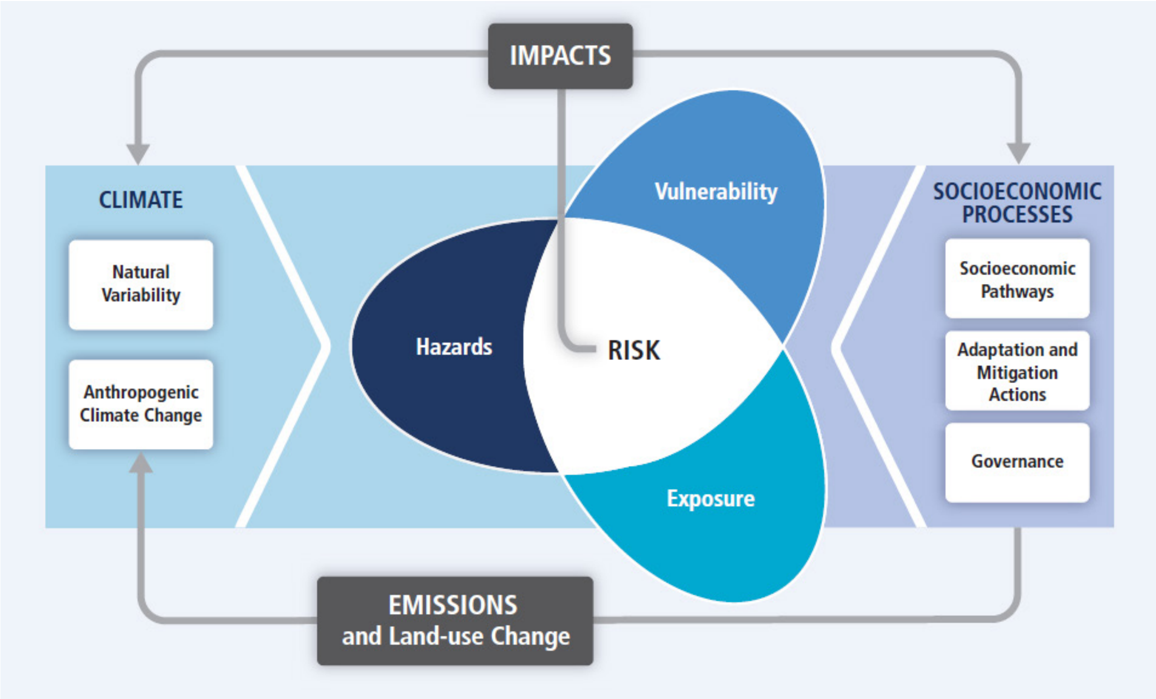


Figure 14: WGII AR5 conceptualised the risk of climate-related impacts as caused when climate-related hazards are exposed to vulnerable natural and human systems (IPCC, 2014b). This risk framing has become a feature of subsequent ARs, and has spread beyond WG II into, for instance, the Synthesis Reports.

A lexical analyses of AR5 SPMs undertaken by Fløttum, Gasper and St. Clair (2016) demonstrate the extent of the use of risk in WGII AR5. The authors ranked the 30 most frequently used words in each of the WG SPMs. The lexical distribution of words through WGII was dominated by terms – such as *impacts*, *risk*, *vulnerability*, *exposure*, *capacity* etc. In the view of Interviewee R4, risk was inherently embedded into WGII AR5 and helped to *"...guide the entire process from the beginning to the end"*.

Even so, some commentators have been critical of WGII's risk-based approach in that it catastrophized the future and homogenised traditional knowledge systems (subcategory construct *representation*). On the other hand, one peer reviewer who completed the open-ended question in the survey, noted methodological and conceptual concerns about the risk framework which they considered to *"...still be very weak"*.

However, according to Interviewee R4 [parentheses added] "*…they [the IPCC] have decided to continue to use [risk] for AR6"*. In spite of the criticisms levelled at the risk-based methods, this might be viewed as an overarching user endorsement of the approach. The consensus through most of the literature, surveys and interviews was that in spite of its flaws and need for improvement, it seems to offer practitioners and users with a consistent and comprehensible lexicon for discussing the consequences for, and solutions to, climate change.

4.3.4 Trust

The subcategory construct *trust* refers to the use of transparent procedures (Kowarsch *et al*., 2016) which serve to manage human biases (Edenhofer and Kowarsch, 2012) and potential manipulation (Young *et al*., 2013). This requires the declaration of special interests among authorship (Sarkki *et al.*, 2015), processes to mediate conflict between assessment participants (Young *et al.*, 2013) and efforts to promote procedural fairness (Okereke, 2017). Perhaps most importantly, developing trust in the public eye requires building an open communicative relationship with the media (O'Neill *et al.*, 2015).

Even though trust is so essential to the work of the IPCC, it has been criticised for being based on poor science, not communicating effectively, succumbing to hidden value judgements and being overly policy prescriptive (Kowarsch *et al.*, 2016) – with respect to the latter – demonstrating an alignment with political interests rather than those of objective science (Booker, 2018). Other commentators have claimed that IPCC authors can be motivated by recognition, notoriety and funding opportunities (Edenhofer and Kowarsch, 2012). McKitrick (2011: 7) has called the IPCC *"…biased, conflicted, secretive and opaque"*.

Geden (2015) provides an instance of policymakers seeking to manipulate the IPCC assessment process. The author cites the example of policy-makers exerting pressure on IPCC authors to increase the relative contributions of 'carbon debt' through 'negative emissions' in model runs. To this end, some *"…policy-makers view the IPCC reports mainly as a source of quotes with which to legitimize their preferences"* (Geden, 2015: 28).

On the other hand, Victor (2015) describes how diplomacy can be favoured over science in the IPCC's co-generative processes. In these instances, controversial issues are skirted through the political push for consensus. This means that policy options are only explored within a politically sensitive paradigm – constraining proper problem framing and scope delineation. What then emerges from IPCC reports, according to Victor (2015), is politically sanitised – statements which could have any substantial effect on social behaviour and government action, are avoided. As one WGII AR5 author who answered the open-ended survey question stated: *"…the IPCC has a bias to the mean or* *central values as way of summarising information. However, outliers and variance are paid little attention".*

Also related, Interviewee R1 posed the question, citing the example of West Africa [parentheses added]: *"What is the biggest barrier to effective climate policies in West Africa? If you were really honest about it, you would probably say that it is corruption. If the IPCC, constitutionally is not prepared to make a useful contribution to the question of corruption [in West Africa], you are sort of stuck."*

As regards manipulation of the IPCC processes by appointed authors, the so-called 'Climategate' scandal broke-out in the lead-up to the 2009 Framework Convention on Climate Change meeting in Copenhagen (Vardy *et al.*, 2017). The scandal involved an anonymous hacking of the email server of the University of East Anglia. Thousands of emails and documents which followed discussion between IPCC authors were leaked to the public *via* mainstream media sources.

Critics of the IPCC believed the emails provided evidence of a nefarious plot to deliberately manipulate data – to exaggerate the relationship between lower atmospheric carbon concentrations and global warming (McKitrick, 2011). On the other hand, defenders of the IPCC process viewed the Climategate scandal as nothing more than a smear tactic by critics, and several separate independent reviews have dismissed the claims of collusion to bias the outcomes (Vardy *et al.*, 2017).
As one interviewee (R2) suggested, within the IPCC [parentheses added]: *"…there will always be criticism of manipulation […] from both sides – […] people who deny that a level of urgent climate action is necessary who would accuse the IPCC having been taken over by elements of the green movement […]. Then […] the NGOs who would say the actions of certain countries as pulling the science back. From time to time there is […] some credibility in both of those claims, but you might also say that if you are being attacked by both sides then you are probably doing something right, and it is the case that the IPCC remains the organisation that everybody turns to".*

Interviewee R4, noted that even in the face of potential manipulation, the WGII approach [parentheses added]: *"…was that we wanted to make [WGII AR5] as open as possible. Not to have any filters, and the one concern was that you might then allow some kind of a coordinated campaign from climate deniers […]. That didn't happen. I think it could happen, but I think there would be ways to deal with it if it did. I guess I would err on the side of transparency and openness to allow the assessment, in the end, to be seen as more credible and legitimate".*

However, one author from WGII AR5 who completed the open-ended survey question complained about [parentheses added] *"…well established cliques [which] make it difficult for a newcomer to feel welcome"*. Supporting this view, in bibliometric analyses, Hughes and Paterson (2017: 744) demonstrate the proportional dominance of a group of highly influential experts and institutions in the IPCC process. However, in their critique, the authors fail to distinguish between what they refer to as *"…symbolic power"* versus ordinary competence, which may lead to highly citeable, influential knowledge, rather than the notion of dominant 'symbolic power'. In the context of WGII AR5, when asked about power relations in terms of what gets included in the assessment and what gets left out, one interviewee (R3) simply stated *"…my impression isn't so much that it's about power, just inertia"*.

But the lines between conscious manipulation versus human error are continually blurred and unclear. For example, the IPCC has been known to make serious content errors which IPCC critics have interpreted as stealth issue advocacy. In perhaps the most notorious example, AR4 (published in 2007) made the claim that Himalayan glaciers would retreat entirely by 2035 (IAC, 2010). This finding was based on a non-peer reviewed World Wildlife Fund report and ran contrary to the established scientific consensus on Asian glacial retreat patterns (Griggs, 2014).

In another example, the IPCC's Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) published in 2011, made the claim that 80% of the world's energy needs could be met by 2050 using renewable sources, if supported by the necessary political agenda. The scientific evidence supporting the claim originated from a non-peer reviewed Greenpeace report whose author had also been selected by the IPCC to draft the SRREN[51]. This, according to McKitrick (2011), demonstrated part of a growing trend of conflicting interests, where IPCC authors simultaneously operate as authors while 'wearing the hats' of activist organisations. These kinds of instances have called into question the efficacy of the multi-author team model and the veracity of the multi-layered peer review processes.

Due to the Climategate scandal, high-profile errors and growing concerns about waning public trust – UNEP commissioned the InterAcademy Council (IAC) (a subsidiary of the InterAcademy Panel on International Issues) to undertake an independent review of the IPCC (McKitrick, 2011).

[51] The fact that the scientific consensus now supports that conclusion is not relevant to the situation that existed in 2011.

The contract for the review was signed in April 2010 (IAC, 2010), with work commencing in early May 2010. The review costs $ 950 000 and was completed with publication of the IAC report in October 2010. The IAC report found that the IPCC review process had failed to carefully consider review comments, which would have improved the quality of the report (IAC, 2010). While the IAC review acknowledged that the scandal led to a decline in public confidence, there was little evidence to support a case of deliberate malpractice (IAC, 2010). Some believed that the IAC review demonstrated that the peer review mechanisms of the IPCC are effective and, according to Vardy *et al.* (2017), more rigorous than conventional peer review procedures.

Even so, the IAC report made a number of recommendations about how to improve IPCC in terms of its processes and operations. Pielke (2018: 27) notes that the [parentheses added] "*…resulting [IAC] report, published in 2010, recommended a large number of steps to the IPCC to improve its management, treatment of uncertainties, and assessment process. While the IPCC did not accept or implement all of the IAC recommendations, it did take on board many of them".* According to Vardy *et al.* (2017), this demonstrates an ability within the IPCC to take criticism on board, evolve and update the necessary processes and procedures through reflexive dialogue.

In response to S27: *"The process you participated in was free from bias"*, the mean response was 3.61 (± 1.09) which was not especially unusual (Table 15). On the other hand, in response to S28: "*The process was free from manipulation"*, the mean response was higher, at 4.02 (± 0.93), with 34% of the 274 respondents Strongly Agreeing with the statement. This would suggest that survey participants are more concerned about bias in the forms of personal value systems or professional affiliation, rather than overt manipulation tactics or stealth issue advocacy. The fact that the mean response to the statement S30: *"The process was trustworthy"* was 4.13 (± 0.79) with 35% of respondents Strongly Agreeing, is testament to overall public and participant trust which AR5 WGII, and the IPCC more generally, enjoys.

Table 15: Subcategory construct trust mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
27	Managed bias	3.61 (± 1.09)	4 – Agree	20
28	Freedom from manipulation	4.02 (± 0.93)	4 – Agree	34
29	Declaration of interests	3.54 (± 0.93)	4 – Agree	14
30	Trust	4.13 (± 0.79)	4 – Agree	35
31	Conflict mediation	3.44 (± 0.79)	4 – Agree	10
32	Transparent procedures	3.35 (± 0.81)	4 – Agree	9
33	Fairness	4.04 (± 0.82)	4 – Agree	30
34	Media relations	3.11 (± 0.85)	4 – Agree	6

Even though conflict of interest procedures were implemented by AR5 WGII and internal conflict was managed through facilitated discussion by Co-Chairs and independent facilitators (Ms Katharine Mach, WGII AR5 Co-Director of Science, pers comms, 25/09/18), in response to S31 (conflict mediation) (Table 15), the mean response was 3.44 (± 0.79). Similarly, in response to S32 (transparent procedures), the mean response was relatively low. On the other hand, regarding S33 (procedural fairness), the mean response was 4.04 (± 0.82), indicating a belief in the overall fairness of the AR5 WGII process.

Regarding the prioritisation of media coverage, an official IPCC communications strategy was launched in 2012 following the recommendation of the IAC evaluation. Its overarching goals were to guide the communication of assessment findings in a clear and balanced fashion; and provide a transparent overview of the IPCC to the public. The communications strategy has been applauded by analysts such as Hickman (2015).

On the other hand, since science relies on evidence, reason and scepticism, while journalism relies on colourful and emotional messaging (Eide, 2017), the IPCC and the popular press are sometimes at odds in their messaging approaches and outputs. This is made more challenging given the heated political context within which the IPCC undertakes its work*"…amplified by a frenzied and often polarizing media environment"* (IAC, 2010: 3). This is reflected in the differing tones of media coverage of the AR5 reports discussed below.

O'Neill *et al.* (2015: 382) evaluated the overall newsworthiness of the IPCC reports based on their levels of dramatization and personalisation. The author concluded that WGI had a well-developed story about scientists battling it out at the coalface. However, the scientific evidence for anthropogenic warming received mixed coverage with some media factions emphasising a lack of scientific consensus, controversy and a lack of public trust (O'Neill *et al.*, 2015). Overall, the well-developed story, public controversy and the release of headline statements by WGI, may have increased instances of WGI reporting relative to its peers (Figure 15).

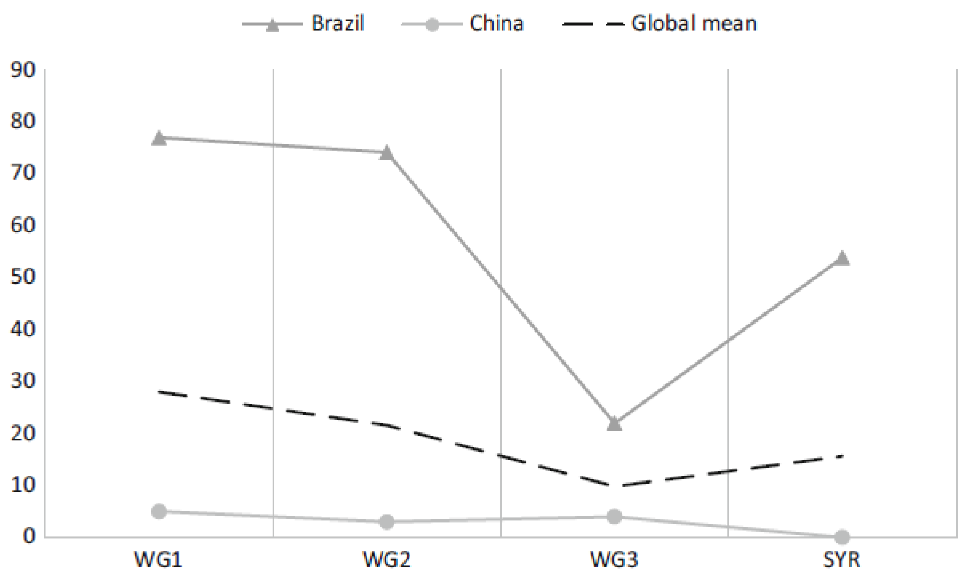


Figure 15: Differences in media reports on climate change (n = 780) in Brazil (high), China (low) and a global mean following release of AR5 reports (Kunelius and Yagodin, 2017). It shows a waning interest by the time of the release of WGIII, but this may be attributable to the sequenced release of reports and hence, reader fatigue.

The communication strategy of WGII portrayed a set of *"...doom laden and visually rich stories"* which also attracted readership (O'Neill *et al.*, 2015: 382). Its focus on vulnerabilities and impacts focused the narrative within the frame of risk and opportunity. It also used a series of innovative media communication procedures (Ms Katharine Mach, WGII AR5 Co-Director of Science, pers comms, 25/09/18). In a similar way to WGI, Kunelius and Yagodin (2017: 68) [parentheses added] note that these "*...changes in the general level and tone of attention can be viewed as a modest success for the WGII communication strategy*".

In contrast to the relative success of WGI and WGII, WGIII lacked a consolidated language, narrative and had poor visuals (O'Neill *et al.*, 2015). This is reflected in the net number of media reports on each of the WGs in Brazil (high) and China (low) versus a global mean, as analysed by Kunelius and Yagodin (2017). The journal publication *Nature* importantly highlights that some of reasons for the reduced interested in WGIII may be attributable to the sequenced release of reports and hence, reader fatigue (Nature, 2015).

However, the assessments of AR5 WGII media effectiveness by Kunelius and Yagodin (2017) and O'Neill *et al.* (2015) are at odds with survey responses. S24 posed the statement: *"Media communication was prioritised"*. The mean response was 3.11 (± 0.85), with only 5.84 % of the 274 surveyed respondents Strongly Agreeing with the statement. This indicates that the general position of WGII AR5 participants was that media and communication relationships could have been more highly prioritised.

4.3.5 Capacity building

Capacity building refers to the empowerment of assessment actors, including marginalised groups (Kowarsch *et al*., 2016) and young people (van der Veer *et al*., 2014). While capacity building is not an official function of the IPCC in the same way that it is for IPBES, the IPCC does advance a variety of capacity development initiatives.

For example, a series of IPCC scholarships were made available, funded by a portion of the proceeds from the 2007 Nobel Peace Prize. Similarly, the Nairobi Work Programme on Adaptation and the Adaptation Committee of the UNFCCC's subsidiary Body for Scientific and Technical Advice provide capacity development opportunities as well as parallel initiatives such as the Climate and Development Knowledge Network and the Programme on Mitigation Action Plans and Scenarios (Brooks, Lamoreux and Soberón, 2014).

More specifically in relation to WGII AR5, a Chapter Scientists (CS) programme was piloted. In the experiment, CS – who were mostly MSc or PhD students or early career scientists – were introduced as a way of supporting Lead Authors with technical assistance (Schulte-Uebbing *et al.*, 2015). In total 36 CS were appointed with some operating in a paid capacity and others operating in a voluntary capacity. The CS worked from their home institutions, acting as *de facto* TSU staff. They also received funding to attend all WGII AR5 Lead Author Meetings (Schulte-Uebbing *et al.*, 2015).

The CS Terms of References included the requirement to *"...support chapter teams with technical aspects of chapter development, including cross-checking between findings presented in different parts of the report, additional fact-checking, reference management, and assistance with figures and tables"* (Schulte-Uebbing *et al*., 2015: 251). Most CS were younger than 35 and two-thirds of the CS were female. Of the paid CS, the majority (75%) came from developed countries. Of the voluntary

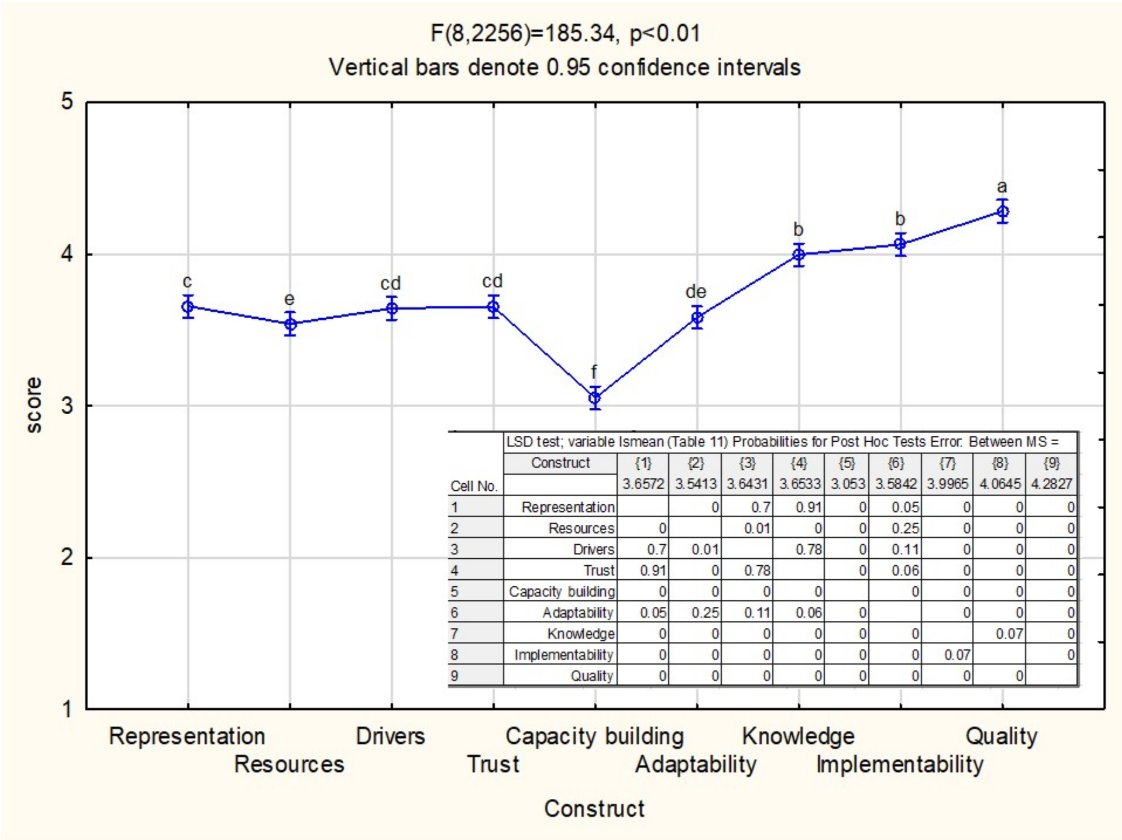
CS, 54% were from developing countries or countries with 'economies in transition' (Schulte-Uebbing *et al*., 2015).

Following completion of the programme, the 36 CS were surveyed by Schulte-Uebbing *et al.* (2015). Their survey revealed a high degree of satisfaction with the programme, with more than 80% of overall experiences being rated as 'positive' or 'highly positive'. The opportunity to *"...network and interact with the international climate science community"* was cited as the most rewarding aspect of the CS programme (Schulte-Uebbing *et al.*, 2015: 254). The largest complaint was that *"...their role should have been better defined, as their responsibilities were not always clear"* (Schulte-Uebbing *et al.*, 2015: 254).

Overall Schulte-Uebbing *et al.* (2015: 254) reported that CS "…*were highly satisfied with the program and benefitted from the opportunity to be involved in the IPCC process in multiple ways"* (Schulte-Uebbing *et al.*, 2015: 254). In this regard, Interviewee R7 states: "*...in my own experience I think that was an incredibly valuable service that was provided"*.

In a similar programme, the Dutch government initiated a process to review the content of the WGII report within the allotted review window (van der Veer *et al.*, 2014). During the programme, 90 Dutch PhD students were appointed to review the 30 chapters. In a subsequent examination of the programme, undertaken by van der Veer *et al.* (2014: 147), 25 out of 30 chapters reviewed were determined to be of *"...good-quality"* with the reviews being *"...positively received by the IPCC"*. In this respect, one author who responded to the open-ended survey question stated: *"...we worked in small groups, were given clear instructions and got feedback at the end. I'm hesitant to commit the time required to be a proper co-author, so this was a nice introductory opportunity. More governments should do this!*"

In spite of the CS programme, Dutch government initiative, the fact that 14% of WGII authorship was below 40 years of age, as well as other capacity development, survey respondents felt that more could have been made of the opportunity to capacitate young researchers. A statistical analysis of survey responses comparing each of the subcategory constructs against one another, based on their mean responses, reveals a relatively low score of 3.05 (±0.68) for *capacity building.*



	LSD test; variable lsmean (Table 11) Probabilities for Post Hoc Tests Error: Between MS =									
	Construct	{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}
Cell No.		3.6572	3.5413	3.6431	3.6533	3.053	3.5842	3.9965	4.0645	4.2827
1	Representation		0	0.7	0.91	0	0.05	0	0	0
2	Resources	0		0.01	0	0	0.25	0	0	0
3	Drivers	0.7	0.01		0.78	0	0.11	0	0	0
4	Trust	0.91	0	0.78		0	0.06	0	0	0
5	Capacity building	0	0	0	0		0	0	0	0
6	Adaptability	0.05	0.25	0.11	0.06	0		0	0	0
7	Knowledge	0	0	0	0	0	0		0.07	0
8	Implementability	0	0	0	0	0	0	0.07		0
9	Quality	0	0	0	0	0	0	0	0	

Figure 16: Subcategory construct comparison based on 2 547 survey responses from the 283 respondents who participated in WGII AR5. It shows a substantially reduced effectiveness score of the subcategory construct capacity building.

One reason for this may be young researcher participation in the IPCC is not always encouraged and universities often do not equip their students with the skills they need to be successful assessment practitioners. Academic supervisors may actively discourage them from engagement with science–policy activities in the early part of their career, arguing that it is a distraction at a time when they need to be doing primary research and building their publication record (Scholes, Schreiner and Snyman-Van der Walt, 2017).

However, Scholes, Schreiner and Snyman-Van der Walt (2017) demonstrated that this advice can be misguided. Researchers who are active in assessments, regardless of whether they are young researchers or established researchers, tend to outperform their non-participating peers on many metrics of impact, including publications (Figure 17). The mean author *h*-indices[52] of authors from the three most recent IPCC assessments are around double that of the mean for environmental scientists as a whole and compare well to that of the top 1% of environmental scientists. This may

[52] The index is based on the set of the scientists most cited papers and the number of citations that they have received in other publications.

provide some evidence that the pure research undertaken at universities and the applied research undertaken within scientific assessment processes are not necessarily mutually exclusive, but can be mutually reinforcing.

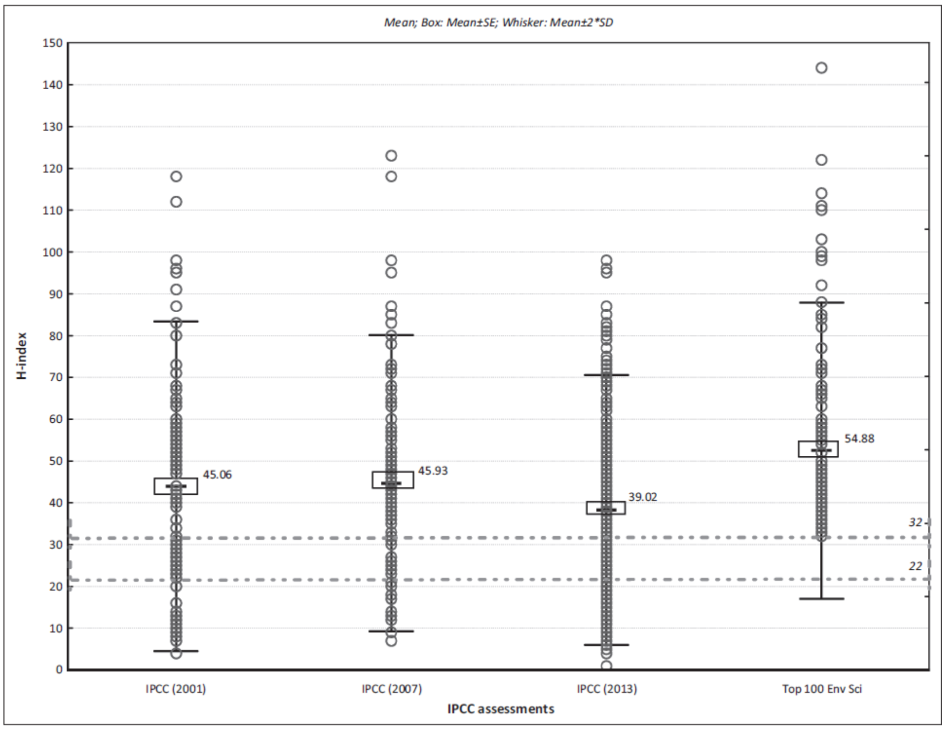


Figure 17: Mean H-indices of authors involved in IPCC assessments from 2001 to 2013 and the top 100 environmental scientists in 2016. The horizontal grey lines show the mean h-index of authors in the 'Environmental Science' domain (22) and the top 1% of environmental scientists (32).

Scholes, Schreiner and Snyman-Van der Walt (2017) develop five reasons to explain the differences in *h*-index between IPCC authors and non-IPCC authors. Firstly, there is a degree of self-selection by top researchers – they feel that participation is a duty and a good way to ensure that their science is used. Secondly, for less established researchers, participation in assessments leads to close exposure to new ideas and helps create very effective research networks, spanning countries, disciplines and levels of experience.

Thirdly, involvement in assessments tends to stimulate research by revealing important gaps, ideas and opportunities. Fourthly, assessment processes coach participants in delivering high quality scientific work in brief, within the prescribed methodology, and encourages scientists to engage with other domains and stakeholders to 'co-generate' knowledge in a manner which makes it usable for society and decision-makers, and thus more salient. Finally, it often leads to co-authorships on high-impact papers. While it is acknowledged that the association of high personal scientific impact and involvement in assessments could have other causal explanations, the evidence presented rejects the argument that being involved in assessments has a negative effect on scientific and publication performance.

In addition, Vardy *et al.* (2017) cite benefits of global South authors participating in IPCC processes. In this regard, the authors demonstrate that CLAs and LAs increased their publications in the 5-year interval following release of assessment reports, providing evidence of a net career benefit (measured in terms of publication and citation frequency) in IPCC process participation.

In relation to the inclusion of participants believed to be 'marginalised' (S37), in response to the statement: *"Participation opportunities were provided to marginalised stakeholder groups"*, the mean response was 2.87 (± 0.82) and only 2.19 % of respondents Strongly Agreed with the statement (Table 16). This could be due to the fact that operationalising an assessment at global scale frequently means that local scale knowledge, often from marginalised people across the developing world, is more challenging to engage with. Coupled with this, individuals representing countries from the global South frequently face problems with lack of funding, weak communication infrastructure and other travel constraints, such as entry visa problems (Yamineva, 2017).

Table 16: Subcategory construct capacity-building mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
35	Capacity development	3.18 (± 1.01)	3 – Neutral	9
36	Youth development	3.14 (± 0.90)	3 – Neutral	8
37	Marginalised groups	2.87 (± 0.82)	3 – Neutral	2

As regards opportunities for co-production between scientists and policy-makers, is response to S35: *"Scientists and policy-makers had opportunities to engage with one another"*, the mean response was 3.18 (± 1.01) and only 9 % of the surveyed respondents Strongly Agreed with the statement. In one author response in the open-ended survey question, they suggested that [parentheses added]: *"Governments commission and approve the assessment outline [but there is a] need for more discussion about questions / issues that are at the core of the government's interests"*.

4.3.6 Adaptability and uncertainty

Adaptability refers to the ability to change and evolve (Young *et al*., 2013) through iterative processes (Sarkki *et al.*, 2015) and structures which can account for uncertainty in various forms (Mach and Field, 2017).

The IPCC has been criticized for not changing substantially since its creation in 1990 (Devès *et al.*, 2018). In this way, suffering from both a bureaucratic (Carraro *et al.*, 2015) and innovation 'inertia' (Tol, 2011). For this reason, Beck and Mahony (2018) have called for a new commitment to self-reflexivity and an openness to change within the IPCC. On the other hand, Vardy *et al.* (2017: 67) suggests that the IPCC has already demonstrated *"…a long institutional record of trying to reformulate its policies and procedures in light of new information"* through reflexive dialogue. One example of this is cited by Pielke (2018), where the IPCC adopted and implemented many, but not all, of the IAC recommendations.

In relation specifically to AR5 WGII, the process was designed to be *"…nimble and responsive, where authors had to think about imminent policy changes"* (Ms Katharine Mach, pers comms, 25/09/18). In agreement, Interviewee R4 noted [parentheses added]: *"…it [WG II AR5] was more of an organic and ad hoc process […] where different author teams might take slightly different approaches […] because it is such a diverse range of disciplines […] where one very rigid set of rules probably wouldn't work".*

While there was general agreement in survey responses that the process was iterative, in that it allowed for multiple steps for engagement and content revision, for S35 in response to the statement: *"The process was able to adapt to change"*, the mean response was 3.21 (± 0.83), with only 4 % of respondents Strongly Agreeing with the statement. One reason for this may be because consensus processes in the IPCC are slow (Ms Katharine Mach, WGII AR5 Co-Director of Science, pers comms, 25/09/18) and subject to their own rules and institutional norms – which potentially limit flexibility and adaptability, for example, adhering to the government approved scoping report.

Table 17: Subcategory adaptability and uncertainty mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
38	Adaptive	3.21 (± 0.83)	3 – Neutral	4
39	Management of uncertainty	3.73 (± 0.91)	4 – Agree	19
40	Iterative	3.84 (± 0.91)	4 – Agree	24

A specific way of being adaptable to change is through the adoption of structured procedures to manage multiple forms of uncertainty. Uncertainty is inherent to the IPCC assessment for a range of reasons, one of them being that the IAMs used to generate future scenarios are based on various input data which can differ from model to model, which creates a distribution of the different states of nature and hence a range of uncertainty (Drouet, Bosetti and Tavoni, 2015).

In the past, the communication of uncertainty has been a major impediment for IPCC authors (Eide, 2017). For example, Budescu *et al.* (2014) show that the public interpret probability language to mean closer to 50% in situations where IPCC authors actually intended to convey much higher probability levels. On the other hand, content analyses of newspapers between 1987 and 2006 demonstrated that the media tended to ignore likelihood estimates, preferring a sensationalised version of potentially unlikely events (Eide, 2017).

In light of this, the IPCC sought to standardize uncertainty (Vardy *et al.*, 2017), with AR5 adopting a consistent framework of uncertainty language (Cochrane, 2017). This was achieved via three key systems. The first was through calibrated uncertainty language, based on the strength of evidence and the level of agreement in the literature (IPCC, 2014c). Strength of evidence was expressed as either *limited*, *medium* or *robust* and level of agreement was expressed as either *low*, *medium* or *high* (IPCC, 2014b).

The second system was through the expression of the confidence in findings, which included five qualifiers: *very low*, *low*, *medium*, *high* and *very high*. The third system of uncertainty communication was via the use of calibrated and quantified likelihood language where *virtually certain* meant 99–100% probability of occurrence, *very likely* (90–100%), *likely* (66–100%), *about as likely as not* (33–66%), *unlikely* (0–33%), and *very unlikely* (0–10%) (Woodward *et al.*, 2014). Budescu *et al*. (2014) have shown that supplementing the verbal terms within numerical ranges has the potential to increase certainty communication effectiveness between authors and audiences.

Even so, Minx *et al*. (2017) have suggested that the IPCC uncertainty framework demonstrates an overemphasis on strength of evidence. In other words, quantity over quality of evidence. This means the results of potentially low-quality studies are viewed in a similar light to the results of high-quality studies. The Minx *et al*. (2017) concern was echoed by one of the WGII AR5 authors who responded to the open-ended question stating: *"...studies are rather evenly 'weighted' and taken at face value rather than being critically synthesized. I would favour a slightly more critical view of the science"*.

However, the rigorous standardisation of uncertainty within the IPCC is not without its own pitfalls. For example, Adler and Hirsch Hadorn (2014) have documented how dealing with uncertainty in knowledge production requires the integration of diverse values and interests through deliberative procedures. However, the regimented structure of the IPCC framework provides too narrow a definition of uncertainty and lacks precision in core concepts and methods (Aven and Renn, 2015).

The IPCC has also been criticized for falling into its own 'certainty trap' where attempting to convince the public of scientific certainty has caused the reverse of the desired effect, where wider public trust has eroded (Hollin and Pearce, 2015). On this point Eide (2017: 40) notes that *"…the challenge for climate communication may also be too much certainty, or to be more exact, alleged certainty spurred by journalism's drive toward conclusiveness, drama and the sensational"*.

4.3.7 Knowledge

The three indicators for knowledge production come from its ability to enhance social debate (Kowarsch *et al.*, 2016), cover emerging and important research areas (Young *et al.*, 2013) and deliver answers to questions formulated by society at large (Scholes, Schreiner and Snyman-Van der Walt, 2017).

The results of the survey, in relation to S41: *"The outputs will enrich public debate"*, the mean response was 4.35 (± 0.78), with 49 % of the 274 surveyed respondents Strongly Agreeing with the statement (Table 18). This demonstrates that survey respondents felt that AR5 WGII assessment outputs are enhancing useful debates on the issue of climate change. Regarding scientific publications and important research areas, Vasileiadoua, Heimeriks and Petersen (2011) have traced an increasing impact of IPCC reports on the scientific literature, with a greater contribution of sources from the social sciences and less developed countries accruing over time. In this regard, Interviewee R5 suggests: *"…the IPCC has been a remarkable success in the way that it has galvanised and stimulated the global scientific community to get their science in gear"*.

Table 18: Subcategory construct knowledge mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
41	Enhances debate	4.35 (± 0.78)	4 – Agree	49
42	Covers emerging research areas	4.01 (± 0.93)	4 – Agree	34
43	Delivers on social questions	3.65 (± 0.86)	4 – Agree	16

However, Beck and Mahony (2018) suggest that the IPCC relies too heavily on its assumption that the primary problem with climate change is a lack of scientific knowledge in society. They critique the positivist, supply-driven model to knowledge production based on its assumption that the delivery of value-free science offers the only practicable solution to the problem (Hulme *et al.*, 2011). In this way, the IPCC exemplifies the 'scientific management' of knowledge and participation (Adler and Hirsch Hadorn, 2014), which is not necessarily fit for purpose in supporting climate action and decision-making support (Petersen, Blackstock and Morisetti, 2015).

Fløttum, Gasper and St. Clair (2016) contend that that science related issues can be framed by experts, under the guise of neutrality, without the inclusion of wider stakeholder values. This was reflected by one author who completed the open-ended survey question [parentheses added] *"…[the]… IPCC does not contain "negotiation" […]. There is nothing to negotiate about, since it is a science-based assessment"*. This statement attempts to make the ostensibly neat divide between *"…pure science"* and *"…dirty politics"*, which Devès *et al.* (2018: 56) argue can be perceived as disingenuous by user audiences.

This gives rise to two further problems. Firstly, according to Ford, Vanderbilt and Berrang-Ford (2012), it homogenises knowledge into one epistemological basis and detaches it from local values making it less meaningful and more challenging to implement (Fløttum, Gasper and St. Clair, 2016)[53]. Secondly, according to Booker (2018), it spurs a type of 'groupthink' – where an ideologically-based paradigm, operating under the collective illusion of scientific neutrality, provides the rationale for political action, undertaken in the name of a false social morality.

This has prompted calls for the IPCC to broaden its audiences by engaging with multiple types of knowledge (Fløttum, Gasper and St. Clair, 2016). Including a necessity for addressing the 'fact versus value' dimension of assessments in a more explicit way (Beck and Mahony, 2018) – within new and accessible epistemological frameworks. In this regard, Vardy *et al.* (2017: 67) suggest that *"…instead of framing climate change as a problem that can be solved by experts following formal rules of procedure, the reflexive turn suggests that the IPCC should be open to the diversity of social priorities that different audiences articulate"*.

[53] In disagreement with Fløttum, Gasper and St. Clair (2016), Klenk and Meehan (2015) suggest that the IPCC does need to act in a top-down way to ensure that local knowledge is, in some sense, 'institutionalised' – so as to prevent a fragmentation of knowledge co-production activities to the extent that it becomes impossible to integrate them in any meaningful fashion.

4.3.8 Quality

The quality of a scientific assessment depends primarily on its technical adequacy – does it present the high quality evidence in a robust but accessible form? (Watson, 2005). Generally, audiences do view IPCC reports as of high quality, offering an authoritative source of knowledge (Howarth and Painter, 2016). Although some scholars suggest the quality of IPCC reports has declined over the years (Tol, 2011) due to deficiencies in the peer review process and multi-author model, amongst other issues (McKitrick, 2011).

Drafts of WGII AR5 were prepared by the author teams and went through two rounds of expert review and one round of government review. Governments also participated in the final round of review of the draft SPM. Based on the review, author teams made edits to their respective sections with REs providing oversight.

In total, the WGII contribution to AR5 received 50 492 comments [19 598 review comments and 28 544 comments in the second review (IPCC, 2014c)] from 1 729 individual expert reviewers from 84 countries (IPCC, 2014a). As Interviewee R5, suggested [parentheses added], the *"...key feature that really pushes towards credibility is the degree to which these reports undergo multiple rounds of scientific review or anyone around the world signs up, provides their comments, and authors have to adjust the text, and provide written responses of how comments were or were not accommodated and why [...] It does an amazingly good job of getting the science right"*.

All comments and responses were published on the WGII website. The final draft of the WGII AR5, made available to governments on 28 October 2013 for a final round of comments on the SPM, had over 2 155 pages of draft text, 211 scientific figures and graphs, and 161 tables. It cited over 12 000 scientific references (IPCC, 2014c). One respondent of the open-ended survey question stated [parentheses added]: *"...when one sees some of one's comments included in the final product we see that [peer review] helped tweak the nuances and directions of the information presented*".

However, historically, there have been concerns over substantive discrepancies between the body of assessment chapters and the negotiated SPM (Cash and Clark, 2001). According to Tol (2016), this was evident again in AR5. Based on an analysis of AR5 SPMs, the author found that the report makes errors in its assessment of the impacts of climate change to agriculture, overstates the influence of climate change on violent conflict, ignores cold-related mortality and morbidity and overlooks cited literature relating to poverty traps. Based on this, Tol (2016: 1) contents that *"... the IPCC has yet to reach the quality that one would expect from a gold standard"*.

One Author who completed the open-ended survey question complained of [parentheses added]: *"... anonymous editing out of my contributions, late addition of authors who wrote nothing"*. Another peer reviewer noted that "…it was very unclear what, if anything, was going to be done with our comments", while another peer reviewed suggested that *"…there were significant and sometimes severe flaws and biases, if not myopic stances which were signalled and flagged, to no avail"*.

Schulte-Uebbing *et al.* (2015) suggest that owing to various factual errors in AR4 (2007), under the guidance of the IAC review, various changes were made to the IPCC's procedures and protocols, including those for finding error. The current double-loop peer review system, and the same system employed for AR5, according to Cochrane (2017), exceeds what is conventionally required for peer-reviewed journal publications. This was supported by the survey data, where in response to S44: *"The outputs were of adequate technical quality"*, the mean was 4.30 (± 0.71), the median response was 4 – Agree, with 42 % of respondents Strongly Agreeing with the statement (Table 19).

Table 19: Subcategory construct quality mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
44	Sufficient technical quality	4.30 (± 0.71)	4 – Agree	42

One respondent of the open-ended survey question stated: *"…as an older researcher, this is my 5th role in IPCC Assessments. The process has greatly improved since 1990"*. Another peer reviewer simply noted: *"Good process, good scholars, good product"*.

4.3.9 Implementability

Implementability refers to reaching multiple audiences and being useful to policy-makers and wider decision-makers in society (Young *et al.*, 2013). As such, scientific assessments need to be based on expert judgement (Scholes, Schreiner and Snyman-Van der Walt, 2017) and have the ability to inform, at least partly, other assessments undertaken at a smaller scale (Ash *et al.*, 2010).

The ability to do this depends on the usefulness of products. For AR5 WGII, four direct types of products were developed. This included: the full reports (30 thematic chapters with annexes), technical summaries, an SPM, plus a collection of supporting documents and outreach materials, such as Frequently Asked Questions (Devès *et al*., 2017). All of these were made available to the public, at no charge, from the official IPCC website (www.ipcc.ch.). Additionally, so-called 'derivative products' – not produced explicitly through the IPCC assessment process – were generated externally, for example, through university post-graduate programmes (Painter, 2015).

The IPCC product perhaps most synonymous with reaching wide audiences and being used to inform decision-making process is the SPM. The SPM process initiated with circulation of a SPM draft for review. Appointed government reviewers provided initial text submissions on the review draft. Based on these submissions, the author teams made revisions to text, tables, figures, graphs etc. (Mach *et al*., 2016). The revised draft was then taken into the plenary session and goes through a consensus-based, line-by-line approval process where government representatives verbally discuss the revised draft SPM, amongst other things, commenting on the extent to which it conforms to the underlying chapters.

The SPM process is the only component of the scientific assessment where the text is subjected to the full scrutiny of policy-makers (Fløttum, Gasper and St. Clair, 2016). In order to achieve consensus, co-Chairs – who are often supported by CLAs – enter into discussions with Panel members, addressing the questions and issues raised from the floor (Mach *et al*., 2016). SPMs are structured as highly condensed, synthesized information package produced as 'booklets' in the region of 12 000 to 15 000 words in length.

The drafting process leading toward the SPM is highly intensive – it takes time to reach consensus on text, sometimes several days of negotiation. Interviewee R2 [parentheses added] conceded that a *"…number of scientists in particular feel quite bruised by the process, [however] there is a recognition at the end of it when the gavel goes down that you have a document which is owned both by science and by the policy world"*. Interviewee R5 said: *"…line-by-line approval is a remarkably intense and unique process […] What is really key for those government is leaving and saying, "this is our report!"*

In line with Victor's (2015) concerns about diplomacy being favoured over science in some cogeneration procedures – Interviewee R6 cites that the *"…concern has always been that whoever works hardest and fights longest, can ultimately get their way"*. In a similar way, one of the authors on WGII AR5 who completed the open-ended survey question stated a concern over the quality of underlying report information used in the drafting of the SPM: *"…the vast amount of material in the* *main reports was not transparent and unbiased. And yet these summary materials are what most people read"*.

On the other hand, Interviewee R4 suggested that while SPM co-production can be seen [parentheses added] *"…as a battle between the scientists and governments […]. My experience […] was that governments wanted to ensure that, if a scientist said something […] that it would actually be something that was intelligible and understandable and useful"*. In this view, the SPM drafting process primarily acted to make scientific content as intelligible as possible to the policy-maker – rather than an attempt to subvert content in favour of particular nation states.

With regards to the maintenance of scientific reliability in the SPM following policy-maker negotiation, Interviewee R6 said [parentheses added]: *"…they fight over a couple of sentences for hours […]. All sorts of things can happen in that summary, [but] I think the underlying integrity of the report always comes through"*. In agreement, Interviewee R5 said [parentheses added]: "…*I have done a lot of research on how do the [SPM] reports actually change, and the answer might be – not as much as some of the people would fear"*.

With regards to the usability of products, in accordance with the Mitchell *et al.* (2006) insistence that scientific assessments deliver useable knowledge – one of the open-ended survey respondents questioned [parentheses added]: *"…how much […] will be taken up? A challenge with the IPCC and other assessments is to bring in the practice perspective of solutions which have found implementation in the field"*.

However, as expressed by Interviewee R2 [parentheses added]: *"…the only thing that the IPCC is actually mandated to communicate is the approved reports which have been signed off by the world's governments […] From a communications point of view that can be very frustrating, but it is also a very important safeguard to the IPCC's reputation"*. In light of this, there have been some accusations that the *"…IPCC is no longer fit for purpose"* in delivering useable knowledge to society (Hulme, 2010: 730).

Coupled with this, the direct AR5 products have been criticised for cluttered graphics (Painter, 2015) and ineffective visualisation of scientific content (McMahon, Stauffacher and Knutti, 2016). Additionally, Painter (2015) reports that SPMs are not always user friendly – offering a generally low readability. According to Howarth and Painter (2016: 28), this makes them inaccessible to non-expert audiences, with some stakeholders describing them as *"…heavy and dense"*. Black (2015) suggests that WGII AR5 could have conveyed important findings in more capturing ways – using clearly summarized messages.

Using sentiment analysis tools and readability metrics (the Flesch reading ease score [FRE]) for SPMs published between 1990 and 2014, Barkemeyer *et al.* (2015: 1) found that the IPCC *"…clearly stands out in terms of low readability, which has remained relatively constant despite the IPCC readjusting its communication policy"*. However, Stocker and Plattner (2016) critique the Barkemeyer *et al.* (2015) analysis for excluding headline statements[54] from the evaluation. Stocker and Plattner (2016) suggest that when headline statements are included in the FRE evaluation – IPCC SPMs are comparatively similar to the kinds of text one would find in editorials and popular articles from well-known journals.

The IPCC is known to have made attempts to communicate complex findings in ways that are digestible for stakeholders and useful for policy-makers. For example, the Reasons for Concern framework – which was first developed in AR3 – is used by the IPCC to communicate risk assessment findings in a condensed, simplified form. The Reasons for Concern categorisation system allowed for the generation of the so-called 'Burning Embers' Diagram, which O'Neill *et al.* (2017) reports wide use of in the policy-making and stakeholder communities (Figure 18).

[54] Even though the practice of producing the headline statements for WGI AR5 and SYR AR5 was widely praised (Painter, 2015) and may have led to more media coverage (O'Neill *et al.*, 2015), the practice was not adopted in WGII AR5. That being said, WGII AR5 did produce a condensed summary of 'top-level findings' which were made available to all stakeholders at http://www. ipcc.ch/report/ar5/wg2/ (Kunelius and Yagodin, 2017).

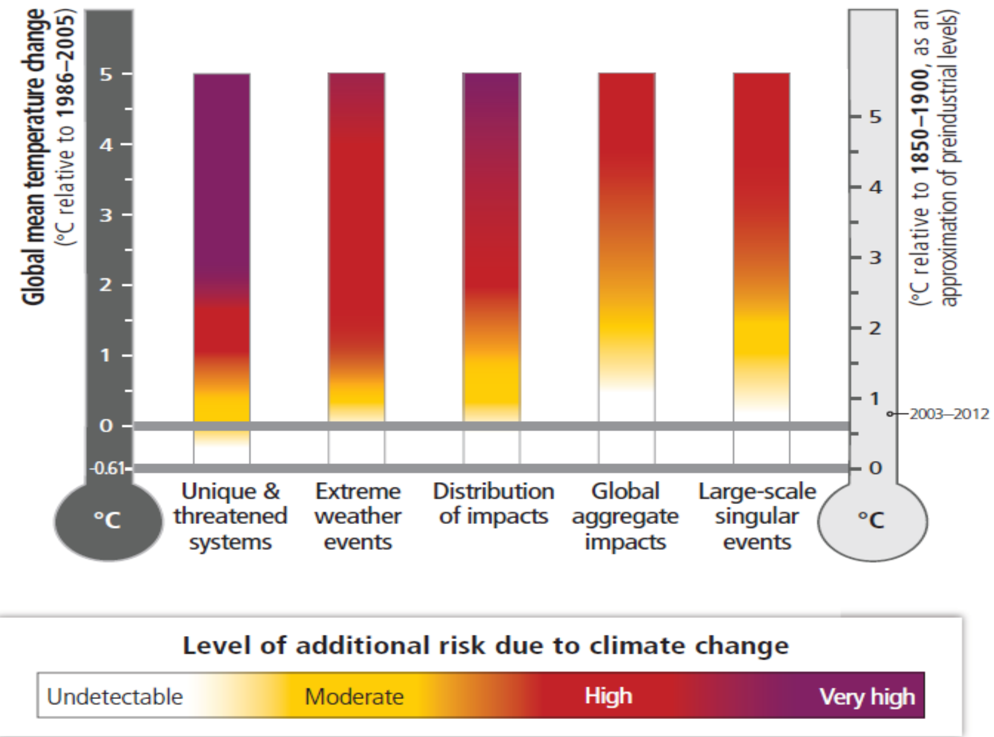


Figure 18: The 'Burning Embers' diagram from the WGII AR5 SPM was used to illustrate cumulative risk judgements across the five risk categories of the Reasons for Concern framework (IPCC, 2014b). It aggregates global risks into five categories (O'Neill *et al.*, 2017): threats to endangered species and unique systems; damages from extreme weather events; effects that fall most heavily on developing countries and the poor within countries; global aggregate impacts (i.e. various measurements of total social, economic and ecological impacts) and large-scale high-impact events.

In another example of special measures to develop derivative products (Painter, 2015) and communicate findings, as cited by Interviewee R2 [parentheses added]: *"For AR5 [...] a project together with Cambridge University Business School [tried] to make AR5 more accessible and understandable to different sections of the business community"*. According to Interviewee R2, twelve reports were produced for different business sectors, such as banking and transport, focused on the implications of AGII AR5 for those respective sectors of the economy.

Even though climate change is a global problem, the causes originate and the impacts manifest at local scales. This is reflected in the Paris Agreement where bottom-up adaptation and mitigation strategies are strongly endorsed (Devès *et al.*, 2017). However, some scientific assessments, especially those undertaken at the global scale, do not adequately address the multi-level nature of climate change (Cash and Clark, 2001) by offering concrete local examples of best practice mitigation and adaptation (Howarth and Painter, 2016).

In this regard, one author who completed the open-ended survey question noted [parentheses added]: *"…the process involves a broad area and expertise so; it is kind of difficult to use it as a tool for decision-making at a local level but, [but] it is useful to give an idea of the general scenarios".* One peer reviewer, also who completed the open-ended survey question proclaimed: *"From a geographical perspective, scale is always an issue! Most of the global data are global and the questions and concerns of most lay public and policymakers are localized".* Some commentators, such as Schiermeier (2014: 298), suggest that the *"…big-picture stuff is not very helpful for decision-makers in specific countries"* and that the usability of IPCC findings for national actors needs to be improved (Petersen, Blackstock and Morisetti, 2015).

Downscaling climate data from a global assessment to enhance saliency at local scale has been challenging (Ash *et al.*, 2010). Policy options formulated at the global scale cannot easily be translated into local-level solutions without creating high amounts of uncertainty (Devès *et al*., 2017). Even so, there is perhaps the unrealistic expectation that municipal governments will integrate IPCC findings within their plans, regulations and budgets (Satterthwaite, 2014). For example, in France, the Association for Disaster Risk Reduction undertook a review of the IPCC and pointed out that many local actors had a great amount of difficulty applying the results of the global assessment at regional and local scales (Devès *et al*., 2017).

Having said that, various techniques such as regression methods, weather pattern-based approaches, stochastic weather generators and limited-area climate models have been shown to perform reasonably well at integrating global and local scales (Wilby and Wigley, 1997). This has allowed IPCC data to be used in various decision-making exercises at local scale. In the context of the United States, providing inputs into the US National Climate Assessment (Ms Katharine Mach, pers comms, 25/09/18), as well as state-level assessments, such as the recently published California Climate Assessment (Interviewee R4, 2019).

In examples from the United Kingdom, at the national scale, IPCC scenarios were used in the development of the United Kingdom Climate Change Risk Assessment (Chapter 7). At the local scale, the Environmental Strategy for Norwich City Council used WGII AR5 to provide an overarching generic picture of climate change (Howarth and Painter, 2016). In other examples at the regional scale, one author who completed the open-ended survey question believed that AR5 WGII *"…has helped in the UNFCCC negotiations process on the impacts of climate change on agriculture in Africa".* At the sub-regional scale, Riede *et al.* (2016) used the temperature projections from AR5 to explore the specific consequences of climate variation for West Africa.

At the national scale, based on interviews with local policy representatives, academics, practitioners and local decision-makers in the United Kingdom, Howarth and Painter (2016) suggest that local councils tended to draw on evidence from other councils more readily than from IPCC reports. Howarth and Painter (2016: 5-7) found that IPCC reports are not very *"…useful in communicating the local impacts and dimension of climate change"* but do provide *"…a necessary and useful evidence base",* especially for providing background information and to check alignment with existing policy.

This is reflected by the statement by Interviewee R4, who noted that [parentheses added]: *"…there was a lot of talking within the IPCC […] around who is the audience […] because it is a global report, it is at a very high level, it is not meant to ever go into all the details that are most relevant for any one place […] even though it is trying to touch in a comprehensive way on state of knowledge"*.

However, the seemingly widespread use of IPCC assessments at finer scale are reflected in the findings of the survey in S48 in response to the statement: *"The outputs have been / will be used in future assessments undertaken at a finer scale"*, the mean response was 4.05 (± 0.84), the median response was 4 – Agree, with 32 % of the 274 surveyed respondents Strongly Agreeing with the statement (Table 20).

Table 20: Subcategory implementability mean and median responses (n = 283).

S	Indicator	Mean response (± SD)	Median response	Strongly Agree (%)
45	Reaches multiple audiences	3.89 (± 0.87)	4 – Agree	24.82
46	Uses expert judgement	4.07 (± 0.82)	4 – Agree	30.29
47	Meets practical and policy needs	4.26 (± 0.80)	4 – Agree	43.80
48	Guides assessments at smaller scale	4.05 (± 0.84)	4 – Agree	31.75

Since the IPCC reports are designed to be policy relevant, not policy prescriptive, the role of the IPCC is to inform governments about the most up-to-date scientific knowledge on an issue and, where appropriate, to highlight policy options to overcome challenges (IPCC, 2014c). However, there are always tensions between policy neutrality and political saliency on the one hand (Kowarsch, 2016) – and between coverage (the extent to which a policy option covers all the necessary issues) and comprehensibility (the extent to which a policy option can be easily understood and thus implemented) (Brick *et al.*, 2018). These tensions are known by the IPCC who placed them at the forefront of their agenda when they hosted a special meeting to discuss their future work. The meeting focused on the importance of making knowledge more accessible and useable (Devès *et al.*, 2018).

Even so, IPCC reports are not known to be especially well adapted for directly informing political decision-making (Kowarsch, 2016) although little is known about how specifically AR5 affected policymakers in their decision-making tasks (Painter, 2015). This was reflected in a statement of one peer reviewer in the open-ended survey question: *“The extent to which this knowledge is useful for decision-making is a more complex task, over which the IPCC has limited influence. In other words, knowledge is just one element of the decision-making process”.*

Based on Painter's (2015: 89) empirical examination of the United Kingdom science-policy context, the author found that AR5 products were generally used in the context of providing background for *“…top civil servants to brief ministers”* (Painter, 2015: 89). But the IPCC’s direct influence on decision-making is less obvious.

Based on interviews with AR5 participants, Eide (2017: 52) suggests that “*…there are doubts concerning how well the essential scientific conclusions and their perspectives were digested by stakeholders and society at large”.* Black (2015: 282), on the other hand, proposes that the IPCC, in general, has failed *“…to communicate its conclusions directly and effectively to policymakers”.*

Even so, the findings of the survey in S47 in response to the statement: *“The outputs have been / will be useful for decision-making”* seem to counter this. The mean response was 4.26 (± 0.80), the median response was 4 – Agree and 44 % of the 274 surveyed respondents Strongly Agreed with the statement.

This suggests strong agreement among survey participants that AR5 WGII did produce useable products for decision-making. Similarly, it conforms with the IAC review undertaken in 2010 (IAC, 2010: 1) [cited in Kowarsch (2016)] [parentheses added] which stated that *“…at the interface between science and politics, the IPCC assessment process has sustained a working dialog between the world’s governments and scientists since its inception in 1988. […] Through its assessment reports, the IPCC has gained enormous respect […] for informing climate policy and raising public awareness worldwide*”.

CHAPTER 5. CASES FROM THE INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM FOR BIODIVERSITY AND ECOSYSTEM SERVICES

5.1 Introduction

In this chapter I first introduce the larger IPBES platform, then the three IPBES cases which form part of this analysis:

1. The IPBES assessment report on land degradation and restoration ('LDR') (IPBES, 2018b);
2. The IPBES regional assessment report on biodiversity and ecosystem services for Africa ('Africa') (IPBES, 2018c); and
3. The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia ('ECA') (IPBES, 2018d).

In a similar way to the previous chapter, each of the three cases are subjected to the nine evaluative subcategory constructs. Given that the subcategory constructs are introduced in Chapter 4; less text is devoted to explaining them in each case.

5.2 The genesis, purpose, structure and processes of IPBES

The world has experienced unprecedented socio-economic growth in the last 50 years, which has substantially improved the quality of life for the majority of people in the world (Pinker, 2018) (see Chapter 2). Since 1970, the human global population has doubled, the global economy has grown four-fold and global trade ten-fold, driving ever increasing demands for energy, food and materials and a concomitant alteration of global land cover (IPBES, 2019).

These pressures have resulted in a decrease in the fraction of the land and sea that functions predominantly in a semi-natural way, the increased exploitation of organisms, pollution in different forms and the ubiquitous spread of alien and invasive species. All of which now negatively impact in the region of 3.2 billion people globally (IPBES, 2018b). For example, the recently approved SPM of the IPBES global assessment found that 75% of the global land surface has been significantly altered, 66% of the ocean is experiencing increasing cumulative impacts and around 25% of animal and plant species are threatened by extinction (IPBES, 2019b).

This is particularly concerning given that nature, through its ecological and evolutionary processes, support all life on this planet in the form of ecosystem services such as production of oxygen, delivery of fresh water, regulation of the climate, pollination and pest control. For example, marine and terrestrial ecosystems are the sole sinks for anthropogenic carbon emissions, with a gross sequestration of 5.6 gigatons of carbon per year, which is equivalent to around 60% of global anthropogenic emissions (IPBES, 2019b). When these resources are degraded, they lose their ability to provide planetary and ecosystem services.

Growing awareness about ecological overexploitation and degradation emerged in the socio-political consciousness in the 1960s and 1970s. This inspired many social and environmental changes, one of them being the 'Stockholm Conference' in 1972 which laid the groundwork for the mainstreaming of environmental assessment (Chapter 2). The term 'biodiversity'[55], which refers to biological diversity, was officially coined a decade or so later by a group of US biology conservationists (Granjou *et al.*, 2013) and in 1992, the Convention on Biological Diversity (CBD) declared biodiversity as a common concern of humankind (Montana, 2016).

Following the period after the CBD, the notion of an intergovernmental science-policy platform for biodiversity was born in the scientific community (Granjou *et al.*, 2013) – inspired by a few factors. The results of the MEA and its follow-up processes highlighted the full extent of biodiversity loss (Vadrot, 2014) and its apparent disconnection with coordinated policy action (Gustafsson and Lidskog, 2018). This led to widespread consultations initiated via the International Mechanism of Scientific Expertise on Biodiversity (IMoSEB) between 2005 and 2008 (Granjou *et al.*, 2013) where it was decided that there was a necessity to continue SPIs on the subject of biodiversity and ecosystem services at a global scale[56].

IPBES was formally launched in December 2013 at its second plenary session (IPBES-2) where it adopted an initial four-year Work Program from 2014 to 2018 (Beck *et al.*, 2014). The United Nations Environment Program (UNEP) – who co-manage the IPCC and manage the Secretariat for

[55] The CBD defines biodiversity as [parentheses added] *"…[t]he variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species ('genetic diversity'), between species and ecosystems"* (IPBES, 2018c: 5).

[56] Other reasons for the formation of IPBES include a desire to replicate, in the biodiversity knowledge community, the perceived success of the IPCC. It is also suggested that French President Francois Hollande desired a legacy project and strongly motivated for the formation of IPBES.

the CBD –were seen as a suitable intergovernmental body to manage IPBES[57] (Granjou *et al.*, 2013). Since IPBES was birthed out of *"...protracted, complex and difficult discussions"*, a diverse landscape of stakeholders has been created (IPBES, 2019a: 6). While still a nascent organisation, IPBES has evolved into an established intergovernmental platform with *"...rules of procedure, a functional secretariat, a membership of 131 countries and a network of national focal points, partnerships and communities of experts"* (IPBES, 2019a: 2).

On the other hand, IPBES exists within a *"...crowded landscape"* (IPBES, 2019a: 6) with many other assessment processes contemplating the impact of human activities of biodiversity processes (Beck *et al.*, 2014). These include the World Water Development Report (UN water, published in 2019), the Global Wetland Outlook (Ramsar, published in 2018), the State of the World's Biodiversity for Food and Agriculture (FAO, published in 2019), the Global Environment Outlook (UNEP, published in 2019), the Global Land Outlook (UNCCD, published in 2017 with the 2nd Edition planned in 2021), the IPCC Special Report on Climate Change and Land (SRCCL) published in August 2019 and the Global Forestry Assessment completed in July 2018 for the International Union of Forest Research Organizations (IUFRO).

As such, many governments questioned the need for another global biodiversity institution. Even as late as 2010 there was still some hesitancy to offer IPBES full endorsement (Granjou *et al.*, 2013). To encourage members, it was argued that the rationale for IPBES was to feed into existing CBD processes like the Global Biodiversity Outlook – as well as other governing conventions like Ramsar and CITES (Timpte *et al.*, 2018).

IPBES had a successful turn-out at IPBES-6 in March 2018 in Medellin, where four regional assessments covering Europe and central Asia, Asia-Pacific, Americas and Africa, as well as a global thematic assessment, the land degradation and restoration assessment (LDRA), were all approved. Armenia, Bulgaria and Paraguay joined the platform at IPBES-6, taking the number of participating states up to 129 (Bridgewater and Schmeller, 2018). In addition, there are ~200 participating inter- and non-governmental organisations, who have a somewhat lesser status in IPBES, but are absent except as observers in the IPCC.

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[57] People perceive IPBES as a representative body of the UN, but it is actually an independent intergovernmental platform with its own governance structure (IPBES, 2019a).

In terms of the overarching IPBES purpose, it is driven by its mandate which is to: *"…strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development"* (IPBES, 2012: 1) IPBES fulfils this mandate by operating across four core functions (IPBES, 2018a):

1. Catalyses the generation of ***new knowledge*** to address gaps in knowledge identified in IPBES assessments;

2. Deliver global, regional, sub-regional and thematic ***assessments***, and at the same time promote and facilitate assessments at the national level;

3. Promote development and use of ***policy support tools and methodologies*** so that assessment results can be more effectively applied; and

4. Identify and prioritize capacity building needs for improving ***the science-policy interface*** at appropriate levels, and provide, call for and facilitate access to the necessary resources for addressing the highest priority needs directly relating to its activities.

IPBES has an emphasis on policy relevance and the inclusion of policymakers in the assessment process. This is reflected in the name of the IPBES, which uses the word 'platform' instead of the IPCC's nomenclature 'panel'. 'Platform' was seen as *"…vaguer and offering more latitude than panel"* (Granjou *et al.*, 2013: 16). IPBES also has strong emphasis on capacity building which was a key early negotiating point in securing broad intergovernmental support (Montana, 2016) as well as the unique objective to synthesise different forms of knowledge (Gustafsson, 2018). Its large and diverse membership, a key ingredient for transdisciplinarity, is seen as its major strength (IPBES, 2019a).

In relation to core function two, the production of scientific assessments, whereas the IPCC typically produces three scientific assessment reports, plus a synthesis report through every 5 year cycle, IPBES' first and highly ambitious work programme aimed to publish a succession of 11 thematic, methodological, regional, and global assessments[58] (Table 21). Of the 11 commissioned assessments, 8 have been completed (mostly on schedule) and three – invasive species, sustainable use and values

[58] The IPBES website (https://www.ipbes.net/) offers free access to all completed and draft assessments, multiple reports, notes on decisions, meeting minutes, guidelines, catalogues, glossaries and capacity development opportunities such as journal access and e-learning.

– which were frozen at IPBES-5 due to budget constraints (Bridgewater and Schmeller, 2018), are now due to be completed in the next 2-3 years (Montana, 2016).

Table 21: The scientific assessments forming part of the IPBES work programme from 2014-2018 (Montana, 2016).

Assessment type	Name	Completion date / progress
Global	Biodiversity and ecosystem services	**Completed**: May 2019
Regional	Biodiversity and Ecosystem Services for Europe and Central Asia	**Completed**: March 2018
Regional	Biodiversity and Ecosystem Services for Asia and the Pacific	**Completed**: March 2018
Regional	Biodiversity and Ecosystem Services for Africa	**Completed**: March 2018
Regional	Biodiversity and Ecosystem Services for the Americas	**Completed**: March 2018
Thematic	Pollinators, Pollination and Food Production	**Completed**: February 2016
Thematic	Invasive alien species and their control	**In progress**: First author meeting August 2019
Thematic	Sustainable use of wild species	**In progress**: Second author meeting November 2019
Thematic	Land Degradation and Restoration	**Completed**: March 2018
Methodological	Scenarios and Models of Biodiversity and Ecosystem Services	**Completed**: March 2018
Methodological	The diverse conceptualization of values of biodiversity and nature’s benefits	**In progress**: External review September 2019

From a governance perspective, at the highest tier of decision-making in IPBES is the plenary. It releases calls for assessment requests, initiates scoping and assessments, approves SPMs and accepts assessment chapters (IPBES, 2018a). The plenary involves participation from stakeholders and observers. Stakeholders include scientists and knowledge holders encompassing assessment contributors and users from civil society organisations, professional societies, and other representative groups who providing an independent oversight function (Montana, 2016) (Figure 19).

IPBES has three other permanent bodies: the Bureau, the Multidisciplinary Expert Panel (MEP) and the Secretariat (Gustafsson, 2018). The Bureau oversees the policy and administrative aspects of the scoping process and the assessment process (including the preparations of SPM), takes part in the Management Committee and validates the final draft report. Some Bureau members may also act as review editors (IPBES, 2018a). Since any major decisions are made at the plenary, the Multidisciplinary Expert Panel, Bureau and Secretariat are responsible for the implementation of those decisions (Montana, 2016).

The first MEP, regarded as an ‘experiment, was established in 2010. A second MEP was elected in January 2015, comprising 25 experts – five from each of the United Nations 5 regions: Africa; Asia-Pacific; Eastern Europe (EE); Latin America and The Caribbean (GRULAC); and Western Europe and Other (WEOG) (Montana and Borie, 2016). In the second MEP, members were elected by the Plenary after government nomination and are appointed to three-year fixed terms (Kovács and Pataki, 2016).

The MEP currently oversees the scientific and technical aspects of the scoping process and the assessment process including the preparation of the Summary for Policy Makers, selects nominated experts, takes part in the Management Committee and validates the final draft report. Some of its members may also act as review editors (IPBES, 2018a). In this way, members of the MEP oversee both the coordination of an assessment, as well as aspects of content generation. However, one of the key findings of the IPBES External Review was that the separation of the Bureau and the MEP is resource intensive and has *“...become both cumbersome and seems to add little value”* (IPBES, 2019a: 11).

The Secretariat support the Bureau, MEP and Management Committees in overseeing the production of the assessment report, oversee the provision of support by the TSU and store and provide access to assessment related materials that are not publicly available. Other Secretariat roles include supporting the Plenary, interacting with governments and stakeholders (IPBES, 2018a), preparing documents, organising meetings, facilitating communication and managing finances (Gustafsson, 2018).

IPBES also includes non-permanent bodies such as *“...time bound and task-specific expert groups, task forces, and technical support units (TSU)”* (Gustafsson and Lidskog, 2018: 446). The Expert Group and Taskforces consists of assessment co-chairs (who oversee the preparation of the assessment and its overall quality, scientific standard and relevance to key stakeholder questions) along with the Coordinating Lead Authors (CLAs), Lead Authors (LAs), Contributing Authors (CAs), Review Editors (REs), Peer reviewers, Volunteers and Fellows (Chapter 2).

In a similar way to the IPCC, experts are not paid for their time, but their travel expenses are covered if they are from developing countries outside of the EU. All experts provide their time working under a conflict of interest policy when any conflicts have to be made transparent to the platform (Montana, 2016).

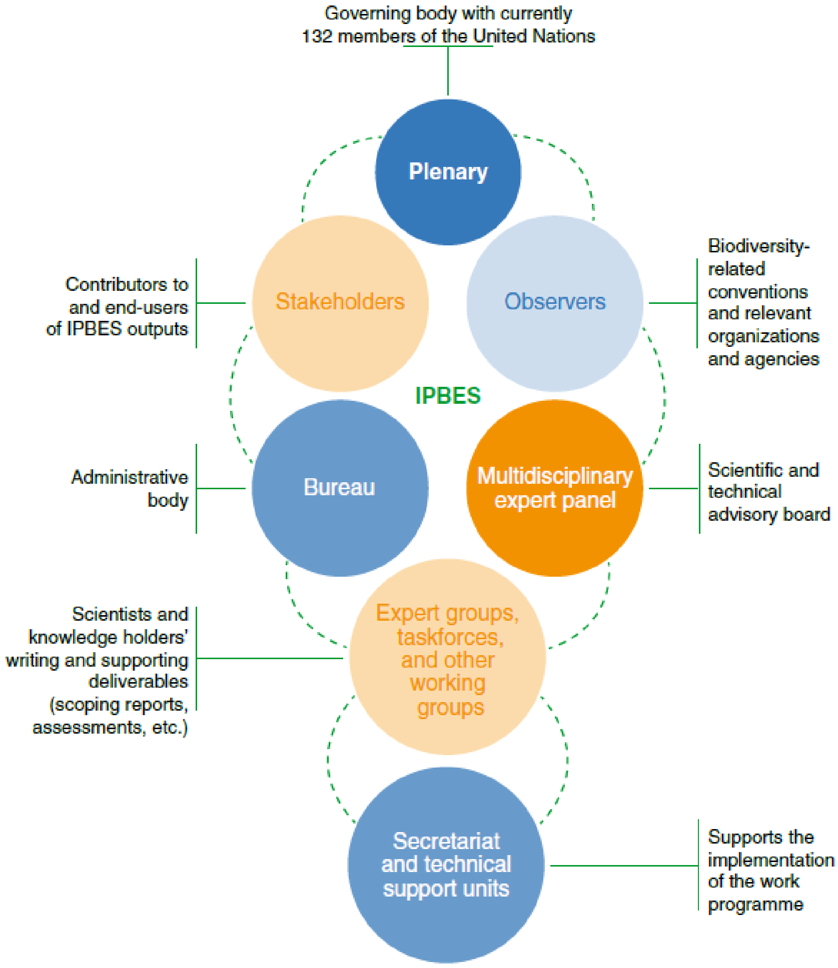

Figure 19: The multiple participant groups who make up the IPBES platform and fulfil different functions. These start with the scope of work delivered by the plenary and are ultimately delivered upon by the expert groups, task forces and TSUs through engagement with governance structures (bureau and MEP) as well as observers and stakeholders (Díaz-Reviriego, Turnhout and Beck, 2019).

From a procedural perspective, IPBES has adopted Rules of Procedure based on the IPCC. These dictate the manner in which issues in the plenary are negotiated. In a similar way to IPCC, decisions are based on consensus which does not necessarily mean unanimous agreement, but rather that no formal objections have been registered[59] (Montana, 2016). The rules dictate that experts are nominated by governments and stakeholders, where each author group consist of a maximum of 20 % nomination from stakeholders and a minimum of 80 % nomination from government. The MEP and Bureau select experts from the nominations with the advice of the co-Chairs and Coordinating

[59] In situations when consensus has not been achieved, through the logging of formal objections, the Rules of Procedure do allow for a vote among members (Montana, 2016).

Lead Authors (once they are appointed) to reflect breadth of disciplinary, geographical and gender balance (Montana, 2016).

IPBES assessments commence with a scoping exercise. This is followed by an expert selection process and a series of three author meetings where FODs and SODs are generated, coupled with transparent double loop peer review, overseen by the REs. All IPBES reports are developed with a SPM highlighting the pressing and pertinent issues uncovered in the assessment. The SPM is negotiated line-by-line within the plenary in a similar way to the IPCC (Montana, 2016).

5.3 IPBES cases: LDR, Africa and ECA

The following are the cases drawn from the IPBES platform for the purposes of this research (see Chapter 2 for the reasons for their selection):

1. The IPBES assessment report on land degradation and restoration ('LDR') (IPBES, 2018b);
2. The IPBES regional assessment report on biodiversity and ecosystem services for Africa ('Africa') (IPBES, 2018c); and
3. The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia ('ECA') (IPBES, 2018d).

Guided by the IPBES mandate and functions and accounting for difference in thematic orientation (in the case of the LDR) and spatial distribution (in the cases of Africa and ECA) – the overarching purpose of all three assessments is consistent. Their intention is to provide a critical analysis of the state of knowledge regarding the importance, drivers, status, and trends of terrestrial ecosystems and identify a mix of governance options, policies and management practices that can help support stakeholders working at all levels to reduce the negative environmental, social and economic consequences of biodiversity loss (IPBES, 2018b; IPBES, 2018c; IPBES, 2018d).

Structurally, the LDR is comprised of eight chapters, and also includes an SPM (30 pages with 36 key messages). Chapter 1 (52 pp) introduces the topic, establishes the geographic scope, and definitions. It also reviews approaches, and identifies success cases on how to avoid, reduce and reverse land degradation through land restoration and rehabilitation, while benefitting human well-being and quality of life and incorporating nature's contributions to people. Chapter 2 (84 pp) explores concepts, perceptions and differing worldviews of land degradation and restoration. Chapter 3 (84 pp) documents the causes of land degradation and factors favouring restoration.

Chapter 4 (120 pp) assesses the current state and trends of land degradation and restoration and associated changes in biodiversity and ecosystem functions. Chapter 5 (94 pp) explores the changes in benefit flows to people resulting from land degradation and restoration, the consequences for people of incorporating differing values, including changes in ecosystem services and functions, human well-being and good quality of life, and embracing the many worldviews on human-nature relations. Chapter 6 (96 pp) presents and discusses the actions, which can be taken to prevent or reverse land degradation including restoration.

Chapter 7 (60 pp) provides future projections of land degradation and restoration under several scenarios to better understand and synthesize a broad range of options, and to alert policymakers to future impacts of global changes. Chapter 8 (60 pp) evaluates tools, competencies and actions to support evidence-based decision-making and policy relevant guidance to reduce land degradation and promote restoration activities. The LDR Annexes (97 pp) consist of a glossary of terms, list of acronyms, and list of authors, review editors and expert reviewers (IPBES, 2018b).

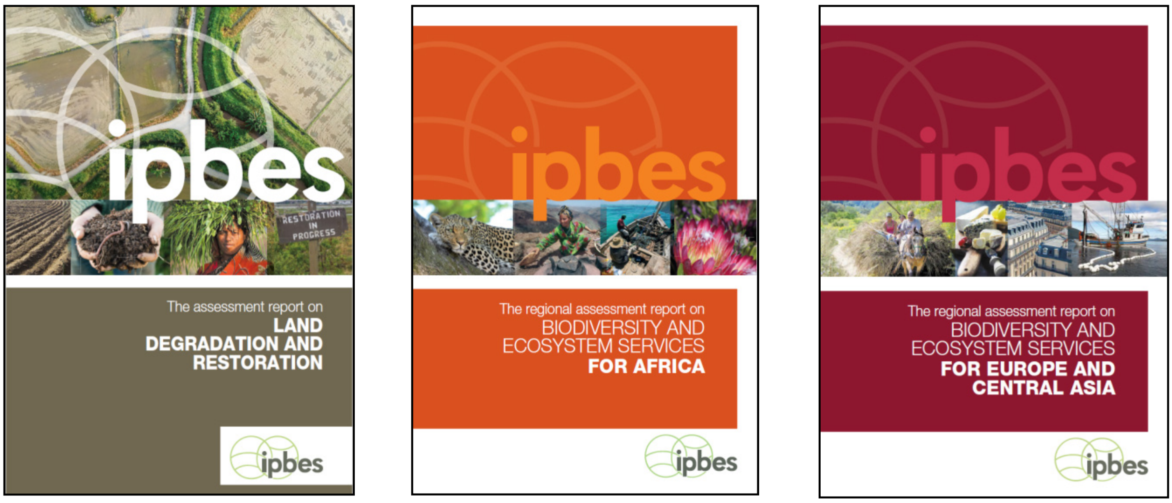

Figure 20: IPBES assessment reports on land degradation and restoration (left), Africa (middle) and Europe and Central Asia (right).

The Africa and ECA assessments each have 6 chapters with the same chapter structure, including an SPM (Africa: 38 pp, 22 key messages; ECA: 66 pp, 20 key messages). Guided by the IPBES conceptual framework Chapter 1 (Africa: 67 pp; ECA: 56 pp) sets the scene, providing the background context and describing the scope and key policy questions guiding the assessment. Chapter 2 (Africa: 54 pp; ECA: 130 pp) describes how nature contributes to the lives of people directly and indirectly.

Chapter 3 (Africa: 76 pp; ECA: 198 pp) describes the status, trends and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people. Chapter 4 (Africa: 90 pp; ECA: 186 pp) discusses the direct and indirect drivers of change in biodiversity and nature's contributions to people. Chapter 5 (Africa: 56 pp; ECA: 90 pp) discusses the current and future interactions between nature and society and Chapter 6 (Africa: 66 pp; ECA: 144 pp) provides policy-relevant decision options for improved governance across scales and sectors (IPBES, 2018d). Both the Africa and ECA include four Annexes (Africa: 75 pp; ECA: 89 pp) with a glossary of terms, list of acronyms, and list of authors, review editors and expert reviewers.

The sections which follow use the CRELE evaluation framework consisting of the nine subcategory constructs to discuss the effectiveness of the IPBES LDR, Africa and ECA assessments.

5.3.1 Representation

Right at the inception of IPBES, the need to integrate different knowledge systems was clearly communicated through IMoSEB consultations (Timpte *et al.*, 2018). Following formation of IPBES, it was agreed that expert groups should *"...reflect the range of scientific, technical and socioeconomic views and expertise; geographical representation, with appropriate representation of experts from developing and developed countries and countries with economies in transition; the diversity of knowledge systems that exist; and gender balance"* (Timpte *et al.*, 2018: 17).

There are two reasons for encouraging a diversity of author representation in IPBES. Firstly, having a diverse expertise in authorship offers the most reasonable potential for capturing the complexity of human-nature interactions. Secondly, diverse authorship offers representation from diverse epistemic dimensions (Montana and Borie, 2016).

In a similar way to the IPCC, the primary means through which IPBES seeks to achieve representivity is through its multi-author teams. These are selected through the following procedure: Firstly, the Secretariat opens calls for expert nomination. National focal points from governments and mandated individuals within stakeholder organisation then make nominations. Following receipt of the nominations, the nominations are organised by the Secretariat and the MEP, in consultation with the Bureau, over the selection process (Timpte *et al.*, 2018).

However, multiple critiques of IPBES representivity are presented in the literature. These focus most commonly on the perceived exclusion of social sciences and humanities (Heubach and Lambini, 2018), lack of knowledge diversity (Borie, Mahony and Hulme, 2015), unequal geographical representation (Timpte *et al.*, 2018), gender imbalances (Montana and Borie, 2016), insufficient cogeneration opportunities for experts and policymakers (Tinch *et al.*, 2016) and a need to make IPBES more open to stakeholder inputs (Vohland and Nadim, 2015).

Many authors have suggested that the social sciences and humanities can add substantial value for IPBES. Since social science underpins our understanding of the political and social drivers of change (Heubach and Lambini, 2018) it allows for the investigation of motives, meanings and emotions. This can assist in the development of more accurate conceptual frameworks about biodiversity loss (Jetzkowitz *et al.*, 2018) including commonly overlooked factors such as livelihoods, values, power, behaviour, discourses and conflicts (Stenseke and Larigauderie, 2018). Importantly, social science can also help IPBES to review its own functions, offering the prospect of improved processes and procedures in the execution of its mandate (Vadrot *et al.*, 2018).

Gustafsson and Lidskog (2018) ask the question: Who counts as an IPBES expert? The substantive view is that expertise is based on having a specialised form of knowledge – one which can be reflected through the processes of knowledge exploits, such as peer reviewed publications. The relational view is that expertise is a form of status – bestowed by groups or organisations outside of the expert community. This creates a hierarchy of competence, where social positions act as a proxy for epistemic excellence. Gustafsson and Lidskog (2018: 452) argue that IPBES, through its organisational rules, provide elements of both – and act to [parentheses added] *"…hold the organization together, and make it appear as […] providing credible and relevant knowledge"*.

However, the authors highlight concerns of imbalances regarding the relational view of expertise, which seems to demonstrate *"…a great bias in favour"* of scientific knowledge and specifically the natural sciences (Gustafsson and Lidskog, 2018: 450). There are examples of IPBES making attempts to reach out more widely to social sciences. Calls for participation and the provision of outreach programmes directed at scholars from sociology, economics, geography, anthropology, political science and psychology have been issued by IPBES leadership to *"…fill gaps in expertise"* (Larigauderie, Stenseke and Watson, 2016: 313). In addition, a special issue on IPBES and social sciences and humanities was recently published in 2018 in the European Journal of Social Science (Stenseke and Larigauderie, 2018).

Even so, properly integrating experts from the social sciences and humanities into IPBES authorship teams[60] has proved challenging (Vadrot *et al.*, 2018). In the region of 60-65% of authors nominations in IPBES come from the natural sciences, 12% come from economics, 3-10% from law and only 10-15% from the social sciences (Timpte *et al.*, 2018). The actual social science authorship reflects these nomination ratios – where about 10% of IPBES authors come from the social sciences (Vadrot, Jetzkowitz and Stringer, 2016). This increases to around 20% of authorship if you include experts from the humanities and ILK (Díaz-Reviriego, Turnhout and Beck, 2019).

The lack of nominations for scholars from the social sciences and humanities clearly represents the biggest hurdle, along with the perception that IPBES framings and assessment methodologies are epistemologically rooted in the natural sciences. In this way, scholars from the social sciences and humanities may not feel connected to IPBES. While, IPBES publications and achievements might be viewed less favourably by home institutions for social scientists compared to natural scientists (Stenseke and Larigauderie, 2018).

Using social network analysis, Morin *et al.* (2017) assessed the 'social representativeness'[61] of forty-one individuals working at the core of IPBES along three 'dimensions'– 16 from the Bureau and 25 from the MEP. The first dimension of analysis consisted of issue areas such as agriculture, environment, trade, culture etc. The second dimension consisted of biological and political orientations where biological expertise was organised along the genetic, specific and ecosystemic levels while political expertise was organised along four levels of governance: local, national, transnational and international. The third dimension of analysis was along epistemological background and analysed according to the knowledge system and profession of the individual.

In terms of the first dimension, the authors found that environmental and developmental concerns were *"…well represented and positioned within the IPBES network"*. Regarding the second and third dimensions, a *"… weak social representation of cultural issues, local level interests, genetic scale and traditional epistemologies"* was found (Morin *et al.*, 2017: 23). Although social scientists were numerically low in their representation, they were socially well connected through the IPBES network. Morin *et al.* (2017: 25) argue that the *"...gloomy picture"* portrayed in the literature is

[60] With respect to representation of social scientists in IPBES governance structure, the share of non-natural scientists on the MEP increased from 16% to 24% between the first and second round of MEP elections in 2010 and 2015 respectively (Heubach and Lambini, 2018).

[61] Social representativeness is defined "…as the capacity of actors to create dense relationships inside groups with the same attributes and create bridging ties with groups having different characteristics" (Morin *et al.*, 2017).

unnecessary since a substantial opportunity exists to leverage the existing social sciences epistemic resources to provide the basis for future transdisciplinary improvements.

In this regard, the LDR had 77 CLAs and LAs, Africa had 74 while ECA had 91. The disciplinary background ratios for CLAs and LAs were as follows: Applied Sciences (LDR = 12%, Africa = 20%, ECA = 1%), Arts & Humanities (LDR = 4%, Africa = 1%, ECA = 1%), Economics & Social Sciences (LDR= 12%, Africa = 19%, ECA = 18%), Health Sciences (LDR = 1%, Africa = 6%, ECA = 2%) and Natural Sciences (LDR = 70%, Africa = 51%, ECA = 74%). Using the Science-Metrix multidisciplinary measurements based on CLA authorship only (discussed in Chapter 4), the three IPBES cases[62] achieved mid-range to high scores. The LDR scored 0.39 (mid-range), while Africa and ECA scored high with 0.82 and 0.83, respectively.

However, 'levels' of academic multidisciplinarity are not necessarily representative of transdisciplinarity levels – in other words, the incorporation of non-academic knowledge into the assessment process. One of the main ways to enhance transdisciplinarity in the IPBES-based literature seems to be by way of incorporation of indigenous and local knowledge into the scientific assessment processes.

The arguments presented suggest that the Western philosophical view of nature underemphasised its continuities in that it failed to see nature as an intricate system within which human life was embedded. This paradigm constructed humans as unique and placed societies in opposition to nature, creating cultural and economic systems of dominion (Nakashima, 2015).

Moving away from this paradigm, it is argued that since biodiversity and ecosystem services are 'boundary objects' they are experienced and perceived at the boundaries of multiple worldviews, values and knowledge systems (Heubach and Lambini, 2018). This requires the integration of complementary epistemic and value-based perspectives in order to strengthen the quality and usability of knowledge (Sutherland and Burgman, 2015).

However, there are a few problems with actually doing transdisciplinary assessments in IPBES. Firstly, there are the seemingly intractable tensions between the need to achieve expert consensus

[62] **0.1–0.2:** is a low score, meaning that there is one 'home' discipline with a few 'secondary' areas also included. **0.3–0.5:** is a mid-range score, meaning that there is a balance amongst the disciplines represented but that they're all still quite clustered in one intellectual area. >**0.6:** is a high score, meaning that several different disciplines are involved, they're relative balanced and they're drawn from a broad intellectual diversity.

versus the need to reflect a diversity of perspectives (Díaz-Reviriego, Turnhout and Beck, 2019). There is always a competing tension between these two principles (or competing 'epistemic logics') and IPBES faces the not insignificant challenge of creating a new and previously unseen epistemic foundation (Gustafsson and Lidskog, 2018).

In this respect, IPBES has not made it clear whether consensus versus a need to adequately reflect dissensus is more important. This lack of clarity results in a failure to *"...leverage all the diversity in the room"* (R9, LDR) which means that what inevitably occurs in writing teams is that western, English-speaking experts *"...run forward with ideas",* while non-mother tongue English speakers, generally from non-Western countries, fail to participate in important discussions. This leads to a situation where "*...if you have 40 people in the room and you have 5 people that are really driving the conversation"* (R9, LDR).

The second limitation is a lack of engagement opportunities across assessments (Tinch *et al.*, 2016) and with knowledgeable stakeholders, for example, those with ILK or in the private sector. This lack of an operational participatory mechanism (IPBES, 2019a) has meant that good intentions for transdisciplinary procedures largely remain unrealised (Kovács and Pataki, 2016).

Having said that, IPBES has established a Task Force on Indigenous and Local Knowledge to *"...provide IPBES with appropriate approaches and procedures for bringing indigenous and local knowledge into global and regional assessments"* (Nakashima, 2015: 17). In the IPBES external review, it was found that *"...efforts have been made to incorporate indigenous and local knowledge into IPBES processes, with noticeable improvements and learning over the past few years"* (IPBES, 2019a: 8). These efforts include the following examples, cited in the literature:

- IPBES recently made changes to the MEP so that an increased proportion have ILK knowledge (Bridgewater and Schmeller, 2018);
- An ILK study in the Nordic region – financed by the Swedish Environmental Protection Agency – was developed, with one purpose being to *"...feed into a regional IPBES assessment for the region Europe and Central Asia"* (Tunón, Kvarnström and Malmer, 2015: 13);
- The Norwegian Ministry of Foreign Affairs, the Ministry of Climate and Environment and the Norwegian Environmental Agency piloted a biodiversity informatics project in partnership with the Indian Government. The overarching purpose of the project was to

"…enhance the capacity of India to take evidence-based policy decisions about its own biodiversity management and conservation issues" (Hanssen *et al.*, 2014: 10); and

- In support of the Africa assessment an African Dialogue Workshops was hosted in September 2015 funded by UNESCO. It was organised by the Task Force on Indigenous and Local Knowledge Systems in collaboration with the IPBES Expert Group for the African assessment. It culminated in a report (Roué *et al.*, 2015) with the objective of making ILK assessable to Africa assessment authors and piloting *"…initial approaches and procedures for building ILK into IPBES assessments"*.

However, one interviewee (R24, ECA, a social scientist) argued that the dialogue around ILK had become overly influential in IPBES decisions and unnecessarily narrow – excluding the diversity of other knowledge systems potentially just as important (if not more) in certain contexts. They questioned *"…where are the other knowledge systems? Where are the artists? Where are the planners?"* They criticised the social sciences for claiming to be so underrepresented while not making sufficient efforts to collaborate and *"…nit-picking around ILK"*. They concluded that *"…social scientists can make stuff incredibly difficult and complicated"*.

As regards expert country representation in IPBES, Timpte *et al.* (2018) analysed expert nomination and selection processes for three of the first expert nomination calls in January 2014, May 2014 and February 2015. During these three rounds over 2 500 expert names had been put forward (although demographic data was only available for around half the nominations). From the nominations, for 803 of the selected authors, 34% came from West European and other States (WEOG), 18% from Latin America and Caribbean (GRULAC), 17% from Africa and 21% were proposed by Asia-Pacific. France (WEOG), Japan (Asia-Pacific), South Africa (African) and Brazil (GRULAC) have supplied the highest number of IPBES experts from inception up to 2015 (Table 22).

Table 22: Ten countries with the most IPBES experts up to December 2015 (Timpte *et al.*, 2018).

Rank	Country (no. selected)	Regional group
1	France (46)	WEOG
2	Japan (39)	Asia-Pacific States
3	South Africa (35)	African States
4	Brazil (32)	GRULAC
5	India (31)	Asia-Pacific States
6	Australia (30)	WEOG
7	United Kingdom (29)	WEOG
8	China (28)	Asia-Pacific States
9	United States (25)	WEOG
10	Germany (23)	WEOG

With specific reference to the LDR, Africa and ECA cases, the following author geographical distribution was recorded: High-income (LDR = 59%, Africa = 24%, ECA = 87%), Upper-middle income (LDR = 22%, Africa = 15%, ECA = 9%), Lower-middle income (LDR = 15%, Africa = 45%, ECA = 4%), Low-income (LDR = 4%, Africa = 16%, ECA = 0%).

Some survey participants and interviewees, especially those from NGOs, commented on geographical unevenness of representation, where certain regions were completely unrepresented, such as the Pacific Islands. Geographical balance and imbalance, while not entirely numerically uneven in the data presented here, manifest through different causal pathways.

For example, wealthier nations generally have larger delegations at Plenaries (sometimes as large as 10 people), providing more scope to attend multiple engagements, become familiar with more documents and ultimately have more opportunity to shape outputs. On the other hand, delegations from Lower-middle and Low Income countries will seldom have delegations large than 1 or 2 people[63] (R17, Africa). In another example, one peer reviewer on the Africa assessment suggested a highly uneven balance of experts and data supply from South Africa compared with other African nations (R14, Africa).

Regarding gender balance among authors, in the first call for experts in January 2014, 30 % of nominations were for female authors with actual female authorship being in the region of 30-35 %. In

[63] For the Global Assessment according to Interviewee R16 (an author on Africa and the Global Assessment) since participation costs were paid for experts from developing countries and not for those from more developed countries, lower-middle and low-income countries represented a high ratio of Global Assessment authors.

the second call for nominations in May 2014, 28% of nominations were for female authors (Timpte *et al.*, 2018) while 39 % of authors were female (Díaz-Reviriego, Turnhout and Beck, 2019) demonstrating an author selection processes favouring female experts.

These gender ratios are consistent with what was measured for the cases analysed in this research where for LDR (men = 64 %, women = 32%), for Africa (men = 65 %, women = 35 %) and for ECA (men = 59 %, women = 41 %) (Table 23). These are analogous with gender ratios of the MEP (Montana and Borie, 2016). When the MEP – which consists of 25 experts – was first established is 2010, 19 out of 89 candidates were women, with seven being selected, therefore females represented 28 % of total membership. In the second MEP (constituted in 2015), 29 out of 87 candidates were women, with nine being selected for the MEP, representing 36 % of the members.

Table 23: IPBES CLAs and LAs by country, gender and disciplinary background.

	LDR	**Africa**	**ECA**
No. of CLAs and LAs	77	74	91
Country income			
High-income (%)	59	24	87
Upper-middle income (%)	22	15	9
Lower-middle income (%)	15	45	4
Low-income (%)	4	16	0
Total %	**100**	**100**	**100**
Gender			
Man (%)	64	65	59
Woman (%)	32	35	41
Total %*	**96**	**100**	**100**
Disciplinary background			
Applied Sciences (%)	12	20	1
Art & Humanities (%)	4	1	1
Economics & Social Sciences (%)	12	19	18
Health Sciences (%)	1	6	2
Natural Sciences (%)	70	51	74
Total %**	**99**	**97**	**97**
* LDR: No gender data for 3 participants ** LDR: No disciplinary background data for 1 participant ** Africa: No disciplinary background data for 2 participants ** ECA: No disciplinary background data for 3 participants			

Some interviewees and survey respondents suggested that aiming for representivity is a good thing, but that the *"... minimum critical standards need to be raised a bit"* (R11, LDR) to maintain and build trust. Some respondents complained about substantial weaknesses in chapter teams due to the selection of [parentheses added] *"...total unknowns in the [..] field"* (R10, LDR) who were selected to ensure geo-political representation.

In the view of some interviewees, these authors – sometimes described as *"...dead weight"* (R11, LDR) – contributed nothing to very little, while others made contributions which completely *"...missed the mark"* (R18, Africa). One of the survey respondents from the LDR complained that experts who were nominated for political reasons [parentheses added] *"...ultimately [ended up] making very limited and sometimes negative contributions"*.

Some respondents believed that chapter teams did have sufficient expertise but struggled to get commitments from the *"...individuals to really follow through"* (R11, LDR) potentially owing to a lack of time, interest or skills (Díaz-Reviriego *et al.*, 2017). IPBES typically uses 'champions' with high profiles and *h*-indices[64] to advance its visibility (Tinch *et al.*, 2016) and develop trust and enhance credibility (R8, LDR). However, some interviewees noted that while having *"...silverbacks"* is valuable for public profile – often they don't have the time to meaningfully contribute toward the assessment which creates a gap in the type of hands-on leadership which is required at the top (R24, ECA).

Moving onto co-generation opportunities – since scientific assessments include more than knowledge experts, they offer environments for engagement between policymakers and stakeholders representative of broader societal interests. Although IPBES is growing in membership (Bridgewater and Schmeller, 2018), it still seems to conform to the *"...linear framework of knowledge speaking truth to power"* (Tinch *et al.*, 2016: 1696). This means that, up to now, the generators and users of IPBES knowledge have not engaged in sufficient co-production processes.

This was partly reflected in the findings of the survey – where in response to S11: *"Government/s actively participated in various roles during the assessment"* – the mean responses were 3.27 (± 0.90) for the LDR, 3.15 (± 0.90) for Africa and 2.97 (± 0.78) for ECA (Table 24). While co-chairs did have some contact with government through *"...regional dialogue meetings",* the overall levels of interaction were still *"...pretty limited"* (R20). The exclusion of national focal points at nationally hosted writing workshops which seemed *"...strange"* to Interviewee R17 (Africa), offers another reason for the relatively low Likert scores in S11.

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[64] The *h*-indices for CLAs who participated in LDR = 18 (± 14), Africa = 12 (± 9) and ECA = 23 (± 16). The standard deviation shows high variability for CLA *h*-index among the cases.

Table 24: Subcategory construct representation across the LDR, Africa and ECA from 274 survey responses.

S	**Indicator**	**LDR (± SD) *n* = 88**	**Africa (± SD) *n* = 76**	**ECA (± SD) *n* = 110**
9	Knowledge co-production	3.81 (± 0.77)	3.92 (± 0.93)	3.99 (± 0.87)
10	Diverse expertise	3.98 (± 0.78)	4.05 (± 0.87)	3.99 (± 0.84)
11	Government involvement	3.27 (± 0.90)	3.15 (± 0.90)	2.97 (± 0.78)
12	Openness to participants	3.48 (± 0.91)	3.70 (± 0.98)	3.50 (± 0.94)
13	Transdisciplinarity	3.33 (± 0.95)	3.50 (± 0.91)	3.31 (± 0.79)
14	Use of social sciences	3.62 (± 0.94)	3.68 (± 0.88)	3.62 (± 0.89)
15	Knowledgeable experts	3.94 (± 0.86)	3.97 (± 0.83)	4.00 (± 0.86)

However, Heubach and Lambini (2018) suggest that IPBES does create opportunities for co-design, co-production and co-dissemination. The authors argue that during the co-design phase, stakeholders have the opportunity to i.) submit requests to the Platform, ii.) participate in the scoping phase as a member of the MEP, iii.) be selected as a part of the expert group appointed to undertake the scoping and iv.) provide review of the scoping document.

During the production phase of the assessment (the co-production phase), Heubach and Lambini (2018) argue that stakeholders had the opportunity to become involved in the process by i.) making nominations for expert groups, ii.) becoming members of the expert group if selected and iii.) reviewing draft assessment chapters. While, during the co-dissemination phase stakeholders have the opportunity to i.) become a member of the SPM drafting team and ii.) review the first draft SPM (Heubach and Lambini, 2018).

As regards stakeholder engagement, mapping exercises have shown that IPBES exists within a complex biodiversity governance system represented by multiple governments, organisations and institutions who contribute substantial human and financial resources. Given its breadth of participation, IPBES appeals to a wide range of audiences (Tinch *et al.*, 2016) and *"…benefits from a wide sense of stakeholder ownership"* (IPBES, 2019a: 3).

There are a few ways for individuals to engage with IPBES (Vohland and Nadim, 2015) in addition to cogeneration pathways highlighted above by Heubach and Lambini (2018). If you are an expert, you have the opportunity to become a member of the MEP; work as an author on assessment chapters; generate knowledge for assessment e.g. in journal articles or reports; or by making comments on draft chapters.

In stances where individuals are not acknowledged experts, their primary means of engagement is via the Open-ended Network of IPBES Stakeholders[65] – which is open to any IPBES registered individual, institution, authority and local government (Schmeller, Niemelä and Bridgewater, 2017). The fact that stakeholders are widely drawn from society and contribute to all stages are both seen as essential to the platform's success (Lundquist *et al.*, 2015).

Registered observer organisation are also permitted to attend plenary sessions, however, there are strict rules to become accredited. While the primary role of observers is observation of plenary sessions, they are permitted to intervene if the Chair agrees and their ideas can be taken forward if supported by a member state (Bridgewater and Schmeller, 2018). During the plenaries, the participating observers hold their own consultation meetings, participate in contact groups (while they are allowed to speak only with the invitation of the Chair) and have the possibility to share their opinion on documents and decisions under discussion with member state delegations (Schmeller, Niemelä and Bridgewater, 2017).

Stakeholder days are hosted before plenaries to gather recommendations for the secretariat and MEP (Schmeller, Niemelä and Bridgewater, 2017). For example, a stakeholder day was arranged for IPBES-6 by the International Indigenous Forum on Biodiversity and Ecosystem Services and Centres of Distinction on Indigenous and Local Knowledge and the Open-ended Network of IPBES Stakeholders. The stakeholder day was open to all IPBES members, observers and stakeholders. The purpose of the event was to provide updates to stakeholders on the work programme and gain insights into stakeholders views into specific issues on the plenary session agenda with the purpose of delivering consolidated stakeholder feedback to the plenary (Monroy, 2017).

However, in spite of all these initiatives, the IPBES External Review recently concluded that *"…there is currently a very significant lack of clarity in IPBES regarding the various types of actors that are interested or involved in the Platform and the limited pathways to participation in IPBES activities"* (IPBES, 2019a: 5).

There are also limitations to what Oubenal, Hrabanski and Pesche (2017) refer to as 'stakeholder democracy' in IPBES and a diversity of participation does not necessarily inform us of stakeholder

[65] The work of the stakeholder network is informed by an IPBES Stakeholder Engagement Strategy – which has the overarching intention of supporting the work programme through transparent, inclusive and participatory processes (Díaz-Reviriego, Turnhout and Beck, 2019).

dynamics. For example, Tinch *et al.* (2016) found evidence that some stakeholder inputs are ignored, while Vohland and Nadim (2015) suggest that stakeholders are known to bemoan the fact that their views and ideas are not included into IPBES assessments. Some experts expressed surprise at the limited opportunity for stakeholder engagement through the process due to confidentiality issues.

Oubenal, Hrabanski and Pesche (2017) argue that the approach taken at stakeholder days is utilitarian – the Secretariat and governments determine the scope, methods and extent of engagement and work to narrow down the agenda by seeking consensus (Esguerra, Beck and Lidskog, 2017). Kovács and Pataki (2016) suggest that IPBES attempts to create an impression of depoliticisation, while acting in a 'supervisory' manner (Oubenal, Hrabanski and Pesche, 2017).

An example of dominate narratives perpetuated by power dynamics can be found in the case of the platform decision whether to allow or not allow MEP nomination from stakeholder organisations, in addition to the nominations currently received from government (Hotes and Opgenoorth, 2014). In the end, it was decided that stakeholder organisations should not be permitted to nominate MEP experts. This, along with other examples cited in Hof *et al.* (2017) regarding use of the IPBES name, acronym and logo has contributed to the perception that member states and the IPBES Secretariat have sought to exert a tight control on the nature and methods of participant engagement (Tinch *et al.*, 2016).

With respect to strategic level participation partnerships, the recent IPBES External Review[66] found evidence of *"…insufficient synergetic collaboration and partnerships"* with potential partner organisations like FAO, UNDP, UNEP and UNESCO (IPBES, 2019a: 3). While IPBES may be influential within its own stakeholder network, there seems to remain far more scope for accessing larger global environmental governance networks.

5.3.2 <u>Resources</u>

IPBES budgets are made up by contributions from member states, as well substantial in-kind contributions , for example, by experts offering their time at no charge (Montana, 2016). IPBES has

[66] At IPBES-5 it was decided that a review of IPBES would be commissioned. Two processes were agreed – one internal review managed by the Secretariat and one external review managed by a body external to IPBES (Bridgewater and Schmeller, 2018). At IPBES-6 in Medellin, in March 2018, a ten-person external review panel was approved by the Plenary. The review panel, which was coordinated by the International Science Council (ISC), was tasked with evaluating IPBES at the completion of its first 5-year work programme. The panel based their review on an analysis on the internal review, (completed by the Secretariat prior to the external review), an online survey, focus group meetings, interviews and also commissioned bibliometric and media studies to assess the extent of IPBES impact in the public domain (IPBES, 2019a).

spent in the region of $3-10 million per annum fulfilling the core functions of its four-year work program from 2014 to 2018[67] with 21 nations making donations into the Platform's Voluntary Trust Fund (Montana, 2016). Norway has offered the largest contribution so far of $8.2 million (Hof *et al.*, 2017), while donations from other members have been sporadic, with most members not contributing anything at all (IPBES, 2019a).

About half of the budget in the first work programme was used for executing the IPBES assessment mandate, while the other half was used for operation and management functions along with policy support and capacity development (IPBES, 2019a). There have been calls to member countries to increase financial and human resource commitments to IPBES (Balvanera *et al.*, 2017), one of the reasons being that by far the majority of available resources are dedicated to the assessment function, while the new knowledge, capacity development and policy support functions are far less resourced core functions (Díaz-Reviriego *et al.*, 2017).

This is consistent with findings of the external review panel who found that "…progress has been uneven across the four functions. The assessment function has clearly been prioritized in terms of outputs, staff time and budget over the other three elements of the work programme" (IPBES, 2019a: 8). However, austerity-driven budget cuts in 2017 and 2018 (Hof *et al*., 2017), as well as substantial fluctuations in income from the Voluntary Trust Fund have led to concerns around a "…lack of reliable long-term sources of income" (IPBES, 2019a: 3)[68].

This sentiment was well communicated in the online survey data where – in response to the statement S16: *"Adequate financial resources were made available"* – the mean responses were 2.83 (± 0.99) for LDR, 2.88 (± 1.13) for Africa and 2.44 (± 0.97) for ECA (Table 25).

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[67] Budgets were similar for the African and ECA regional assessments – in the vicinity of $ 1 million covering TSU time costs and other disbursements costs such as author travel, workshops, formatting and graphics. Data on the budget for the ECA was unavailable.

[68] In early 2020, IPBES secured its first partnership with the private sector when it joined forces with the Kering Group who will make *"...non-earmarked contributions to the work of IPBES"* (IPBES, 2020:1).

Table 25: Subcategory construct resources across the LDR, Africa and ECA from 274 survey responses.

S	Indicator	LDR (± SD) *n* = 88	Africa (± SD) *n* = 76	Europe (± SD) *n* = 110
16	Financial resources	2.83 (± 0.99)	2.88 (± 1.13)	2.44 (± 0.97)
17	Human resources	3.44 (± 0.90)	3.39 (± 1.07)	3.11 (± 0.98)
18	Personnel continuity	3.71 (± 0.89)	3.84 (± 0.72)	3.63 (± 0.72)
19	Information systems	3.67 (± 0.91)	3.88 (± 0.86)	3.83 (± 0.83)
20	Sufficient time	3.54 (± 0.75)	3.38 (± 0.87)	3.45 (± 0.88)

Balvanera *et al.* (2017) estimate that, depending on your role in an assessment process, an expert working on an assessment can spend anywhere between 10% (in the case of CAs) and 80% (in the case of CLAs or chairs) of their time working on deliverables, attending meetings, responding to comments etc. As such, many interviewees and survey respondents raised concerns about lack of funding, tight timelines and requirements to undertake IPBES work in personal time (R16, Africa).

Some suggested that the financial costs associated with contributing to IPBES assessments (in the form of time spent away from home institutions) means that the number of experts capable of contributing is limited. Interviewee R16, who worked on the Africa assessment, suggested that this might be the basis for people questioning the credibility of IPBES since some *"...people were excluded on financial grounds"* (R16, Africa).

Some peer reviewers complained that their pro bono *"...academic service"* activities (R20, Africa) were already stretched between theses and journal review work – and that the addition of IPBES responsibilities was too much for those employed in full-time positions (R14, Africa). While focal points suggested that a lack of resources made it difficult to generate any meaningful continuity in staff, since only one intern could be afforded (R19, Africa).

On the other hand, some participants enjoyed the processes they participated in – believing them to be valuable contributions to global biodiversity governance. For example, one ECA participant (R24) said: "…we *had a really good team. I think we achieved a huge amount. Everyone is really pleased with the end product"* (R24, ECA). Another survey participant, also part of the ECA, simply noted: *"...great experience, satisfied with the outcome, would love to do it again"*.

With respect to the performance of IPBES management teams, some authors lauded the performance of the TSUs, while other suggested that their inexperience and lack of *"...scientific depth"* meant that they could only engage in basic tasks (R16, Africa). In this regard, the IPBES External Review found the first work plan – although *"...overcommitted"* (IPBES, 2019a: 2) – had been managed *"...effectively and efficiently"* (IPBES, 2019a: 9) "*…despite an underfunded budget"* (IPBES, 2019a: 2). It was also noted in the IPBES External Review that better financial management needed to be adopted by the platform.

In the view of some survey participants, there was a lack of continuity as it remained challenging to keep some experts involved. One interviewee cited a lack of remuneration as the primary reason for this[69] (R24, ECA). In some of the IPBES cases, there was a high turnover of experts – with many dropping out of their appointed roles (R11, LDR). In other instances, non-responsive authors had to be released from their services. For this purpose, a policy for non-responsive authors was developed[70].

A relatively high rate of attrition may also be attributed to the fact that some experts found IPBES work challenging. For example, interviewees from the LDR and Africa complained that authors were nominated to chapters which weren't necessarily in-line with their area of expertise (R9, LDR). This left experts in need of leadership, complimented by a well-defined scope of work. However, one interviewee found an inability of leaders to work to a vision and then delegate accordingly – *"…that was their role. That often wasn't done"* (R16, Africa). Other interviewees added that leaders often lacked the 'soft' (R9, LDR) and 'listening skills' (R24, ECA) so essential in cogenerative processes.

5.3.3 Drivers

Widely mandated processes are known to enhance policy impact in IPBES (Tinch *et al.*, 2016). For this reason, the IPBES Secretariat, in 2013, started to gather stakeholder requests which would drive the content of the first work programme. Based on these requests, the MEP and Bureau undertook a prioritisation screening of the requests. The results were taken to the second plenary of IPBES (IPBES-2) in December 2013 where the first work programme was approved. In this sense, the first IPBES work programme was broadly driven by stakeholder questions and fully mandated by user governments

[69] Other reasons include struggles to cope with workload, waning interest, personal conflicts, poor time management skills or a lack of useable communication infrastructure. For example, interviewees on the Africa assessment reported connectivity and communications problems where it was difficult to use Skype and other web-based platforms (R17, Africa).
[70] The policy for non-responsive authors included the following steps: After the TSU managers and CLAs had written three unanswered emails, the co-chairs would contact the non-responsive expert. A failure to respond to this communication would lead to the expert being removed from the assessment (R18, Africa).

IPBES then launched a call for experts to undertake the scoping process. This was undertaken jointly for all four regional assessments and separately for the thematic assessments, such as the LDR. The scoping process included multiple stakeholder inputs from *"...member states and other governments, multilateral agreements, United Nations institutions, and other relevant stakeholders"* (Heubach and Lambini, 2018: 4).

The scope of the regional assessments was guided by a generic scoping document which addressed (i) the scope, rationale, utility and assumptions, (ii) the chapter outline, (iii) the key datasets, (iv) the operational structure, (v) strategic partnerships, (vi) the process and timetable, (vii) the cost estimate, (viii) the communication and outreach, and (ix) the capacity building potential. One interviewee suggested that the assessments are *"...fully legitimised by the scoping process which summarise requests by governments"* (R22, ECA).

The scoping reports were made available for review by members and stakeholders. Following this – in January 2015 – IPBES-3 approved the scoping documents which then marked the official start of the assessments. After the scoping documents had been approved, the IPBES Secretariat launched a second call for experts who would be responsible for undertaking the actual assessment component (Heubach and Lambini, 2018).

The clear guiding policy questions helped to develop a sense of direction for experts, with one interviewee suggesting that the scoping process *"...really informed the Africa assessment"* (R17, Africa). On the other hand, survey respondents noted a failure to remain flexible and adaptive to policy needs. This was reflected in the findings of the survey in S22 in response to the statement: *"Imminent policy changes were considered during the process"*, the mean responses were 3.17 (± 0.90) for LDR, 3.24 (± 0.92) for Africa and 3.24 (± 0.82) for ECA (Table 26).

Table 26: Subcategory construct drivers across the LDR, Africa and ECA from 274 survey responses.

S	Indicator	LDR (± SD) n = 88	Africa (± SD) n = 76	Europe (± SD) n = 110
21	Clear goals and objectives	3.67 (± 0.90)	3.82 (± 0.83)	3.75 (± 0.92)
22	Adaptation to policy changes	3.17 (± 0.90)	3.24 (± 0.92)	3.24 (± 0.82)
23	Different scenarios assessed	3.49 (± 0.80)	3.51 (± 0.85)	3.54 (± 0.74)
24	Mandated process	3.61 (± 0.85)	3.54 (± 0.88)	3.53 (± 0.93)
25	Delineated scope	3.79 (± 0.92)	3.89 (± 0.80)	3.74 (± 0.95)
26	Stakeholder questions	3.32 (± 0.76)	3.54 (± 0.80)	3.31 (± 0.77)

For consistency and coherency, all policy and stakeholder questions were analysed within the IPBES conceptual framework developed by Diaz *et al.* (2015) (Figure 21). The framework depicts the relationship between well-being, nature's benefits to people (or ecosystem services), human activities and their impacts to natural and social systems; and the human institutions which are responsible for managing human-nature interactions.

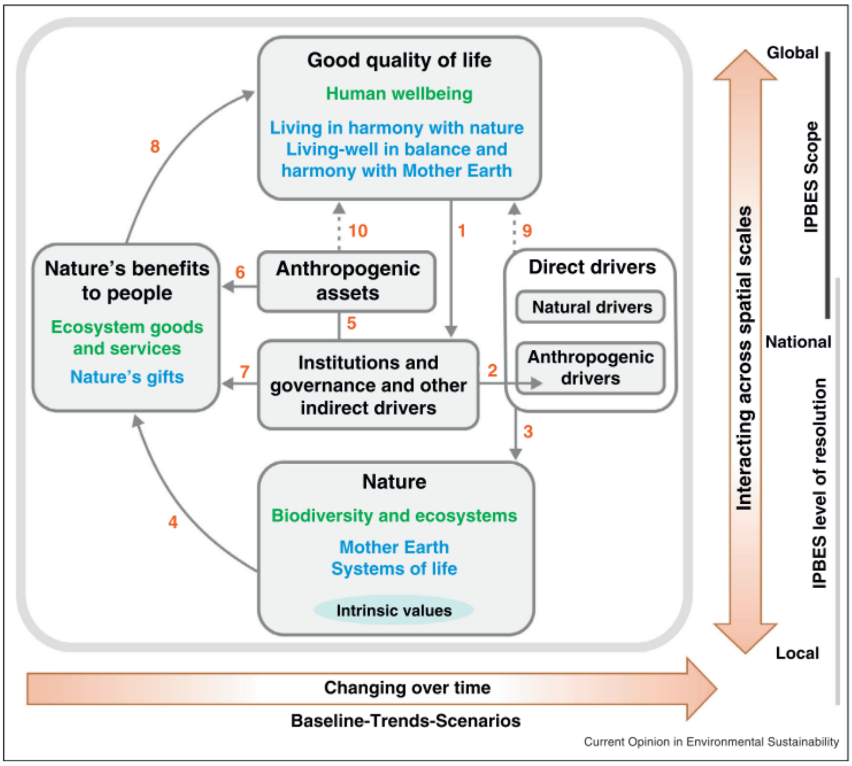


Figure 21: The IPBES conceptual framework (Diaz *et al.*, 2015) is partly the result of an attempt to be epistemologically inclusive and pluralistic. Most of the 'boxes' contain several alternate terms, representing the same broad idea. At the time of the IPBES-6, a paper by leading IPBES scientists had just been published that, among other things, proposed replacing the term 'Ecosystem Services' with the term 'Natures Contributions to People'. This led to a great deal of confusion and dissension among experts and policymakers alike.

Within the framework, 'good quality of life' means access to food, water, energy and livelihood security, and also health, good social relationships and equity, security, cultural identity, and freedom of choice and action. 'Drivers' are natural or human factors which directly or indirectly causes a change in nature. 'Anthropogenic assets' are built-up infrastructure, health facilities, knowledge, technology etc. 'Nature' is the natural world, with emphasis on biodiversity and evolutionary processes. 'Institutions' encompass all formal and informal interactions among stakeholders and social structures. 'Nature's benefits to people' are the benefits that humanity obtains from nature (Diaz *et al.*, 2015).

The conceptual framework of IPBES is seen by some as the 'Rosetta Stone' (Löfmarck and Lidskog, 2017) capable of balancing worldviews, knowledge systems and diverse conceptualizations and values of nature. In doing so, offering a translation mechanism between Western rationalist concepts like 'ecosystems services' and non-Western knowledge concepts like 'Mother Earth' (Díaz-Reviriego, Turnhout and Beck, 2019).

However, for some, the conceptual framework it is still too focused on Western scientific rationalism. For others, the framework and subsequent decision to move from ecosystem services to nature's contributions to people (NCP) (see subcategory construct *knowledge*) is unnecessary and may impede the future success of the platform (Díaz-Reviriego, Turnhout and Beck, 2019). For example, one interviewee believed that the IPBES conceptual framework had been inflexibly thrust upon authors with little room for negotiation (R9, LDR).

The LDR, Africa and ECA all adopted the Diaz *et al.* (2015) conceptual framework in their assessments, and made assessments of different socio-economic development scenarios. The IPBES cases used scenarios in an attempt to help develop an understanding of how biodiversity changes over space and time in response to human pressures (Rosa *et al.*, 2017). Importantly, scenarios offered the IPBES cases insights into the consequences associated with different development paths and policy options (Lundquist *et al.*, 2015).

As such, the LDR included a special chapter dedicated to scenarios entitled *"Chapter 7: Scenarios of Land Degradation and Restoration"*. The chapter assessed the scenarios of future land degradation and restoration in terms of changes to soil properties, biodiversity and ecosystem services as a result of human activities up to 2050 (IPBES, 2018b). It drew from a diversity of global and regional change scenarios from the published literature, including the IPCC's RCPs and SSPs (Chapter 4).

The LDR specially adapted the IPCC SSPs in relation to land-use activities as they concern biodiversity and ecosystem services.

The methodological assessment of scenarios and models, published in 2016 (IPBES, 2016), aimed to create an *"…institutional epistemology inclusive of diverse ontologies and different ways of knowing biodiversity"* (Borie, Mahony and Hulme, 2015: 14) by unifying different modelling and scenario building approaches (Obermeister, 2018).

It recommended that *"…the approaches adopted for the four regional assessments should be coherent enough to enable the collective contribution of results to the global assessment while still allowing for significant regional differences"* (IPBES, 2016: 30). This means that the Africa and ECA adopted different variants of the scenario archetypes, each specially selected to account for regional contexts (IPBES, 2018d). For example, the Africa assessment drew strongly from other published assessments and studies such as the MEA for its scenario development.

However, existing scenarios of biodiversity and ecosystem services have important limitations and gaps that constrain their usefulness (CBD, 2017). For example, the poor examination of the link between biodiversity and socio-economic development means that biodiversity and ecosystem services have been treated as the consequence of human decisions, but were not at the centre of the analysis (Rosa *et al.*, 2017). Additionally, scenarios and models thus far have failed to incorporate policy objectives related to nature conservation (CBD, 2017).

As such, Bridgewater and Schmeller (2018) suggest that an important part of future IPBES work will be the extent to which it is able to generate reliable scenarios and models which can be incorporated into its assessments. While IPBES does intend on working more with scenarios in a more consistent manner, in a similar way to the IPCC (Borie, Mahony and Hulme, 2015), modelling biodiversity and ecosystem services is more complex than climate models (Hof *et al.*, 2016).

Achieving this requires the development of multi-scale models. Multi-scale models can account for different spatial and temporal scales and – through coupled analyses of society and nature contributions to people – take cognisance of social-ecological feedbacks (Rosa *et al.*, 2017). While [parentheses added] *"…multi-scale [biodiversity and ecosystem models] and scenarios […are] still very much science in the making"* (Obermeister, 2018: 2), IPBES intentions are ambitious but achievable, according to Hof *et al.* (2016).

In this regard, a Nature Futures Research Programme, funded by CBD, was initiated in 2017 (CBD, 2017). It was planned that new, positive and aspirational scenarios would be produced by 2019, before the second IPBES work plan (Rosa *et al.*, 2017). Their intention is to integrate social-ecological feedback loops across drivers, biodiversity, ecosystem services, and human well-being, and incorporate multiple systems of knowledge (Rosa *et al.*, 2017). With the publication of *'From visions to scenarios for nature and nature's contributions to people for the 21st century'* (PBL, 2019) in March 2019 this was achieved. The report presents a *"…toolbox and template for the use of the Nature Futures Framework, consolidating the diverse values represented in the three perspectives, the visual representations of these perspectives, the participatory scenario-building process, and the metrics"* (PBL, 2019: 6).

5.3.4 <u>Trust</u>

Since *"…loss of trust can be rapid and very hard to reverse"* (Tinch *et al.*, 2016: 1694), IPBES places substantial emphasis on developing and nurturing public trust. The procedures generally used to promote trust are those which manage bias and manipulation; stimulate transparency (Gustafsson and Lidskog, 2018), fairness and widespread communication (Vohland *et al.*, 2011); and implement structures which enable a level of decision-making symmetry among participants (Esguerra, Beck and Lidskog, 2017). Trust creates the willingness to participate (essential for people volunteering their time), creates opportunities for transdisciplinarity and cogeneration, thereby making scientific assessment outputs useable.

In a similar way to other scientific assessments, the primary means of managing bias in IPBES is through building balanced multi-author teams, engaging transparently with stakeholders, undertaking rigorous peer review procedures and establishing credible governance structures[71] (Vohland *et al.*, 2011). These procedures are not without their challenges (for examples see subcategory construct *representation*) but they seem to offer something, as one Africa peer reviewer put it: *"…as close to objectivity as possible"* (R14, Africa).

Even so, the notion of process manipulation – by experts, countries and stakeholder lobbies – was raised by a number of interviewees. In relation to manipulation by experts specially, Tinch *et al.*

[71] Vohland *et al.* (2011) suggest that the most important means of achieving this is through effective platform and assessment governance. Carefully constituted governance structures – comprised of credible people – provide oversight on the topics to be assessed, make expert nominations and ensure balanced country representation. In this way, public trust emanates from both the people and processes intrinsic to the functioning of IPBES (Tinch *et al.*, 2016).

(2016) found strong evidence that IPBES has been known to be affected by cliques of experts. As one interviewee explained [parentheses added]: *"[there is a] small group of people that worked together for a long time at the core of IPBES"* (R15, Africa). Some have argued that over time, this 'clique' has come to play a dominant role in shaping the course of the IPBES and its scientific assessments. In this way, they *"…tactically exploit the politics of legitimation to influence the process and its outcomes and to enhance their own influence"* (Esguerra, Beck and Lidskog, 2017: 72).

Other interviewees took a more utilitarian approach to this issue. They suggested that influence in IPBES is more determined by conscientiousness and competence – rather than within 'power centred' cliques. As one interviewee from the ECA (R25) put it: "*…if they work more, they have more power. That is normal. If they were interacting more, coming to all the author meetings, attending them all, of course they have more power, more influence"* (R25, ECA). As an example, one expert from the Africa assessment commented that: *"…I definitely pushed my chapter for certain things to go in there and because I kept on commenting, they got included… but they were all good things" (R17, Africa).*

In mixed methods analyses, Tinch *et al.* (2016) found that participants in biodiversity-based SPIs do frequently favour advocacy roles, while for IPBES, the dominant expert position is one of 'honest broker'. In other words, experts participating in IPBES seem to mostly strive to make neutral judgments based on evidence, while other global biodiversity SPIs are seen more as advocacy driven. This is consistent with the findings of the survey, where, for S28, in response to the statement: *"The process was free from manipulation"*, the mean responses were 3.90 (± 0.87) for the LDR, 4.00 (± 0.68) for Africa and 4.05 (± 0.86) for ECA (Table 27).

Table 27: Subcategory construct trust across the LDR, Africa and ECA from 274 survey responses.

S	**Indicator**	**LDR (± SD) *n* = 88**	**Africa (± SD) *n* = 76**	**Europe (± SD) *n* = 110**
27	Managed bias	3.63 (± 0.93)	3.64 (± 0.93)	3.47 (± 1.01)
28	Freedom from manipulation	3.90 (± 0.87)	4.00 (± 0.68)	4.05 (± 0.86)
29	Declaration of interests	3.56 (± 0.84)	3.57 (± 0.81)	3.49 (± 0.92)
30	Trust	4.05 (± 0.71)	4.00 (± 0.68)	4.08 (± 0.75)
31	Conflict mediation	3.55 (± 0.67)	3.57 (± 0.78)	3.42 (± 0.77)
32	Transparent procedures	3.48 (± 0.70)	3.57 (± 0.76)	3.34 (± 0.80)
33	Fairness	3.93 (± 0.69)	4.05 (± 0.64)	3.82 (± 0.77)
34	Media relations	3.35 (± 0.75)	3.28 (± 0.94)	3.26 (± 0.85)

This however tells us little about stealth advocacy[72] (Pielke Jr, 2007), as many experts who perceive and identify themselves as objective honest brokers can be consciously or unconsciously operating as issue advocates. As one interviewee suggested, there is so much evidence available now that *"...you can definitely shape an assessment pretending to have scientific evidence to underpin your opinion"* (R10, LDR).

For example, in the view of one Africa assessment participant, European and North American peer reviewers attempted to *"...influence the development pathway"* for the Africa assessment by strongly pushing back against perceived promotion of development activities like agriculture and hydro-electric power (R18, Africa) – which in the eyes of the interviewee, was ideologically-based, rather than evidence-based

Another expert who participated in the LDR suggested that it is important to remain conscious of people's agenda, including those of your writing colleagues (R9, LDR). This is also supported in the findings of Tinch *et al.* (2016) who suggest that there exists some evidence that an understanding of the different motivations driving IPBES participants is very important for IPBES assessments, and overall platform success. In the author's view, concepts from different actors made transparent prevents breakdown of process through *"...inappropriate framings, misinterpretations and mistrust*" (Tinch *et al.*, 2016: 1695). This has the potential to positively influence transdisciplinarity and cogeneration.

Uncovering potential stealth issue advocacy and guiding experts through sincere and transparent disagreement is an essential part of assessment processes. This has been aided in IPBES with the establishment of a formalised conflict of interest policy and procedures established to mediate internal conflict[73]. However, initially, IPBES did not have a conflict of interest policy, which in the eyes of one interviewee, *"...seriously undermined its credibility"* at the time (R15, Africa).

In response, reasonably early into the first work programme, following the selection of two authors from the agrochemical industry into the Pollinator's Assessment – Hochkirk, McGowan and van der Sluijs (2014) made a call for an explicit IPBES policy addressing 'conflicts of interest'. The authors

[72] Experts from the ECA suggested feeling very little pressure from issue advocates although it was suggested that *"...as soon as IPBES gets taken up more seriously, then of course these lobbies will get interested"* (R25, ECA).

[73] According to Ms Amor Torre-Marin, the manager of the TSU for the ECA, some formal mediation procedures (e.g. in the case of lack of contribution from an author) and some informal mediation procedures (e.g. when there was difference of opinion within chapters or between co-chairs) where adopted in the ECA.

called for a requirement for experts to publicly declare positions held, funding sources and any other interests, including financial, in the topic being assessed. The policy was subsequently implemented by IPBES and welcomed by the extended stakeholder community, including NGOs (R13, LDR). This form of transparency seems to have built trust to the point where members of the NGO community suggested that including business experts in the pollinator's assessment was overall a *"...positive experience"* (R13, LDR).

Experts, policymakers and stakeholders need to strike, what Hotes and Opgenoorth (2014) have referred to as a 'golden balance' between mutual trust and the control required to execute the four functions. However, some authors have identified a decision-making asymmetry (Esguerra, Beck and Lidskog, 2017) where decision-making power rests primarily with governments. In the process they have made attempts to impede decision-making opportunities in IPBES for the wider stakeholder community (Díaz-Reviriego, Turnhout and Beck, 2019) – reflected, for example, by member states not supporting the proposed increase of authors permitted from stakeholder nomination (which currently sits at 20%) (subcategory construct *representation*).

Concerns of member state manipulation were also raised by a number of interviewees. One interviewee from the LDR (R11) suggested that powerful nations such as China and the United States can be sensitive about information which might be construed as criticism. As a result, they attempt to *"...strong arm"* negotiations. The interviewee cites "*… a couple of cases in our LDR SPM where this happened – where certain parties were just very, very insistent on certain results being highlighted, and others being buried or obscured in wishy-washy language. That is part of the game"* (R11, LDR).

In support of this, Bridgewater and Schmeller (2018: 2778) highlight this concern in the published literature. They suggest that the LDR approval process took much longer than expected because governments entered negotiations on text, rather than offering a *"...spit and polish editing, ensuring the evidence to support policy development and implementation was crisp, correct and understandable"*.

On the other hand, according to one policy-maker who worked on the ECA process, the plenary negotiations were fair in that they provided experts with the opportunity to speak up if demands from the country representatives strayed too far from the scientific evidence (R23, ECA). This is consistent with the findings of Tinch *et al.* (2016) who concluded that generally IPBES participants did not support the notion that the platform was dominated by politics, with no room made for science. It also seems generally consistent with the findings of the participant survey. In response to the survey statement S30: *"The process was trustworthy"*, the mean responses were 4.05 (± 0.71) for LDR, 4.00 (± 0.68) for Africa and 4.08 (± 0.75) for ECA (Table 27).

Tinch *et al.* (2016) suggest that these high levels of trust come from an increased opportunity for wider and more effective public communication efforts. Vohland *et al.* (2011) contends that while, communication is not one of IPBES' core functions, excellent communication should be continually strived for. However, in the findings of the survey, in S34 in response to the statement: *"Media communication was prioritised"*, the mean responses were 3.35 (± 0.75) for LDR, 3.28 (± 0.94) for Africa and 3.26 (± 0.85) for ECA (Table 27).

IPBES has taken some noteworthy steps to increase its media profile through initiatives. For example, early in 2020, it launched the 'United for #Biodiversity' coalition, made up of zoos, aquariums, botanical gardens, national parks, and natural history and science museums from around the world, launched by the European Commission (IPBES, 2020). In another example in 2020, a Ted Talk by BBC science journalist cited the recently released IPBES Global Assessment (IPBES, 2020). The IPBES External Review note that while progress has been made, *"...further improvements in communications could be achieved through more coverage on television and in other digital media, more placement of opinion pieces and more diversity among IPBES spokespersons"* (IPBES, 2019a: 12).

5.3.5 <u>Capacity building</u>

IPBES builds human resource capacity on three fronts. Firstly, through the capacitation of young people as future assessment leaders including skills such as good writing and media engagement (Gustafsson, 2018). The second element of capacitation lies in a need to work with 'marginalised'[74] groups – collaborating with, upskilling and learning from participants from poorer countries or participants with non-academic knowledge. The third is the skills transfer inherent to scientific assessments in the relationships built between experts, policymakers and stakeholders, where there is a transfer of knowledge between the 'science' and 'policy' domains.

In respect of youth development, while IPBES does not yet have a mechanism for establishing external capacity building partnerships across organisations (Brooks, Lamoreux and Soberón, 2014),

[74] "Marginalisation", as far as I can tell, is mostly synonymized with low to low-middle income country participation – and more specifically, those individuals or groups with knowledge systems which are traditionally overlooked in the scientific discourse – such as local and indigenous knowledge.

it has initiated internal capacitation efforts. Many of these have been modelled on the success of the capacitation programmes established for the MEA. For example, a task force on capacity building was established with the first work programme (Gustafsson, 2018). Their brief is to ensure that capacity building needs are supported by adequate resources. The first action was developing a proposal for a fellowship programme. In late-2015 the fellowships initiated when 33 young scholars were assigned to assessments (Gustafsson, 2018)

Fellows were nominated by their home institutions and then selected by the MEP, the co-chairs and the management committee, with consideration paid to disciplinary background, gender and regional spread (Gustafsson and Lidskog, 2018). The selection criteria for fellows was based on their research and analytical skills, a demonstrated ability to work with people from other disciplines and an interest in learning about IPBES assessment processes (Gustafsson and Lidskog, 2018). The aim of the fellowship programme is to create *"…a pool of competent professionals able to carry forward the Platform agenda"* (Gustafsson, 2018: 22). In this way, an 'IPBES person' is 'created' – one who has sense of loyalty and a *"...self-imposed responsibility to represent IPBES outside the organisation"* (Gustafsson, 2018: 36).

Although still in process, the fellowship programme was evaluated by Gustafsson (2018). The analysis shows that participants have benefitted through the programme via the opportunity to network with professionals, create a resume and gain experience and new knowledge. This creates what the author refers to as a 'socialisation process' where young scholars develop a new identity as 'IPBES people'. The relative success of the fellowship programme was seconded by the external review panel. However, they noted broader capacity development with stakeholders and policy-makers has been less successfully implemented. Better partnerships will help this problem (IPBES, 2019a).

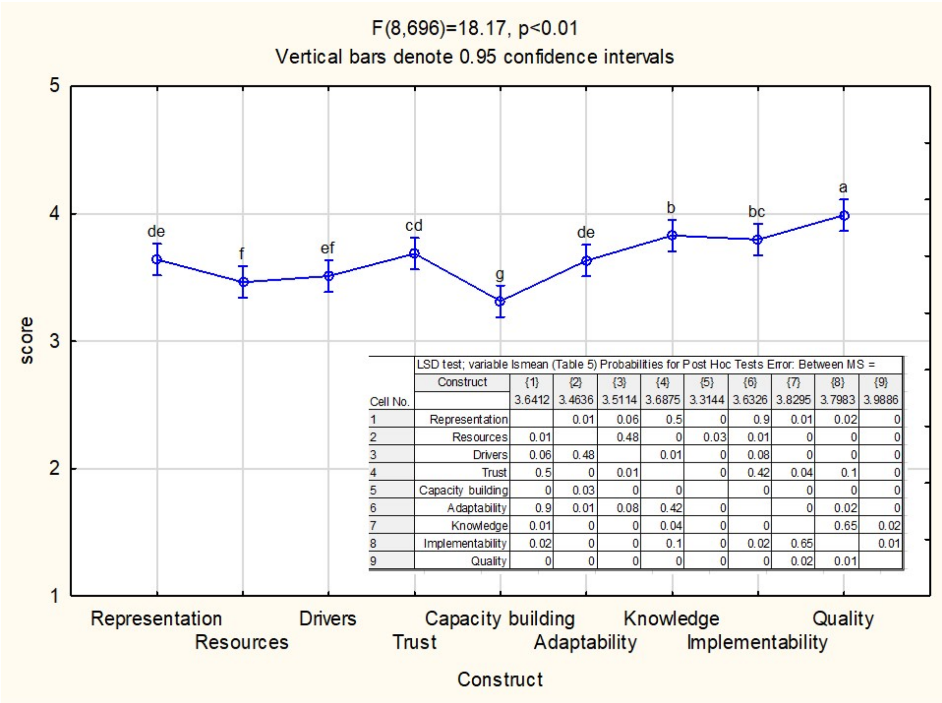
For the LDR 29% of authorship was below 40 years of age, for the ECA 25% of authorship was below 40 years of age, while for Africa, 59% of authorship was below 40 years of age. However, one interviewee from the Africa assessment spoke less favourably of the fellowship programme suggesting that *"…at least to the people that I spoke to, thought it didn't work that well"* (R17, Africa). The primary reason being that it was the fellow's responsibility to choose a mentor at the inception of the programme which is challenging because the fellows does necessarily know people and just selecting on publication record is a poor marker for the essential soft skills (R17, Africa). The result, according to the interviewee, was an overall lack of professional synergies between fellows and their mentors.

As regards the inclusion of ILK holders, experts from developing countries and co-production opportunities between experts and policymakers, IPBES has identified all of these as some of their highest priorities (Gustafsson, 2018) (which are discussed within the subcategory construct *representation*). Even so, it seems that, on average, survey respondents still questioned the relative effectiveness of these ambitious targets, in response to S37: *"Participation opportunities were provided to marginalised stakeholder groups"*, the mean responses were 3.08 (± 0.76) for LDR, 3.07 (± 0.94) for Africa and 3.08 (± 0.75) for ECA (Table 28).

Table 28: Subcategory construct capacity building across the LDR, Africa and ECA from 274 survey responses.

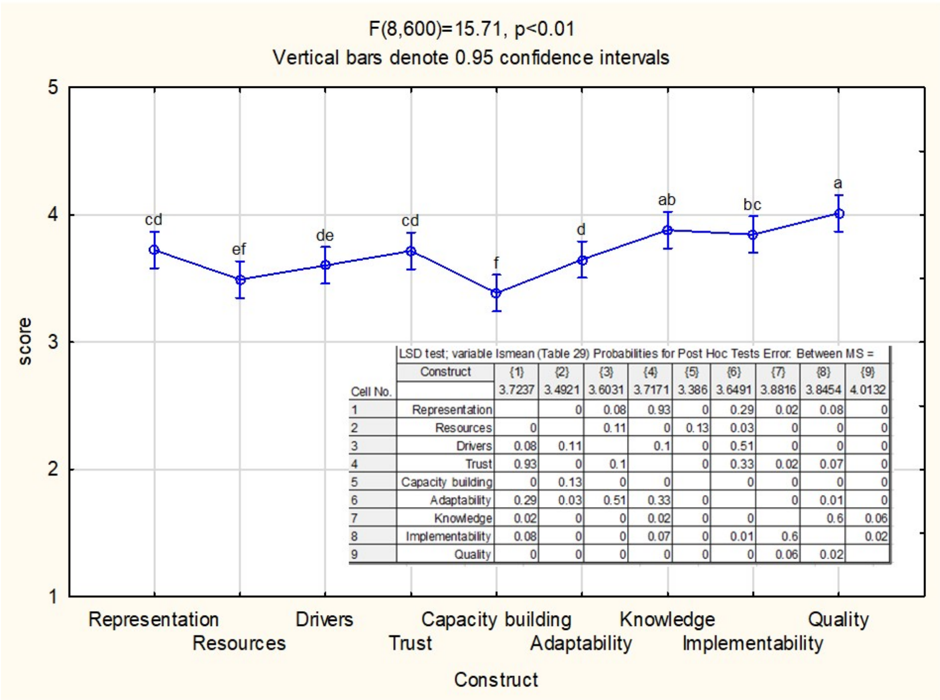
S	**Indicator**	**LDR (± SD) *n* = 88**	**Africa (± SD) *n* = 76**	**Europe (± SD) *n* = 110**
35	Co-generation capacity development	3.31 (± 0.97)	3.22 (± 1.06)	3.25 (± 0.93)
36	Youth development	3.50 (± 0.88)	3.80 (± 1.09)	3.53 (± 0.86)
37	Marginalised groups	3.08 (± 0.76)	3.07 (± 0.94)	3.08 (± 0.75)

The subcategory construct *capacity development* (a product of cogeneration capacity development, youth development and the inclusion of marginalised groups) was statistically evaluated for differences across the nine subcategory constructs. Interestingly, for all three IPBES cases, capacity development was the lowest scoring subcategory construct (Figures 22, 23 & 24).



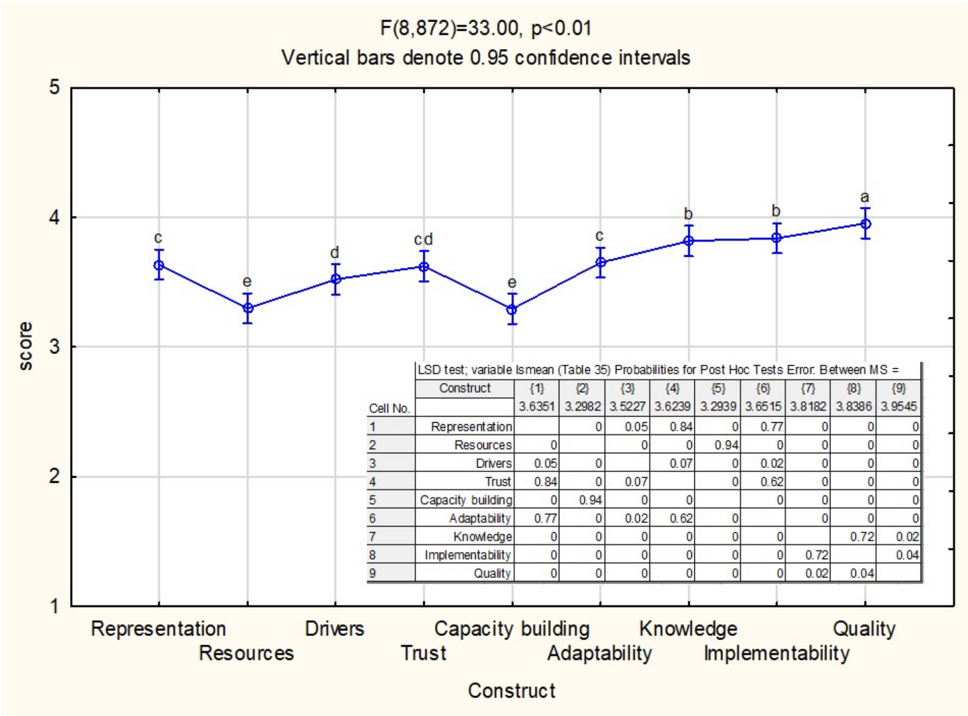
Cell No.	LSD test; variable lsmean (Table 5) Probabilities for Post Hoc Tests Error: Between MS = Construct	{1} 3.6412	{2} 3.4636	{3} 3.5114	{4} 3.6875	{5} 3.3144	{6} 3.6326	{7} 3.8295	{8} 3.7983	{9} 3.9886
1	Representation		0.01	0.06	0.5	0	0.9	0.01	0.02	0
2	Resources	0.01		0.48	0	0.03	0.01	0	0	0
3	Drivers	0.06	0.48		0.01	0	0.08	0	0	0
4	Trust	0.5	0	0.01		0	0.42	0.04	0.1	0
5	Capacity building	0	0.03	0	0		0	0	0	0
6	Adaptability	0.9	0.01	0.08	0.42	0		0	0.02	0
7	Knowledge	0.01	0	0	0.04	0	0		0.65	0.02
8	Implementability	0.02	0	0	0.1	0	0.02	0.65		0.01
9	Quality	0	0	0	0	0	0	0.02	0.01	

Figure 22: For the IPBES LDR, based on 792 survey responses from 88 respondents, capacity building was the lowest scoring subcategory construct, while perceived quality was the highest.



Cell No.	LSD test; variable lsmean (Table 29) Probabilities for Post Hoc Tests Error: Between MS = Construct	{1} 3.7237	{2} 3.4921	{3} 3.6031	{4} 3.7171	{5} 3.386	{6} 3.6491	{7} 3.8816	{8} 3.8454	{9} 4.0132
1	Representation		0	0.08	0.93	0	0.29	0.02	0.08	0
2	Resources	0		0.11	0	0.13	0.03	0	0	0
3	Drivers	0.08	0.11		0.1	0	0.51	0	0	0
4	Trust	0.93	0	0.1		0	0.33	0.02	0.07	0
5	Capacity building	0	0.13	0	0		0	0	0	0
6	Adaptability	0.29	0.03	0.51	0.33	0		0	0.01	0
7	Knowledge	0.02	0	0	0.02	0	0		0.6	0.06
8	Implementability	0.08	0	0	0.07	0	0.01	0.6		0.02
9	Quality	0	0	0	0	0	0	0.06	0.02	

Figure 23: For the IPBES Africa, based on 684 survey responses from 76 respondents, capacity building was the lowest subcategory construct while perceived quality was the highest.



LSD test; variable lsmean (Table 35) Probabilities for Post Hoc Tests Error: Between MS =

Cell No.	Construct	{1} 3.6351	{2} 3.2982	{3} 3.5227	{4} 3.6239	{5} 3.2939	{6} 3.6515	{7} 3.8182	{8} 3.8386	{9} 3.9545
1	Representation		0	0.05	0.84	0	0.77	0	0	0
2	Resources	0		0	0	0.94	0	0	0	0
3	Drivers	0.05	0		0.07	0	0.02	0	0	0
4	Trust	0.84	0	0.07		0	0.62	0	0	0
5	Capacity building	0	0.94	0	0		0	0	0	0
6	Adaptability	0.77	0	0.02	0.62	0		0	0	0
7	Knowledge	0	0	0	0	0	0		0.72	0.02
8	Implementability	0	0	0	0	0	0	0.72		0.04
9	Quality	0	0	0	0	0	0	0.02	0.04	

Figure 24: For the IPBES ECA, based on 990 survey responses from 110 respondents, capacity building was the lowest subcategory construct while the quality of outputs was perceived as the highest.

These results are consistent with the findings of the IPBES External Review panel who concluded that while capacity development is a core function of IPBES, *"…slow progress in the Platform's complex yet very important capacity-building efforts"* was noted (IPBES, 2019a: 3).

5.3.6 Adaptability and uncertainty

Tinch *et al.* (2016) have found some evidence that IPBES participants view repetition as an effective tool for enhancing the quality of outputs and the overall effectiveness of the platform. They also found that longer-term continuity and iterative engagements has the potential to build trust. In a similar way to other scientific assessments, iterativity in IPBES is achieved through the content iterations of a double-loop review process consisting of both peer and stakeholder review, coupled with multiple face-to-face author meetings.

The changes induced through these iterative procedures were considered substantive by many survey respondents, with one of the TSU managers from the regional assessment suggesting that the progression of text from FOD to the SOD stage resulted in a *"…almost completely a different document"* (R21, ECA). Another ECA participant who completed the open-ended survey response suggested that *"…the whole approach was new to experts and to IPBES team. However, the process* *was very adaptive and after initial confusion the effectiveness of the work and clarity increased quickly. I'd say it was quite steep learning curve for experts, but it resulted in rapid build-up of collaborative approach*".

This sentiment seems to be more-or-less reflected in response to S40: *"The process was iterative"*, where the mean responses were 3.90 (± 0.67) for the LDR, 3.76 (± 0.68) for Africa and 3.80 (± 0.78) for the ECA (Table 29).

Table 29: Subcategory construct adaptability across the LDR, Africa and ECA from 274 survey responses.

S	Indicator	LDR (± SD) *n* = 88	Africa (± SD) *n* = 76	Europe (± SD) *n* = 110
38	Adaptive	3.44 (± 0.72)	3.68 (± 0.70)	3.61 (± 0.76)
39	Management of uncertainty	3.52 (± 0.74)	3.49 (± 0.76)	3.53 (± 0.86)
40	Iterative	3.90 (± 0.67)	3.76 (± 0.68)	3.80 (± 0.78)

Mechanisms for dealing with uncertainty have been purposefully built into IPBES (Lundquist *et al.*, 2015). The platform manages this through two key mechanisms. Firstly, through the adoption of calibrated uncertainty language, and secondly, using scenarios (see subcategory construct *drivers*). Regarding the former, key findings in the Executive Summaries and SPMs of each IPBES assessment is accompanied by 'confidence statements'. Confidence statements refer to both the degree of agreement contained within knowledge sources ('level of agreement') and the amount of evidence which is available ('quality/quantity of evidence').

Low confidence describes a situation of incomplete knowledge – when an outcome cannot be fully explained or reliably predicted. For example, from the ECA: *"In Artic and Alpine regions, permafrost melting will cause large greenhouse gas emissions (unresolved)"* (IPBES, 2018d). On the other hand, high confidence conveys extensive knowledge and the ability to explain an outcome or predict a future outcome with greater certainty. For example, from the Africa assessment: *"Africa is extremely vulnerable to the impacts of climate change (well established)"* (IPBES, 2018c).

5.3.7 Knowledge

According to Balvanera *et al.* (2017), IPBES helps to build a public understanding of the co-dependencies between people and nature. In agreement, survey participants strongly believed that the knowledge outputs generated from IPBES processes play a useful role in knowledge generation. In response to S41: *"The outputs will enrich public debate"*, the mean responses were 4.14 (± 0.85) for the LDR, 4.24 (± 0.66) for the Africa assessment and 4.15 (± 0.77) for the ECA (Table 30).

Table 30: Subcategory construct knowledge across the LDR, Africa and ECA from 274 survey responses.

S	Indicator	LDR (± SD) $n = 88$	Africa (± SD) $n = 76$	Europe (± SD) $n = 110$
41	Enhances debate	4.14 (± 0.85)	4.24 (± 0.66)	4.15 (± 0.77)
42	Covers emerging research areas	3.62 (± 0.92)	3.58 (± 1.03)	3.74 (± 0.91)
43	Delivers on social questions	3.67 (± 0.66)	3.81 (± 0.75)	3.56 (± 0.77)

This is consistent with the findings of the independent review panel who found that IPBES "*…had impressive success in catalysing the generation of new knowledge"* (IPBES, 2019a: 3) and that IPBES outputs have contributed toward *"…building of understanding and capacity among a range of knowledge brokers and policy developers and to the transfer of knowledge across the knowledge policy interface"*. (IPBES, 2019a: 7).

However, at present, an epistemological schism exists within the IPBES community. According to Masood (2018) – it pits the valuation system known as 'ecosystem services' versus the newly evolving concept of Nature's Contributions to People (NCP). The concept of ecosystem services[75] – which came to prominence following adoption by MEA in 2001 – has been foundational in the work of IPBES in its first work programme (see subcategory construct *drivers*).

Within the IPBES community over the past 5 years or so, the ecosystem services concept has come under increasing criticism for its association with western, rationalist, neoliberal ways of thinking which "*...promote an economic perspective on biodiversity"* (Turnhout, Neves and De Lijster, 2014: 593 & 594). This argument (in this instance directed at IPBES) is part of a much larger postmodern critique of knowledge generation processes and institutions (Chapter 2) – where concerns have been raised about unbalanced epistemological orientation and dominant institutional power structures (Masood, 2018).

In response, 'Nature's contributions to people' (NCP), has been presented by Díaz *et al*. (2018) as providing a full range of contributions to people's quality of life beyond mere economic conceptions.

[75] Ecosystem services are ecological resources and processes which directly or indirectly contribute to human well-being. To ensure saliency, they are purposefully embedded with economic valuations techniques and language, so that they speak to a full range of social and political actors.

While still a fledgling concept (Bridgewater and Schmeller, 2018), the intention is that promoting epistemological considerations beyond scientific and economic framings will make knowledge more socially legitimate and hence useable to a wider audience.

However, there has been some push-back against the NCP concept. Those who were part of the development of ecosystem services dating back to the MEA and before want to maintain its use because it is seen as a pragmatic language (Borie, Mahony and Hulme, 2015). As illustration, according to Bridgewater and Schmeller, (2018), European countries generally wanted to keep ecosystem services because it is well-known in knowledge generation and policy sectors. On the other hand, countries from Asia–Pacific, African and Americas regions preferred the NCP framework, primarily owing to its reduced focus on economics.

Others have argued that economists have always been happy to accept that 'intrinsic values' exist, but point out that there is no basis for including them in collective decision-making by humans. In this way, the move away from ecosystem services (which is an obvious feature in the name of IPBES) is based on poor empirical foundations, appears to be led by a special interest lobbying effort and risks eroding years of traction built up for the term in the scientific and policymaking communities (Pers Comms. Prof Bob Scholes).

In agreement, some interviewees believed that NCP was driven by a [parentheses added] *"...group of people who wanted to have the exclusive rights on a term [hoping…] that new publications [would contribute toward] their papers or personal impact factor"* (R10, LDR). Others felt that NCP was *"... imposed"* upon them (R24, ECA), while online survey respondents raised concerns about NCP promoting *"…confusing messages to policymakers"*.

With respect to the ecosystem services versus NCP 'dilemma', others have argued for a pluralistic, hybrid approach – embracing the different perspectives of the way people and nature interact (Peterson *et al.*, 2018)[76]. Within this model, ecosystem services and NCPs do not need to be integrated into one framework, rather, that each approach is endorsed by IPBES and used on a case-by-case basis depending on the nature of policy questions which arise (Harris and Kotiaho, 2018). This hybrid approach seems to have been adopted, in part, in all three IPBES cases evaluated here. However, the terms *ecosystem services* and *nature's contributions to people* were cited

[76] Kenter (2018) suggests that both ecosystems services and NCPs fail to account for the contributions people make to nature. As such, the NCP 'makeover' does little to improve our understanding of the two-way interactions between nature and people.

unequally in the LDR, Africa and ECA assessment. For the LDR, NCP was used <1% of the time, for Africa it was used 8% of the time and for ECA it was used 7% of the time.

5.3.8 Quality

Like other scientific assessments, the IPBES cases had built-in quality control procedures – the primary ones being elaborate processes for iterative revision, representative multi-author teams and rigorous peer review procedures (Lundquist *et al.*, 2015). While these are major and onerous undertakings, substantial IPBES resources are dedicated toward their execution based on the belief that they substantially increase the quality of IPBES products.

For example, the first draft of the thematic assessment of pollinators received 5 211 comments, while the second draft received 5 166 comments – for a total of 10 377 comments from hundreds of reviewers (Schmeller, Niemelä and Bridgewater, 2017). Peer review comments on the IPBES cases evaluated in this research were slightly fewer that the Pollinator's Assessments, ranging between 3 000 and 6 000 for the regional assessments, and up to 6 500 for the thematic (global) LDR assessment (Table 31).

Table 31: Number of peer review comments across first and second drafts for each of the IPBES cases.

Case	~FOD	~SOD	~Total
LDR	~2 500	~4 000	~6 500
Africa	~1 200	~1 800	~3 000
ECA	~2 000	~4 000	~6 000

Assessment experts, in general, believed the *"…the peer review process was extremely helpful for developing high quality, high validity and high reliability"* products (R11, LDR). One participant from the regional assessment claimed *"… I was very pleased with how it unrolled. Four thousand plus sources were checked. References were in tune scientifically with the others and I couldn't see any bias in selecting this material. I couldn't see any gaps or oversights"* (R22, ECA).

Interviewees from the NGO community also lauded the peer review process, with some claiming it was *"…brilliant"* (e.g. R15, Africa). This sentiment was reasonably well reflected in the online survey responses, where, in response to S44: *"The outputs were of adequate technical quality"*, the mean responses were 3.99 (± 0.81) for the LDR, 4.01 (± 0.73) for Africa and 3.95 (± 0.81) for the ECA (Table 32).

Table 32: Subcategory construct quality across the LDR, Africa and ECA from 274 survey responses.

S	Indicator	LDR (± SD) *n* = 88	Africa (± SD) *n* = 76	Europe (± SD) *n* = 110
44	Sufficient technical quality	3.99 (± 0.81)	4.01 (± 0.73)	3.95 (± 0.81)

Even though quality control procedures have been tightly implemented in IPBES assessments, there remain some concerns over the quality of products emerging from the scientific assessments. For example, some online survey participants claimed an overall *"…low quality"* product. Other interviewees complained that the content in chapters often fell short of what is required for a scientific assessment, and simply *"…ended up being a literature review for a thesis"* (R14, LDR).

From the published literature, some commentators have questioned the short timeframes between the ZOD and production of the FOD – thereby increasing the chance that peer reviewers will receive substandard assessment chapters (Díaz-Reviriego *et al.*, 2017). This concern was echoed by Interviewee R21 (ECA) who suggested that more time could have been allowed for the development of the FOD to increase its quality prior to the peer review.

Quality is also mediated by balance and the honest presentation of evidence – something which IPBES has not always achieved. For example, IPBES has not been immune to the influence of alarmist statements. Bridgewater and Schmeller (2018) cite the case of the Asia-Pacific assessment, where projections were made that if current fishing practices continued, no exploitable fish would be available by 2048. In the view of the authors, *"…this is an example where headline-grabbing statements, uncritically filtered from assessment to SPM, need more careful quality control than the timetable evidently allowed"* (Bridgewater and Schmeller, 2018: 2780).

5.3.9 Implementability

IPBES appears to have made some impact on policy generation so far, albeit a modest one. For example, in 2016, at CBD COP 13 in Cancun, according to Hof *et al.* (2017), the Pollinator's Assessment received widespread policy attention, with its key messages being recognized in COP decision-making. While the pollinator assessment did not stimulate officially binding policy decisions, a limited number of countries formed a 'coalition of the willing' on a voluntary basis. The coalition is led by the government of the Netherlands, with a mandate to work together on some of the key problems identified in the assessment[77] (Schmeller, Niemelä and Bridgewater, 2017).

In other, more recent and relevant examples, the ECA made uptake presentations to the European Commission as part of its outreach programme. It also undertook to develop a document comparing the results of the four regional assessments. This docuemnet was was used as a background information document to inform discussions at the CBD COP 14 at Sharm El Sheikh in 2018.

These examples offer glimpses of the interactions between IPBES products and the policy-making environment. While more prominent examples are scarce since IPBES is so nascent, the belief among participants is that the platform does serve a useful decision-making function. This was reflected in S47, where in response to the statement: "*The outputs have been / will be useful for decision-making*", the mean responses were 3.90 (± 0.75) for the LDR, 3.95 (± 0.84) for Africa and 4.04 (± 0.87) for the ECA (Table 33).

Table 33: Subcategory construct implementability across the LDR, Africa and ECA from 274 survey responses.

S	Indicator	LDR (± SD) *n* = 88	Africa (± SD) *n* = 76	Europe (± SD) *n* = 110
45	Reaches multiple audiences	3.65 (± 0.75)	3.65 (± 0.83)	3.67 (± 0.82)
46	Uses expert judgement	3.92 (± 0.68)	3.78 (± 0.78)	3.77 (± 0.79)
47	Meets practical and policy needs	3.90 (± 0.75)	3.95 (± 0.84)	4.04 (± 0.87)
48	Guides assessments at smaller scale	3.67 (± 0.84)	3.99 (± 0.82)	3.87 (± 0.83)

However, since policy support is considered by many to be the *"...most critical function"* of IPBES (R13), some remain unsatisfied with its policy impact so far. Some interviewees suggested that policymaking initiatives emanating from IPBES are in very short supply, while others criticised the lack of derivative products, co-generated with partner institutions (e.g. R10, LDR). This message is consistent with the results of the IPBES External Review which found that policy-support has been the least successfully pursued core function of IPBES[78] – having failed to reach [parentheses added] *"...practitioners [...] local policymakers, the private sector and citizens"* (IPBES, 2019a: 3).

[77] From the data it was not possible to determine the relative progress of the coalition of the willing 2016.

[78] While policy support is still considered to be reasonably weak, the impact of IPBES in the academic community seems to have been pronounced (IPBES, 2019a). According to Web of Science and Scopus data organised by Díaz-Reviriego, Turnhout and Beck (2019), the number of journal articles published with IPBES as a central focus increased from a mean of 3 between 2010 and 2012, to a mean of 15, between 2016 and 2018.

There are a few reasons for IPBES having limited effect in the policy-making environment[79] – one of them being the problems associated with achieving relevancy at both global and local scales (IPBES, 2019a). In this respect, Interviewee R8, who worked on the LDR, described the problems of scale as *"…an honest struggle"*. Another member of the LDR MEP noted *"…substantial obstacles"* around the issue of downscaling (R12, LDR), while other survey respondents who completed the open-ended survey questioned the *"…practical utility of assessments"* undertaken at such a broad scope and scale.

Since *"…global solutions to environmental governance cannot realistically be contemplated without at the same time finding new opportunities for local self-expression"* (Jasanoff and Martello, 2004: 5), local relevancy is contingent upon scientific assessment policy options which conform to traditional biodiversity management units, such as the municipal boundaries, catchment areas or vegetative units. These geographical regions are generally unique in context in that they are subject to differing ecological features, socio-economic conditions and systems of governance (Soberón and Peterson, 2015). What is more, data – which is frequently slow and expensive to obtain – is spread across a diversity of knowledge systems, many of them indigenous and local. This makes it virtually impossible to precisely account for local scale context within regional or global assessments.

Even so, IPBES assessments have made efforts to deal with local case studies – hoping that generic learning can be extracted from specific examples and then applied, in modified form, to other contexts. For example, on page 180 of the LDR, the case study of Cheatgrass (*Bromus tectorum*) prevalence and its impact in Sagebrush ecosystems was cited as an example of how invasive species can lead to changes in vegetative cover and land degradation (IPBES, 2018b).

On page 239 of the Africa assessment, the overexploitation of freshwater and marine fishes in Senegal offers an example of depleting natural resources with the potential to drastically affect food security (IPBES, 2018c). On page 479 of the ECA, the case study of grassland restoration in Saarernaa, Estonia is presented to offer insights into the potential benefits of land restoration practices for local livelihoods and biodiversity.

[79] There are three other reasons for this according to the independent review panel (IPBES, 2019a). Firstly, IPBES has a tendency to see assessment outputs as end products rather than a piece of a wider knowledge-policy engagement. Secondly, there is an overrepresentation of natural scientists in the MEP and author teams. And thirdly, there has been a failure to review the effectiveness of existing procedures for policy support. An additional reason, cited by Tinch *et al.* (2016), is that the knowledge generated from IPBES is focused toward the biodiversity policy sector only – meaning that it remains relatively unknown to policymakers not working directly with biodiversity issues on a day-to-day basis.

Because of the problems associated with local-scale relevancy, IPBES does encourage the commissioning of national-scale assessments *"…using a similar concept or frameworks",* according to Interviewee R17, who worked on the Africa assessment. The idea is that IPBES conceptual and methodological frameworks are replicated through national-scale assessment procedures. In this way, knowledge is built from the bottom-up, making evidence more transdisciplinary, robust and comparable. Numerous examples of national assessments aligned to IPBES are evident, one of them being the National Biodiversity Assessment for South Africa, published by the National Biodiversity Institute (SANBI) which uses the IPBES model for uncertainty (IPBES, 2018b). In another example, according to Interviewee R26 (ECA), the next United Kingdom National Ecosystem Assessment, planned for 2022, will be conducted within similar, if not the same, conceptual frameworks as those developed by IPBES.

In addition to the problems of scale, the emphasis on product rather than process, the overrepresentation of natural scientists, a failure to review existing policy support procedures and the narrow focus on biodiversity policy-makers only – many interviewees highlighted concerns around the ineffective communication of knowledge, especially to policy-makers. Since reports run into the hundreds of pages (LDR ~750 pp, Africa ~500 pp & ECA ~900 pp), one expert who worked in the LDR (R13) referred to the assessment as "*…a thick pile of documents".*

For this reason, the primary means of policy-maker communication other than the plenary negotiations is the SPM[80]. For the LDR, Africa and ECA, their SPMs were approved, line-by-line, after plenary review at IPBES-6 in March 2018 (Bridgewater and Schmeller, 2018). During SPM co-generation, authors are expected to *"…strip away"* complexity from chapters, synthesising the most essential information into punchy headline statements which also serve as basic press releases (R24, ECA). However, the IPBES SPMs have been criticised by the independent review panel, the published literature and by interviewee and survey respondents. These criticisms generally fall into the following four themes:

[80] SPMs were made available, along with comments and responses records, summary documents, agreements, decisions, latest developments and IPBES-related publications, free of charge, at https://ipbes.net/assessing-knowledge.

1. Being too generic: The IPBES External Review panel found that SPMs can be *"…too generic and do not allow Governments to take immediate and effective action"* (IPBES, 2019a: 8).

2. Varying styles and formats: The regional assessment SPMs accepted at IPBES-6 did not use the same format and structure making it difficult to make cross-regional comparisons (Bridgewater and Schmeller, 2018).

3. Parallel production processes: Streamlining the assessment finalisation and SPM in parallel is *"...problematic"* as there are expectations for a succinct summary when the assessment itself is not yet complete (R17, Africa).

4. Non-reflective of underlying chapter text: For example, in the Africa assessment, one interviewee noted that *"…the SPM might not have been the exact representation of the assessment. It focused on some things more and some things less than it possibly should have"* (R16, Africa). In general, respondents cited two reasons for the disconnect between underlying chapters and SPM. Firstly, since the SPM is drafted by authors who volunteer themselves, they have a tendency to raise issues associated with their areas of specialisation to the front of the SPM text, while other messages potentially reflecting a broader author interest are side-lined (R17, Africa). Secondly, some interviewees complained about pressure from delegates in negotiation sessions, where political messages were [parentheses added] *"... pushed quite strongly [even if...] they weren't necessarily based on evidence"* (R17, Africa) (see subcategory construct trust).

CHAPTER 6. CASES FROM SOUTH AFRICA AND THE UNITED KINGDOM

6.1 Introduction

This chapter focuses on two national scientific assessment cases. One is from South Africa (the Shale Gas Scientific Assessment, SGSA) and one from the United Kingdom (the 2nd Climate Change Risk Assessment Evidence Report, CCRA2 ER). In the same way as the previous chapters, the nine CRELE-based subcategory constructs are used to analyse the cases.

6.2 Shale gas scientific assessment

'Shale gas' is largely methane, present in relatively low concentrations in weakly-porous shales, from where it is liberated by hydraulic fracturing ('fracking'). Conventional natural gas, by contrast, is present in large reservoirs in porous rock, usually capped by a layer of less-porous material, from which it is spontaneously released when penetrated by a borehole. The shale gas energy revolution in the United States, which peaked in about 2010, demonstrated the opportunities and risks associated with unconventional gas development. Elsewhere in the world, countries with shale gas potential have taken a more cautious approach than the United States to exploration and production (collectively called 'development'). Shale gas development (SGD) followed a similar cautionary trajectory in South Africa, with government making a commitment to a stepwise approach for augmenting and amending the existing regulatory regime prior to SGD at significant scale.

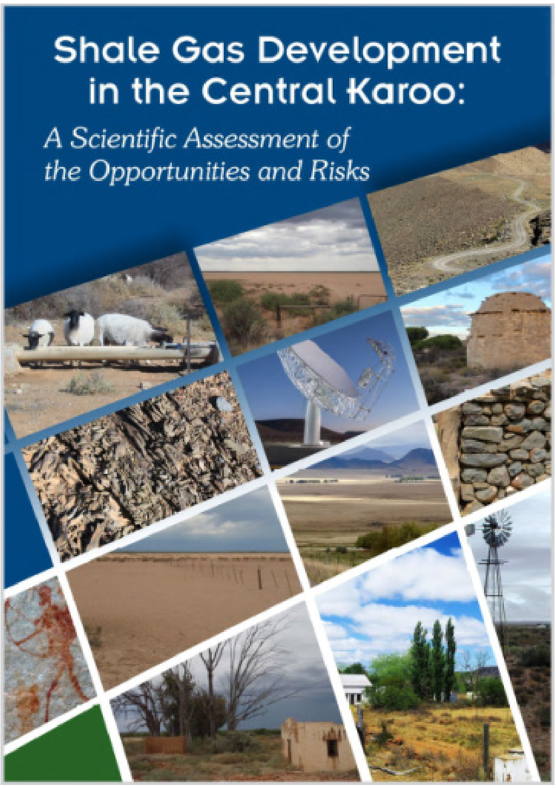
Even so, SGD in South Africa remained a contested issue with high uncertainty regarding both the distribution and magnitude of gas reserves and the potential social and ecological consequences of extraction. Since 2010, when the intention to explore was first mooted, SGD has been a highly divisive issue, but one which was poorly informed by publicly available evidence. The national discourse since that time had been framed, as it has in many other parts of the world, as a polarised opposition between those promoting economic and energy security benefits versus those who believe that any kind of shale gas development has unacceptable social and environmental consequences.

To address this lack of critically evaluated information, South African government commissioned an independent Strategic Environmental Assessment (SEA, see Chapter 2) in February 2015. The SEA consisted of three phases. The first phase consisted of the preparation phase. The second phase included an independent scientific assessment phase (the Shale Gas Scientific Assessment phase, SGSA), where information was organised by multi-author expert teams, including two review rounds, initially by independent review experts, and then by stakeholders plus experts. The SGSA consisted of 18 multi-authored, peer reviewed chapters and covered a geographic scope of 171 811 km^2 in the Central Karoo of South Africa.

The third phase included the somewhat novel design of an operational Decision Making Framework (DMF) for government, based on the scientific outputs of the SGSA. The DMF drafting process was led by the South African statutory science councils (the Council for Scientific and Industrial Research [CSIR], the South African National Biodiversity Institute [SANBI] and the Council for Geoscience [CGS]). The DMF commenced with initial drafts after the delivery of the SGSA SOD and continued into the final revision of the final SGSA report. Phase 3 was intended to provide government with the necessary tools to enable responsible decision-making[81].

Since the DMF was not official legislation or policy, its primary purpose was to guide the development of the Minimum Information Requirements (MIRs), gazetted in terms of the National Environmental Management Act (107 of 1998). The MIRs are intended to provide the regulatory framework within which applications for environmental authorisation for onshore shale gas exploration activities will be received – prescribing, the format, nature of assessments and monitoring requirements.

[81] The separation between the SGSA phase and the DMF phase was to honour the scientific assessment 'mantra' of being 'policy relevant, but not policy prescriptive'. The experts involved in the SGSA were not asked to make decisions about the development of shale gas. They were asked to give an informed, evidence-based, scientifically sound and balanced opinion on the consequences of different scenarios and development options for shale gas development into the future.



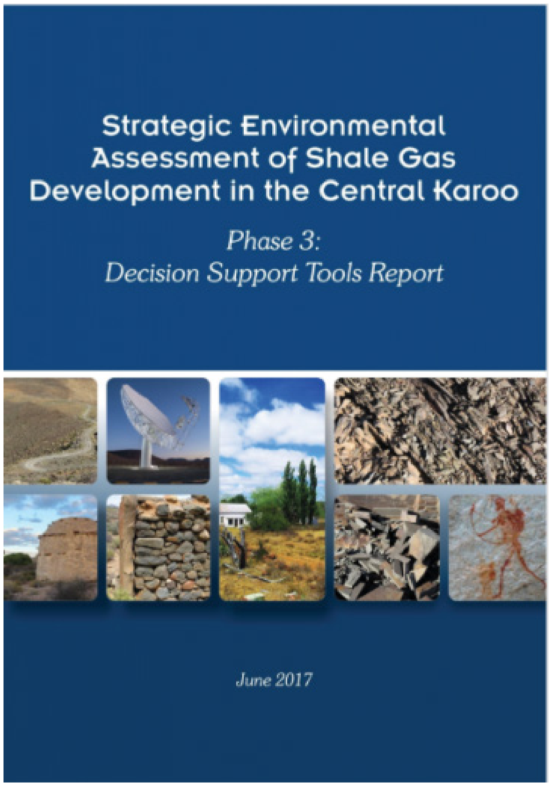


Figure 25: On the left, the Shale Gas Scientific Assessment (SGSA) (Scholes *et al.*, 2016) published in November 2016 provided the evidence base for the government issued Decision Support Tools Report (DEA, 2017), which was published in June 2017.

6.3 Climate Change Risk Assessments from the United Kingdom

The UK, like most countries, is vulnerable to the impacts of climate change. Higher than average temperatures and the frequency of extreme weather events have mirrored global trends escalating risks associated with altered coastal dynamics, human health, public water supply and food production systems (ASC, 2016).

The UK has a strong history of evidence-based decision-making (R35)[82]. In response to increasing evidence for climate change, the UK was one of the first countries to introduce a risk-based approach to legislation promulgation (Howarth *et al.*, 2018). This initiated in 2008 when the UK Climate Change Act was signed into legislation. The Act provides the overarching legislation governing decision-making. With respect to mitigation, it puts into national legislation the requirements of the Kyoto Protocol to reduce greenhouse gas emissions to 80 % lower than the 1990 baseline, by 2050.

[82] For example, the swift transition from leaded to unleaded petrol. As highlighted by Interviewee R35, the move from leaded to unleaded fuel was relatively smooth as alternative technologies were available. Alternatively, CO_2 emissions are more complex, with less attractive technological and financial alternatives.

With respect to adaptation, it obligates the UK Government to produce a five-yearly Climate Change Risk Assessment (CCRA) (CCC, 2019).

The scientific content of the risk assessment report produced by government is underpinned by an independently developed Evidence Report (ER) which is prepared under the auspices of an independent, statutory body mandated by the Climate Change Act (2008) called the Committee on Climate Change (CCC). The purpose of the CCC *"…Government on emissions targets and report to Parliament on progress made in reducing GHGs* (CCC, 2019: 1).

Within the CCC, an Adaptation Sub-Committee[83] (ASC) oversees the production of the independent ER and has a statutory duty to advise the Department for the Environment, Food and Rural Affairs on the preparation of each CCRA. The CCC and its ASC are jointly sponsored by the UK Government, the Scottish Government, the Welsh Assembly Government and the Northern Ireland Executive (CCC, 2010). The first Climate Change Risk Assessment ('CCRA1'), was published in 2012, the second report was published in 2017 ('CCRA2'), with a third risk assessment report ('CCRA3') planned for publication in 2022[84]. The reports have been used to inform policy and guide future research, however, their main purpose – as mandated by the Climate Change Act (2008) – is to provide the basis for the UK Government's National Adaptation Programmes (NAPs)[85].

[83] The ASC is made up of experts in the fields of climate change impacts, science, environmental economics, conservation, public health and business. It provides independent, expert advice on preparing for and adapting to climate change to UK and devolved governments and parliaments (CCC, 2019).
[84] In a similar way to the CCRA and CCRA2, the CCRA3 will largely draw on the ASCs independent Evidence Report (ER), which is due to be published in the summer of 2021. The third ER will be supported by new research, part-funded by the UK's Research Councils, including projects on thresholds in the natural environment, future water availability, future flooding, how climate-related risks interact, and how behaviour change can affect risks and opportunities (CCC, 2019).
[85] The NAPs establish the UK Government's adaptation objectives by identifying how the risks identified in the CCRA should be addressed in policy action (Warren *et al*., 2018). This enables Local Authorities to build local adaptation capacity with non-state actors. For example, CCRA1, published in 2012 led to the statutory implementation of the UK National Adaptation Programme (NAP) in 2013 (Howarth *et al*., 2017).

Figure 26: The 2nd Climate Change Risk Assessment Evidence Report (CCRA2 ER) published in January 2016 (left) provided the evidence base for the CCRA2 Government Report published in January 2017 (right).

The CCRA2 ER consisted of 8 chapters drafted by multi-author teams comprising experts from academia, the private sector and organisations representing civil society across Great Britain and Northern Ireland (ASC, 2016).

The report had the following structure[86]:

- Chapter 1 – Introduction
- Chapter 2 – Approach and context
- Chapter 3 – Natural environment & natural assets
- Chapter 4 – Infrastructure
- Chapter 5 – People and the built environment
- Chapter 6 – Business and industry
- Chapter 7 – International dimensions
- Chapter 8 – Cross-cutting issues

[86] By structuring the CCRA2 ER around systems of receptors such as 'People and Built Environment' rather than conventional sectors such as 'Energy', 'Transport', 'Health' – authors were *"...compelled to think more deeply about the interconnectedness of risks and opportunities"* (Warren *et al.*, 2018: 21).

Table 34: Summary of the similarities and differences between the SGSA and the CCRA2 ER.

	Shale Gas Scientific Assessment (SGSA)	2nd Climate Change Risk Assessment Evidence Report (CCRA2 ER)
Date published	November, 2016	January, 2016
Scale	~170 000 km^2 of the Central Karoo	Entire United Kingdom
Thematic focus	Unconventional gas development	Climate change risks and adaptation
Assessment methods	Qualitative, risk-based, adopted from WGII AR5	Qualitative, urgency scoring
Intended policy use	Minimum Information Requirements (MIRs)	National Adaptation Programmes (NAPs)
Legislative mandate	Environmental Management Act (1998)	Climate Change Act (2008)
Scenarios and time scale	Four scenarios considered across 2018 – 2050	2020s, 2050s, 2080s & post 2100 (for sea level rise)
Sources of literature	~1 500	~1 700
Authorship	2 co-chairs, 21 CLAs (paid), 63 LAs, 62 CAs	Chaired by the ASC chairperson, 11 LAs (paid), 60 CAs. ASC (~19 individuals) acted in CLA positions
Peer review	Review process managed by TSU. 76 expert peer reviewers. 114 government and stakeholder reviewers	Formal review panel, with independent chair. 25 appointed expert peer reviewers. ~150 government and stakeholder organisations equating to hundreds of reviewers
No. of chapters	18	8
No. of pages	~ 1 100	~ 850
Budget	~$ 920 000	~$ 845 000
Honorarium to authors	$ 4 500 – $ 8 900 stipend to CLAs. None to CAs	CLAs were paid ASC staff. $ 11 700 stipend to LAs. None to CAs
TSU location	Stellenbosch, South Africa	London, UK
Final approval	Project Executive Committee (PEC) & Process Custodians Group (PCG)	Adaptation Sub-Committee (ASC)

6.3.1 Representation

The SGSA included 21 ‘integrating authors’ (equal to CLA in IPCC nomenclature), 63 ‘contributing authors’ (equal to LA) and 62 ‘corresponding authors’ (equal to CA)[87]. Authors were drawn from academia, the private sector, government, national science councils, NGOs and the oil and gas industry – with the majority coming from academia and the private sector.

[87] Out of a total of 83 CLAs and LAs, 55 (70%) were male and 28 (30%) were female. Although there was a gender imbalance in authorship, none of the interview participants (*n* = 8 of which 3 were female) or survey respondents (*n* = 88 of which 29 were women) raised this as concern.

Of the total 83 CLAs and LAs, 37% were from the natural sciences, 33% from the applied sciences, 16% from economics and social sciences, 10% from arts and humanities and 5% from the health sciences. This disciplinary diversity score based on multi-disciplinary authorship was 0.87 according to the Science-Metrix widget evaluation, which is considered a very high score[88].

Disciplinary diversity was achieved through implementing an elaborate author nomination and appointment process[89]. The TSU issued a wide call for author nominations shortly after the commencement of the SGSA. Nominations were received from stakeholder groups and governance group members. These were supplemented with nominations from the project management TSU. The entire nomination list, plus expert CVs, were presented to the two project governance groups (see subcategory constructs *drivers* and *trust*). Governance group members were asked to sign-off on the author list – based on the overall balance and representivity of chapter teams[90]. If no objections were received, the TSU proceeded to engage the nominated experts to see if they were interested in, and available for, their nominated roles.

With regard to this authorship model, one of the SGSA CLAs (R30) suggested that *"…we had a AAA plus team – most of those scientists where the most respected scientists, social scientists, natural scientists and economists in South Africa"*. This positive sentiment was generally supported in the findings of S10 and S15 of the participant survey[91] (Table 35).

[88] 0.1–0.2: is a low score, meaning that there is one 'home' discipline with a few 'secondary' areas also included. 0.3–0.5: is a mid-range score, meaning that there is a balance amongst the disciplines represented but that they're all still quite clustered in one intellectual area. 0.6 and above: is a high score, meaning that several different disciplines are involved, they're relative balanced and they're drawn from a broad intellectual diversity.

89 SGSA used a specially developed procurement plan which conformed to national legislation while still allowing flexibility in author selection. This enabled the project team to select experts based on nominations from the PCG and wider stakeholder community, without the requirement of open tender evaluation procedures.

[90] This was the case for CLAs and LA, while in the case of CAs – these were appointed by CLAs with the approval of the TSU on a needs basis, without the approval of the governance structures.

[91] Mean H-indices for CLAs for the SGSA and CCRA2 ER were 6.3 (± 5.9) and 22.9 (± 16.4) respectively.

Table 35: Subcategory construct representation for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
9	Knowledge co-production	4.01 (± 0.80)	28	3.96 (± 0.84)	24
10	Diverse expertise	4.48 (± 0.61)	52	4.46 (± 0.51)	45
11	Government involvement	3.49 (± 0.90)	11	3.75 (± 1.04)	24
12	Openness to participants	3.87 (±0.92)	26	3.32 (± 1.06)	14
13	Transdisciplinarity	3.44 (± 0.73)	5	3.14 (± 0.89)	7
14	Use of social sciences	4.12 (± 0.82)	34	3.64 (± 0.91)	17
15	Knowledgeable experts	4.43 (± 0.66)	50	4.54 (± 0.51)	52

On the other hand, the CCRA2 ER used 10 'lead contributors' (equal to LA in IPCC nomenclature) and 61 'contributing authors') (equal to CA). Their job was to provide specific technical text sections as and when required. Based on the evidence, it seems that CLA positions were occupied by ASC staff (~19 individuals) who undertook the bulk of the drafting work – including chapter text integration and responses to comments. This was captured in the ASC invitation to tender, where it states that (ASC, 2014: 7): "*... the ASC secretariat will do the majority of the work in planning and drafting the chapters. However, we would also like lead contributors to draft the most technical content".*

The CCRA2 ER LAs and CAs were mainly drawn from academia. Applications from employees from *"...central government departments, non-departmental public body and executive agencies"* were not accepted (ASC, 2014: 2) – perhaps due to the need to keep the CCRA2 ER independent from government influence.

Of the 71 LAs and CAs, 50 were male (70%) and 21 were female (30%)[92]. Of the 71 authors, 20 % were from the applied sciences, 1 % from the arts and humanities, 30% from economics and social sciences, 42% were from the natural sciences and 7% from the health sciences. Based on this, multidisciplinary scores – using the Science-Metrix widget were 0.78 for the CCRA2 ER – which is also a very high score according to the calibration system[93].

[92] In a similar way to the SGSA, survey respondents, many of whom were female, highlighted the gender imbalance in authorship as a point of concern.

[93] 0.1–0.2: is a low score, meaning that there is one 'home' discipline with a few 'secondary' areas also included. 0.3–0.5: is a mid-range score, meaning that there is a balance amongst the disciplines represented but that they're all still quite clustered in one intellectual area. 0.6 and above: is a high score, meaning that several different disciplines are involved, they're relative balanced and they're drawn from a broad intellectual diversity.

LAs positions were put on open tender by the ASC in April 2014. To ensure quality of expertise, LA bidders were required to present a copy of their Curriculum Vitae (CV) and a cover letter explaining how they met the following criteria (ASC, 2014):

- Evidence of relevant expertise demonstrated by academic publication record;
- Being a recognised peer reviewer of articles for academic journals;
- Knowledge of climate change adaptation research and policy;
- Proven track record in writing technical documents for a policy audience;
- Track record of collaborating with other researchers on joint projects;
- Evidence that the required amount of time can be spent on the project;
- A commitment to see the project through to completion; and
- Freedom from any conflicts of interest.

The LA selection criteria seem to have been effective in promoting knowledge diversity and expert competence. This was demonstrated by the positive responses to S10 and S15 (Table 35). Even so, some participants felt that the author selection process could have been more transparent – thereby promoting a greater diversity of perspectives. For example, one CA suggested that people use [parentheses added] "*…informal networks [to get onto] these committees and it might be that it could benefit from a more transparent process of appointment"* (R37, CCRA2 author).

On the other hand, another interviewee believed that experts CCRA 2 ER required a level of independence in the selection of supporting authors – precisely using the aforementioned networks since *"... assessments are in people's own time, they are volunteers. You have to allow them a certain level of autonomy and chose who they want to work with"*.

With respect to author balance in the CCRA2 ER, while there was generally a *"...balance between academic and non-academic literature"* (R36, CCRA2 author), some interviewees believed that more effort could have been made to specifically draw in a greater number of experts from industry. One LA (R36) noted [parenthesis added] "*…a very heavy kind of academic proctoring of authors"*, where only one person from industry was present on the chapter team.

Another issue raised by one of the open-ended survey respondents related to the way the different CCRA2 ER inputs were compiled. They reflected upon whether the process accurately reflected the consensus of the scientific field as little time was spent coordinating views, seeking agreement or disagreement, identifying gaps and managing uncertainty. They believed that the final CCRA2 ER was more like "…*a compilation of 100 different documents, with authors chosen for their known views and not an objective expression of consensus"* (CCRA2 author).

With respect to transdisciplinarity in the case of the SGSA, the process made efforts to engage non-academic knowledge systems. The primary means for achieving this was through appointing experts holding knowledge from different epistemological domains such as ILK, artists, farmers etc. – in this way incorporating a diversity of knowledge systems and worldviews. For example, the CLA for the social fabric chapter was a Karoo small-town resident; the CLA for the agriculture chapter farms (and lives) in the Karoo; while on the sense of place chapter, photographers, film-makers and artists participated in LA and CA positions[94].

Even so, in response to S13: *"Non-scientific knowledge was adequately considered"* – the mean response from SGSA participants was 3.44 (± 0.73) with only 5 % of respondents Strongly Agreeing with the statement. In agreement with this lack of transdisciplinarity, Borchardt (2016) claimed that the scientific focus and use of large reports served to exclude a number of participants from fairly engaging with the process.

Similarly, Interviewee R30 questioned the effectiveness of the knowledge integration practices of the SGSA – referring to the 18-chapter structures as *"…fragmented silos"* not capable of reflecting inherent complexity. One governance group member (R31), suggested that the SGSA had *"…reductionist*" elements which were based on overly simple and generic principles. Another author who completed the anonymous open-ended survey question concluded that it was *"…a large process that was structured in ways that perhaps resisted integration"*.

In response to the same survey statement (S13), the mean response for the CCRA2 ER was 3.14 (± 0.89) (Table 35). Perhaps a result of it mainly being a science-based assessment (Brown *et al.*, 2018). As such, it was not established with the intention of incorporating multiple epistemological systems at its outset. It could be argued that knowledge systems across the UK are more homogenised in comparison to other cultural systems (such as in South Africa) – however, the purportedly

[94] Additional efforts were made to engage with tacit, values-based experiences of potential shale gas development in the Central Karoo. For example, one of the stakeholder workshops held at Iziko Museum in Cape Town was co-presented alongside a local art exhibition demonstrating artistic impressions of possible hydrocarbon development in an environment which many people have an intrinsic connection to.

reductionist, scientific approach taken in the CCRA2 ER has been criticised by scholars such as Howarth *et al.* (2018) (subcategory construct *knowledge*).

Stakeholder participation in the SGSA was enabled through the diverse multi-author teams, where any knowledgeable person was permitted to become an author. Participation was also facilitated through public outreach meetings and project governance structures (subcategory constructs *drivers* and *trust*). Neither of these participation mechanisms were mutually exclusive of the others (Schreiner *et al.*, 2018).

The questions of the broader public were gathered in early rounds of three local community meetings in the Central Karoo and a consultative workshop with registered stakeholders in Cape Town in November 2015. In July 2016, before finalisation of the SGSA report, the draft findings were presented back to the same local and stakeholder communities to check that the key questions which had been raised in November 2016, had been adequately addressed. Feedback was incorporated via page/line numbered comment sheets and facilitated – where necessary – by capturing verbal input at the meetings for stakeholders without access to internet.

The primary, but not exclusive, means of communication was via the project website (http://seasgd.csir.co.za/), launched on 13 May 2015 following the parliamentary launch of the SEA[95]. By the time of the SGSA publication, there were in excess of 650 registered stakeholders[96]. Some participants thought the SGSA participation procedures worked well. For example, one PCG member (R27) believed that the SGSA had [parentheses added] *"…been a highly effective vehicle for […] just levelling the playing field between different stakeholders"*.

On the other hand, other commentators and stakeholders have cited substantial limitations in SGSA public participation. For example, Borchardt (2016), in her Honours thesis, analysed the efficacy of SGSA public participation processes in terms of their ability to establish legitimate spaces of free public engagement. While she found that while public meetings had created environments for

[95] Throughout the process, the management team used multiple communication mediums such as face-to-face meetings, the publication of written documents, explanatory video graphics and materials on the project website, interviews with the media and press releases and even novel approaches to raising awareness such as art exhibitions.

[96] This was a deliberate result of public outreach meetings over this period, where meetings were widely advertised through national and local radio stations, direct liaison with municipalities, the release of flyers to local communities, bulk SMS distribution, newspaper adverts in provincial and local media houses, social media notices such as Facebook, dissemination of notice through government channels such as South African Local Government Agency and members of the PEC and PCG.

participatory democracy, the amount for engagement was unevenly stratified along racial, gender, income-group and educational demographics (Borchardt, 2016).

Borchardt (2016) also criticised the implicit assumption that local stakeholders had the prerequisite background knowledge to properly engage with the technical content of the SGSA as well as the primary use of online tools for information dissemination. In agreement, one CLA (R30) noted: "*I would have done the consultation process once you have educated people"*. Additionally, one of the project management team (R28) noted difficulties in *"... communicating something so complex and it might have been better to have more time to really bring people along*".

With respect to the CCRA2 ER, various stakeholder engagement events were held across the four countries in the UK (ASC, 2016). These included an open call for evidence to collect relevant published literature in 2014; stakeholder workshops (~ 100 participants) in 2014 and 2015 do discuss assessment methods and numerous chapter meetings (10-20 authors) to discuss key risks and opportunities, key policy considerations and gaps in evidence (Warren *et al.*, 2016).

These engagements were mainly arranged for public officials and other key stakeholder organisations such as NGOs. Of these procedures, interviewees spoke highly, describing them as *"... good processes for engaging people throughout"* (R36). On the other hand, the mechanisms for general stakeholder engagement within the CCRA2 ER drafting process are not obvious – it is not clear exactly how, or if, stakeholders were permitted to register, *ad hominin*, and provide inputs into drafts of the assessment. In the view of one of the experts who answered the online survey, there was very little to *"...no stakeholder engagement"*. This might explain why, in response to S12: *"The process was open to all interested stakeholders",* the mean response for the CCRA2 ER was 3.32 (± 1.06) (Table 35).

6.3.2 **Resources**

The budget for the entire SEA for SGD was $ 920 000 (ZAR 12.5 million in 2015). Around two-thirds of this was allocated toward the SGSA (i.e. the actual scientific assessment component). This covered project management fees for 4-5 staff, author meetings, travel expenses, two rounds of public meetings, media liaison, printing / publishing costs, CLA honorariums etc. The SGSA, from ZOD to final publication, took 14 months from September 2015 to November 2016.

CLAs were paid honorariums of between ~$ 4 500 (for smaller chapters) and ~ $ 8 900 (for larger chapters) to cover a portion of their time. No honorariums were paid to LAs and CAs – although CLAs were able to redistribute their honorarium at their own discretion[97]. CLAs were asked to spend approximately 30 days of their time working on the SGSA including attending three, three-day author meetings hosted at Goudini, in the Western Cape. LAs were asked to contribute in the region of 15 days of their time (including attending the author meetings), while CAs were used on an *ad hoc* basis to make nominal text or data contributions. CAs were not expected to attend author workshops.

The purpose of the writing workshops was to assemble author teams in one place without distraction, providing the opportunity to engage with their chapter colleagues and with the writing teams from other chapters[98]. These meetings were undertaken at three points in the process. Firstly, to generate the ZOD; secondly, to respond to peer review comments on the FOD; and thirdly to respond to stakeholder comments on the SOD and generate the final assessment. The writing workshops were popular among participating experts and the management team (R32). For example, one SGSA expert who answered the open-ended survey believed the workshops were *"…well-constructed and assembled"*, while another interviewee (R30) noted that "…g*oing away from home to write was incredibly effective - it got everybody focussed"*.

The SGSA TSU operated out of the CSIR Stellenbosch offices where one of the project leaders was based (the other project leader was based at the University of the Witwatersrand in Johannesburg). The Stellenbosch team included a full-time project manager, a project officer and GIS technician, and two interns. One intern was responsible for public participation and the other responsible for editing, database management[99] and quality control. Being the largest science-policy interface process to ever be undertaken in South Africa, the project team were faced with numerous challenges on a day-to-day basis – emanating from expert management, stakeholder engagement, maintaining governance

[97] In some instances, CLAs made contributions to the time costs of LAs when their participation otherwise would not have been possible. This was especially necessary for the experts from the private sector and sole supplier practitioners. The efficacy of this model is not clear, as in some cases it seems to have navigated procurement constraints and encouraged more author participation. In other cases, CLAs were not pleased about having to manage and decide upon project funds – which they felt was a job for the TSU.

[98] This was important as there was a high degree of overlap in between some chapters. For example, between heritage and visual resources, water and waste, social fabric and agriculture and economics etc. The author meetings provided an opportunity to highlight common issues, delineate scope and ensure both cross-chapter consistency and full coverage of important issues.

[99] The primary means of managing data among the writing teams was via an encrypted Google Drive folder. It contained author guidelines, draft texts, GIS-based maps (which were major component of the SGSA) and a curated online literature repository full of hundreds of literature sources, each organized into relevant chapters for the writing teams.

trust and keeping a satisfied client. Few complaints were registered about the TSU management of the process. One SGSA author who completed the open-ended survey question praised the TSU for their *"professionalism, commitment and courtesy, which brought out the best in the researchers".*

On the other hand, a number of experts raised serious concerns – usually around the funding model. One CA who answered the open-ended survey complained of "*…insufficient funding"* to cover time commitments. Another CA cited the *"...shockingly low funding available to independent/self-employed experts as disgraceful".* This sentiment was reflected in the responses to S16 (Table 36).

Table 36: Subcategory construct resources for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
16	Financial resources	3.24 (± 1.08)	13	2.46 (± 1.00)	0
17	Human resources	4.02 (± 0.81)	27	3.32 (± 1.12)	10
18	Personnel continuity	4.16 (± 0.72)	34	4.25 (± 0.59)	31
19	Information systems	4.08 (± 0.88)	34	3.32 (± 0.90)	3
20	Sufficient time	3.50 (± 0.73)	7	3.61 (± 0.69)	3

Even so, one open-ended survey respondent suggested that the SGSA was the [parentheses added] *"…most interesting and educative process that [they] have been involved in".* Others were impressed by the levels of expertise and the networking opportunities. This overall positive sentiment was reflected in the question of whether experts would willingly participate in another similar process – where the mean response was 4.20 (± 0.73), with about half of participants Strongly Agreeing that they would.

There was some continuity through SGSA, reflected in the survey results, where, in response to S18, a third of respondents Strongly Agreed that there had been continuity (Table 36). Even so, there was some participant attrition. One CLA dropped out shortly after appointment and around 5 LAs chose to leave the process – primarily because of being overcommitted, but also because of personality clashes and disagreements over methodological design. The TSU, chairs and governance groups remained unchanged, with no human resource losses.

However, since the SGSA was a scientific assessment embedded within a larger SEA process, the government clients always had expectations of implementing the outputs into national legislation and policy (subcategory construct *implementability*). As unpacked in Chapter 2, these policy processes are procedurally messy and rarely follow a linear model. They generally require at least 3-5 years following completion of an SPI and are thus heavily reliant on a continuity of personnel beyond the lifespan of the assessment. This was supported by one interviewee (R32), who noted that *"...to be effective you have to have a continuity of people involved for about 5 years. The work gets done in 2014 and then it gets gazetted in 2018"*.

With respect to the CCRA, for CCRA1 ER, the process was led by consultants who were appointed following a competitive tender process with the ASC providing methodological advice and peer review support (ASC, 2014). For the CCRA1 ER, the consultants designed and implemented the assessment based on the climate projections made by an IAM developed by the national Met Office called UK Climate Projections 2009 ('UKCP09'). Much of CCRA1 ER included new simulations and analyses based on UKCP09. This took a substantial amount of time and cost in the region of £ 3.2 million, over three years (Warren *et al.*, 2018).

The consultant-led procurement model was considered to be detrimental to the process as it failed to adequately include the wide diversity of climate change expertise in the UK, from a wide variety of institutions and organisations. For this reason – coupled with substantial funding cuts – the CCRA2 ER had a far reduced budget, costing about one fifth of CCRA1 ER, at £650 000 over 3 years (excluding ASC time costs, which were already covered within other government budgets)[100]. The CCRA2 ER was led by the ASC, this time playing a much more hands-on role (Warren *et al.*, 2018).

LAs were asked to contribute 25 days of their time between June 2014 and August 2016[101] – including participating in meetings with key stakeholders (ASC, 2014). As mentioned, CLAs were drawn from the ASC, while LAs comprised well-known UK academics (appointed *via* the formal ASC bidding). CAs were appointed following joint ASC and LA consideration although it is unclear if any formal vetting process was required for final CA selection. CLAs, being ASC staff, were paid a salary for their contributions. LAs, who also undertook a large amount of the writing work (R37), were awarded an honorarium fee of around $ 12 000. CAs were not compensated for their time.

[100] Other differences between the CCRA1 and CCRA2 were methodological (the CCRA1 was more technical, quantitatively-based and focused on the new generation of knowledge while the CCRA2 was focused on existing knowledge and used quantitatively-based assessment approaches such as urgency scoring) and output related (the CCRA1 had less of a policy focus, it produced 11 sector reports, 1 synthesis and 3 national summaries; while the CCRA2 has more of a policy focus producing 1 synthesis, 1 evidence report, 4 summaries national summaries and 4 research reports).
[101] The actual time from production of ZOD to final publication and sign-off was 15 months (Ms Kathryn Brown, pers comms, 19/09/18).

The TSU was hosted out of the ASC, based in London[102]. The process had one dedicated project manager and an ASC team providing support where necessary. Interviewee and survey participants spoke highly of the way the CCRA2 ER was managed. For example, Interviewee R37 claimed to have *"…huge respect"* for the TSU, suggesting that they *"…were very enterprising in saying what do we actually need to inform better policy"*. Another open-ended survey respondent suggested that the TSU were *"…very good"* and *"ensured a consistent approach and high quality of the work"*.

Most survey respondents believed that there was continuity in personnel. In response to S18, the mean response was 4.25 (± 0.59) – with a third of the survey respondents Strongly Agreeing with the statement (Table 36). This was a result of the fact that the CCRA2 ER – unusually in scientific assessments – did not lose a single author through the process (Ms Kathryn Brown, pers comms, 19/09/18) and had an unchanged TSU and leadership managing the process.

The substantial budget reduction from CCRA1 ER to CCRA2 ER was raised as a concern by some survey respondents and interviewees. Some positioned the changes from the first ER to the second ER, as merely a result of insufficient funding (e.g. R37), rather than the novel and advantageous process innovation purported by Warren *et al.* (2018).

The majority of survey respondents Strongly Disagreed that the CCRA2 ER had made adequate financial resources available to participants. For S16 (Table 36), the mean response was 2.46 (± 1.00). This was perhaps due to CA positions being unfunded[103] or perhaps due to an overall agreement that further CCRA budget reductions were a cause for future concern. Warren *et al.*, 2018, in their review of the CCRA2 ER, question whether the 'goodwill' model will be repeatable in the future as the novelty of the process wears off while Interviewee R35 suggested that there needed to be greater recognition of the *"…effort and the excellence that goes into the assessments"*.

However, in spite of concerns around the funding model and a potential lack of academic recognition, in response to the question of whether authors would participate again another CCRA process again, the mean response was 4.43 (± 0.57) – with about half of participants Strongly

[102] Information and data was managed by the ASC using document collaboration and client engagement portals such as Huddle (https://www.huddle.com/) (Ms Kathryn Brown, pers comms, 19/09/18).
[103] One of the CAs interviewed (R37) suggested that their contributions to the final CCRA2 ER had been rather minimal and that the paid LAs had made a much larger contribution. In response to the question of whether a paid role would have changed the level of their contribution, they answered: "*Probably, but on the flip side you might say that the UK government pays for me to work in the university – and maybe this should just be part of my university role"* (R37, CCRA2 author).

Agreeing that they would. To that end, discussions have already initiated on CCRA3 ER, carrying forward the learning from the previous two assessments *(*R37).

6.3.3 Drivers

The broader SEA process for SGD was launched in the South African parliament in February 2015[104] by the Department of Environmental Affairs with the support of five other national departments and three provinces[105]. The scope of potential SGD activities, from cradle to grave, included a large and diverse footprint – transcending multiple national and local government mandates. As such there was therefore a high degree of government interest in the process, each with varying expectations.

As such, a special oversight governance committee was established called the Project Executive Committee (PEC). It comprised representatives of the government departments who commissioned the assessment. Their responsibilities were threefold: 1.) to coordinate and communicate information; 2.) ensuring that the project remained on scope, within timelines and budget; and 3.) that strategic and that policy issues were adequately assessed by the expert team. From the multi-departmental launch in Parliament to the specialised policy-specific role of the PEC – the SGSA was fully mandated. This was reflected in the survey where the mean response was 4.24 (± 0.73) with 41% of survey respondents Strongly Agreeing that the process was mandated (S24) (Table 37).

Table 37: Subcategory construct drivers for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
21	Clear goals and objectives	4.17 (± 0.69)	31	4.07 (± 0.72)	24
22	Adaptation to policy changes	3.43 (± 0.88)	9	3.18 (± 0.94)	10
23	Different scenarios assessed	3.84 (± 0.94)	24	3.46 (± 0.84)	7
24	Mandated process	4.24 (± 0.73)	41	4.43 (± 0.79)	55
25	Delineated scope	4.29 (± 0.73)	41	4.29 (± 0.53)	31
26	Questions from stakeholders	3.83 (± 0.90)	23	3.29 (± 1.08)	14

However, one PEC member expressed concerns with the way the PEC was constituted and its functioning (R31). They believed the PEC mandate remained unclear and that the group suffered

[104] Phase 2, the scientific assessment component of the SEA, commenced a few months following the parliamentary launch in September 2015, when the first author meeting was held.
[105] This included, the Departments of Water and Sanitation (DWS), Energy (DoE), Mineral Resources (DMR), Agriculture, Forestry and Fisheries (DAFF) and the Eastern, Western and Northern Cape Provincial Governments.

from highly unbalanced *"...power dynamics"* with ultimate control vested with the Department of Environmental Affairs, since they were sole financers. This enabled "…*individual viewpoints to sway the way that the structure operated and even the outcomes or the use of the information"*. In addition, the interviewee raised concerns about the non-performance of many PEC members. They suggested that a mechanism for evaluating the performance of the PEC and its members should have been adopted at the outset to get full value from members.

In the case of the SGSA, the diversity of national departmental interest created a fully 'authorising environment', but this also had a flip side. According to one interviewee (R32), the effectiveness of the SGSA was constrained by a lack of coherent government coordination – with multiple mandates pulling in different directions[106].

As the national Department of Environmental Affairs attempted to drive the process forward with its partners, they were frustrated in the lack of contributions from other important national decision-making departments, particularly the Department of Mineral Resources. On the other hand, since the SGSA was nationally constituted and funded, provincial PEC members felt that the issues assessed at local and municipal scale where insufficient. In the view of Interviewee R32, *"...I think the tricky thing here, being commissioned by so many national governments, was that there was a strong element of control set by the national government"* (subcategory construct *trust*).

Even so, the point of departure for the SGSA was that South African government had already made high-level public commitments to shale gas exploration and that if economically-viable gas deposits and flow regimes were revealed, South Africa would seriously consider permitting the development of those resources at significant scale. From this understanding, a mission statement[107] was developed to guide the SGSA in somewhat coherent fashion. The mission statement was to *"...provide an integrated assessment and decision-making framework to enable South Africa to establish effective policy, legislation and sustainability conditions under which development of shale gas could occur"* (DEA, 2017: 12).

[106] This point is illustrated by the fact that the SGSA was commissioned shortly after another strategic investigation in SGD called South Africa's Technical Readiness to Support the Shale Gas Industry. It was drafted by ASSAf and the South African Academy of Engineering (SAAE) (ASSAf, 2016). The ASSAf study and the SGSA were published at virtually the same time and had multiple points of overlap and intersection. However, in spite of countless attempts by the TSU, chairs and governance groups, the ASSAf study was embargoed by the DST and therefore was not assessed within the scope of the SGSA, which constituted a not insignificant technical and procedural flaw.

[107] The mission statement, developed in collaboration with government, was phrased in the conditional. It did not presume that SGD would occur, but that it might occur, assuming that certain scientific and regulatory conditions were met.

This overarching aim served to guide the SGSA chapters. The 17 topics chapters were generated by a combination of ‘top down’ and ‘bottom up’ dialogs – where candidate topics were gleaned from reviews of the literature housed in an electronic repository developed for the SGSA over 12 months. Topics were then debated and revised among authors – and where necessary – by the project governance structures and stakeholders in public meetings.

At the time of the SGSA, the policy environment surrounding SGD in South Africa was deeply uncertain for two reasons. Firstly, from 2011 onwards, multiple legislative and decision-making procedures were simultaneously underway. These included private sector Exploration Right applications, technical fracking regulations gazettes and even wholesale, and controversial, amendment proposals to the overarching national mining legislation. Many of these independent legal procedures either directly or indirectly affected the SGSA; however, since they were separately constituted with protracted legal proceedings (which are ongoing at the time of writing [June 2020]) – the regulatory and policy environment was especially difficult for experts to interpret, let alone government officials and the general public.

Secondly, the SGSA occurred at a time of great political schism in South Africa. During the time of the SGSA, the President of South Africa and Minister of Mineral Resources faced various charges of nepotism and corruption. This corresponded with a generally waning trust in South African government following almost a decade of President Jacob Zuma’s first and second terms.

Because of the uncertainty, it was decided that a scenarios-based approach would be the best method of guiding the scientific assessment forward. The SGSA scenarios were set out in chapter 1, which described the nature and scale of activities assumed for three SGD scenarios of increasing magnitude. The scenarios were described in the context of a reference scenario where there was no SGD (i.e. a baseline). Scenarios were selected to cover a range of plausible futures. In this way, Chapter 1 served as a common point of departure for the 17 topic-specific chapters, which evaluated, for the issues on which they focused, the levels of opportunity and risk associated with each of the scenarios and their main defining activities (Scholes *et al.*, 2016).

Three development scenarios: ‘Exploration Only’, ‘Small Gas’ and ‘Big Gas’, were produced in relation to a Reference Case, where no shale gas exploration occurred but other baseline changes proceeded. The scenarios were co-designed through collaborative processes of engagement workshops consisting of experts from the oil and gas industry, petroleum geologists, engineers, energy planners, and natural and social scientists. Qualitative information was presented as narrative descriptions of future developments in the form of storylines and images. These formed the basis for numerical estimates of key parameters of future development (such as volumes of economically recoverable gas reserves, number of well pads, kilometres of road, litres of water used and so on) presented as tables, graphs and maps[108].

For each of the scenarios, each chapter went through a systematic and structured risk assessment for the impacts described, assessed both with and without mitigation, and across the three development scenarios. Likelihood was estimated qualitatively against a common framework of probability ranging from extremely unlikely to very likely. Consequence was determined by considering the nature of an impact, the level of exposure of an entity to that impact and the vulnerability of the receiving environment or entity.

However, Interviewee R30 questioned the utility of the risk assessment framework, believing it to be outdated: *"…risk methodologies have been around for yonks. Engineers have used them. I was quite surprised at how old fashioned the assessment method was"* (R30, SGSA author). The same interviewee was also concerned about the reductionist nature of risk assessment, where [parentheses added] *"…you take this incredibly complicated thing and force specialists […] many of whom kicked and fought against it, saying that you will not reduce it to one purple colour […] purple or red…".*

In the case of the CCRA, the production of the second ER was overseen by the ASC (under the auspices of the CCC) and mandated by the Climate Change Act of 2008. Since the ERs have a specific purpose of informing the CCRA Government Report and then subsequently the NAPs – the ERs are fully authorised by policy- and decision-makers. This confirms the findings of S24, where around 55% of respondents Strongly Agreed that the CCRA2 ER was mandated by the relevant government departments (mean response was 4.43 [± 0.79]) (Table 37).

The overarching aim of the CCRA2 ER was to answer the following policy-relevant question (Humphrey *et al.*, 2016: 4): *"…what should the priorities be for the next UK National Adaptation Programme and adaptation programmes of the devolved administrations?"* This question guiding the CCRA2 ER was further divided into a series of sub-questions which aimed to ensure that the content development was policy relevant (Humphrey *et al.*, 2016):

[108] The first draft of the scenarios chapter was submitted for national and international peer review followed by general stakeholder review with a traceable comments and responses record. Following finalisation, the scenarios formed the common basis upon which the 17 topic-specific chapters undertook their respective structured risk assessments (Schreiner and Snyman-Van der Walt, 2018).

- How has our understanding of climate change, risks and opportunities changed since 2012?
- How does climate change interact with other socio-economic factors to affect the level of risk or opportunity?
- How might current and planned policies and other actions affect the overall level of risk or opportunity?
- What is the urgency of action needed for different risks and opportunities?
- What are the uncertainties, limitations and confidence in the underlying evidence and analysis for different risks and opportunities?
- What are the net effects of different risks or opportunities acting together?

Survey participants felt that the scope of the CCRA2 ER was clearly defined, in response to S25 regarding clear scope, the mean response was 4.29 (± 0.53), with about one third of respondents Strongly Agreeing that the issues were clearly defined. This is consistent with the opinion of Interviewee R36, who stated [parentheses added] "*I think that articulating a clear question, helped bound the purpose and the structure of the analysis"*.

In order to answer the guiding question and sub-questions, the CCRA2 ER method included three steps: Firstly, to develop an understanding of present-day vulnerability and adaptation capacities. Secondly, to estimate future vulnerability in light of climate variability and macro socio-economic change based on model projection in the 2020s, 2050s and 2080s. And lastly, to develop urgency scores for the next 5 years (2017-2022) based on the identified gaps between current vulnerability and adaptation (step 1), and future change (step 2) (Warren *et al.*, 2016).

CCRA2 used a simple conceptual framework based on the notion of 'urgency'. This focused attention on areas most in need of policy intervention within the five year timeframe of the NAP (2018-2022) (Warren *et al.*, 2018). In the view of one of the CCRA2 ER authors who completed the open-ended survey, the urgency approach was *"...focused on actions that policy teams needed to take"* and was *"...something that really distinguished it from other processes"* (R36).

Each risk or opportunity assessed in the CCRA2 ER was assigned one of four urgency categories. The definitions used for each category were as follows (Warren *et al.*, 2018):

- **More action needed:** New, stronger or different government policies or implementation activities over and above those already planned – are needed in the next five years;

- **Research priority:** Further investigation is needed in the next five years to fill significant evidence gaps or to reduce the uncertainty;
- **Sustain current action:** Current or planned levels of activity are appropriate, but continued implementation of these policies or plans is needed; and
- **Watching brief:** Evidence in these areas should be kept under review, with long-term monitoring of risk levels and adaptation activity.

While CCRA2 ER authors were not required to evaluate specific policy interventions, they were asked to estimate the level of benefit which might be derived from a generic level of policy intervention within different sectors. In this way, the assessment framework was inherently ‘solution’ rather than ‘problem’ facing (Warren *et al.*, 2018).

Since the process was qualitatively-based – relying on expert judgement – it enabled the transparent assessment of multiple forms of evidence (R36). This contrasted the first, quantitatively based CCRA ER[109], which sought to determine risk magnitude probabilistically[110]. As a result, the CCRA2 ER enabled a more *“…inclusive”* assessment process which was less sensitive to assumption errors and allowed for collective expert judgement across a range of scenarios informed by a wider array of published evidence (Warren *et al.*, 2018: 21).

6.3.4 Trust

The SGSA featured an elaborately designed project governance structure which was the primary means of building public trust. In addition to the PEC (subcategory construct *drivers*), the SGSA included a new innovation, the Process Custodians Group (PCG). The PCG comprised 16 individuals drawn approximately equally from NGOs, the private sector, the research community and government. The organisations from which the PCG members were sourced were selected by the PEC as having credibility in their ‘sectors’ through having a mandate of some distinction, broad stakeholder representation and a demonstrated interest in the topic of SGD.

[109] CCRA1 ER also used Delphi-panel assessments which were considered too resource intensive. The Delphi method is a forecasting process framework based on the results of multiple rounds of questionnaires sent to a panel of experts. Several rounds of questionnaires are sent out to the group of experts, and the anonymous responses are aggregated and shared with the group after each round (Twin, 2019).

[110] In relation to the CCRA1 ER, according to Webb (2011), the over-reliance on a reductionist risk-based analysis or ‘socio-technical devices’ excludes critical data on social priorities – which is often generated from stakeholder engagement and wider public discussion in one form or another.

The PCG met at key junctures to ensure that the process of evidence collection and evaluation had been fair, comprehensive and rigorous[111]. In this way, they acted as the 'process referee' – specifically responsible for evaluating the following five questions:

1. Did the SGSA follow within the guidelines of the vetted Process Document[112]?
2. Did the chapter teams have the necessary expertise and show balance?
3. Did the scope cover the material issues as indicated by the ZOD?
4. Were expert reviewers independent, qualified and balanced?
5. Were review comments adequately addressed?

Based on these five questions, 'no objections' were noted at the last PCG meeting in September 2016. Following this, the final SGSA was published for stakeholder use. Most interviewees and survey participants believed the PCG to be a useful body (R32). A PCG member from the NGO sector thought that the process *"…was a very fair, open and transparent process"* (R27)[113]. While interviewee R28 claimed that *"…the governance structures, the multi-author teams, the credibility of the process lead – just the openness of the whole project"* was what contributed toward building public trust[114].

This sentiment was echoed in the findings of the online survey – where respondents were of the general opinion that the process was free from manipulation (S28), trustworthy (S30) and procedurally fair (S33) (Table 38).

[111] The PCG convened to discuss the ZOD in October 2015, the scenarios and activities FOD and SOD in October 2015 and May 2016 respectively, and the FODs of the 17 topic-specific chapters in May 2016. Feedback to the PCG was also provided on the progress of stakeholder engagement, public outreach processes and stakeholder commenting mechanisms.

[112] The SGSA 'Process Document' published by the project co-chairs explained the processes from governance procedures, stakeholder engagement to multi-author team coordination. The Process Document was used at the outset of the SGSA to mobilise governance and expert groups, as well as to encourage stakeholder registration.

[113] The SGSA did not enforce formal conflict of interest procedures, neither were formalised conflict resolution approaches adopted. With respect to the latter, the TSU were the first line for party mediation, followed by the chairs, the PCG and then finally the PEC. For both rounds of the public participation an independent, bilingual facilitator was used to good effect to act as a conduit of information between the project team and stakeholders.

[114] Some PCG members were dissatisfied that they had to pay their own travel expenses to attend meetings. About five nominated members refused, or were unable, to participate on account of the lack of financial support from the project. This potentially contributed toward waning attendance at PCG meetings where – by the end of the process – only around half of members were physically present (although they remained formally part of the process and participated remotely via email).

Table 38: Subcategory construct trust for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
27	Managed bias	3.91 (± 0.94)	25	3.75 (± 0.84)	17
28	Freedom from manipulation	4.08 (± 0.87)	35	4.14 (± 0.80)	31
29	Declaration of interests	3.58 (± 0.86)	11	3.68 (± 0.90)	17
30	Trust	4.03 (± 0.91)	34	4.32 (± 0.55)	34
31	Conflict mediation	3.44 (± 0.76)	9	3.71 (± 0.76)	17
32	Transparent procedures	3.53 (± 0.78)	9	3.64 (± 0.78)	17
33	Fairness	4.12 (± 0.80)	34	4.07 (± 0.81)	31
34	Media relations	3.07 (± 0.84)	5	2.89 (± 0.83)	3

The success of the PCG was perhaps best demonstrated when it was replicated shortly afterwards in the next large scientific assessment undertaken in South Africa – the Predators Assessment or 'PredSA' (Chapter 2). In a similar approach to SGSA, the PredSA appointed an independent six person body (also called the PCG), broadly representative of the societal interest in the issue of livestock predation (Kerley *et al.*, 2017). The role of the PredSA PCG was to serve as an independent and trustworthy collective broadly responsible for oversight of the process (Kerley, Wilson and Balfour, 2018).

Even though there was a high degree of trust in the SGSA process – established through a variety of mechanisms – some still raised concerns about manipulation. Borchardt (2016: 36) [parentheses added] suggests that *"…while participants displayed a degree of trust in the credibility of the process they remained unconvinced about the larger processes and believed that the South African government would not consider the report in full"*. This is an insightful and fair account. Throughout the process, the TSU encountered numerous members of the public highly apprehensive of the science-policy process because they had little faith that the evidence generated would be acted upon by decision-makers in a responsible way.

This was partly due to the SGSA being undertaken at an especially turbulent time in South African political and public life – when the President of South Africa and a cadre of influential politicians faced numerous allegations of nepotism and corruption ranging actors a variety of sectors, including mineral resources. This corresponded with a rapidly deteriorating public trust in South Africa's institutions – especially those charged with governance over mineral resources. At the time, this spurred a vocal media and a highly sensitised public readership which increased the level of government anxiety about negative sentiment in the popular press (R32).

For this reason, some SGSA participants noted that *"... a couple of key lead authorities did restrict the frankness of some aspects of the study"* (R32). In one instance, political officials expressed sensitivity over content of a vaguely political nature contained in one of the chapter FODs. In response to the pressure, the TSU amended the language of the text, in collaboration with the chapter CLA. However, the respective CLA remained concerned that the TSU and chairs *"...rolled over and agreed to"* make the changes government found to be *"...offensive"* (R30).

On the other hand, Interviewee R32 suggested that "…*government thought, they were being pragmatic – doing it to get broader buy in. That is the world of politics".* Since the SGSA did not negotiate the SPM with policy-makers in a similar way to other assessments, it is probable that the South African authors making up the SGSA teams were quite unaccustomed to text negotiations with policy-makers, perceiving this as mere 'political interference', rather than useful semantic negotiation.

Having said that, there was noticeable government anxiety around the issue of perceived negative press. Part of this emanated from not having a dedicated media engagement strategy for the SGSA. As such media events were handled in an uncoordinated manner with the TSU only really using the media to notify stakeholders about public meetings in the form of paid adverts. Rather than inviting the media into the process (and taking the good press with the bad), the lack of coordinated engagement created an environment of separation and potentially stakeholder distrust.

However, TSU members "…*tried to get the word out there"* (R28) with some notable articles published in established media houses (e.g. the Engineering News). However, online interest in the *Shale gas SEA* was a fraction of the broader social interest in the topic of *fracking* in South Africa (Figure 27). This was corroborated in the findings of the participant survey, where in response to S34 about the prioritisation of media communication, the mean response was 3.07 (± 0.84) with only 5% of respondents Strongly Agreeing that it had been prioritised (Table 38). In a similar way to the SGSA, online interest trends in the CCRAs do not match those of the broader issue of climate change in the United Kingdom, although small fluctuations in interest are evident (Figure 27).

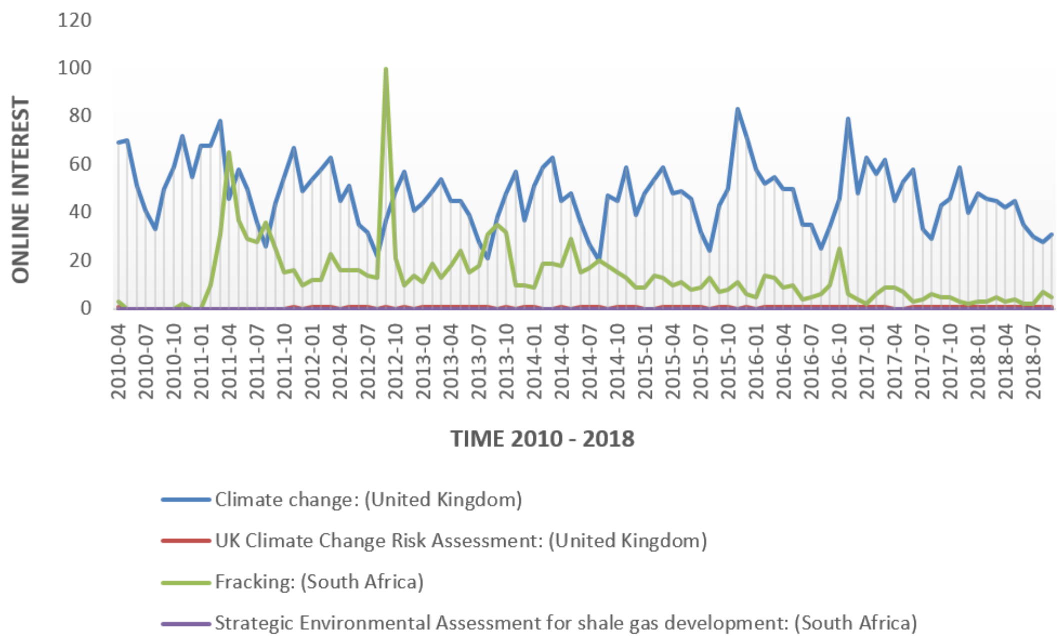


Figure 27: Online interest trends showing the terms *climate change* (blue) and *fracking* (green) compared to the online interest in the actual knowledge-policy processes used to assess the issues, namely the *UK Climate Change Risk Assessment* (red) and *shale gas strategic environmental assessment* (purple) (Google, 2019). The demonstrates that the CCRA platform and the SGSA project only garnered a fraction of public interest dedicated to the actual social issues themselves.

Interviewee R38 thought that while the CCRA2 might have got some media coverage, it's diffusion out into the general public would remain slow because of the "*…limited pool of people, many of whom probably share similar views on how these things should be done*". In this regard, Howarth *et al.* (2018) found that CCRAs in general needed to be better communicated, especially outside of government. One interviewee quoted in Howarth *et al.* (2018: 418) believed that [parentheses added]*"…less than 0.1% of the population of the UK has ever even heard of [the CCRA]"*. This also seemed to have been the case of the CCRA2 ER – where the mean response to S34 was 2.89 (± 0.83) with only 3% of respondents Strongly Agreeing that media engagement has been prioritised.

Since the CCRA2 ER had only moderate levels of public engagement and a reasonably poor presence in the popular media, how did it garner public trust? The main reason is that the CCRA2 ER was embedded within existing legal and institutional frameworks – such as the Climate Change Act (2008), the CCC, the ASC and the NAP[115]. Over about a 10-year period two Evidence Reports, two government CCRAs and two NAPs have been developed, providing stakeholders with some degree

[115] See subcategory construct *quality* for a description of the CCRA2 ER peer review process which was also responsible for building trust. As well as subcategory constructs *representivity* and *resources describing* the financial and participatory model of expert engagement.

of confidence that the team putting together the CCRA2 ER are both competent and interested in evidence-informed decision-making[116].

This was reiterated through the survey, where participants strongly believed that the process was free from manipulation (S28), trustworthy (S30) and procedurally fair (S33) (Table 38). As such, none of the interviewees cited concerns about unbalanced power dynamics, stealth issue advocacy or ideological possession. Regarding manipulation Interviewee R36 believed that it was *"…not an issue on this assessment"*. Part of the reason for this, according to Interviewee R35, was that there are transparent procedural steps from the Evidence Report to the Government Report and then the NAP – making it very easy to *"…see the hands of government"*, versus those of the independent experts.

6.3.5 Capacity building

Technical content cogeneration through the SGSA (S9) was enabled through the inclusion of policy-makers in writing teams[117]. For example, the scenarios (Ch 1), water (Ch 5) and agriculture (Ch 8) chapters all included policy-makers actively working for government. The main knowledge exchange 'pathway' for cogeneration was through hosting the three, three-day author meetings held at important junctures through the SGSA process (subcategory construct *resources*). This provided a collegial base for a close physical and epistemological proximity between policy-makers and experts.

Regarding youth development, as part of the Memorandum of Agreement between the Department of Environmental Affairs and CSIR, skills development was a specific contract output[118]. To this end, two interns were appointed to the SGSA TSU on 18-month contracts.

One intern was responsible for management of public participation activities, while the other was responsible for editing, database management and quality control[119]. The appointment of interns to chapter teams was also encouraged by the TSU, although only one chapter made such an appointment – in the case of the air quality and GHG chapter where a student was appointed as a CA.

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[116] TSU manager Ms Kathryn Brown (pers comms, 19/09/18) notes that one of the conditions of the formal ASC tender process was that LAs had to disclose any conflict of interests. It does not seem that ASC CLAs or CAs were required to disclose conflicts of interest. She also notes that no formal mechanisms of conflict resolution were required during the CCRA2 ER.

[117] Content generation through process and methodological design was facilitated through PEC meetings, where the process steps where discussed and vetted prior to execution.

[118] In the region of 5% of the contract budget was allocated to skills development.

[119] The interns were recent university graduates, both in their twenties. They also received funding and time allowances in pursuance of future studies – one a PhD in Environmental Geography which focused on determining biophysical baseline conditions in the Karoo Basin prior to SGD, the other studied a Post-Grad Diploma (PGD) in Environmental Management from the University of Stellenbosch.

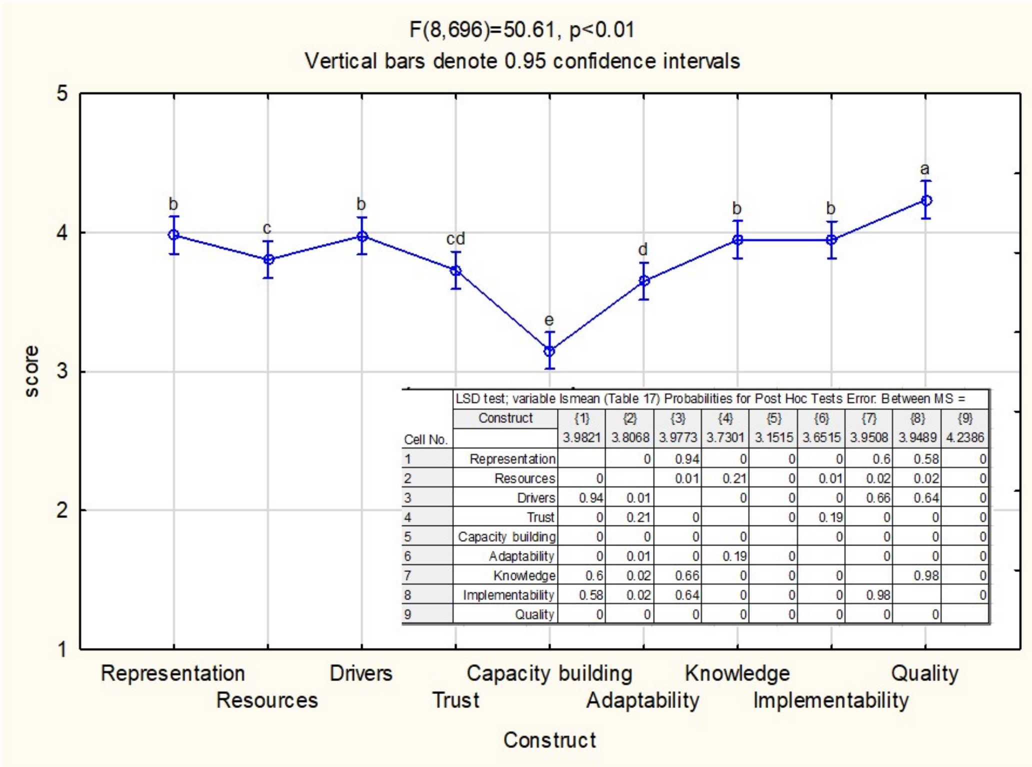
The lack of young people in the authorship was also evident from a demographic analysis of survey responses. Of the 88 SGSA respondents, only 16% of them were below 40 years of age. This would explain the response to S36 regarding youth development, where the mean response was only 3.20 (± 0.82) (Table 39).

Table 39: Subcategory construct capacity building for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
35	Co-generation capacity development	3.34 (± 1.01)	13	3.57 (± 1.03)	17
36	Youth development	3.20 (± 0.82)	6	2.43 (± 0.79)	0
37	Marginalised groups	2.88 (± 0.82)	0	2.39 (± 0.57)	0

The constraints around public participation in respect of language barriers, unequal levels of education and other socio-economic constraints, as cited in Borchardt (2016) meant that survey respondents generally believed that ‘marginalised people’ (in the instance interpreted to mean poor people living in rural regions of the Central Karoo), had not been adequately included in the SGSA process. While numerous public meetings were hosted through the study area (see subcategory construct *representation*) – which included diverse modes of advertisement e.g. through flyer distribution and radio announcements – in response to S37 *“Participation opportunities were provided to marginalised stakeholders”*, the mean response was 2.88 (± 0.82) with 0% of respondents Strongly Agreeing with the statement.

A statistical analysis of SGSA survey responses (n = 88) comparing each of the subcategory constructs against one another, based on their mean responses, revealed a relatively low score of 3.15 (±0.65) for capacity building, compared to the combined overall mean of 3.83 (±0.51) for all the subcategory constructs (Figure 28).



LSD test; variable lsmean (Table 17) Probabilities for Post Hoc Tests Error: Between MS =

Cell No.	Construct	{1} 3.9821	{2} 3.8068	{3} 3.9773	{4} 3.7301	{5} 3.1515	{6} 3.6515	{7} 3.9508	{8} 3.9489	{9} 4.2386
1	Representation		0	0.94	0	0	0	0.6	0.58	0
2	Resources	0		0.01	0.21	0	0.01	0.02	0.02	0
3	Drivers	0.94	0.01		0	0	0	0.66	0.64	0
4	Trust	0	0.21	0		0	0.19	0	0	0
5	Capacity building	0	0	0	0		0	0	0	0
6	Adaptability	0	0.01	0	0.19	0		0	0	0
7	Knowledge	0.6	0.02	0.66	0	0	0		0.98	0
8	Implementability	0.58	0.02	0.64	0	0	0	0.98		0
9	Quality	0	0	0	0	0	0	0	0	

Figure 28: Subcategory construct comparison based on 792 survey responses from 88 respondents who participated in the SGSA demonstrating that capacity building scored substantially the lowest.

With respect of the CCRA2 ER, since it was firmly built into an existing legal and institutional framework, there were multiple points at which experts and policymakers had opportunities to engage – from the drafting of the CCRA2 ER, to the formulation of the CCRA2 Government Report, through to the actual development and implementation of the NAP. Within the specific ambit of the CCRA2 ER, the extent to which these engagements can be considered ‘cogeneration’ is unclear – since policy-makers were not permitted to participate in chapter teams as drafting authors. The CCRA2 ER survey responses to S35 were also inconclusive, failing to shed light on the issue.

Since the CCRA ER is mandated for production every 4 years, Interviewee R37 expressed the need to build capacity and *“…maintain engagement with the individuals in the process so that they keep learning and build-up expertise and experience, and tacit knowledge”* for future iterations. Even so, it seems like survey respondents expected more opportunities to be given to youth participants. In response to S37, the mean response was 2.39 (± 0.57) with 0 % of respondents Strongly Agreeing with the statement. From the 29 survey responses for the CCRA2 ER, 19 % of them were from authors below the age of 40 years.

In relation to the issue of marginalised groups in the process, CCRA2 ER participants believed that inadequate attention had been given to marginalised people. The mean response to S37 was 2.39 (± 0.57) which was very low. Like the SGSA, this was reflected in the statistical analysis of the subcategory constructs for CCRA2 ER, where the mean for capacity building was statistically different to any the other subcategory construct means (Figure 29).

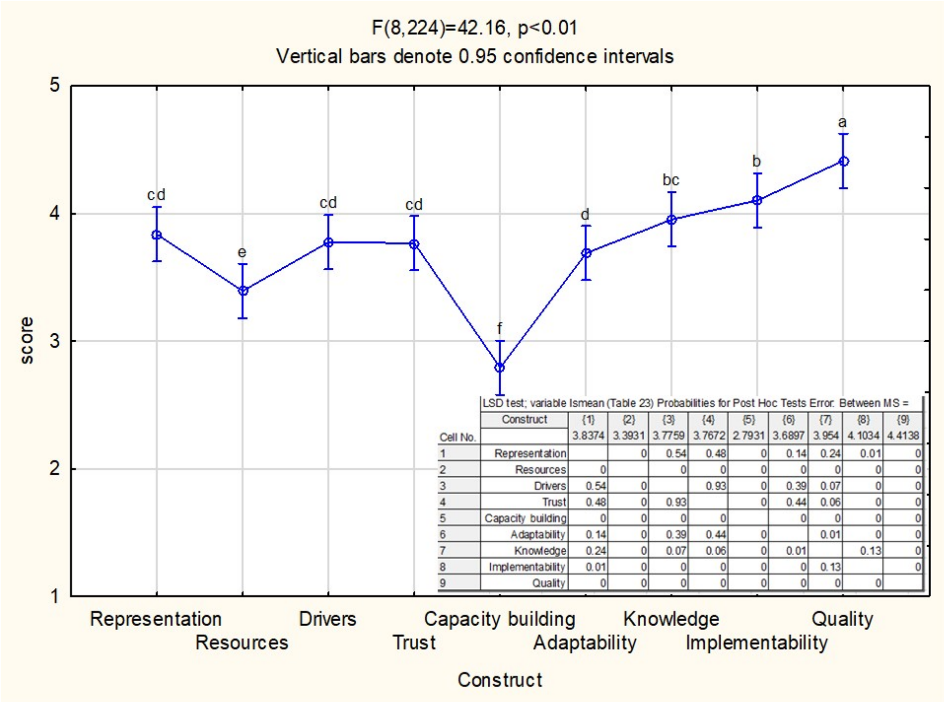


Figure 29: Subcategory construct comparison based on 261 survey responses from 29 respondents who participated in the CCRA2 ER also demonstrating that that capacity building scored substantially the lowest.

6.3.6 Adaptability and uncertainty

The SGSA followed a series of iterative steps, initiating from production of the ZOD following the first author meeting. The ZOD was then used in public outreach meetings to check consistency with stakeholder questions (subcategory construct *representation*). Following governance group approval (see subcategory construct *trust*), author teams then drafted FODs, which were received by the TSU and circulated for peer review. The next author meeting was scheduled for teams to review FOD peer review comments and initiate with drafting the SODs. Completed SODs where then sent back to peer reviewers with responses to comments as well as being distributed more widely to registered stakeholders for comment. Stakeholder comments (plus any objections from peer reviewers to FOD responses), were then distributed back to authors prior to the third author meeting and final assessment publication.

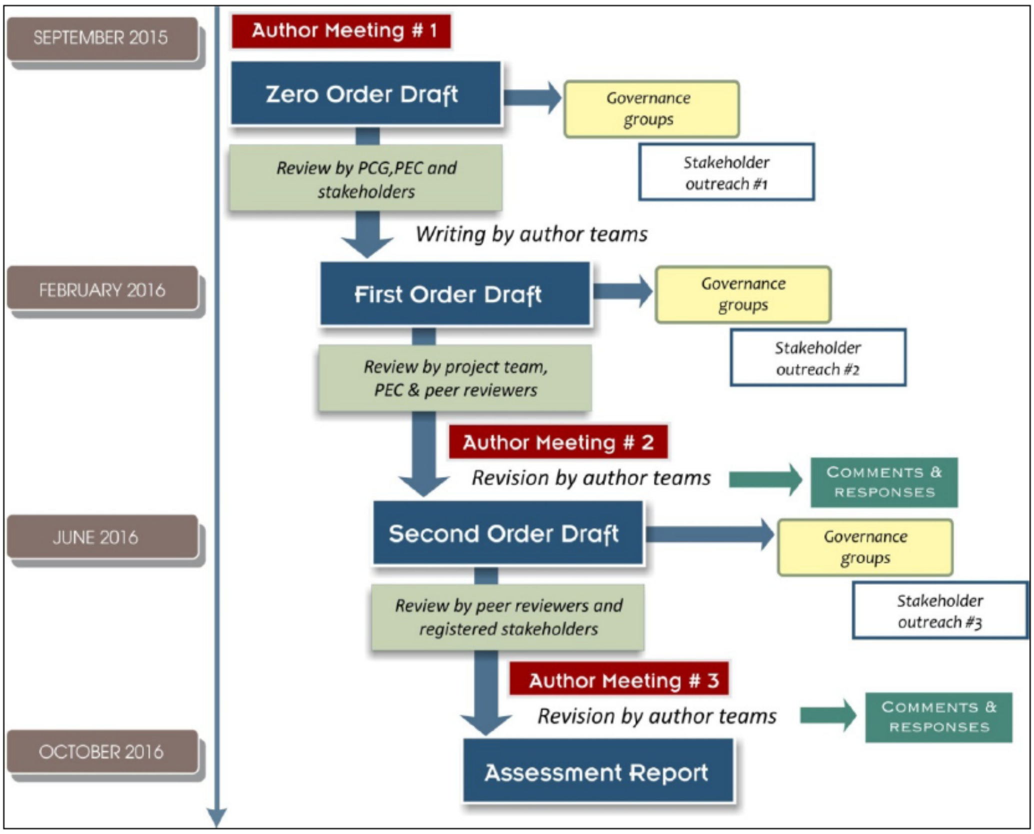


Figure 30: The ZOD was generated following the first author meeting and approved by governance groups and wider stakeholders following a public outreach programme. The FOD was then sent for expert peer review, with comments forming the basis for the second author meeting. The SOD was then sent back to peer reviewers (to check their comments had been addressed) and simultaneously released for wider stakeholder comment. This second review formed the basis of the third author meeting and shaped the final scientific assessment outputs which were published in November 2016.

With respect to process adaptability, an example of necessitated deviation occurred during the public outreach programme of the SGSA. After the first round of public meetings in Graaff-Reinet and Beaufort West, local residents expressed dissatisfaction that they had not been made sufficiently aware of the meetings. This meant that local people were not willing to proceed with the meeting. In response, following the advice of the independent facilitator, the TSU agreed to return to Graaff-Reinet and Beaufort West 6 months later, at the FOD stage, to undertake the meetings then. The key learning from this was that novel approaches to meeting advertisements were required, such as engagement with national and local radio stations, direct liaison with municipalities, the release of flyers to local communities, bulk SMS distribution, newspaper adverts in provincial and local media houses, social media notices such as Facebook and dissemination of notice through government channels such as the South African Local Government Agency and members of the PEC and PCG.

This illustrates that some scope for process deviation was permitted, even though the process was fairly regimented in order to deliver the products within brief and budget. This may have contributed to feelings among participants that adaptability to change was not sufficiently prioritised. In response to S39, the mean response was 3.43 (± 0.82), with only 7% of respondents Strongly Agreeing with the statement (Table 40).

Table 40: Subcategory construct adaptability and uncertainty for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
38	Adaptive to change	3.43 (± 0.82)	7	3.39 (± 0.79)	0
39	Management of uncertainty	3.78 (± 0.90)	20	3.89 (± 0.79)	21
40	Iterative	3.74 (± 0.92)	20	3.71 (± 0.94)	21

During the SGSA, policy uncertainty was managed using scenarios (subcategory constructs *drivers*) as well as by embedding policy-makers into drafting teams (subcategory construct *capacity building*). With respect to probabilistic uncertainty – as was the case with IPCC and IPBES assessments (which used calibrated certainty scales) – the SGSA did not adopt such a mechanism in its assessment chapters or SPM which can be seen as a flaw in the methodological design.

On the other hand, the SGSA did initiate one supplementary research process to fill an obvious data gap. This exercise, called a 'BioBlitz', involved conducting biodiversity field surveys at single sites in a short time period (usually one day) with as many observers as possible, including citizen scientists and any interested stakeholders. By conducting rapid scans of underrepresented geographical regions in the Central Karoo, it was possible to infer broader ecological representivity patterns, which assisted in identifying regions of high ecological sensitivity (DEA, 2017). The main purpose of the BioBlitz was to include new knowledge and spatial sensitivity layers within the risk assessments made in chapter 7 (Biodiversity and Ecological Impacts) of the SGSA.

With respect to the CCRA, there is evidence of adaptability to change. This is especially noticeable between the first and the second CCRA ERs, where, after independent reviews of the first CCRA ER, two main shortcomings were identified. Firstly, that the scope of the CCRA1 ER did not include international dimensions of climate change and secondly, that it did not focus on current risks, placing the majority of its emphasis on risks in the future, based on a single set of model assumptions.

In response, when the ASC initiated the CCRA2 ER, they sought greater emphasis on framing risks and opportunities within the current decision-making and policy context by providing a sense of where adaptation interventions are most urgently required. The methodology developed for CCRA2 ER then allowed for the inclusion of a broader range of evidence, as such it was possible to take account of the international policy dimensions of climate change[120] (see subcategory construct *drivers*) (Warren *et al.*, 2016). In spite of this, one respondent who completed the open-ended survey question believed the "…*process was linear, without any time nor ability to explore, iterate and fine-tune the outcomes"*.

To account for knowledge uncertainty, the CCRA2 ER used a series of scenarios (see subcategory constructs *drivers*) to account for future change. In addition, confidence statements underlying findings were included in the final Synthesis Report (ranging from low to high confidence), although there was no obvious calibration system developed for the confidence language.

Knowledge uncertainty was also supplemented by rapid research programmes, in a similar way to the SGSA BioBlitz programme. The CCRA2 ER used four research projects to fill obvious knowledge gaps – each of them guided by a steering committee and peer review process[121]. These included: projects to determine future projections of flood risk; updated projections of water availability; an aggregate assessment of climate change impacts on natural assets; and the development of the H++climate change scenarios[122]. In spite of these efforts, it seems as if survey participants believed that the CCRA2 ER was not especially adaptive, where the mean response to S38 was 3.39 (± 0.79) with none of the survey respondents Strongly Agreeing with the statement (Table 40).

6.3.7 <u>Knowledge</u>

Survey respondents believed that the SGSA enhanced public debate. In response to S41, the mean response was 4.34 (± 0.75), with around half of respondents Strongly Agreeing with the statement

[120] This was particularly relevant to the UK, who at the time of CCRA2 ER drafting, voted to leave the European Union. In this respect, a disclaimer was put into the chapters to point out that the policy analysis had been done prior to the vote (Ms Kathryn Brown, pers comms, 19/09/18).
[121] With support funding form the Natural Environment Research Council, four research projects were commissioned and completed in 2015 to bring new evidence to light for the purposes of the assessment (Howarth *et al.*, 2018). This included a flood risk analysis undertaken by Sayers and Partners; an updated account of water availability projections for the UK by HR Wallingford; an updated aggregate assessment of climate change impacts on the goods and services provided by the UK's natural assets undertaken by AECOM; and a new climate change scenarios assessment undertaken by the Met Office.
[122] The project investigated the development of plausible 'high-end' climate change scenarios, referred to as H++ scenarios, which are typically extreme climate change scenarios on the margins or outside of the 10th to 90th percentile range.

(Table 41). As an example, one CLA (R26) interviewee believed that in enhancing the substance of the once polarised debate, the SGA "…*was effective to an astonishing degree, one could actually sense the level of militancy and hysteria declining as the process wore on"*.

Table 41: Subcategory construct knowledge for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 (± SD)	Strongly Agree (%)
41	Enhances debate	4.34 (± 0.75)	47	4.25 (± 0.70)	34
42	Covers emerging research areas	3.64 (± 0.92)	16	3.75 (± 1.04)	24
43	Delivers on social questions	3.86 (± 0.81)	22	3.75 (± 0.84)	10

As regards the generation of new knowledge, Interviewee R32 from the SGSA TSU believed that more academic papers could have been published about the SGSA and that *"…there is still a lot of scope to actually capture the learning more"*. That being said, the SGSA did make the following contributions toward new knowledge generation in the form of journal, book and theses publications:

- Scholes, Schreiner and Snyman-Van der Walt (2017)[123]: Published in a South Africa journal detailing the SGSA process and its potential application in the science-policy landscape;
- Schreiner and Snyman-Van der Walt (2018)[124]: Published in an international journal as a methodological review of the SGSA, explaining its approach to scenarios, risk assessment and predictive landscape modelling.
- Schreiner *et al.* (2018)[125]: Book chapter written for an American book publication describing the novel mechanisms adopted for public and stakeholder engagement during the SGSA.
- Borchardt (2016)[126]: Honours Thesis undertaken through Stellenbosch University examining the effectiveness, or lack thereof, of the SGSA, interpreted through the conceptual lens of social engagement and public spaces.

[123] Scholes, R. J., Schreiner, G. O., & Snyman-Van der Walt, L. (2017). Scientific assessments: Matching the process to the problem. Bothalia, 47(2).

[124] Schreiner, G. O., & Snyman-Van der Walt, L. (2018). Risk modelling of shale gas development scenarios in the Central Karoo. International Journal of Sustainable Development and Planning, 13(2), 294–306.

[125] Schreiner *et al.* (2018). Evidence-based and participatory processes in support of shale gas policy development in South Africa. In J. Whitton, M. Cotton, Charnley-Parry I.M, & K. Brasier (Eds.), Governing Shale Gas: Development, Citizen Participation and Decision Making in the US, Canada, Australia and Europe (pp. 149–168).

[126] Borchardt, S. (2016). Honours Research Project - What are we SEA-ing? An exploration of the communication strategies and extent of public participation at the Strategic Environmental Assessment (SEA) public briefings for Shale Gas Development in the Karoo.

In respect of addressing the knowledge-based questions raised by society, for the SGSA, this was overseen by the PCG (see subcategory construct *trust*). Direct liaison between the TSU, project leadership and the general public was also undertaken, through 'bottom up' dialogs where salient topics were debated and revised, where necessary, with stakeholders in public forums. In July 2016, before finalisation of the SGSA, the draft findings addressing these stakeholder questions were presented to the same local and stakeholder communities to check that the questions had been adequately considered.

As documented by Borchardt (2016), the knowledge generated through the SGSA was predominantly science-focused although efforts were made to engage with, and generate new knowledge from, alternative knowledge domains (see subcategory construct *representation*). These same epistemological constraints were evident during the CCRA2 ER according to Howarth *et al.* (2018) who suggested the process was *"...scientifically heavy"* (Howarth *et al.*, 2018: 416). They noted that [parentheses added] *"...both CCRAs [...] are symptomatic of the UK state reinforcing scientific reductionism in adaptation assessments for policymaking"* (Howarth *et al.*, 2018: 412).

In addition to the suite of report outputs generated from the CCRA2 ER and the publications from the four research programmes (see subcategory construct *adaptability and uncertainty*), the following new knowledge was generated[127]?

- Brown *et al*. (2018)[128]: Opinion piece reflecting on the past two CCRAs and a series of recommendations to make the CCRA framework more useful for experts and policy-makers;
- Warren *et al*. (2018)[129]: Journal publication offering a summary of the CCRA1 and describing how the CCRA2 adapted its process and methods to improve on identified weaknesses; and
- Howarth *et al*. (2018)[130]: Provides a critical discourse analysis of the past two CCRAs based on interviews to determine epistemological trends in knowledge generation in the climate sciences.

[127] Publications which have emanated from specifically from CCRA2. A handful of other publications were drafted with following the CCRA1 and ER processes.
[128] Brown *et al*. (2018). Turning risk assessment and adaptation policy priorities into meaningful interventions and governance processes. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376 (20170303).
[129] Warren *et al*. (2018). Advancing national climate change risk assessment to deliver national adaptation plans. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376 (2121).
[130] Howarth *et al*. (2018). Co-producing UK climate change adaptation policy: An analysis of the 2012 and 2017 UK Climate Change Risk Assessments. Environmental Science and Policy, 89, 412–420.

For this reason, CCRA2 respondents believed that the process was generally successful in enhancing debate (S41) where the mean response was 4.25 (± 0.70) with 34 % of respondents Strongly Agreeing with the statement (Table 41).

6.3.8 Quality

Each SGSA chapter was allocated between two and seven peer reviewers. FOD chapters were submitted to 25 local and 46 international independent experts selected by the management team, with the approval of the governance structures. Peer reviewers were drawn from government, NGOs, academia, and the private sector, with many international volunteers coming from the United States of America, Canada, Australia and other European countries.

Incorporating the comments from the peer reviewers, the author teams developed the SOD which was sent back to the peer review experts and simultaneously released to the general public for comment[131]. Based on the feedback from the peer review experts and the general stakeholder comments, the final SGSA was published. Survey respondents were satisfied with the overall quality of the final product reflected in the mean response to S44 which was 4.24 (± 0.68) (Table 42).

Table 42: Subcategory construct quality for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
44	Technical quality	4.24 (± 0.68)	35	4.39 (± 0.63)	45

This was supported by most of the interviewees, for example, one SGSA author (R30) noted *"…as far as regular good scientific studies go, certainly the SGSA was one"*. Another interviewee (R26) suggested that the SGSA *"…really set a benchmark"* for future assessments. One author who completed the online survey believed that the SGSA "…*was done, very effectively. And both technically and scientifically at a high standard"*. On the other hand, one governance group member (R33) stated: *"I was pretty disappointed with the outputs. I thought that there was really going to be some really wow stuff and it just didn't seem to be there"*.

CCRA2 ER respondents also believed that the outputs produced were of a sufficiently high quality (S44 Table 42). This was borne out of a similarly elaborate peer review process adopted during the

[131] Peer and stakeholder review comments were submitted as structured page-and-line numbered statements. The responses to the peer review comments by the author teams were required to be sufficiently descriptive for stakeholders to trace them in the text or understand the basis upon which they had been accepted or rejected.

CCRA2 ER consisting of panel of 25 technical experts, led out of the University of Reading. Chapter drafts were subjected to two rounds of peer review in October 2015 with the FOD and then again in March 2016 with the release of the SOD[132] (ASC, 2016). In the view of Interviewee R36, the peer reviewer [parentheses added] "…*engagement […] really helped to improve the quality of the work. It […] gave the report additional credibility amongst those that had to take action on the decisions".*

While CCRA quality processes are generally viewed as authoritative and effective (Howarth *et al.*, 2018), minor concerns were cited about relating to the potentially biased literature review methodology which relied upon an open call for data, rather than the conventional systematic review process (Warren *et al.*, 2018). Another concern raised by one of the interviewees was that the CCRA2 ER and subsequent government processes might have been slightly rushed in light of government uncertainty, and general unease, about the decision to leave the European Union (R35).

6.3.9 Implementability

The primary outputs from the overarching SEA process included 18 peer reviewed chapters of the SGSA (1 000+ pp) (Scholes *et al.*, 2016), a 60 page SPM and a Decision-Support Tools report (DEA, 2017) which included the Minimum Information Requirements (MIRs) to be used to guide Environmental Impact Assessment (EIA) applications[133]. In addition, a series of information material and videos explaining the processes of SGD and the procedures underpinning the SGSA were developed, made available through a dedicated project website http://seasgd.csir.co.za/[134]. The overall breadth and quality of the outputs meant that survey respondents felt that these met with practical and policy-making needs (S47, Table 43). Borchardt (2016) also contends that the SGSA provided a broader perspective of development constraints in the region beyond that of SGD activities – offering insights into multiple development sectors in the Central Karoo such as tourism, renewable energy, agriculture and uranium mining.

[132] Chapters were reviewed by peers and around 100 stakeholder organisations, mainly from government and around 50 non-Governmental organizations (Brown *et al.*, 2018). Chapter 5 for example, had over 800 comments on it through the review process (R35).

[133] The MIRs also set in place a recommendation to split the EIA regulatory process between the relatively benign exploration activities associated with pre-fracking SGD, from the potentially consequential activities associated with test-fracking.

[134] One of the open-ended survey respondents noted: "I do not think that the outcomes (large difficult to download documents) could reach many people in this format".

Table 43: Subcategory construct implementability for the SGSA (n=88) and CCRA2 ER (n=29).

S	Indicator	SGSA (± SD)	Strongly Agree (%)	CCRA2 ER (± SD)	Strongly Agree (%)
45	Reaches multiple audiences	3.70 (± 0.84)	17	3.57 (± 0.92)	14
46	Uses expert judgement	4.17 (± 0.74)	34	4.50 (± 0.51)	48
47	Meets practical and policy needs	4.09 (± 0.81)	33	4.36 (± 0.56)	38
48	Guides assessments at smaller scale	3.79 (± 0.74)	17	3.86 (± 0.89)	24

However, with respect to the broader question of the whether the SGSA had successfully contributed toward the resolution of the SGD debate in South Africa (in other words, did it have a real-world impact?), the mean response was not especially high, at 3.85 (± 0.80). How can the discrepancy between technical quality of outputs and social or policy impact be explained?

It may stem from unease among respondents that government would not consider, in earnest, the findings of the SGSA – by taking the necessary regulatory steps following on from the scientific evidence. This sentiment was widespread among interviewees (see subcategory construct *trust*). For example, Interviewee R30 believed that a "…*brilliant piece of work"* had been *"...delivered into a corrupt system"*.

One respondent who answered the open-ended survey question suggested that the SGSA was subverted by "…*narrow political and economic imperatives"*, while another believed that the study was only "…*commissioned to check the boxes without any political willingness to underwrite the recommendations"*. The overwhelming response from participants was that, for these reasons, the real-world impact of the SGSA would remain negligible.

This synopsis seems to be true in part. Government still makes little reference to the SGSA or broader SEA process – preferring to publicly reference outdated information sources, for example, those relating to inaccurate estimates of economically recoverable gas resource (R27). So, while the SGD debate in South Africa has certainly simmered, this can't be entirely attributed to the effectiveness of the SGSA within the policy-making environment. As highlighted by Interviewee R26, it is far more likely that interest in SGD dissipated following the rapidly declining global oil price in the lead up to 2010. In this sense, Interviewee R26 noted: *"...we actually never tested or saw whether it remotely had any impact on policy-makers, or if policy makers have ever read the damn thing"*.

Furthermore, there remains high levels of policy and regulatory uncertainty regarding SGD. During the SGSA, it was noticeable how different government departments pulled in different directions – each one trying to protect their respective mandates. What resulted was a lack of clear overall messaging and coordination, which is still evident today by the confused national discourse on SGD mentioned above. As an example, the technical regulations first gazetted in 2015 to guide SGD (which were not within the ambit of the SGSA but confusingly ran parallel) were recently overturned in the South African Supreme Court[135]. The impact of this decision for the Exploration Right applications and overall progression of SGD in country remains unclear – as does the ultimate intended purpose of the SGSA outputs.

Interviewee R31, a SGSA governance group member believed that in this sense, the SGSA [parentheses added] *"...wasn't taken to fruition because up to now I haven't seen a government report. Nor do I understand how we are going to measure successful implementation [of the SGSA]"*. The respondent believed that the SGSA had not been taken through to its logical conclusion, with a clear delineation of government roles and responsibilities for the policy implementation phase. While the MIRs are still in draft format (DEA, 2017), there has not been a follow-up PEC meeting strategizing their implementation since the beginning of 2017.

The CCRA2 process developed the ~850-page Evidence Report (ER) (consisting of 8 chapters), a Synthesis Report, Country Summaries published for England, Northern Ireland, Scotland and Wales and four research projects (see subcategory construct *adaptability and uncertainty*). Relevant CCRA2 materials were made freely available at the CCC's website (www.theccc.org.uk/uk-climate-change-risk-assessment-2017) (ASC, 2016).

Where the CCRA1 ER had less of a policy focus, the CCRA2 ER was strongly policy oriented. According to Interviewee R36 *"...for the CCRA2, the audience was very much aimed at government – so the questions were framed for them"*[136]. To meet these ends, it developed a 'customer requirement document', produced by the Department for Environment, Food and Rural Affairs in consultation with other Government departments. The purpose of the document was to ensure policy-maker satisfaction with the outputs by establishing clear guidance and success metrics. It included the following criteria (Warren *et al.*, 2018):

[135] https://www.timeslive.co.za/news/south-africa/2019-07-04-exploration-for-petroleum-by-fracking-cannot-go-ahead-sca-rules/

[136] Howarth *et al.* (2018) have called for more accessible language and communication with a wider audience than government and policy-makers alone.

- That the CCRA fulfils the ASC's statutory duty of providing independent advice;
- That it assesses the key risks and opportunities as they affect countries in the UK;
- That it is fit for purpose;
- That it is completed on time and within budget;
- That it is conducted in a transparent way;
- That it is subject to a documented peer review process;
- That the academic community consider it to be both a robust and intelligent analysis;
- That it provides new insights beyond what is already known to the policy community; and
- That it improves upon the limitations of the CCRA1.

An *ex-post "…review and reflection process"* undertaken by the Committee on Climate Change revealed that the CCRA2 ER had met with these criteria (Ms Kathryn Brown, pers comms, 19/09/18). This was supported by the results of the online survey, where respondents generally believed that the outputs had met practical and policy needs (S47 Table 43). Participants also believed that the CCRA2 had positively contributed toward the resolution of the problem, where the mean score was 4.11 (± 0.69). In addition, participants held that the urgency scoring methodology (see subcategory construct *drivers*) was useful in the way that it *"…prioritised risks and focused attention"*, which enabled decision-making (R35).

Howarth *et al.*, 2018 conducted 27 interviews with CCRA participants (from both the Government and Evidence Reports)[137]. The authors found that people used the CCRA in three main ways: (i) to make business cases for their work; (ii) to shape direction of policy; and (iii) for practical applications such as the design of engineering structures. The production of the iconic UK 'Reasons for Concern' (RFCs) provided a useful synthesis indicating how climate change risks accrue with global mean temperature rise (Figure 31) (Warren *et al.*, 2018).

[137] Interviewees were split across policy (n=9), practitioners (n=9) and academic/science (n=9) communities. Just under half of the interviewees had contributed to the CCRA in some way, while others were users or from the broader stakeholder community (Howarth *et al.*, 2018).

Figure 31: The UK 'Reasons for Concern' (RFCs) framework developed for the CCRA2 ER (ASC, 2016). The figure depicts risk profiles (low, medium and high) organised temporally from present day through to +5 years into the future. For each of the five RFCs an urgency score (right blue column) suggests the levels of policy response required (either 'more action needed', 'research priority', 'sustain current action' or 'watching brief').

However, some interviewees (from the Howarth *et al.*, 2018 study) raised questions around issues of quality and value for money. Some remained "*...sceptical of its true value to their own organization"* (Howarth *et al.*, 2018: 418) while others expressed concerns about the multi-organisational drafting model (where the ER is generated by the ASC, while the CCRA is generated by the government, along with NAP), the primary one being loss of continuity and content between drafts (Howarth *et al.*, 2018).

A dominant theme in the Howarth *et al.*, 2018 research establishes the need to make the CCRA more relevant at the local level. For example, it was found that the CCRA inadequately addressed the risks to UK cities such as London – where the UK's key financial investments are likely to be at risk from future climate change (Howarth *et al.*, 2018). While according to the TSU lead, Ms Kathryn Brown (pers comms, 19/09/18), it was never the intention to guide local decision-making beyond the provision of the *"...national summaries to allow each of the four UK countries to undertake their own national adaptation programmes"*.

CHAPTER 7. CROSS-CASE ANALYSIS

7.1 Introduction

The purpose of this chapter is to undertake a cross-case analysis applying the same nine subcategory constructs as adopted for the 'within-case' analysis to look for similarities and differences between (rather than within) the cases. The final part of the chapter uses a 'confidence framework' (described in Chapter 3) to integrate evidence from different sources and across different performance measures to i.) determine performance areas of strength versus performance areas requiring future improvement and ii.) generate broad-scale inferences about overall scientific assessment effectiveness.

7.2 Differences across subcategory constructs

7.2.1 Representation

There were small to medium statistically relevant differences across the cases for the subcategory construct *representation* (Figure 32).

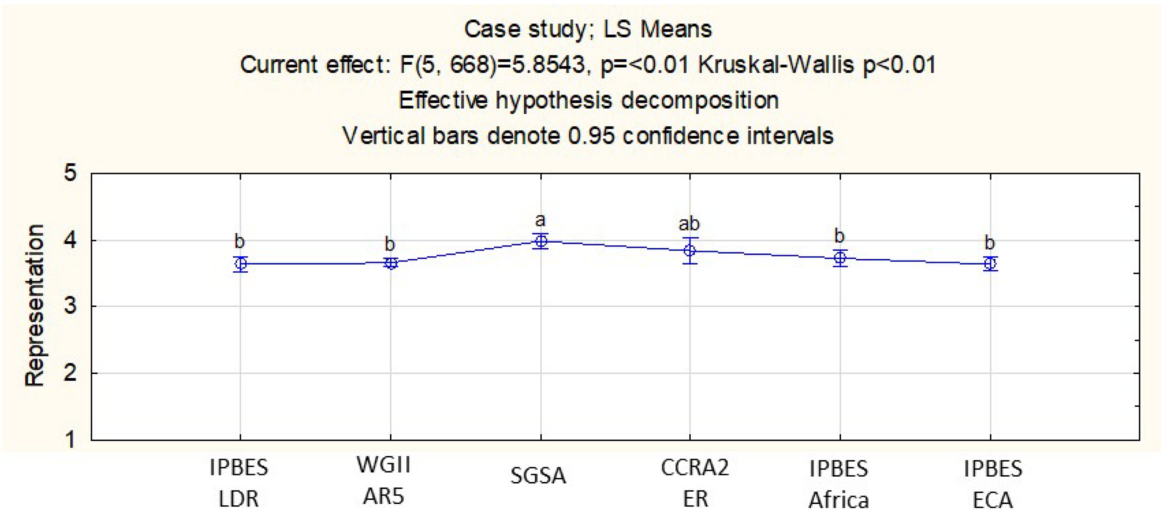


Figure 32: Representation was highest for the two national-scale cases (SGSA and CCRA2, medium difference), with negligible to small effect differences between IPCC and IPBES cases.

The higher *representation* scores for the two national cases and lower scores for the global and regional cases from the IPCC and IPBES are interesting to note. The expectation would have been that IPBES would have recorded the highest scores since many of its core functions specifically address issues related to *representation* such as transdisciplinarity, the inclusion on social sciences, stakeholder participation to name a few.

Using the *Science-Metrix* team composition evaluation widget, the 'level' of multidisciplinarity among authors was measured (using CLAs disciplinary representivity as a proxy), where 0.6 constitutes a *high* score and 1.0 constitutes *maximal* diversity (Struck, 2017) (Figure 33).

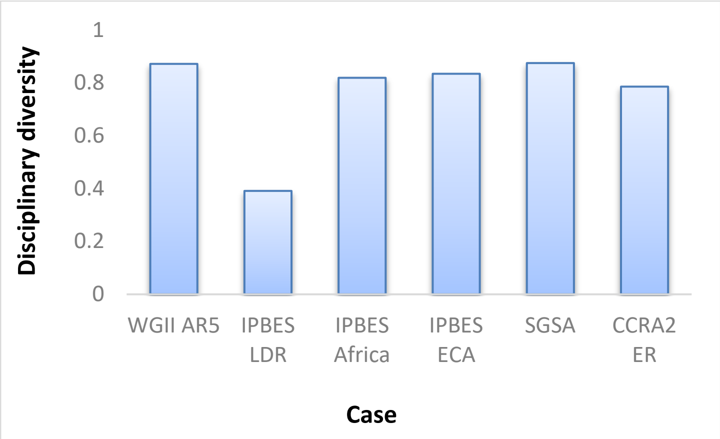


Figure 33: Disciplinary diversity scores based on the Science-Metrix evaluation widget. High and maximal scores were recorded for WGII AR5, IPBES Africa, IPBES ECA, SGSA and CCRA2 ER. IPBES LDR scored just under 0.4, which is considered a mid-range score.

WGII AR5's high score is more than likely a result of its hybrid social and ecological model which seeks to combine a range of disciplinary backgrounds to offer a fully integrated assessment. IPBES alike, since its inception, has made an ever-increasing commitment to multidisciplinarity in authorship, as did the national assessments of the SGSA and CCRA2 ER. From this perspective, it is unsurprising that disciplinary diversity scores were so high. Paradoxically, the level of multidisciplinarity in scientific assessment is commonly criticised in the literature, although based on the evidence presented here, the opposite would seem true.

The relatively low score of IPBES LDR can be attributed to its lack of disciplinary diversity in CLA positions since CLAs were used as proxy measures for this analysis. However, when one looks at the overall disciplinary diversity across the entire authorship of each assessment (i.e. CLAs plus LAs), the IPBES LDR is quite balanced from a multidisciplinary perspective, even more so than, for example, the IPBES ECA (Figure 34).

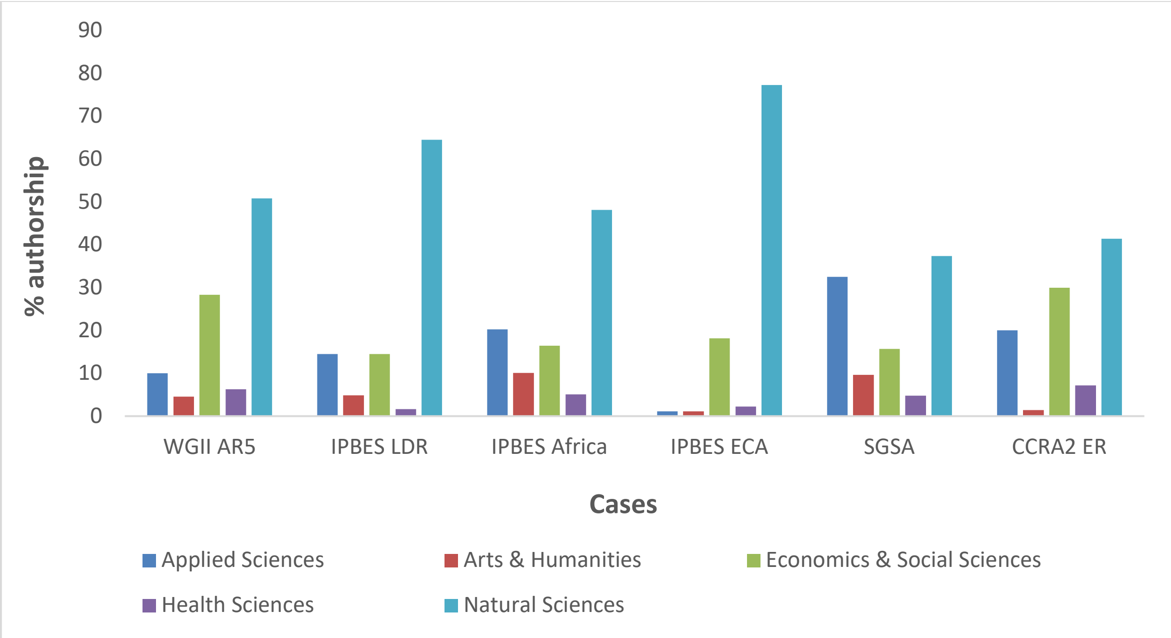


Figure 34: Relative disciplinary representation of authors across the cases. While the LDR had the lowest disciplinary diversity score based on CLA analysis, when CLA was combined with LA, the LDR showed more disciplinary balance than the ECA. The global and regional cases tended to be more dominated by natural scientists, while the national cases showed the most disciplinary balance.

There are legitimate concerns from a range sources about disciplinary imbalances and the future role of the social sciences and arts within scientific assessment platforms. As an example, for IPCC assessments published in 1990, 1995, 2001 and 2007, 95% of total citations were from the physical sciences and only 5% from the social sciences (Vasileiadoua, Heimeriks and Petersen, 2011), while for the entire IPBES work programme, only about 10% of authors represented the social sciences (Vadrot, Jetzkowitz and Stringer, 2016).

In terms of total author numbers, it is interesting to note that the national assessments of the SGSA and CCRA2 ER achieved closer to what could be considered disciplinary balance than global and regional assessments of the IPCC and IPBES (Figure 34) which tended to be dominated by the natural sciences. Overall levels of positivity among survey responses was largely unaffected by disciplinary domain. In other words, even though experts from economics and social sciences made up a smaller proportion of total participation, the perceived effectiveness of the cases between these two groups was more similar than different.

Within the broader IPCC structure, since 1990, the proportion of female authors has increased from less than 5% in 1990 to more than 20% in AR5 (Gay-Antaki and Liverman, 2018). This increase was also evident in the cases analysed here, where the average proportion of authors was around 33% for females and 67% for males (Figure 35).

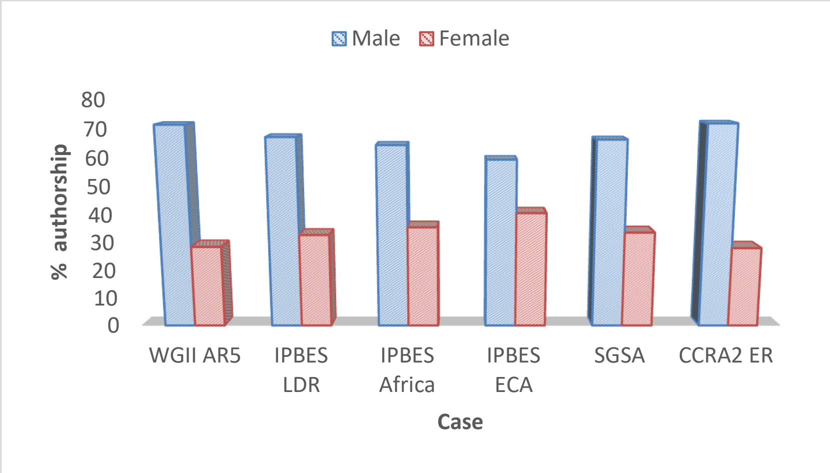


Figure 35: Gender ratios in authorship across the cases. The IPBES cases generally had the highest proportion of female authors (ECA was the highest at 41%), while WGII AR5 and the national cases had lower proportions of female authorship (~30%).

Using the number of doctoral degrees awarded at US universities as a proxy, where 66% of PhDs in the physical and earth sciences are awarded to men (Okahana and Zhou, 2018), the relative gender ratio can be considered fairly representative of the physical and earth sciences disciplinary domain. However, since an increasing number of authors are being drawn from disciplines other than the natural science where females dominate the number of PhD graduations (e.g. health and medical sciences) one would expect gender diversity to increase over time proportional to increased disciplinary diversity. It is also worth noting that there were no statistical differences in perceived case effectiveness between male and female survey respondents.

The number of IPCC authors from upper-middle, lower-middle and low income countries increased, albeit modestly, from 12% in 1990 to 17% in 2007 (Ho-Lem, Zerriffi and Kandlikar, 2011) and was around 33% for WGII AR5 in 2014. For IPBES, based on an analysis of author nominations between 2014 and 2015, 34% came from West European and other States, 18% from Latin America and Caribbean, 17% from Africa and 21% were proposed by Asia-Pacific (Timpte *et al.*, 2018).

With specific reference to the LDR, Africa and ECA cases, the following author geographical distribution was recorded: High-income (LDR = 59%, Africa = 24%, ECA = 87%), Upper-middle income (LDR = 22%, Africa = 15%, ECA = 9%), Lower-middle income (LDR = 15%, Africa = 45%, ECA = 4%), Low-income (LDR = 4%, Africa = 16%, ECA = 0%) (Figure 36).

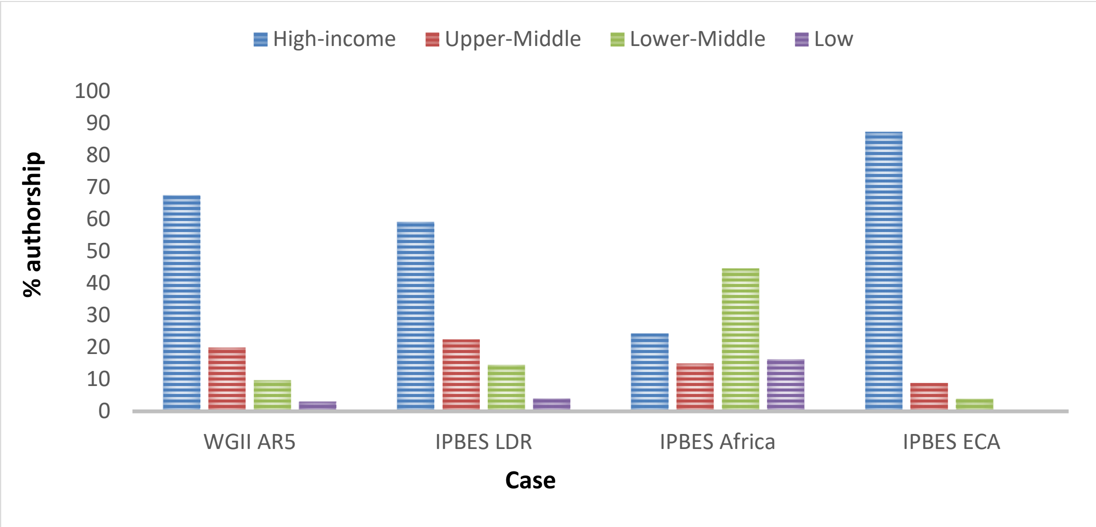


Figure 36: The geographical distribution of authorship across the cases (note this was not undertaken for the national cases of the SGSA and CCRA2 ER as there was no nationality-based diversity). The global cases were very similar in geographical representation, while the regional cases were substantially different.

The global assessments of WGII AR5 and IPBES LDR are very similar in their geographical representation with around 60-70% of authors coming from high-income countries. On the other hand, as would be expected, the regional assessments reflect a bias toward the geographical region under assessment. In other words, more African authors from lower-middle income countries were selected to the Africa assessment and more European authors from high income countries were selected to the ECA.

As regards transdisciplinarity, it seems that the IPCC and WGII specifically, given its hybrid mandate, need to commit more effort and resources into improving knowledge production practices from non-academic sources. During the early years of the IPCC – which were dedicated to exploring the evidence for human-induced warming – emphasis was placed on the collection and assessment of almost solely scientific knowledge, for obvious reasons (Agrawala, 1997).

However, over the years, as the global narrative has shifted toward the normative question of… *"what should we do about climate change?"*, the IPCC will come face-to-face with different kinds of knowledge and value systems (Kowarsch *et al.*, 2016). This includes the need to tussle with the 'facts versus values' dimensions of scientific assessments in a more explicit way (Beck and Mahony, 2018). The exact route for achieving this still remains unclear, but it will almost certainly require new, innovative and accessible epistemological frameworks (Vardy *et al.*, 2017).

In this respect, some have been critical of the IPCC's tendency to be overly reliant on science and research-based evidence. Others have raised important concerns about a seeming detachment from local and indigenous sources. This problem is partially demonstrated by Ford, Vanderbilt and Berrang-Ford (2012: 3) who revealed that only around 3 % of WGII AR5 authorship had any published material related to *"…climate change and indigenous populations"*.

On the other hand, while IPBES is frequently called the 'IPCC for biodiversity' (Larigauderie and Mooney, 2010) there are some key differences with respect to transdisciplinary knowledge production. Beck *et al*. (2014) tell us that IPBES and the IPCC are at different stages on their development trajectory and fulfil different functions in the knowledge-policy landscape.

While the main task of the IPCC is to deliver scientific assessments, IPBES has a broader, multiscale mandate requiring the need to close fundamental knowledge gaps (which are greater than those in atmospheric science), strengthen capacity at multiple levels and support policy. Closing knowledge gaps, including strengthening capacity at multiple levels requires a special emphasis on the inputs from ILK knowledge holders (Montana, 2016), which has steadily been improving in IPBES according to Díaz-Reviriego, Turnhout and Beck (2019). IPBES has also made tentative, but nonetheless, impressive steps toward transdisciplinary knowledge development. Recent examples have been highlighted in the literature by Bridgewater and Schmeller (2018), Tunón, Kvarnström and Malmer (2015), Hanssen *et al.* (2014) and Roué *et al.* (2015).

At the scale of national scientific assessment, the SGSA made some interesting attempts at promoting and actually 'doing' transdisciplinarity, which was not seen in the CCRA2 ER. For example, experts from different epistemological domains such as ILK, artists, filmmakers and farmers were appointed as authors. Additional efforts were made to engage with tacit, values-based experiences by presenting art exhibitions of Karoo/SGD art alongside stakeholder and outreach meetings.

With respect to the competency and capability of experts, according to the survey results, systematic review and interviews, experts were regarded in very high esteem across all the cases by survey participants and interviewees. While not a truly reflective indicator, but nonetheless interesting to note, author h-indices across the cases were measured using CLAs (note the high standard deviation in all cases) (Figure 37).

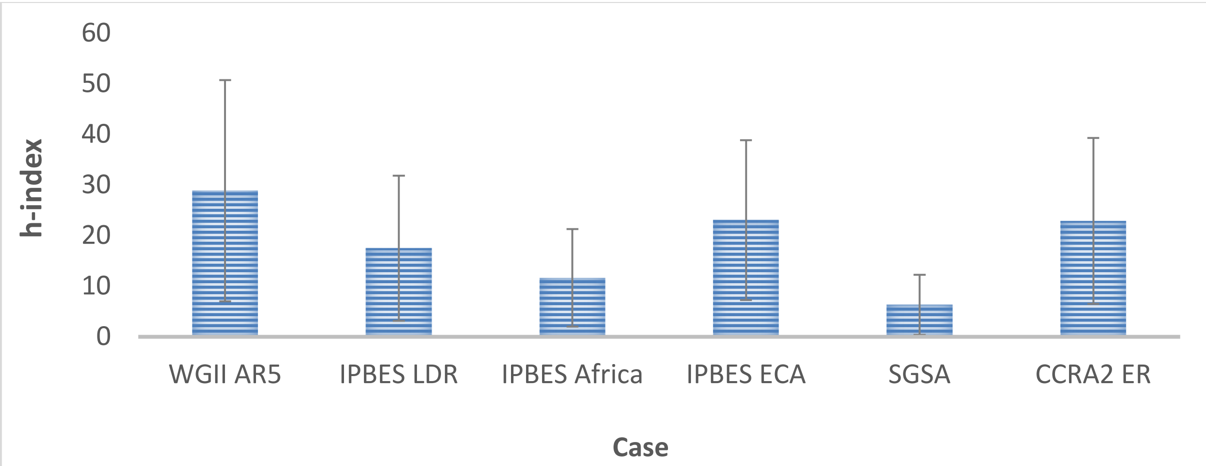


Figure 37: Mean h-indices for CLAs across the cases. WGII AR5 had the highest h-index mean because it is the most prestigious platform and attracts top-rated researchers. SGSA had the lowest because CLAs were often not academics, but were drawn from a range of technical skill sets such as oil and gas experts, farmers, private sector consultants etc. Another factor (and demonstrated by the relatively lower mean for IPBES Africa) is that African researchers face publication challenges such as language barriers, funding, institutional support, data availability and poor Internet connectivity.

7.2.2 <u>Resources</u>

The data indicate that the six cases were fairly well resourced, with an efficient turnover of products, and a reasonable continuity of key staff without high levels of turnover (Table 44).

Table 44: Comparative human resources and budgets across the cases.

Resource	WGII AR5	IPBES LDR	IPBES Africa	IPBES ECA	SGSA	CCRA2 ER
Co-Chairs	2	2	3	2	2	0
CLAs	64	17	15	12	21	uncertain
LAs	179	60	59	79	63	11
CAs	400	uncertain			62	60
Interns	36	33 over the entire first work program			2	0
~Budget	$12.5 million*	$1 million	$1 million	$1 million	$850 000	$900 000

**for entire AR5 cycle, including SREX*

With respect to future expert participation, there do seem to be some concerns about the current non-remuneration model. In response to S16 *"adequate financial resources were made available"*, all case means were below 3, except for the SGSA which was 3.24 (± 1.08). In Figure 38, each of the case means are shown in response to a 'cumulative case mean'. The cumulative case mean is the mean of the entire cases, across all indicators and subcategory constructs.

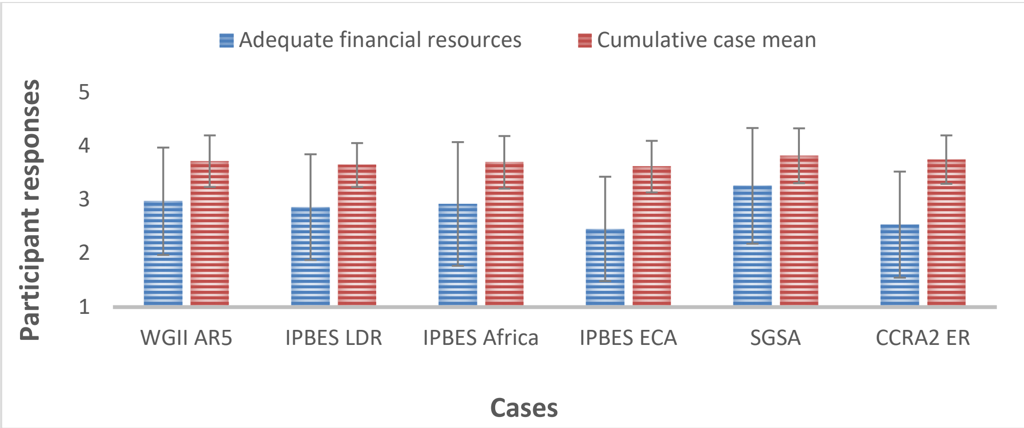


Figure 38: Survey participant responses to whether they thought sufficient financial resources were available in the cases they participated in (S16). Across all cases, participant scores in respect of the adequacy of financial resources (blue) were substantially lower than the cumulative case means (red), especially for ECA and CCRA2 ER.

In response to S16, the higher scores registered for SGSA resulted in a statistically relevant difference between the cases for the subcategory construct *resources* (Figure 39). This might be attributable to the honorarium fees paid to CLAs (and by proxy, high performing LAs) of between ~$ 4 500 for smaller chapters and ~ $ 8 900 for larger chapters. A similar model was also adopted for CCRA2 ER, where honorariums in the region of $ 12 000 were paid to LAs, while the ASC took responsibility for integrative writing roles. Neither the SGSA nor the CCRA2 ER cases paid honorariums to CAs. The overall success and potential for future application of this partial-financing model is uncertain and warrants future research.

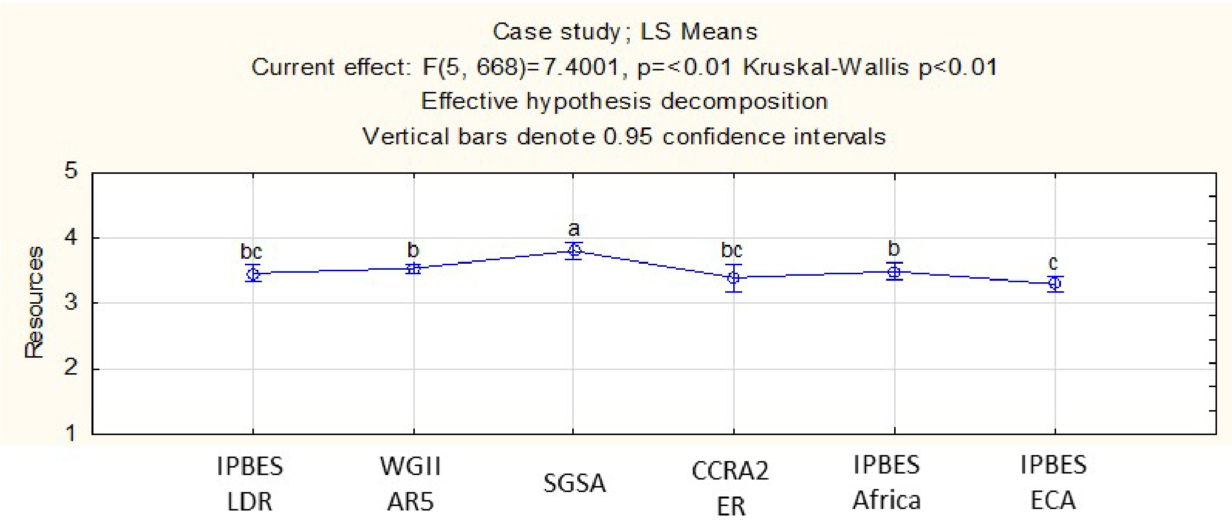


Figure 39: Resources subcategory construct comparison based on responses from 674 survey participants. The SGSA had the highest score for resources, potentially because it was a well-financed project which could afford to pay honorarium fees to CLAs, and in some instances by proxy, to LAs. There was a statistically large difference between the SGSA and IPBES ECA. For the rest, small to medium differences were recorded.

In respect of human resources, IPBES is especially conscious of their secretariat and TSU staff reaching a state of ‘assessment fatigue’ (Rothman *et al.*, 2009). In the IPBES external review, the *“...performance and commitment of the IPBES secretariat and its TSUs”* (IPBES, 2019a: 3) was praised, although concerns over the “*…chronic work overload of the secretariat and the lack of visibility and recognition of the work of the TSUs”* were also raised (IPBES, 2019a: 7).

Excessive workloads were reported elsewhere in all the cases, with, for example, Balvanera *et al.* (2017) claiming that the first work programme pushed IPBES to its full capacity across the LDR, Africa and ECA cases. Similar concerns emanated from the IPCC, not necessarily specific to WGII AR5. Where, for example, Stocker and Plattner (2014: 163) referred to IPCC work as “*…utterly exhausting”* while Griggs (2014: 171) on the other hand suggests *“...IPCC work can ruin lives”*. While these are personal (and potentially quite dramatic) accounts, the number of scientific assessments has increased substantially in the last decade – with some high performing researchers spending as much as 70% of their time just doing scientific assessments according to anecdotal estimates.

Regarding overall platform funding, the IPCC and IPBES have adopted rather similar financial models, with income coming from intergovernmental organisations and their member states. The major difference is that IPCC seems to have a steady income driven by large public and political interest, with a diversified income stream from member states.

This is not the case for IPBES. IPBES is still sensitive to fluctuating and unequal funding contributions which makes it especially difficult to plan and execute work programmes. Schmeller and Bridgewater (2016: 804) have described this aspect as the most crucial challenge facing IPBES, describing it as the *“...elephant in the room”*. There have been recent improvements to IPBES budget forecasts (Bridgewater and Schmeller, 2018), aided, for example, through the development of a new fundraising strategy (IPBES, 2019a) and the recent private-sector partnership with the Kering Group who have dedicated *“...non-earmarked contributions to the work of IPBES”* (IPBES, 2020:1).

The CCRA2 ER (which also sits within a larger scientific assessment platform in a similar way to IPCC and IPBES) also has had some problems with fluctuating budgets between its last two CCRA processes. While the reduction in budget from over £ 3 million during CCRA1 to ~£650 000 for CCRA2 has been presented as a potentially positive outcome through allowing the ASC to play a more hands-on role, diversifying the authorship and moving away from a consultant-led process

(Warren *et al.*, 2018) – the reality is that the budget was cut by fourth-fifths and CCRA2 ER participants are clearly concerned about this reduction.

While there were important concerns around resource constraints raised by many of the case participants (particularly in response to the issue of non-remuneration for author participation), the results of this research indicate that, by in large, participants were mostly satisfied with their experiences, in spite of funding challenges. The most accurate measure was asking each participant to either agree or disagree with the statement: "*you would participate in future assessment processes"*. In response to this statement, the mean responses were around or well over 4, with a third to half of survey participants Strongly Agreeing that they would (Table 45).

Table 45: Mean responses to the statement "you would participate in future assessment processes" and the percentage of respondents who Strongly Agreed that they would.

Case	Mean response (± SD)	Strongly Agree (%)
WG II AR5	4.14 (± 0.91)	39
IPBES LDR	3.99 (±0.88)	27
IPBES Africa	4.41 (±0.83)	53
IPBES ECA	4.12 (±0.87)	34
SGSA	4.43 (± 0.57)	45
CCRA2 ER	4.20 (± 0.73)	48

This would suggest that while numerous resource constraints were raised in the survey, the literature and within participant interviews, in general, participants believed cases to be valuable endeavours, worth dedicating their time toward. It is also worth noting the high scores of the SGSA and the IPBES Africa case, perhaps reflective of the higher satisfaction among poorer country participants than those from wealthier countries.

7.2.3 Drivers

For the subcategory construct *drivers*, SGSA participants most strongly believed that there existed a clear mandate from government and that the scope of the assessment was clearly defined. This resulted in a large statistical difference between the SGSA, IPBES LDR and IPBES ECA cases (Figure 40).

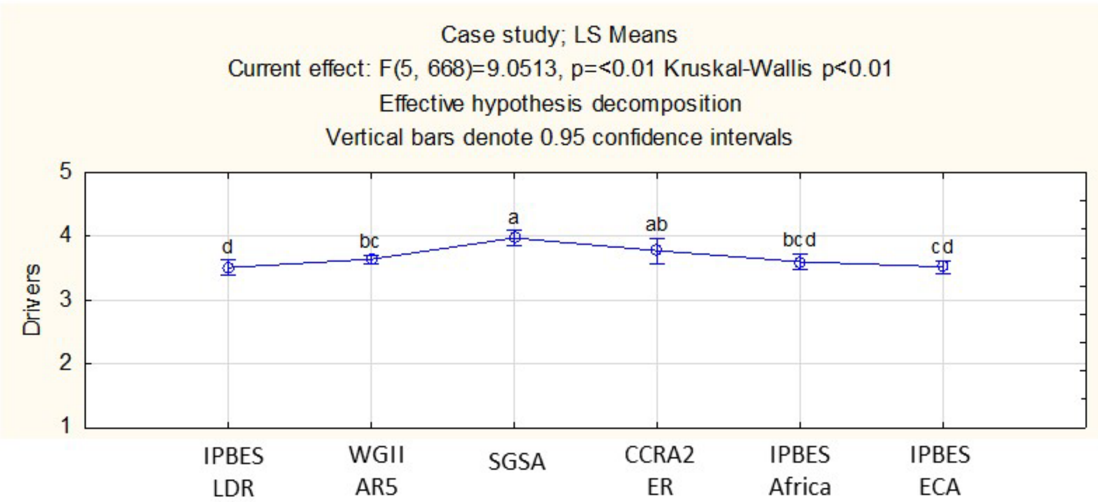


Figure 40: Drivers subcategory construct comparison based on responses from 674 survey participants with the SGSA and CCRA2 ER performing best. There was a statistically large difference between the SGSA and IPBES LDR; and SGSA and IPBES ECA. All other effect sizes between cases were small to medium.

The high scores for the SGSA can be attributed to its multi-institutional governance structure, providing a strong institutional framework and clear mandate. It is also likely that the rigorous structure of the risk methodology used helped participants to focus the scope of their assessments. In a similar way, the CCRA2 ER also had a higher mean for the subcategory construct *drivers*. It is possible that this occurred for two reasons.

Firstly, being a national assessment like SGSA, CCRA2 ER and SGSA participants felt closer to a policy-making mandate compared to the regional and global assessments of the intergovernmental boundary organisations – which occur a level of abstraction away from national policy implementation. It is also probable, that because CCRA2 ER and SGSA (whose clients were national governments) had more control over their briefs, participants felt more strongly that the policy questions had been clearly defined and sufficiently answered.

Secondly, with specific reference to the CCRA2 ER, it enjoyed a niche, institutionally and legislatively sanctioned role at the science-policy interface. It exists within an overarching programme or platform, is overseen by the ASC (under the auspices of the CCC) and mandated by the Climate Change Act of 2008. It also has the highly specific task of developing the evidence-base for the NAP. In this way, participants have an extremely clear idea of what the envisaged products are and how they can be best delivered. The roll-out of the Evidence Reports every 4-5 years, also provides a clear roadmap for continual performance improvement if adequate monitoring and evaluation occurs, (which seems so far to have been the case for the CCRA processes).

On the other hand, WGII AR5 exists a level of abstraction away from national policy – in this way its purpose and direction of scope can feel vaguer for participants and sometimes the clarity of policy questions can be so broad and inclusive to be fairly opaque. For example, in the case of WGII AR5, a clear and succinct set of policy questions were not evident in the chapters. Since only 20% of the available literature on climate change was assessed in AR5 according to Minx *et al.* (2017) – coupled with the fact that it is expected that ~33 000 new climate change publications will be produced every year – there is a need for clear set of policy questions to guide future IPCC WGs.

With respect to IPBES, Tinch *et al.* (2016) found evidence that IPBES participants do want a set of clear objectives to drive their work. In the IPBES cases investigated here, thematic assessments were guided by the content of their scoping documents within their overarching theme of assessment (i.e. the LDR focused on land degradation). The regional assessments, on the other hand, were scoped within the context of geopolitical boundaries, meaning that they were guided by a more succinct set of policy questions. These guiding policy questions were then slightly modified for each regional assessment accounting for the inputs of various experts and stakeholders. One IPBES interviewee suggested that these policy questions *"…really informed"* direction of the IPBES cases (R17, Africa).

Regarding the issue of inclusion of questions from a diversity of stakeholders. The IPCC rules only enable policymaker, scientist and stakeholder engagement right at the beginning of the process and then again right at the end at the scoping stage (Carraro *et al.*, 2015). IPBES implements a similar engagement structure – relying on generation and review of scoping documents at the start and then again with SPM development at the end of the process. This model of expert / policy-maker co-generation is widely promoted, although the full extent of its efficacy is still undetermined. In Conclusions Chapter (Ch 8), I make some recommendations for how this model might be adjusted to facilitate better cogeneration.

While SGSA implemented a similar stakeholder engagement model to IPCC and IPBES, gathering questions from early rounds of community meetings (Schreiner *et al.*, 2018), it was different in some important ways. The TSU operated 'close to the ground', with constant stakeholder interaction on a day-to-day basis through multiple lines of communication including, telephone calls, WhatsApp, SMS and email correspondence. This was enabled because of the national scale of the case, whereas regional and global cases do not have this option. This may have been why survey respondents felt – more so than the other cases – that the queries of the broader stakeholder community had been included within the scope of the assessment. In addition, stakeholders who participated in SGSA did so *ad hominin* – it was not required that they be representative or an organisation or government body.

All cases placed substantial human and financial resources into the generation of elaborate and technically sophisticated scenarios either at the global, regional or national scales. This translated into a mixture of both exploratory (what might happen?) and target-seeking scenarios (what is desirable?) across the cases. IPCC scenarios tended to be more exploratory since climate change exists in a policy environment where there remains great uncertainty about emission targets and scenarios. This was also the case for the national assessment cases of the SGSA and the CCRA2 ER. On the other hand, since IPBES functions within the relative prescription the 2050 Vision and 2020 Aichi Targets (Brooks, Lamoreux and Soberón, 2014), the scenarios consisted of a mixture of exploratory and target-seeking scenarios.

The SGSA and WGII AR5 adopted very similar risk assessment framings. Both of which had positive and negative aspects. On the positive side, the systematic use of risk enabled the development of a consistent language – which policy-makers and stakeholders tended to understand (Painter, 2015). The calibration of consequence terms also facilitated the integration of a diversity of knowledge domains into one coherent framework – making it easier to make comparisons and explore trade-offs (Fløttum, Gasper and St. Clair, 2016). On the negative side, the risk assessment approaches were frequently criticised for weak conceptual foundations, the effect of homogenising knowledge, suppressing divergence and being overly reductionist in the face of complexity.

7.2.4 Trust

For the subcategory construct *trust*, there were no statistically relevant differences between the cases (Figure 41). The limited subcategory construct differences may have been a result of trust being built in very similar ways across the cases. This was achieved through a few different pathways. Multi-author teams strived for representivity in authorship. Plenary sessions and governance oversight groups strived to balance the views of experts with the needs of governments. The peer review system strived for evidence-based quality control. Conflict of interest protocols strived for making financial and ideological interests transparent. Collectively, these pathways were employed across the cases in varying forms as the primary means for mitigating bias and manipulation.

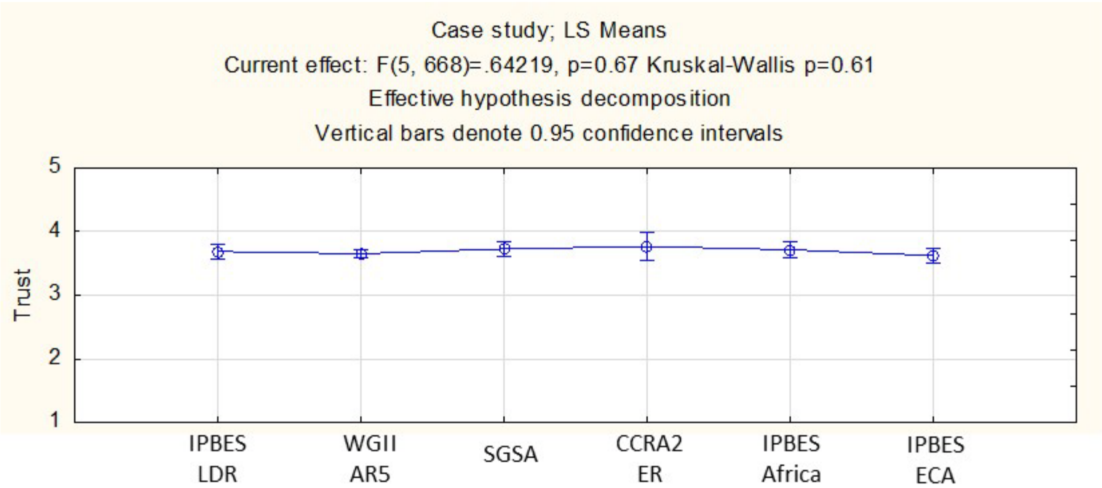


Figure 41: Trust subcategory construct comparison based on responses from 674 survey participants with no statistically relevant differences between the cases. All effect differences were either negligible, or small.

The extent to which these techniques are effective was reflected in the survey responses to S30 *"The process was trustworthy"*, where mean responses to the statement were above 4 for all cases and well above the cumulative case mean (Figure 42).

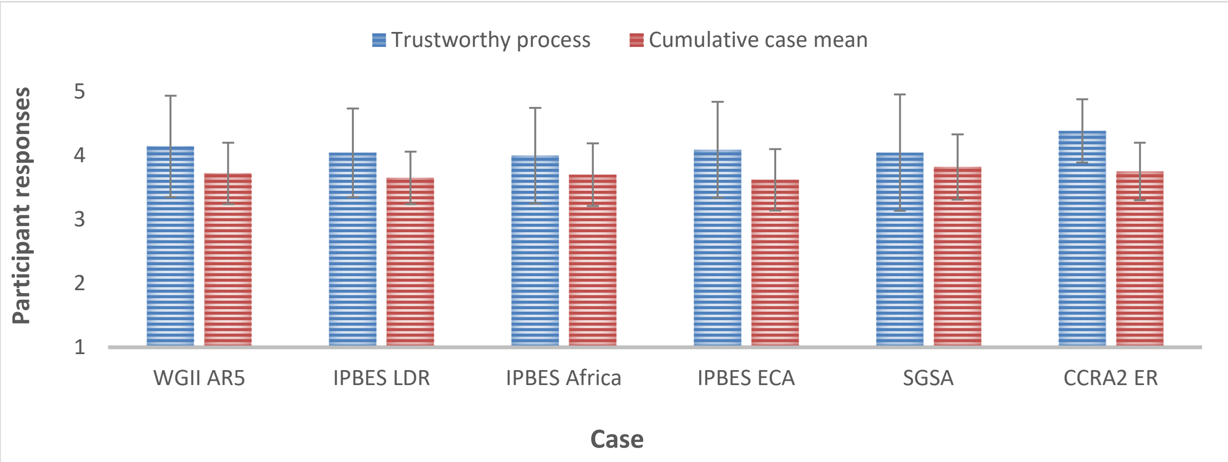


Figure 42: Mean responses to S30 "The process was trustworthy" across the cases. Responses for S30 (blue) are substantially higher than the cumulative case mean (red) indicating that participants did, on average, place a high degree of trust in the cases they participated in.

Even so, there are some substantive concerns around the issue of bias and manipulation in scientific assessments. For example, the phenomena of stealth issue advocacy is documented in the climate change literature (Pielke Jr, 2007) with well-known examples of potential manipulation. For example, by authors participating in the 'Climategate' scandal (Vardy *et al.*, 2017) or the basic errors in IPCC reports discovered, for example, in the case of Himalayan glacial retreat in AR4 (Griggs, 2014). Additionally, there are documented instances of policymaker manipulation, for example, in the case of member states pushing authors to remodel contributions of 'carbon debt' through 'negative emissions', as documented by Geden (2015).

While Tinch *et al.* (2016) found that for IPBES, the dominant expert position was one of 'honest broker', these results were gathered from interviews and surveys of people self-selecting themselves as honest brokers. The reality is that IPBES, along with other scientific assessment platforms, will be subject to the same manipulation risks that the IPCC faces, and these will probably emerge with greater regularity as the platforms increase their profiles and political influence.

With respect to media communication, one key difference which emerged through the analysis was the relative success of the IPCC communication strategy and its societal impact. Overall, the performance of the IPCC in communicating the science of global climate change seems to have been a success and *"…is virtually unparalleled in terms of the attention that it rattles, and the momentum that comes from it"* (Interviewee R6, 2019).

This success is quantitatively reflected in Google Trends data (Google, 2019), indicating that since 2004, there is a high correlation in online use trends between searches for *climate change* and searches for the *IPCC*. Considering the breadth and expanse of climate change as a global concern with exceptionally high online traffic volumes, the IPCC's role in informing the global discourse on the issue is clear. In contrast, there is a rather large gap between the terms *biodiversity*/*ecosystem services* and *IPBES* (Figure 43).

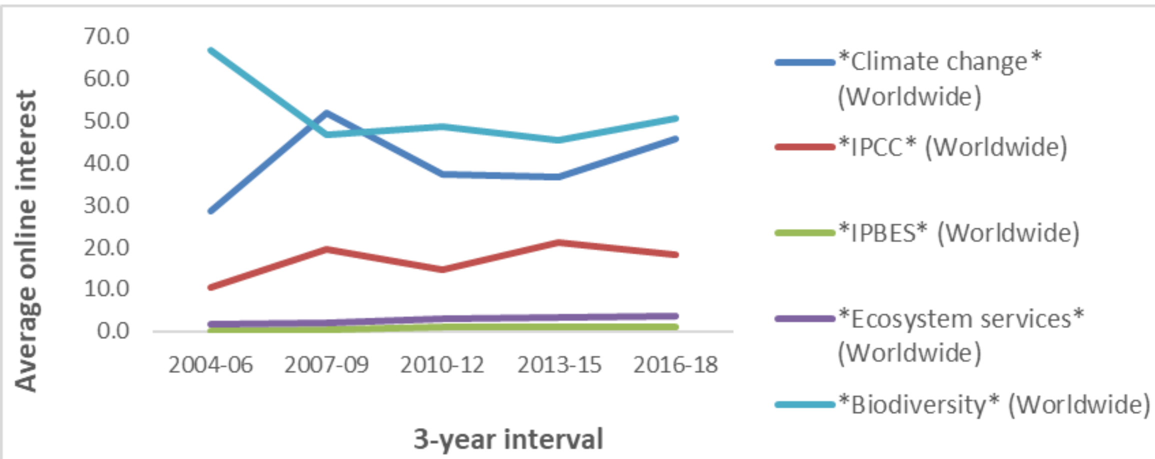


Figure 43: Online interest in key IPCC and IPBES terms at 3-year intervals from 2004 to 2018 (Google, 2019). The profile of the *IPCC* (red) is proportional to the profile of *climate change* (dark blue). The profile of *IPBES* (green) is almost non-existent compared to the profile of *biodiversity* (light blue) but is roughly aligned, albeit at small scale, with the profile of *ecosystem services* (purple).

There are potentially a couple of reasons for this. The first is that IPBES is nascent – it is still in the process of establishing itself as a global authority on the issue of biodiversity and exists within a crowded science-policy landscape. In addition, it is possible that it is still too focused on the natural sciences (Díaz-Reviriego, Turnhout and Beck, 2019), is limited by language barriers (R17, Africa), has a shortage of media competent experts (R24, ECA) and needs to focus more on process communication, as well as results communication (R17, Africa).

Even so, the IPBES External Review found that the platform had made steady improvements in its communication platform since the initiation of its first work programme (IPBES, 2019a). In support of this, one interviewee suggested that IPBES communication around its profile and the results of its assessments should become easier in the second work programme as the platform matures and is more recognisable in stakeholder communities (R22, ECA).

The national assessments of the CCRA2 ER and SGSA did garner high levels of participant trust, the former primarily through its institutional and legislative mandate, the latter through its novel approach to project governance, however, both cases failed to garner public interest in the topic, based on similar analyses of Google Trends data (2019).

7.2.5 Capacity building

In respect of co-production, as mentioned in the subcategory construct *representivity*, the primary opportunities for cogeneration between scientists and policymakers occurred right at the beginning of an assessment process, and then right at the end. This meant that the primary method of engagement with policy-makers was *via* comment submissions on SOD chapters. Policymakers next had an opportunity to engage, in person, with assessment content in the drafting of the SPM. Even after these rather elaborate drafting and review processes, many survey participants, across all the cases, felt that co-generation opportunities with policymakers were limited in their scope and extent.

This is perhaps a result of the highly formalised procedures within which scientist–policymaker engagement occurs. Policymakers are generally not involved in the day-to-day chapter drafting processes, so in some sense, their engagement with content development is limited to the bureaucratic exercises of plenary approval and the somewhat restrictive process of abstract comment submission. In my own experience of over 10 years working with government officials on the development of environmental assessments, even if policymakers are passionate or highly knowledgeable about an issue, managing to secure written inputs from them is mostly a challenging endeavour.

Regarding youth participation, while capacity development is not an official function of the IPCC, it does seem that efforts have been was made toward the provision of opportunities to young and emerging experts (Brooks, Lamoreux and Soberón, 2014). There also exists a range of benefits for young people who participate in IPCC assessments such as experience (Schulte-Uebbing *et al.*, 2015), an increased likelihood of a successful academic career (using *h*-indices as a proxy) (Scholes, Schreiner and Snyman-Van der Walt, 2017) as well as increased publications in the 5 year interval following release of assessment reports (Vardy *et al.*, 2017).

In the case of WGII AR5, the CS programme (Schulte-Uebbing *et al.*, 2015) and Dutch Government peer review process (van der Veer *et al.*, 2014) offer evidence supporting this claim. Even so, survey respondents unmistakably felt that more could have been offered in the way of capacity development in support of young people. In the future, the IPCC may have to determine the extent to which it wants to widen its mandate and offer more capacity development opportunities – potentially through partnering with postgraduate university programmes in the generation of derivative products (Vardy *et al.*, 2017).

On the other hand, for IPBES, capacity building is one of its core functions. This was reflected by in the fact that all three IPBES cases scored statistically higher than the non-IPBES cases (Figure 44).

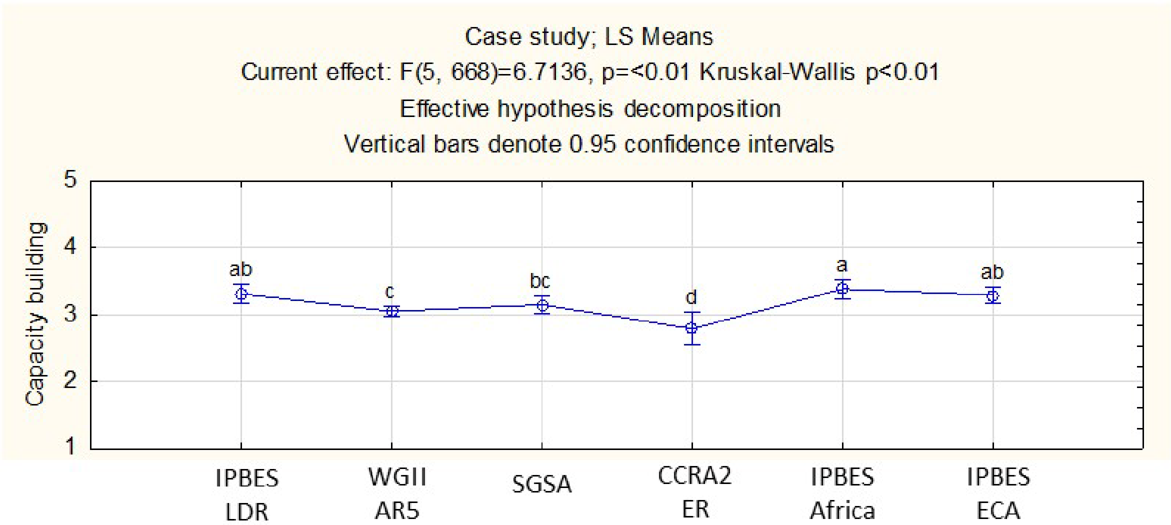


Figure 44: Capacity building subcategory construct comparison based on responses from 674 survey participants where the IPBES cases scored statistically higher than the non-IPBES cases. Large effect differences were recorded between CCRA2 and IPBES LDR; CCRA 2 and IPBES Africa; and CCRA2 and IPBES ECA.

Capacity development is built into the day-to-day operations of the IPBES platform. For example, through its Task Force on capacity building which was established with the first IPBES work programme and which now oversees the fellowship programme which assigned 33 young scholars to the first IPBES work plan. The relative success of the fellowship programme has been documented by Gustafsson (2018) and was also seconded by the external review panel. However, the panel did note that broader capacity development with stakeholders and policy-makers has been less successfully implemented (IPBES, 2019a).

Age related demographic data of participants was not available online, so it was difficult to get a sense of the average age of case participants. The best proxy is to use the age profile of the 674 survey respondents. Across the cases, 21 % of survey respondents were less than 40 years old, 58 % were over 40 but less than 60, while just under 20 % were over 60 years' old (Figure 45).

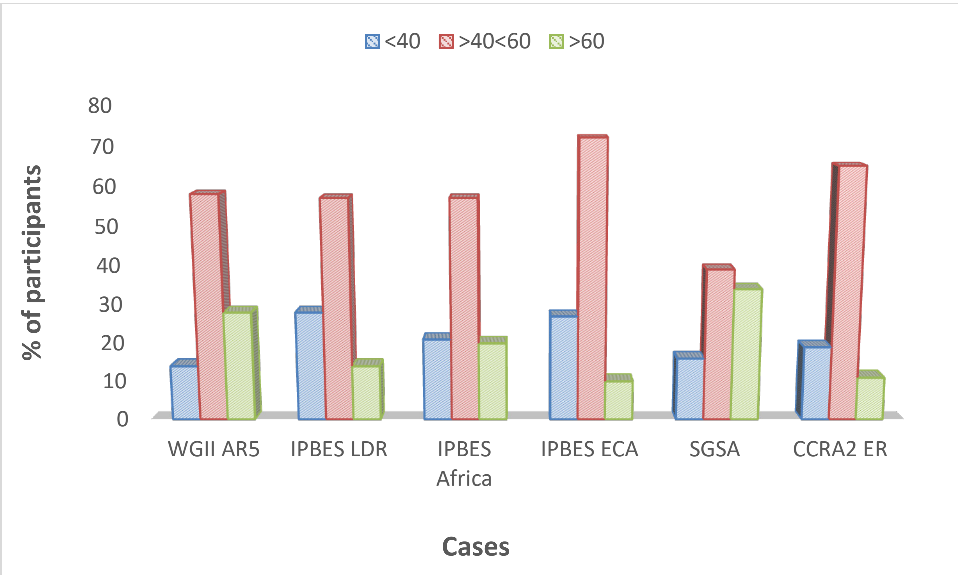


Figure 45: Age profile of the 674 survey respondents across the six cases. In most cases, the majority of survey participants were older than 40, but younger than 60 (red). Some cases like the SGSA had a higher proportion of older participants (green). The IPBES cases generally had the highest proportion of young participants (blue).

From this, there are four interesting things to note. Firstly, all three IPBES cases had more participants younger than 40, than older than 60. This shows some evidence of good successional planning and investment in future participants.

Secondly, in the case of SGSA, a substantial proportion of participants (>85 %) were above the age of 40, showing weak successional planning. This was a result of having to draw experts from a reasonably small national ‘pool’ but also represents a failure to develop a coherent strategy for embedding fellows into writing teams.

Thirdly, while the CCRA2 ER scored very low for youth development in the survey, there were more participants younger than 40, than older than 60, which seems to contradict the findings of the survey.

Lastly, those respondents <40 were more positive about the effectiveness of the case studies they had been involved in, although this difference was only marginal and not statistically relevant. On the other hand, there was zero difference between the 40-60 and >60 age groups.

The other component of the subcategory construct *capacity development* included the provision of participation opportunities to ‘marginalised groups’. In the survey, the definition of ‘marginalised’ was left open to interpretation. However, from analysis of the literature, in-depth interviews and open-ended survey responses – it seems that the notion of ‘marginalisation’ is mostly synonymised with low to low-middle income country participation, and more specifically, those individuals or groups with knowledge systems which are traditionally overlooked in the scientific discourse. In this way, ‘marginalisation’ seems to be mostly applied to participants from poorer countries or participants with non-academic knowledge, which will be discussed further in the subcategory construct *knowledge*. In the case of SGSA, it is hypothesised that the concept of ‘marginalisation’ would have been applied to people of poorer economic backgrounds, commonly stratified along racial lines in the case of South Africa.

7.2.6 Adaptability and uncertainty

There were no statistical differences between the cases for the subcategory construct *adaptability and uncertainty* (Figure 46). This is unsurprising, because all the cases used similar mechanisms to both remain adaptive, promote iterativity and manage uncertainty.

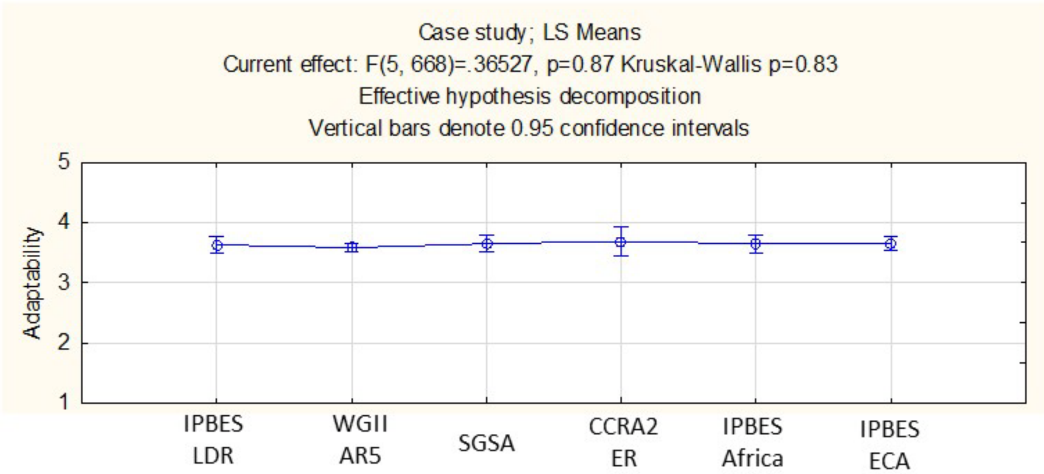


Figure 46: Adaptability and uncertainty subcategory construct comparison based on responses from 674 survey participants showing negligible, to small, effect differences.

With regard to iterativity – both within a scientific assessment project and within a broader platform – the IPCC has been criticised for its stasis (Devès *et al.*, 2018), being overly bureaucratic (Carraro *et al.*, 2015) and suffering an innovation 'inertia' (Tol, 2011).

These slow changing variables, inherent to the IPCC, and indeed all the other cases, are a logical extension of the systems and procedures required to operate national governments and intergovernmental organisations, like the UN. In this way, the bureaucratic, slowly evolving systems of decision-making which typify the policy-cycle at national scale have been absorbed into the procedures of scientific assessments, undertaken at regional and global scales. This is, normatively speaking, neither a good nor bad thing. Rather, it is merely a product of the knowledge-policy processes, where scientific processes are integrated with policy-making at the messy interface of different cultures, worldviews and value systems. Procedurally, this translates into something approximating slow bureaucracy.

While there is a need to be adaptive and flexible to policy changes and new emerging questions (Sarkki *et al.*, 2015), bureaucratic procedures like the sign-off of the mandated scope builds legitimacy and trust. As do the gradual and potentially frustrating procedures required for consensus-making, whether at the stage of draft report writing (amongst experts) or at the stage of SPM drafting (amongst experts and policy-makers).

Within an actual scientific assessment project, the primary mechanism for iterativity (which allows for the continued improvement of products over the duration of the process) is through the seminal double-review loop content generation process which has become symbolic of scientific assessment. None of the cases investigated in this research substantively deviated from this keystone structure.

Across all the cases, the formula, roughly speaking, followed these steps: 1.) co-generation of a scoping document; 2.) assessment of the agreed scope by teams of experts; 3.) production of first draft chapters for peer review; 4.) incorporation of peer review comments into a second draft of the chapters; 5.) release of the second draft back to the peer reviewers and for wider stakeholder review 6.) negotiation and various reiterations of final draft chapters or summaries with clients, governing bodies and governments.

One notable exception occurred in the case of the SGSA, where a distinct phase of the project was designed to follow after the scientific assessment. The Decision Making Framework (DMF) phase, led by the South African research councils, aimed to use the evidence-based outputs of the scientific assessment to craft the policy briefs and regulations specifically required by South African government departments.

The overall success of the DMF in the case of the SGSA can be debated (Chapter 7), but the idea of a policy-generating phase following the scientific assessment is one worth discussing further. In a similar way, within the broader structure of the CCRA (which includes the CCRA ER, the CCRA Government Report and the NAPs) policy-makers and wider stakeholders are invited to engage with the scientific content of the ER, while crafting policy-relevant tools. In this way, it could be argued that the national-scale assessments of the SGSA and CCRA2 ER offered more political saliency than the wide scopes necessarily adopted for the global and regional assessments of the IPCC and IPBES.

Regarding the issue of uncertainty, this was managed across the cases in three ways. Firstly, through the use of scenarios, which were adopted in all the cases. Secondly, WGII AR5, all IPBES cases and the CCRA2 ER communicated uncertainty by using calibrated systems of language (this was lacking from the SGSA). And thirdly, in the case of the national assessments of the CCRA2 ER and SGSA, by closing essential knowledge gaps by commissioning supporting research projects to feed into the scientific assessment process. In the case of the SGSA, foundational biodiversity data were collected through the BioBlitz, while in the case of the CCRA2 ER, flood analyses, water availability projections, good and services assessments, as well as new climate change scenarios were commissioned.

7.2.7 Knowledge

From the survey analysis, there were no statistical differences between the cases for the subcategory construct *knowledge* (Figure 47).

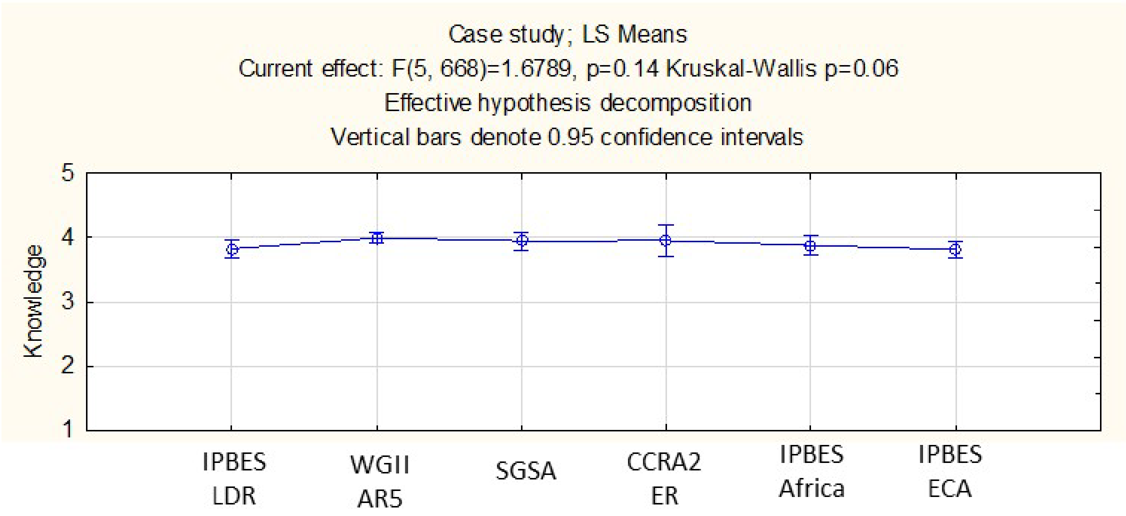


Figure 47: Knowledge subcategory construct comparison based on responses from 674 survey participants with no statistically relevant differences between the cases.

There was agreement that all the cases will deepen the public debate on the issues they respectively inform (Figure 48).

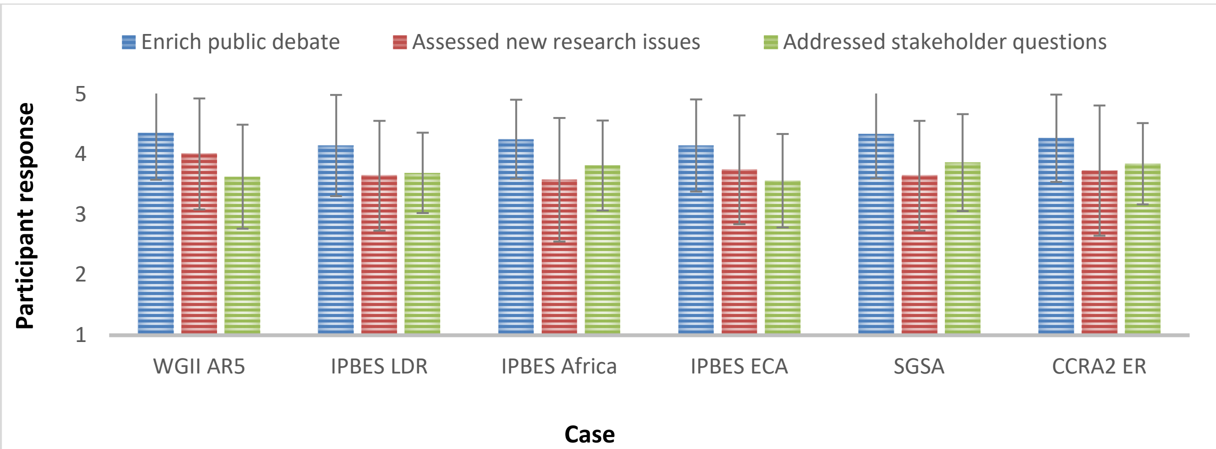


Figure 48: Effectiveness scores across the subcategory construct knowledge consisting of three questions: 1.) "The enrichment of public debate" (blue); 2.) "the assessment of new research areas" (red); and 3.) the "consideration of stakeholder questions" (green). Survey participants felt that the main knowledge production function of the cases was in the enrichment of the broader public debate.

IPCC reports have been shown to play an ever increasing role in the enrichment of knowledge through academic publications, with a larger proportional representation of publications coming from the social sciences and less developed countries than in the initial years (Vasileiadoua, Heimeriks and Petersen, 2011).

A scan of the Google Scholar database for *IPCC* reveals 149 000 matches between 2010-2020 and 186 000 matches between 2000-2010. For *IPBES*, between 2000-2010, there were 305 matches, which increased to 9 720 between 2010-2020. This is a result of quadrupling of research publications related to IPBES between 2010 and 2018 (Díaz-Reviriego, Turnhout and Beck, 2019). Likewise, the national assessment of SGSA and CCRA2 ER have made some valuable contributions to new knowledge generation with a mixture of journal publications, academic theses, book chapters and technical reports.

From the survey responses, the ability of the cases to address important stakeholder questions was perceived to be lower than their ability to enrich public debate (Figure 48). This may be because stakeholder questions are frequently value-based, while the knowledge generated from scientific assessment mostly steers away from value-based questions and toward positivist reductionism.

The numerous arguments against positivist reductionism generally boil down to two key points. Firstly, that scientific assessments assume that the problem in question stems from a lack of scientific knowledge in society, and that therefore, the response must be to generate more scientific knowledge. Secondly, many analysts have claimed that science presents itself as a value-free, 'clean' enterprise – which should be considered a superior brand of knowledge. In these instances, scientific management practices hold a tight grip on the methods of knowledge production and how participation is organised. This serves to dominate and exclude other knowledge forms which might be more effective than science for influencing change e.g. local-scale climate change adaptation approaches.

At the extremes of this philosophical division, modernists only see the primacy of science, while postmodernists present science merely as an oppressive power structure. In a more moderate form, this model of philosophical division can be seen in the case of the 'ecosystem services' versus the NCP 'dilemma' currently affecting IPBES (Chapter 5) (Masood, 2018).

In response to this problem, some are in favour of a pluralistic, hybrid approach (Peterson *et al.*, 2018) where ecosystem services and NCPs do not need to be integrated into one framework, rather, that each approach is endorsed by IPBES and used on a case-by-case basis depending on the nature of policy questions which arise (Harris and Kotiaho, 2018). This approach forms part of a wider call for transdisciplinarity in scientific assessment, where knowledge other than that from traditional academic sources plays a more substantial role, especially in the generation of solutions.

While this modern versus postmodern argument took its most publicised form within the NCP versus ecosystem services argument within the IPBES platform, the tussle between these two worldviews has been longstanding in the IPCC (Hulme *et al.*, 2011). It was also raised as a point of concern in the national cases of the SGSA (Borchardt, 2016) and CCRA2 ER (Howarth *et al.*, 2018). In all instances, models of pluralistic, transdisciplinary, co-generated knowledge production are always cited as the main remedial options, with little practical direction offered.

7.2.8 Quality

To ensure quality of product, all cases relied on iterative content revision processes, representative multi-author teams (subcategory construct *representation*) and rigorous peer review structures (Table 46).

Table 46: Number of reviewers, comments and references across the cases. Being a bigger process, WGII AR5 had substantially more reviewers, comments and reference sources than the other case, which were reasonable consistent across global (LDR), regional (Africa & ECA) and national scales (SGSA & CCRA2 ER).

	Reviewers (peer & stakeholder)	~ FOD comments	~ SOD comments	~ References
WGII AR5	1 729	20k	29k	12k
IPBES LDR	222	2.5k	4k	3.8k
IPBES Africa	106	1.2k	1.8k	1.9k
IPBES ECA	306	2k	4k	4k
SGSA	190	2.5k	1.9k	1.5k
CCRA2 ER	175	2.3k	2.2k	1.7k

The implementation of these quality control measures contributed to the general perception across the cases that outputs were of sufficient technical quality with means > 4. There were some medium statistical differences between WGII AR5, CCRA2 ER, SGSA and the IPBES cases. Overall, this infers that participants from WGII AR5, CCRA2 ER and SGSA more strongly believed in the quality of output than the participants from the IPBES cases (Figure 49).

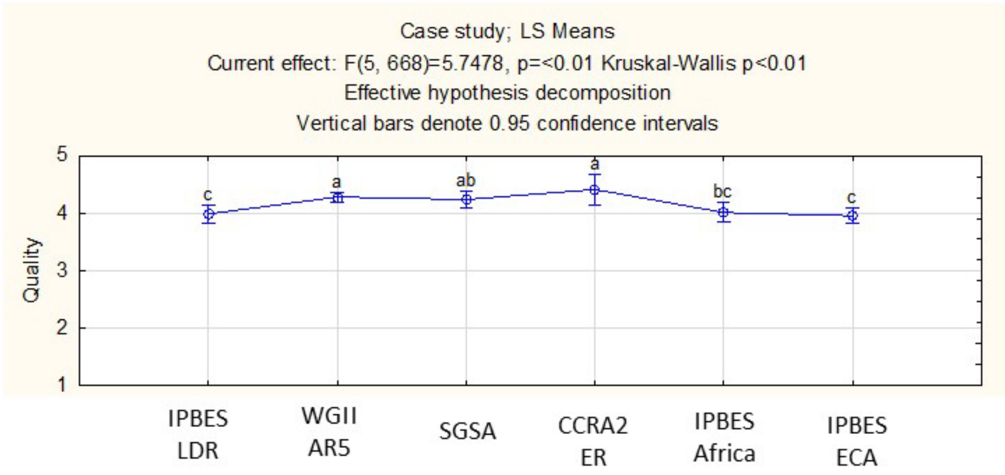


Figure 49: Quality subcategory construct comparison based on responses from 674 survey participants. There were small to medium effect differences between the cases. Participants from WGII AR5, CCRA2 ER and SGSA more strongly believed in the quality of output than the participants from the IPBES cases.

This may be a result of IPBES being a nascent organisation and that quality control measures are still in need of fine tuning. It may be a result of what Bridgewater and Schmeller's (2018) suggestion that IPBES has been known to publish examples of inaccurate and alarmist statements. On the other hand, it may stem from IPBES producing a limited number of outputs (subcategory construct *implementation*).

Questions have also been raised about the perceived quality of IPCC products owing to instances of error (Tol, 2011) and stealth issue advocacy (R. J. Pielke, 2018) (see subcategory construct *trust*). From the published literature, few complaints about the quality of the national assessments were registered. This does not mean they were not subject to the same quality problems encountered by the IPCC and IPBES cases, but is no doubt an instance of absence of evidence, rather than evidence of absence.

7.2.9 Implementability

Generally, survey participants believed that the outputs generated from the cases were useful for decision-making, although they were less certain about the relative contribution of the cases to the overall resolution of the problem in question (Figure 50). This indicates that while survey participants may perceive the cases to have some policy implementability, the impact on social behaviour following policy implementation is perceived to be less.

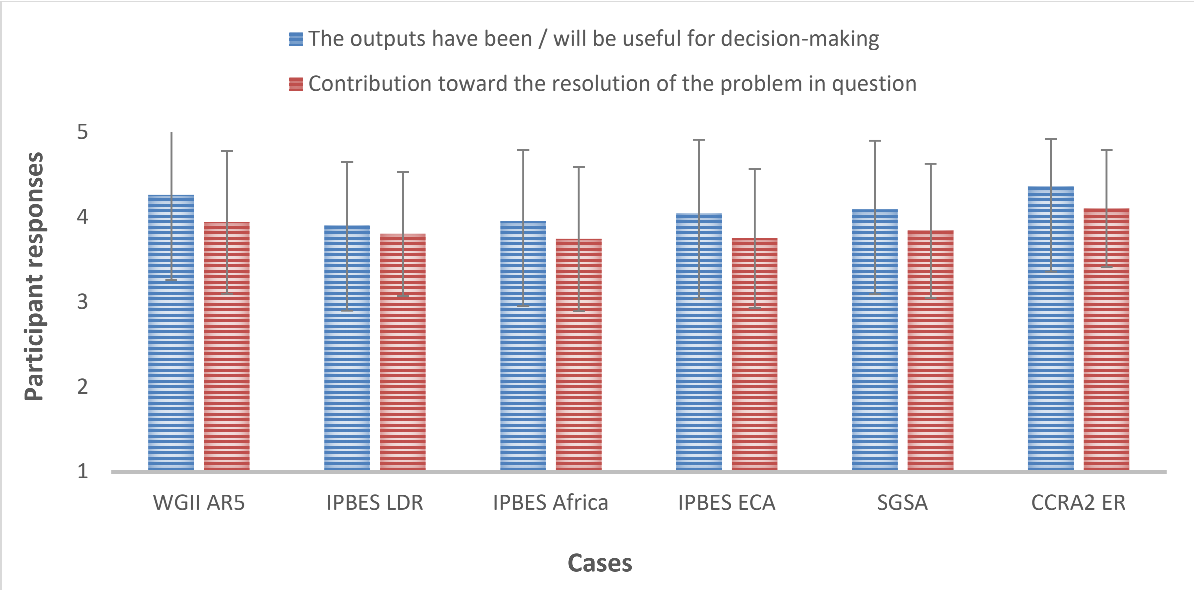


Figure 50: Perceived usefulness of the case outputs and their contribution toward the overall resolution of the problem in question. The impact of the cases on decision-making in the policy realm (blue) was higher than the perceived value in terms of the broader resolution of the problem at a societal scale (red).

The main tool for achieving policy relevancy across the cases was by producing a range of different outputs with different audiences and purposes. The primary one in the WGII AR5 case, the IPBES cases and the SGSA, was a co-generated SPM. In the case of the CCRA2 ER, a synthesis report was developed, along with national summaries relevant to the different countries of the United Kingdom (Table 47).

Table 47: The range of outputs generated across the six cases.

Case	Chapters & Annexes	Summary for Policy-makers (SPM)	Supporting information & iconic images	Publication languages	Post-scientific assessment phase	Research projects	Information portal
WGII AR5	30 thematic chapters & Annexes.	Accepted line-by-line by the Panel at the 10th Session of WGII and the 38th Session of the IPCC Panel, held in Yokohama in March 2014.	Technical summaries, factsheets, FAQs, cross chapter boxes, top-level findings, slide presentations, comment and responses. Iconic image = ‘Burning Embers’ diagram.	Translation of SPM, TS, FAQs and CC Boxes into 5 official UN languages. Some countries undertook their own language summaries e.g. Czech, German, Portuguese, Japanese, Korean Swedish.	None	None	https://www.ipcc.ch/rep ort /ar5/wg2/
IPBES LDR	8 thematic chapters & Annexes.	All three SPM approved at IPBES-6 in March 2018 in Medellin.	Methodological notes, comment & responses. Iconic image -- IPBES conceptual framework.	English	None	None	https://ipbes.net/assessm ent-reports/ldr
IPBES Africa	6 thematic chapters & Annexes.						https://ipbes.net/assessm ent-reports/africa
IPBES ECA	6 thematic chapters & Annexes.						https://ipbes.net/assessm ent-reports/eca
SGSA	18 thematic chapters & Annexes.	No objections to scientific assessment process registered by PCG or PEC groups which provided the mandate for SPM release. Was not negotiated like IPCC	Spatial layers, explanatory & summary videos, comment & responses, FAQs, Decision-making Framework Report. Had a few potential iconic	Reports in English. Meeting notices in local languages.	Decision-Support Tools report (DEA, 2017) which included the Minimum Information Requirements (MIRs) to be used to guide Environmental Impact	Ecological BioBlitz involving rapid scans of underrepresented geographical regions in the Central Karoo.	https://seasgd.csir.co.za/

Case	Chapters & Annexes	Summary for Policy-makers (SPM)	Supporting information & iconic images	Publication languages	Post-scientific assessment phase	Research projects	Information portal
		& IPBES.	images, but not a widely distributed one.		Assessment (EIA) applications.		
CCRA2 ER	8 thematic chapters & Annexes.	Synthesis Report and technical chapters seem to have been approved by ASC and CCC. No evidence of summary negotiations as this would occur when government amends ER text to produce their own CCRA.	Synthesis report, key messages, animations, four national summaries, factsheets & slide presentations, comments & responses. Iconic image -- Top 6 Reasons for Concern	English	Evidence report generated by the ASC, which feeds into government generated CCRA and government generated National Adaptation Plans (NAPs).	(1) Assessment of climate change impacts on UK natural assets (2) Updated projections for water availability for the UK (3) Projections of future flood risk in the UK (4) Developing H++ climate change scenarios.	https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/

It is worth noting that IPBES implementability scores were generally lower than the other three cases (Figure 51). One reason for this is that IPBES produced a limited number of outputs, really only consisting of an SPM and the associated technical chapters. On the other hand, in the cases of WGII AR5 and CCRA2 ER, outputs consisted of synthesis reports, summaries, FAQs, videos, animations and factsheets. For future scientific assessments, IPBES will need to diversify the range of its outputs to meet with the diversity of user needs.

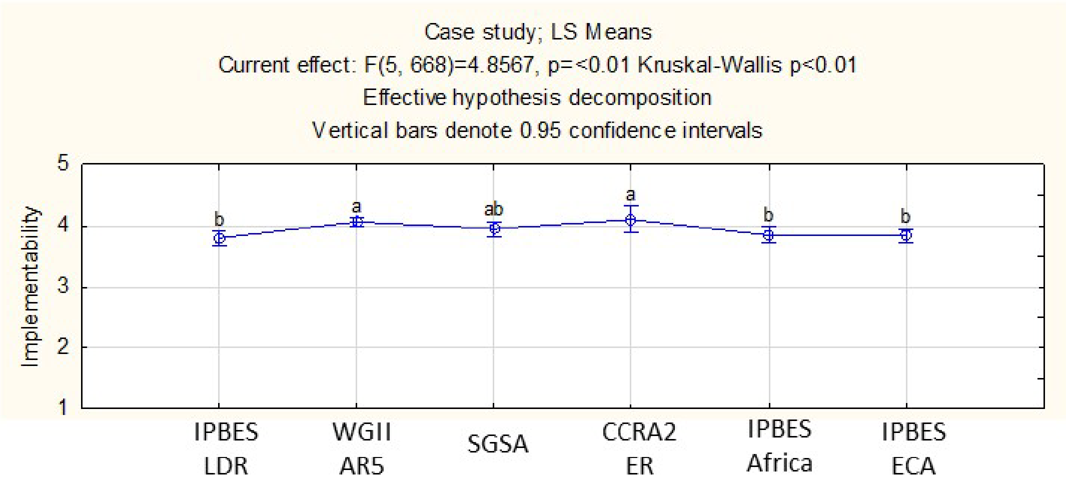


Figure 51: Implementability mean scores across the six cases with the IPBES cases scoring the lowest, probably due to a lack of diversity in outputs compared to the other cases.

SPMs from the IPBES cases have also been criticised for being too generic (IPBES, 2019a), consisting of varying styles and formats (Bridgewater and Schmeller, 2018), being rushed (R17, Africa) and non-reflective of underlying chapter text (R16, Africa). Even the IPCC, with its diversity of outputs, has been criticised for generally low readability (Barkemeyer *et al.*, 2015), being overly dense (Howarth and Painter, 2016) with a lack of captivating messages (Black, 2015) which limits its usefulness in informing political decision-making (Kowarsch, 2016). The outputs of the SGSA and CCRA2 ER were less criticised in the literature, but again, this is likely a result of much reduced public scrutiny compared to IPCC and IPBES cases.

Implementability scores were highest for the CCRA2 ER. This could be because their Evidence Reports feed directly into a parliamentary approved CCRA Government Report, and then into the NAPs. These multi-directional systems of interaction between the scientific assessment and policy process may have played a role in increasing overall perceived implementability among survey participants. Additionally, the CCRA2 ER was undertaken at a national scale, which offers higher levels of decision-making relevancy than the global and regional scientific assessments undertaken for IPBES, for example.

The CCRA's robust institutional and regulatory framework means that their processes are designed with a strong policy-maker focus (which was potentially traded off by less engagement with the wider stakeholder community). In an *ex-post* review of the CCRA2 process according to predetermined success indicators, it was determined that the process had met with government expectations and delivered on its defined scope of policy questions. Since then, according to Howarth *et al.* (2018), the CCRA outputs have been used in three main ways: (i) to make business cases for their work; (ii) to shape direction of policy; and (iii) for practical applications such as the design of engineering structures

On the other hand, the outputs from the other national scientific assessment – the SGSA – had a less structured receiving environment, with some confusion over the desired shape and form of the outputs, their purpose, as well as the roles of the various government departments responsible for implementing them. While slow progress has been made in the formulation of the MIRs which will guide site specific EIAs, there is no less policy uncertainty in South Africa than there was in 2016, although the scientific facts on the issue of SGD are much more clearly established.

In the case of IPBES, there is limited evidence of policy impact, according to Interviewee R26 (ECA). However, a few exceptions were noted in this research. For example, there is evidence of policy impact emanating from the Pollinator's Assessment with the initiation of the coalition of the willing (Hof *et al.*, 2017). There is also evidence of IPBES products informing decision-making at regional scale by the European Council and at a global scale, with the Conference of the Parties (IPBES, 2020). IPBES have made additional attempts to increase their policy relevance, for example, through the development of the IPBES Catalogue of Policy Support tools which is available online (Díaz-Reviriego *et al.*, 2017).

However, these are not necessarily the types of high-profile, high-impact examples which the IPCC has recently been associated with. At this stage, the main benefits of IPBES seem to be in raising awareness about biodiversity loss and in doing so, informing agenda setting for political decision-making bodies. As such, many interviewees and survey participants perceive policy support from IPBES to be inadequate at present, with promising potential for growth. These findings are consistent with the IPBES External Review (IPBES, 2019a).

As a nascent organisation with one work programme under its belt (which included 7 assessments and many other studies), IPBES may still need some time to build the kind of profile and relationships required for policy impact – which can take years. One of the main challenges IPBES faces, along with other international assessments but especially so because IPBES set out to embedded regionality, is generating local-scale relevancy while at the same time rolling out global and regional scale assessments. The IPBES External Review found that IPBES should [parentheses added] *"…be useful at the national level […]. Assessments should, therefore, be scoped and shaped with stronger engagement of policy experts, policy practitioners and biodiversity managers"* (IPBES, 2019a: 4). The proposed mechanism of achieving this is greater interaction with national focal points.

However, the extent to which this is practically possible in the biodiversity sciences is questionable. While the climate sciences use standardised metrics and language to generate regression models, weather pattern-based approaches, stochastic weather generators and limited-area climate models to integrated global and local scales (Wilby and Wigley, 1997), the biodiversity sciences have less developed metrics and language for accounting for distinct geographical regions as well as unique socio-economic conditions and systems of governance (Soberón and Peterson, 2015).

For these reasons, IPBES actively encourages national-scale scientific assessments, through bottom-up, transdisciplinary knowledge production practices (R17, Africa). For these finer-scale scientific assessments, IPBES conceptual and methodological frameworks have been integrated into numerous examples, including processes like the South African National Biodiversity Assessment and the United Kingdom National Ecosystem Assessment, planned for 2022, which will be conducted within similar, if not the same, conceptual frameworks as those developed by IPBES.

There is good evidence for the usefulness of IPCC knowledge in informing policy decisions at local scale (albeit in a limited capacity) (Howarth and Painter, 2016), at national scale (e.g. the CCRA ERs) and at a regional scale (Riede *et al.,* 2016). At the global scale, AR1 contributed to the creation of the UNFCCC, the AR2 influenced the development of the Kyoto Protocol, AR4 was used in the Bali Road Map in 2007 and provided information for the 2009 Conference of the Parties (COP) to the UNFCCC in Copenhagen (Vardy *et al*., 2017) and AR5 contributed to the negotiations leading to the Paris Agreement (Kowarsch, 2016) – where countries pledged to lower emissions and take other complementary actions on adaptation and support (Vardy *et al*., 2017). As Interviewee R1 noted [parentheses added]: *"…after every major IPCC report, especially after the AR5 report, there are big changes"*.

This was formally recognised in 2007, when the IPCC, jointly with Al Gore, received the Nobel Peace Prize (Kowarsch, 2016) "…for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change" (Vardy *et al.*, 2017: 57). This is a notable, if not unprecedented, achievement for a SPI and is consistent with the with the IAC review of the IPCC, which concluded that "…the IPCC assessment process has been successful overall and has served society well" (IAC, 2010: 59).

7.3 Differences across participant demographics and roles

Differences in response patterns between demographic profiles were tested with respect to knowledge domains, age, country of birth, country of residence and gender. Three differences emerged. Firstly, young people (<40) were slightly more positive about the case they had been involved in. Secondly, the lower the income category for country of birth, the higher the perceived effectiveness. Participants from lower-income countries believed the cases were more effective than their peers from higher-income countries. Thirdly, there were some differences in perceived effectiveness across the different scientific assessment roles (Figure 52).

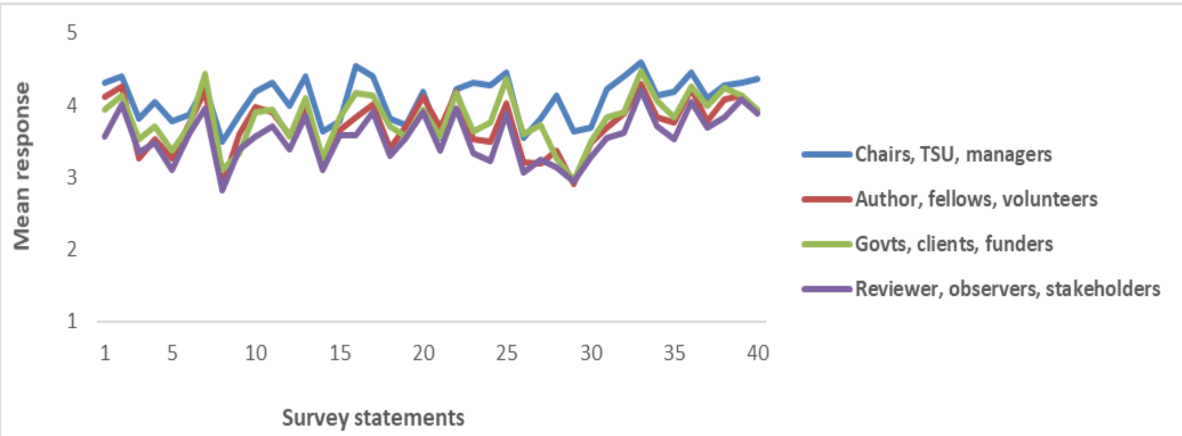


Figure 52: Response patterns across each assessment role for survey statements 1 to 40. Generally speaking, chairs, TSUs and managers viewed the cases as most effective, while reviewers, observers and stakeholders viewed the cases as least effective.

In order to test for differences between responses from authors, fellows and volunteers (representative of 'practitioners') versus govts., clients and funders (representative of 'clients'), a one tail t-test was undertaken[138]. For this test, there were no significant differences between the different groups.

A one tail t-test was also undertaken to check for differences between authors, fellows and volunteers (representative of those 'internal' to the case) versus reviewers, observers and stakeholders (representative of those 'external' to the case)[139]. For this test there was a statistically significant difference between groups – with those 'internal' to the cases scoring effectiveness higher than those 'external' to the case.

This lack of difference (in the case of the first test) and presence of difference (in the case of the second test) is well demonstrated as an example in response patterns to S 39: *The outputs have been / will be useful for decision-making* (Table 48).

Table 48: Responses to S39: "*The outputs have been / will be useful for decision-making"* across the different scientific assessment roles.

	Chairs, TSU, managers	**Authors, fellows & volunteers**	**Govts, clients & funders**	**Reviewers, observes & stakeholders**
	Mean (± SD)	Mean (± SD)	Mean (± SD)	Mean (± SD)
S 39: *The outputs have will be useful for decision-making*	4.32 (0.84)	4.13 (0.77)	4.13 (0.82)	4.00 (0.87)

[138] Effectiveness scores of 'authors, fellows and volunteers' (M = 3.72, SD = 0.37, n = 40) was hypothesised to be greater than those of 'govts, clients, funders' (M = 3.81, SD = 0.36, n = 40). This hypothesis was unsupported, as the difference between the two groups was not significance, t (78) = -1.13, p = 0.13 (one tail).
[139] Effectiveness scores of 'authors, fellows and volunteers' (M = 3.72, SD = 0.37, n = 40) was hypothesised to be greater than those of 'reviewers, observers, stakeholders' (M = 3.56, SD = 0.33, n = 40). The hypothesis was supported as the difference between the two groups was significant, t (78) = 2.05, p = 0.02.

7.4 Integrated effectiveness evaluation

From the survey data, there were no statistically relevant differences between the cases for 'overall effectiveness', in other words, the cumulative means across all subcategory constructs (Figure 53).

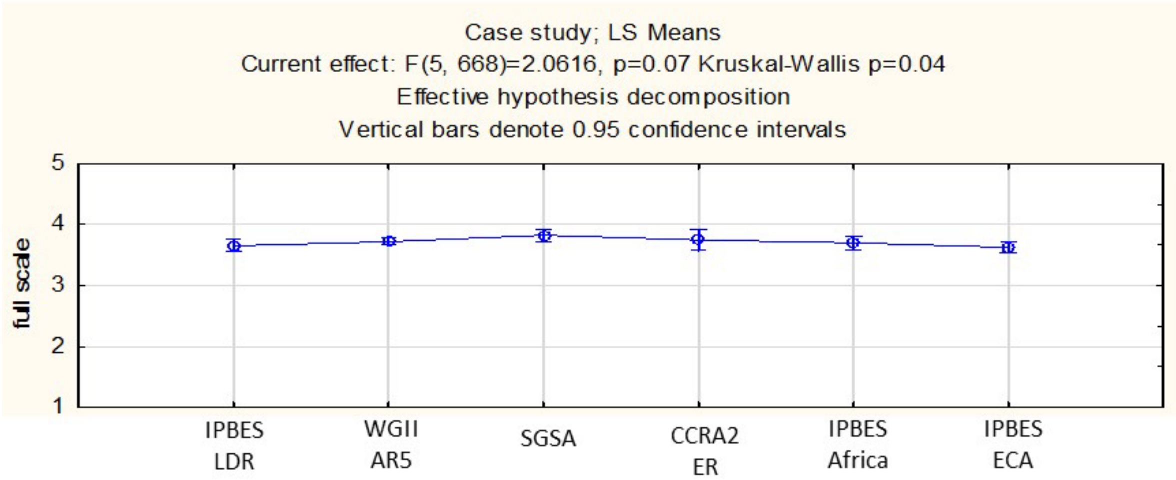


Figure 53: Lack of difference in cumulative case means across cases for overall CRELE–based effectiveness.

This is unsurprising since survey response patterns were very similar across the cases (Figure 54).

Figure 54: Similar response patterns across cases for survey statements 1 to 40. Replication across cases demonstrates a high reliability and the ability of the instrument to discriminate between signal and noise. This indicates that across a wide variety of contexts and countries, scientific assessments have a consistent and predictable set of attributes which explain the participant response patterns.

To test the results of the survey findings, qualitative data from the systematic review and semi-structured interviews were used to both explain the quantitative findings and act as a means of 'calibration' (Chapter 3). From these additional data sources – and considering the high degree of replication across the survey[140] – it was then possible to generate 'meta-inferences' of general scientific assessment effectiveness. In other words, a set of performance measures which can be safely assumed to replicate across most, if not all, scientific assessments (if they are undertaken within the prescribes of Chapter 2).

In order to validate the broad performance measures, the IPBES confidence framework (Chapter 3) was used to synthesise evidence from the different data sources (Chapters 4-7). In this framework, 'confidence' was seen as a product of expert agreement qualitatively multiplied by the quality and quantity of evidence. High confidence conveys extensive knowledge and the ability to explain an outcome with some certainty. Low confidence describes a situation of incomplete knowledge when an outcome cannot be fully explained. Using the framework, a summary of the evidence confidence levels was generated to demonstrate the extent of evidence across indicators and data sources for 1.) indicators determined to be *strengths* and 2.) indicators determined to be in *need of improvement* (Table 49).

Table 49: Confidence levels across data sources either supporting the *strength* or *needs improvement* hypothesis. WE = Well Established; EI = Established but incomplete; UN = Unresolved; IN = Inconclusive.

Indicator	**Data sources**		
	Survey	**Sys review**	**Interviews**
Evidence for indicator as a *strength*			
Multidisciplinarity	WE	UN	WE
Public & participant trust	WE	EI	EI
Usefulness for decision-making	WE	EI	EI
Iterative procedures	WE	WE	WE
Output quality	WE	EI	EI
Evidence that indicator *needs improvement*			
Co-production	WE	IN	IN
Human resources	WE	EI	IN
Financial resources	WE	WE	EI
Capacity building	WE	EI	EI
Media & public comms	WE	WE	EI
Stakeholder access	EI	UN	IN
Transdisciplinarity	WE	EI	IN

[140] In case study research, if >3 cases replicate across the same measures, this is usually considered sufficient to support confirmation of a hypothesis (Rowley, 2002).

Based on the evidence synthesis across sources and considering the definition of effectiveness[141], scientific assessments, across platforms and scales, are effective. Although it is noted that effectiveness does differ across indicators, with some areas of performance showing consistent strengths (**high** confidence), while others show a need for improvement (**moderate** to **high** confidence) (Figure 55).

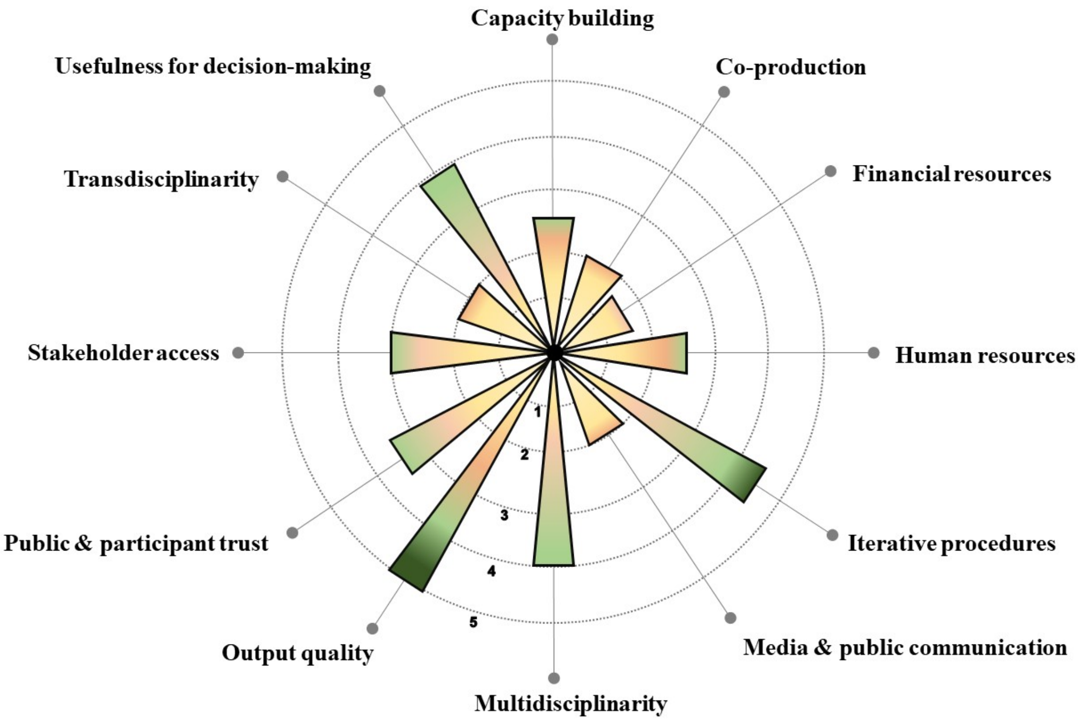


Figure 55: Synthesis, across evidence sources, of the contribution of various indicators to the effectiveness of scientific assessments, where 5 is most effective and 1 is least effective. Specific areas of strength include the ability to engage multidisciplinary teams in iterative knowledge production procedures in a transparent way, producing high-quality scientific outputs which policymakers generally find useful and which garner a high degree of stakeholder trust. Specific areas in which there is scope for improvement include the adequate planning of financial and human resources, taking note of 'assessment fatigue' and the need for future capacity building; the integration of non-academic knowledge systems or 'transdisciplinarity'; the provision of more co-production opportunities between experts, policymakers and stakeholders; and the need for innovative public communication and media strategies.

[141] The definition used for 'effective' is outlined in Chapter 3, in summary, scientific assessments are considered effective when they *"...facilitate interaction processes between science, policy and stakeholders in such a way as to meet the needs and expectations of participants, foster the integration of science in decision-making, and generally exert an influence on both SPI participants and other target audiences"* (Sarkki *et al.*, 2014).

Based on the synthesis, specific areas of scientific assessment strength include:

1. **Multidisciplinarity**: In spite of some social science literature critical of scientific assessment multidisciplinarity, there was *well established* evidence from the survey and interviews that concerted efforts to engage a diversity of academic knowledge domains had been made across all cases with the successful implementation thereof. Independent quantitative analyses undertaken using the Science-Metrix team diversity widget supported this finding (**high** confidence).
2. **Public and participant trust**: There was *well established* evidence from the survey and *established but incomplete* evidence from the systematic review and interviews that all cases attracted a high degree of public and participant trust. Generally, people believe that scientific assessments are designed in a transparent manner and implemented in 'good faith'. Success in establishing trust stems from the structure and procedures inherent to scientific assessment such as balanced multi-author teams, independent peer review, document review transparency etc. Over the years, well-known platforms like the IPCC have garnered an indisputable public trust across broad sectors of society (**high** confidence).
3. **Usefulness for decision-making**: There was *well established* evidence from the survey and *established but incomplete* evidence from the systematic review and interviews that scientific assessment outputs are useful for policymakers. But their usefulness is limited by the spatial scale of analysis. In other words, global assessments are most useful for global agreements, national assessments are most useful for national policies and regulations (**high** confidence).
4. **Iterative procedures**: There was *well established* evidence across the surveys, systematic reviews and interviews that the multi-stakeholder, multi-stage review loops built into scientific assessment offer an exceptionally high level of content development iterativity (**high** confidence).
5. **Output quality:** There was *well established* evidence from the survey and *established but incomplete* evidence from the systematic review and interviews that a high quality of knowledge output, in various forms (Table 47), is one of the core features of modern scientific assessments (**high** confidence).

Specific areas which show a need for improvement are:

1. **Co-production**: There was *well established* evidence from the survey that while there do exist protocols for co-production (such as SPM drafting sessions), participants do see the opportunities for engagement with policymakers as being underexploited. The primary reason for this is the tendency to focus engagement right at the inception of a process and then again, only right at the

conclusion. Some suggestions for improving this are presented in the literature, one being to include more policymakers in writing teams (**moderate** confidence).

2. **Financial resources**: There was *well established* evidence from the survey and systematic review and e*stablished but incomplete* evidence from the interviews that financial resource stress is a substantial concern to many scientific assessment participants. Specific areas of concern relate to the financial sustainability of current and future assessment platforms, as well as the non-remuneration of expert time and disbursements leading to more dropouts of top experts. The primary means for raising more funds is to extend working relationships with the private sector, something IPBES has already achieved successfully (**high** confidence).
3. **Human resources:** There was *well established* evidence from the survey and *established but incomplete* evidence from the systematic review that ‘assessment fatigue’ is a real phenomenon, for experts, TSU staff and stakeholders. This is likely to grow with the increasing frequency of scientific assessments globally and, more so now, nationally. The risk is that the novelty of this ‘type’ of knowledge-policy process may wear off if participants find themselves dedicating too large a chunk of their careers contributing to them. This may make it more challenging to attract the best experts in the future. There is broad agreement across evidence sources that commissioning politically salient scientific assessments (a fully mandated ‘authorising environment’) is the primary means of attracting interest from the knowledge community (**high** confidence).
4. **Capacity building:** There was *well established* evidence from the survey and e*stablished but incomplete* evidence from the systematic review that more emphasis should be dedicated toward capacity development of young experts and policymakers learning how to do scientific assessments, as well as by providing more participation opportunities to ‘marginalised’ groups. The term marginalised groups was deemed to imply participants from non-academic knowledge systems, experts from lower income countries and other stakeholders who struggled to access the cases either through lack of financial resources, educational background, language etc. Opportunities for increasing the scope and breadth of capacity development opportunities are highly contingent on the availability of financial resources (**high** confidence).
5. **Media & public communications**: There was *well established* evidence from the survey and systematic review and *established but incomplete* evidence from the interviews that while solid communications progress has been made over the years (specifically within the IPCC), media communication, more generally, is stunted by a lack of strategic direction and financial support. Other than the IPCC, none of the other cases made impressions upon the popular media and are still virtually unknown to the general public beyond the stakeholders who participate in them (**high** confidence).

6. **Stakeholder access**: There was some *established but incomplete* evidence that scientific assessments do generate some reasonably robust stakeholder access points, either through physical engagement opportunities like meetings, or virtual engagement opportunities like online information portals. Even so, the evidence assessed by and large indicate the presence of barriers to entry for many stakeholders (frequently as a result of inadequate funding and time constraints). This is reasonably easily addressed at the national scale through targeted outreach campaigns. At the global scale it might be necessary to think about more innovative means for wider stakeholder access. While this does create some restrictions based on technological access and connectivity, these restrictions are far less than the actual face-to-face meetings traditionally used for scientific assessments (**moderate** confidence).
7. **Transdisciplinarity:** There was *well established* evidence from the survey that while multidisciplinarity is a strength of scientific assessments, transdisciplinarity (in other words, using non-academic knowledge in union with traditional academic knowledge) is still emerging, conceptually and heuristically. Most recently, IPBES has played a leading role in the transdisciplinarity 'movement', certainly at the level of politically motivated intention, perhaps less so at the level of actual implementation. This is because the actual models and frameworks for 'doing' transdisciplinarity remain unexplored and rather vague (**moderate** confidence).

CHAPTER 8. CONCLUSIONS

8.1 Introduction

The purpose of this chapter is to use the evidence from Chapters 4-7 to build an argument addressing the two research questions.

8.2 Research question 1: Are scientific assessments effective?

A range of **high** confidence evidence across data sources has been presented to support the hypothesis that scientific assessments are effective knowledge-policy processes.

In support of this finding, the perspectives of 'clients' is commonly perceived as a good measure for performance evaluations. Using repeat business as a proxy measure for client satisfaction, scientific assessments must be considered highly effective. Policymakers have shown continued interested in the deployment of scientific assessments despite the high cost, elaborate and slow process, with somewhat uncontrollable outcomes. There have been over 150 scientific assessments undertaken globally since the late 1980s at an increasing frequency (Jabbour and Flachsland, 2017). An increasing number of national scientific assessments have also been commissioned in the United States (at state and national scale), the United Kingdom and South Africa (at national scale).

Some evidence (**moderate** to **high** confidence) has been presented which demonstrates obvious shortcomings in current scientific assessment practice. It must be borne in mind that this evaluation, along with others, compares the practice of scientific assessment against a theoretical 'best-case' – a 'council of perfection' so to speak, which may be unrealisable in any real world situation. This means that while it is easy to criticise scientific assessments measured against theoretical performance metrics, this critique does not necessarily support the hypothesis that scientific assessments are ineffective. In fact, there is very little evidence to support this hypothesis.

Rather, analyses such as this one must be seen as data points within a larger evolving picture – trying to piece together exactly what constitutes good knowledge-policy processes. This makes it necessary to highlight areas of insufficiency and make practical suggestions in the spirit of continual performance improvement. There seems to be good reason to believe that analyses such as this one will prove useful as scientific assessments have already demonstrated a capacity to be reflexive and evolve in response to feedback from the knowledge community (Vardy *et al.*, 2017).

This does not discount the fact that scientific assessment still faces challenges at the knowledge-policy interface. In the previous chapter these challenges were highlighted as the need for better planning of financial and human resources, taking note of ‘assessment fatigue’, while also building for the future by creating more innovative capacity development solutions. The integration of non-academic knowledge systems or ‘transdisciplinarity’, along with the provision of more co-production opportunities between experts, policymakers and stakeholders; and the need for better public communication and media strategies, have also revealed themselves as potential areas needing improvement.

It is acknowledged that the structure of the research undertaken in this thesis, and the evidence collected, does not allow definitive findings on two further questions: Are scientific assessments *more* effective than other forms of knowledge-policy generation; and are scientific assessments *more* cost-effective than other approaches?

However, some inferences can be made relative to both these reasonable questions. Given that all the cases scored highly for overall effectiveness across widely-ranging topics and respondents, it is reasonable to assume an above-average effectiveness by implicit comparison with cases where such approaches were not taken; and especially where no formal knowledge-policy process was involved.

With respect to cost-effectiveness (how much effectiveness you get for the price), I point out that while the apparent cost is high, it is not excessively high relative to the cost of doing new research, on the one hand, or making poorly-informed decisions on the other. It is acknowledged that the full costs of scientific assessments are not reflected in their budgets (due to the non-remunerated portion), but neither are the full costs of most other knowledge-policy processes.

The kind of complex, contested, technically dense issues for which scientific assessments are designed are on the increase in the modern world, rather than the reverse. If it is more firmly established that scientific assessments have been effective over the approximately three decades for which they have been practiced (~1990-2020), the question arises of whether they will remain effective in the 21st Century knowledge-production landscape?

On the knowledge production side, will they mitigate the impacts of knowledge oversupply, shoddy science, bias and the rise of extreme ideologies? On the knowledge dissemination side, will they be able to manage the ascending influence of post-truth politics, or the influence of popularity-based online algorithms, echo-chambers and click-bait media?

These are difficult questions, and I have only lightly touched on them in this research. Having said that, based on the structures and processes inherent to scientific assessment, there is no obvious reason suggesting that they would not be capable of navigating them in a reasonably productive fashion and perhaps they are among the best tools we have to do so. While scientific assessment may not be a perfect social technology, it is far more equipped for the challenges associated with problems in the 21st century than more conventional knowledge-policy processes (Kowarsch *et al.*, 2016).

From this point of departure, the primary question for future research is: In what directions do scientific assessments need to evolve to be maximally effective across the most success indicators possible while managing 21st century knowledge production challenges? As a starting point, this will require crafting mission statements and formally vetting project objectives at the outset of a scientific assessment process, making participants aware of inherent trade-offs between CRELE principles (Figure 9). This will enable the cogeneration of both generic and tailored performance measures, which will then support more refined effectiveness evaluations to guide continual improvement.

8.3 Research question 2: Will they be helpful in the South African context?

South Africa has a well-established knowledge-policy interface rooted within a resilient infrastructure (Stewart *et al.*, 2019). In the last 20 years, policymakers have been placed under increasing pressure to use evidence for decision-making (Godfrey, Funk and Mbizvo, 2010). This has been formally reflected at the highest levels of national planning (NPC, 2012).

Notwithstanding these positive drivers, South Africa still faces substantial challenges at its knowledge-policy interface, the primary one being a surplus of knowledge supply and a deficit in demand (Godfrey, Funk and Mbizvo, 2010). For this reason, it could be argued that a number of high profile, technically complicated and socially contested problems have been poorly managed. The most prominent example is the decision by government in the late 1990s to promote multivitamin treatments rather than antiviral drugs for the treatment of HIV (Goldacre, 2008).

Since then, over the last decade or so, several other issues have emerged and then risen sharply into the public consciousness, seemingly undirected by evidence. These include the proposed nuclear power generation programme; the imposition of e-tolls in the province of Gauteng, and South Africa's perennially vexatious 'Land Question'. The most recent example concerns the management of the COVID-19 pandemic, and the government's decision to implement one of the strictest 'lockdowns' anywhere in the world, at substantial social and economic cost.

Had these problems been assessed using a social technology similar to scientific assessment, would they have been resolved with greater consideration of multidisciplinary evidence[142]? It is not possible to answer affirmatively without detailed baseline and *post hoc* assessments of these issues (while a double-blind, randomised study to answer this question is unfeasible, and probably unethical). But perhaps a more relevant question is: Looking forward, can scientific assessments add value to the South African knowledge-policy interface in areas in which it is currently lacking?

A number of calls have been made for new knowledge production technologies to bridge the knowledge-policy gap – shifting the dial more toward the 'co-create' model, thereby opening up the possibility of collegial engagement rather than conflict (Von Der Heyden *et al*., 2016). The country is already in the process of developing new epistemic practices (Morrell, 2019) in response to an increasing number of calls for local solutions to local problems (Winberg, 2006). For these innovations to be effective, they will require political and scientific leadership to converge on what the agreed norms and methods of engagement will look like (Cronin & Sadan, 2015).

In part, some of these norms have already been established and tested in South Africa. The country has already demonstrated its ability to undertake sophisticated knowledge-policy processes on an *ad hoc* basis, in response to contested, complex issues (Kerley *et al*., 2019). Three or four (if you count the SAfMA) 'full-scale' scientific assessments have been undertaken so far, adopting practices such as integrated scoping exercises, diverse multi-author teams, representative project governance structures and transparent multi-loop review processes.

The scientific assessment of elephant management and its associated Norms & Standards published in 2008 have already demonstrated efficacy in reducing social contestation round the sensitive issue of elephant culling. The shale gas scientific assessment – the largest scientific assessment trialled so far in Africa – produced a government issued Decision-Support Tools report which initiated the drafting process of regulatory tools like Minimum Information Requirements which guide EIA processes.

[142] I do not necessarily mean a 'full-scale' scientific assessment process (which can take 2-4 years to complete), but targeted, derivative processes which borrows key principles from scientific assessment such as multidisciplinarity, two-loop review structures, evidence synthesis, policymakers summaries etc. These can be easily assembled and implemented with relatively rapid turnaround to policymakers.

The structure and processes of scientific assessment outlined in Chapter 2 make them adept to manage a wide variety of social issues, beyond only human-nature problems. While there have been some constraints to actually doing scientific assessments, Kerley *et al.* (2019) suggest they could add substantial value to the domestic knowledge-policy interface by functioning as 'synthesis centres'[143], which have become increasingly popular in countries supporting evidence-based decision-making. No synthesis centres currently operate in Africa, let alone South Africa. So there exists an obvious gap for these kinds of capacities and skills to support South Africa's commitment to making decisions based on evidence.

Since scientific assessments are adaptable in both their processes and structure they can be easily customised and focused, can operate as mobile processes and can be undertaken relatively inexpensively by comparison to the establishment and maintenance of dedicated brick-and-mortar institutions. Also, through their robust and transparent procedures, they offer the potential to increase policymaker accountability, in areas where government has been lacking in the last decade. In this way scientific assessments could offer a customised, focused, cost effective and trustworthy tool at the knowledge-policy interface (Kerley *et al.*, 2019), substantially advancing our current domestic capacity to effectively deal with 21st century problems.

In summary, based upon multiple lines of enquiry, I conclude that scientific assessments are effective knowledge-policy processes. With increasing political appetite, and more frequent use in the South African context, for the wicked, complicated and complex problems for which they are best suited, they would be a substantial improvement upon the 'test' model of knowledge-policy engagement that is usually applied.

[143] A synthesis centre is a dedicated unit or group that offers multidisciplinary knowledge syntheses of evidence on important social issues for policymakers and the wider decision-making public.

REFERENCES

Adler, C. E. and Hirsch Hadorn, G. (2014) 'The IPCC and treatment of uncertainties: Topics and sources of dissensus', *Wiley Interdisciplinary Reviews: Climate Change*, pp. 663–676. doi: 10.1002/wcc.297.

Agrawala, S. (1997) *Explaining the Evolution of the IPCC Structure and Process*. Vienna. Available at: www.iiasa.ac.at.

Agrawala, S. (1998) 'Context and early origins of the Intergovernmental Panel on Climate Change', *Climatic Change*, 39, pp. 605–620.

Alcamo, J. (2017) 'Evaluating the impacts of global environmental assessments', *Environmental Science and Policy*, 77, pp. 268–272. doi: 10.1016/j.envsci.2017.03.009.

ASC (2014) 'Invitation to tender for lead contributors for the UK Climate Change Risk Assessment Evidence Report'. London: Adpatation Sub-Committee of the Committee on Climate Change, pp. 1–16.

ASC (2016) *UK Climate Change Risk Assessment 2017 Synthesis report: priorities for the next five years*. London: Adaptation Sub-Committee (ASC) of the Committe on Climate Change. Available at: https://www.theccc.org.uk/publication/uk-climate-change-risk-assessment-2017/.

Ash, N. *et al.* (2010) *Ecosystems Human Well-Being A Manual for Assessment Practitioners*. Washington.

Aven, T. and Renn, O. (2015) 'An Evaluation of the Treatment of Risk and Uncertainties in the IPCC Reports on Climate Change', *Risk Analysis*, 35(4), pp. 701–712. doi: 10.1111/risa.12298.

Baker, M. and Penny, D. (2016) 'Is there a reproducibility crisis?', *Nature*, 533(7604), pp. 452–454. doi: 10.1038/533452A.

Balvanera, P. *et al.* (2017) 'Urgent need to strengthen the international commitment to IPBES', *Nature Ecology and Evolution*. doi: 10.1038/s41559-017-0197.

Barkemeyer, R. *et al.* (2015) 'Linguistic analysis of IPCC summaries for policymakers and associated coverage', *Nature Climate Change*, 6(3), pp. 311–316. doi: 10.1038/nclimate2824.

Beck, S. *et al.* (2014) 'Towards a reflexive turn in the governance of global environmental expertise the cases of the IPCC and the IPBES', *GAIA*, 23(2), pp. 80–87. doi: 10.14512/gaia.23.2.4.

Beck, S. and Mahony, M. (2018) 'The IPCC and the new map of science and politics', *Wiley Interdisciplinary Reviews: Climate Change*. Wiley-Blackwell. doi: 10.1002/wcc.547.

Biggs, D. *et al.* (2017) 'Elephant Conservation and ivory trade: Navigating taboo trade-offs', *Science*, 358(6369), pp. 1378–1381. doi: DOI: 10.1126/science.aan5215.

Biggs, R. *et al.* (2004) *Nature Supporting People: The Southern African Millennium Ecosystem Assessment*. Pretoria, South Africa: CSIR. Available at: https://www.millenniumassessment.org/documents_sga/SAfMA_Integrated_Report.pdf.

Black, R. (2015) 'No more summaries for wonks', *Nature Climate Change*, 5(4), pp. 282–284. doi: 10.1038/nclimate2534.

Bond, A. and Pope, J. (2012) 'The state of the art of impact assessment in 2012', *Impact Assessment and Project Appraisal*. doi: 10.1080/14615517.2012.669140.

Booker, C. (2018) *Global Warming: A case study in groupthink - GWPF Report 28*. London.

Borchardt, S. . (2016) *Honours Research Project - What are we SEA-ing? An exploration of the communication strategies and extent of public participation at the Strategic Environmental Assessment (SEA) public briefings for Shale Gas Development in the Karoo*. Stellenbosch. Available at: https://cosmopolitankaroo.co.za/wp-content/uploads/2017/04/Borchardt2c-S.P_18033849_Honours-Research-Project2c-Checked_2017.pdf.

Borie, M., Mahony, M. and Hulme, M. (2015) 'Somewhere between everywhere and nowhere: the institutional epistemologies of IPBES and the IPCC', *Resource Politics 2015*, (November 2016), p. 33. Available at: https://www.researchgate.net/publication/301850677.

Brick, C. *et al.* (2018) 'Winners and losers: communicating the potential impacts of policies', *Palgrave Communications*, 4(1), p. 69. doi: 10.1057/s41599-018-0121-9.

Bridgewater, P. and Schmeller, D. S. (2018) 'IPBES-6: the best plenary yet?', *Biodiversity and Conservation*, pp. 1–6. doi: 10.1007/s10531-018-1569-z.

Brocklehurst, T. (2004) 'The Globalising World: The Environment Movement', *Wiley*, pp. 188–225.

Brooks, T. M., Lamoreux, J. F. and Soberón, J. (2014) 'IPBES ≠ IPCC', *Trends in Ecology and Evolution*, pp. 543–545. doi: 10.1016/j.tree.2014.08.004.

Brown, K. *et al.* (2018) 'Turning risk assessment and adaptation policy priorities into meaningful interventions and governance processes', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376(20170303), pp. 1–8. doi: 10.1098/rsta.2017.0303.

Budescu, D. V. *et al.* (2014) 'The interpretation of IPCC probabilistic statements around the world', *Nature Climate Change*, 4(6), pp. 508–512. doi: 10.1038/nclimate2194.

Burkett, V. R. *et al.* (2014) 'Point of departure', in Field, C. . *et al*. (eds) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambride University Press, pp. 169–194. Available at: https://www.ipcc.ch/report/ar5/wg2/.

Burns, M., Audouin, M. and Weaver, A. (2006) 'Advancing sustainability science in South Africa', *South African Journal of Science*, (October), pp. 379–384.

Burton, R., Ronningen, K. and Wedderburn, L. (2008) *Conducting integrated research. A critical literature review of interdisciplinary and transdisciplinary research*.

Carey, M., James, L. C. and Fuller, H. A. (2014) 'A new social contract for the IPCC', *Nature Climate Change*, 4(12), pp. 1038–1039. doi: 10.1038/nclimate2442.

Carraro, C. *et al.* (2015) 'The IPCC at a crossroads: Opportunities for reform', *Science*, 350(6256), pp. 34–35. doi: 10.1126/science.aad3797.

Cash, D. *et al.* (2003) *Salience, Credibility, Legitimacy and Boundaries: Linking Research, Assessment and Decision Making*, *John F. Kennedy School of Government Harvard University Faculty Research Working Papers Series Salience,*. RWP02-046. Boston. doi: 10.2139/ssrn.372280.

Cash, D. and Clark, W. (2001) *From Science to Policy: Assessing the Assessment Process*. Boston. Available at: http://environment.harvard.edu/gea/.

CBD (2017) 'Multiscale, cross-sectoral scenarios for nature futures: The positive visions for biodiversity, ecosystem services and well-being', in *Subsidiary body on scientific, technical and technological advice 21st meeting Montreal, Canada, 11-14 December*. Montreal: Convention on Biological Diversity.

CCC (2010) 'Committee on Climate Change Framework Document', p. pp34.

CCC (2019) *Committee on Climate Change*. Available at: https://www.theccc.org.uk/ (Accessed: 10 September 2019).

Chan, G. *et al.* (2016) *Reforming the IPCC's Assessment of Climate Change Economics*, *Nota di Lavoro*. doi: 10.2139/ssrn.2743107.

Cochrane, K. L. (2017) 'An integrated view of fisheries: Tunnelling between silos', *ICES Journal of Marine Science*, 74(3), pp. 625–634. doi: 10.1093/icesjms/fsw198.

Connell, R. *et al.* (2018) 'Re-making the global economy of knowledge: do new fields of research change the structure of North–South relations?', *British Journal of Sociology*, 69(3), pp. 738–757. doi: 10.1111/1468-4446.12294.

Corbera, E. *et al.* (2016) 'Patterns of authorship in the IPCC Working Group III report', *Nature Climate Change*, 6(1), pp. 94–99. doi: 10.1038/nclimate2782.

Creswell, J. . and Poth, C. N. (2018a) 'Five Qualitative Approaches to Inquiry', in *Qualitative inquiry and research design: Choosing among fiveapproaches*. Fourth. Thousand Oaks, California: Sage.

Creswell, J. . and Poth, C. N. (2018b) 'Philosophical Assumptions and Interpretative Frameworks.', in *Qualitative inquiry and research design: Choosing among five approaches*. Fourth. Thousand Oaks: CA: Sage.

Cronin, G. . and Sadan, M. (2015) 'Use of evidence in policy making in South Africa: An exploratory study of attitudes of senior government officials', *Afr Eval J.*, 3(1), p. 10 pages. doi: http://dx.doi.org/10.4102/aej.v3i1.145.

Cvitanovic, C. (2015) *Four strategies for improving knowledge exchange among scientists and decision-makers*, *Research to Action: The Global Guide to Research Impact*. Available at: https://www.researchtoaction.org/2015/11/four-strategies-for-improving-knowledge-exchange-among-scientists-and-decision-makers/ (Accessed: 12 November 2018).

Cvitanovic, C. and Hobday, A. J. (2018) 'Building optimism at the environmental science-policy-practice interface through the study of bright spots', *Nature Communications*, 9(3466), pp. 1–5. doi: 10.1038/s41467-018-05977-w.

DEA (2017) *Strategic Environmental Assessment for Shale Gas Development in the Central Karoo Phase 3: Decision Support Tools Report.* Pretoria, South Africa. Available at: https://seasgd.csir.co.za/decision-support-tools/.

Department for Performance Monitoring and Evaluation (DPME) (2014) *Evidence for Policy Making and Implementation Workbook*. Pretoria, South Africa.

Devès, M. H. *et al.* (2017) 'Why the IPCC should evolve in response to the UNFCCC bottom-up strategy adopted in Paris? An opinion from the French Association for Disaster Risk Reduction', *Environmental Science and Policy*, 78, pp. 142–148. doi:

10.1016/j.envsci.2017.10.001.

Devès, M. H. *et al.* (2018) 'Rethinking IPCC Expertise from a Multi-actor Perspective', in *Communicating Climate Change Information for Decision-Making*, pp. 49–63. doi: 10.1007/978-3-319-74669-2_4.

Díaz-Reviriego, I. *et al.* (2017) *Five years of IPBES-reflecting the achievements and challenges and identifying needs for its review towards a 2 nd work programme Workshop report*. Leipzig, Germany. Available at: https://www.researchgate.net/publication/325119671_Five_years_of_IPBES-reflecting_the_achievements_and_challenges_and_identifying_needs_for_its_review_towards_a_2_nd_work_programme.

Díaz-Reviriego, I., Turnhout, E. and Beck, S. (2019) 'Participation and inclusiveness in the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services', *Nature Sustainability*. doi: 10.1038/s41893-019-0290-6.

Diaz, S. *et al.* (2015) 'The IPBES Conceptual Framework — connecting nature and people', *Current Opinion in Environmental Sustainability*, 14(1), pp. 1–16. doi: 10.1016/j.cosust.2014.11.002.

Díaz, S. *et al.* (2018) 'An inclusive approach to assess nature's contributions to people', *Science*. doi: 10.1126/science.aap8826.

Doukas, H. *et al.* (2018) 'From integrated to integrative: Delivering on the paris agreement', *Sustainability (Switzerland)*, 10(7). doi: 10.3390/su10072299.

Drouet, L., Bosetti, V. and Tavoni, M. (2015) 'Selection of climate policies under the uncertainties in the Fifth Assessment Report of the IPCC', *Nature Climate Change*, 5(10), pp. 937–943. doi: 10.1038/nclimate2721.

DST (2018) *Draft White Paper on Science, Technology and Innovation.* Pretoria, South Africa. Available at: www.dst.gov.za.

Dunn, G. and Laing, M. (2017) 'Policy-makers perspectives on credibility, relevance and legitimacy (CRELE)', *Environmental Science and Policy*. Elsevier, 76(July), pp. 146–152. doi: 10.1016/j.envsci.2017.07.005.

Edenhofer, O. and Kowarsch, M. (2012) *A Pragmatist Concept of Scientific Policy Advice Introduction : The need for reflecting science-policy models*. doi: 10.1016/j.copbio.2014.11.001.

Eide, E. (2017) 'Scientists, Communication and the Space of Global Media Attention', in Risto Kunelius, Elisabeth Eide, Matthew Tegelberg, D. Y. (ed.) *Media and Global Climate Knowledge: Journalism and the IPCC*. First. New York: Springer Nature, pp. 33–57. doi: 10.1057/978-1-137-52321-1_2.

El-Hinnawi, E. (2011) 'Invited Editorial - The intergovernmental panel on climate change and developing countries', *Environmentalist*, 31(3), pp. 197–199. doi: 10.1007/s10669-011-9312-2.

Van Enst, W. I., Driessen, P. P. J. and Runhaar, H. A. C. (2014) 'Towards Productive Science-Policy Interfaces: A Research Agenda', *Journal of Environmental Assessment Policy and Management*, 16(1), pp. 1–25. doi: 10.1142/S1464333214500070.

Esguerra, A., Beck, S. and Lidskog, R. (2017) 'Stakeholder engagement in the making: IPBES legitimization politics', *Global Environmental Politics*. MIT Press Journals, 17(1), pp. 59–76. doi: 10.1162/GLEP_a_00390.

Farrell, A. E. and Jäger, J. (2006) *Assessments of Regional and Global Environmental Risks.* Washington D.C.: Resources for the Future.

Feynman, R. (1998) *The Meaning of It All*. Reading, MA: Perseus.

Fløttum, K., Gasper, D. and St. Clair, A. L. (2016) 'Synthesizing a policy-relevant perspective from the three IPCC "Worlds"-A comparison of topics and frames in the SPMs of the Fifth Assessment Report', *Global Environmental Change*, 38, pp. 118–129. doi: 10.1016/j.gloenvcha.2016.03.007.

Ford, J. D. *et al.* (2016) 'Including indigenous knowledge and experience in IPCC assessment reports', *Nature Climate Change*, pp. 349–353. doi: 10.1038/nclimate2954.

Ford, J. D., Vanderbilt, W. and Berrang-Ford, L. (2012) 'Authorship in IPCC AR5 and its implications for content: Climate change and Indigenous populations in WGII', *Climatic Change*, 113(2), pp. 201–213. doi: 10.1007/s10584-011-0350-z.

Forsell, N. (2016) 'The SSP-RCP scenarios and their use for forest sector outlooks', in *Streamlining the next round of Forest Sector Outlook Studies*. 12th – 13th of December, 2016, Pushkino, Russia: International Institute for Applied System Analysis. Available at: https://www.unece.org/fileadmin/DAM/timber/meetings/20161212/12-similar-shared-socioeconomic-pathways-for-economic-developments.pdf.

Frost, J. and Osterloh, M. (2001) 'Dialogue Devices : Bridging between " Mode 1 " and " Mode 2 " Knowledge Production', in *Paper Presented at the 1st International and Interdisciplinary Symposium on Communication in Organizations.* Mannheim, pp. 1–14. Available at: https://dimitris.apeiro.gr/files/papers/STS/Frost&Osterloh_Bridging_Mode1_Mode2.pdf.

Funtowicz, S., Ravetz, J. and O'Connor, M. (1998) 'Challenges in the use of science for sustainable development', *International Journal of Sustainable Development*, 1(1), pp. 99–107.

Garard, J. and Kowarsch, M. (2017) 'If at first you don't succeed: Evaluating stakeholder engagement in global environmental assessments', *Environmental Science and Policy*, 77. doi: 10.1016/j.envsci.2017.02.007.

Gay-Antaki, M. and Liverman, D. (2018) 'Climate for women in climate science: Women scientists and the Intergovernmental Panel on Climate Change', *Proceedings of the National Academy of Sciences*, 115(9), pp. 2060–2065. doi: 10.1073/pnas.1710271115.

Geden, O. (2015) 'Climate advisers must maintain integrity', *Nature Comment*, 521, pp. 1–2.

Gibbons, M. *et al.* (1994) *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: Sage.

Gluckman, P. (2018) 'Science advice , public policy and the post-truth dynamic', in *Address to Global Evaluation and Implementation Summit*. Melbourne: International Network for Government Science Advice, pp. 1–10. Available at: https://www.ingsa.org/wp-content/uploads/2018/10/Peter-Gluckman-Address-to-GEIS-Oct-2018.pdf.

Gluckman, P. (2019a) 'Expanding the Diplomatic Toolkit: the Further Evolution of Science Diplomacy', in *Presentation at Wolfson College, Oxford*. Oxford, United Kingdom.

Gluckman, P. (2019b) 'The future of science Text of an address given on the occasion of Jerry Ravetz's 90', in *Text of an address given on the occasion of Jerry Ravetz's 90th birthday*. Available at: https://www.scipods.org/address-jerry-ravetzs-90th-birthday/.

Gluckman, P. (2019c) 'The principles of science advice and understanding risk within that context', in. Vilnius: International Network of Government Science Advice. Available at: https://www.ingsa.org/wp-content/uploads/2019/06/Principles-of-Science-Advice-Understanding-Risk-within-that-Context.pdf.

Gluckman, P. (2020) ‘Speech at the official launch of Koi Tū: the Centre for Informed Futures’. University of Auckland, pp. 1–3.

Godfrey, L., Funk, N. and Mbizvo, C. (2010) ‘Bridging the science-policy interface: A new era for South African research and the role of knowledge brokering’, *South African Journal of Science*, 106(5–6), pp. 1–8. doi: 10.4102/sajs.v106i5/6.247.

Goldacre, B. (2008) *Bad Science*. London: Fourth Estate.

Google (2019) *Google Trends*, *Google*. Available at: https://trends.google.com/trends/?geo=US (Accessed: 4 October 2019).

Graham, I. D. and Tetroe, J. . (2009) ‘Theories of Knowledge to Action: Planned Action Theories’, in Straus, S., Tetroe, J. M., and Graham, I. . (eds) *Knowledge Translation in Health Care Moving from Evidence to Practice*. London: Wiley-Blackwell.

Granjou, C. *et al.* (2013) ‘Assessing Nature? The Genesis of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)’, *Science, Technology and Society*, 18(1), pp. 9–27. doi: 10.1177/0971721813484232.

Gray, I. *et al.* (2013) *Mapping IPCC dynamics*, *Sciences Po, Media Lab*. Available at: http://www.medialab.sciences-po.fr/ipcc/.

Griggs, D. (2014) ‘Streamline IPCC reports’, *Nature Comment*, 508, pp. 171–173.

Guetterman, T. C. (2017) ‘Designing a rigorous mixed methods research study’, *Journal of Qualitative Research*, 18(1), pp. 1–16. Available at: http://www.qualitative.or.kr.

Gustafsson, K. M. (2018) ‘Producing expertise: The intergovernmental science-policy platform on biodiversity & ecosystem services’ socialisation of young scholars’, *Journal of Integrative Environmental Sciences*, 15(1). doi: 10.1080/1943815X.2018.1439509.

Gustafsson, K. M. and Lidskog, R. (2018) ‘Organizing international experts: IPBES’s efforts to gain epistemic authority’, *Environmental Sociology*, 4(4). doi: 10.1080/23251042.2018.1463488.

Haas, P. M. (2017) ‘The epistemic authority of solution-oriented global environmental assessments’, *Environmental Science and Policy*, 77. doi: 10.1016/j.envsci.2017.03.013.

Hanssen, F. *et al.* (2014) *Capacity building for Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES)*, *Final report 2014: Indo- Norwegian pilot project on capacity building in biodiversity informatics for enhanced decision making, improved nature conservation and sustainable development.* doi: 10.5281/zenodo.999027.

Harris, F. and Lyon, F. (2014) *Transdisciplinary environmental research: a review of approaches to knowledge co-production*, *Nexus Network Think Piece Series*. Available at: http://www.thenexusnetwork.org/wp-content/uploads/2014/08/Harris-and-Lyon_pg.pdf.

Harris, J. and Kotiaho, J. S. (2018) ‘Biodiversity: how old is each coinage?’, *Nature*, p. 39. doi: 10.1038/d41586-018-06891-3.

Hausfather, Z. (2018) ‘Explainer: How “Shared Socioeconomic Pathways” explore future climate change’, *The Conversation*, April. Available at: https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change.

Hawkins, S., Míriam, D. Y. and Dixon, J.-T. T. (2018) *Hidden Tribes: A Study of America's Polarized Landscape*. New York: More in Common. Available at: www.accurat.it.

Heink, U. *et al.* (2015) 'Conceptualizing credibility, relevance and legitimacy for evaluating the effectiveness of science-policy interfaces: Challenges and opportunities', *Science and Public Policy*, 42(5), pp. 676–689. doi: 10.1093/scipol/scu082.

Hel, S. Van Der and Biermann, F. (2017) 'The authority of science in sustainability governance : A structured comparison of six science institutions engaged with the Sustainable Development Goals', *Environmental Science and Policy*. Elsevier, 77(July 2016), pp. 211–220. doi: 10.1016/j.envsci.2017.03.008.

Hessels, L. K. and van Lente, H. (2008) 'Re-thinking new knowledge production: A literature review and a research agenda', *Research Policy*, 37(4), pp. 740–760. doi: 10.1016/j.respol.2008.01.008.

Heubach, K. and Lambini, C. K. (2018) 'Distribution and selection of experts in the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES): the case of the regional assessment for Africa', *Innovation*, 31, pp. S61–S77. doi: 10.1080/13511610.2017.1377601.

Von Der Heyden, S. *et al.* (2016) 'Science to policy – Reflections on the South African reality', *South African Journal of Science*, 112(11), pp. 1–6.

Hickman, L. (2015) 'The IPCC in an age of social media', *Nature Climate Change*, pp. 284–286. doi: 10.1038/nclimate2528.

Higgins, K. (2016) 'Post-truth: a guide for the perplexed', *Nature Worldview*, 540, p. 9. doi: 10.1038/540009a.

Ho-Lem, C., Zerriffi, H. and Kandlikar, M. (2011) 'Who participates in the Intergovernmental Panel on Climate Change and why: A quantitative assessment of the national representation of authors in the Intergovernmental Panel on Climate Change', *Global Environmental Change*, 21(4), pp. 1308–1317. doi: 10.1016/j.gloenvcha.2011.05.007.

Hochkirk, A., McGowan, P. J. K. and van der Sluijs, J. (2014) 'Hochkirch, 2014', *Nature*, 517, p. 170.

Hof, C. *et al.* (2016) 'Macroecology meets IPBES', *Frontiers of Biogeography*, 7(4). doi: 10.21425/f5fbg28888.

Hof, C. *et al.* (2017) 'It's not (all) about the money — supporting IPBES through challenging times', *Frontiers of Biogeography*, 9(1). doi: 10.21425/F59134700.

Hollin, G. J. S. and Pearce, W. (2015) 'Tension between scientific certainty and meaning complicates communication of IPCC reports', *Nature Climate Change*, 5(8), pp. 753–756. doi: 10.1038/nclimate2672.

Horton, P. and Brown, G. W. (2018) 'Integrating Evidence, Politics and Society: A Methodology for the Science–Policy Interface', *Ssrn*. Springer US, pp. 1–5. doi: 10.1057/s41599-018-0099-3.

Hotes, S. and Opgenoorth, L. (2014) 'Trust and control at the science-policy interface in IPBES', *BioScience*, 64(4), pp. 277–278. doi: 10.1093/biosci/biu019.

van den Hove, S. (2007) 'A rationale for science-policy interfaces', *Futures*, 39(7), pp. 807–826. doi: 10.1016/j.futures.2006.12.004.

Howarth, C. *et al.* (2017) 'Enhancing the contribution and role of practitioner knowledge in the Intergovernmental Panel on Climate Change (IPCC) Working Group (WG) II process: Insights from UK workshops', *Climate Services*, 5, pp. 3–10. doi: 10.1016/j.cliser.2017.04.003.

Howarth, C. *et al.* (2018) 'Co-producing UK climate change adaptation policy: An analysis of the 2012 and 2017 UK Climate Change Risk Assessments', *Environmental Science and Policy*, 89, pp. 412–420. doi: 10.1016/j.envsci.2018.09.010.

Howarth, C. and Painter, J. (2016) 'Exploring the science–policy interface on climate change: The role of the IPCC in informing local decision-making in the UK', *Palgrave Communications*, 2. doi: 10.1057/palcomms.2016.58.

Hughes, H. R. and Paterson, M. (2017) 'Narrowing the Climate Field: The Symbolic Power of Authors in the IPCC's Assessment of Mitigation', *Review of Policy Research*, 34(6), pp. 744–766. doi: 10.1111/ropr.12255.

Hulme, M. (2010) 'IPCC: Cherish it, tweak it or scrap it?', *Nature Opinion*, 463, pp. 730–732.

Hulme, M. *et al.* (2011) 'Science-policy interface: Beyond assessments', *Science*, pp. 697–698. doi: 10.1126/science.333.6043.697.

Hulme, M. and Mahony, M. (2010) 'Climate change: What do we know about the IPCC?', *Progress in Physical Geography*, 34(5), pp. 705–718. doi: 10.1177/0309133310373719.

Humphrey, K. *et al.* (2016) 'Chapter 1: Introduction.', in *UK Climate Change Risk Assessment 2017: Evidence Report*. London: Adaptation Sub-Committee of the Committee on Climate Change., p. 71.

IAC (2010) *Climate change assessments: Review of the processes and procedures of the IPCC*. Amsterdam. Available at: www.interacademycouncil.net.

IAP Workgroup (2019) *Improving Scientific Input to Global Policymaking: with a focus on the UN SustainableDevelopment Goals*.

IOG (2019) *The complexity of Governance is difficult to capture in a simple definition.*, *Institute on Governance*. Available at: https://iog.ca/what-is-governance/ (Accessed: 14 June 2019).

IPBES (2012) *Functions, operating principles and institutional arrangements of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.*

IPBES (2016) 'Summary for Policymakers of the Methodological Assessment Report of IPBES on scenarios and models of biodiversity and ecosystem services', in Ferrier, S. *et al*. (eds) *Methodological assessment of scenarios and models of biodiversity and ecosystem services of the IPBES*. Bonn: IPBES. Available at: https://ipbes.net/system/tdf/downloads/pdf/spm_deliverable_3c_scenarios_20161124.pdf?file=1&type=node&id=15245.

IPBES (2018a) *The IPBES Assessment Guide Summary*. Bonn. Available at: https://www.ipbes.net/system/tdf/180719_ipbes_assessment_guide_summary_hi-res.pdf?file=1&type=node&id=28499.

IPBES (2018b) *The IPBES assessment report on land degradation and restoration.* Edited by L. Montanarella, R. Scholes, and A. Brainich. Bonn: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

IPBES (2018c) *The IPBES regional assessment report on biodiversity and ecosystem services for*

Africa. Edited by E. Archer *et al*. Bonn: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Available at: https://www.ipbes.net/assessment-reports.

IPBES (2018d) *The IPBES regional ecosystem service assessment report on biodiversity and ecoices for Europe and Central Asia.* Edited by M. Rounsevell *et al*. Bonn: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Available at: https://www.ipbes.net/guide-production-assessments.

IPBES (2019a) 'Review of the effectiveness of the administrative and scientific functions at the Platform 7th session Paris, 29 April–4 May 2019'. Paris: IPBES, pp. 1-12pp. doi: 10.2750/arp.36.13.

IPBES (2019b) *Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*.

IPBES (2020) *IPBES news*. Available at: https://ipbes.net/news (Accessed: 31 March 2020).

IPCC (1998) *"Principles governing IPCC work", adopted at the fourteenth session in Vienna in October 1998.* Available at: https://www.ipcc.ch/site/assets/uploads/2018/09/ipcc-principles.pdf (Accessed: 16 August 2019).

IPCC (2004) 'WHO is WHO in the IPCC'. Bonn: United Nations Environment Programme, pp. 1–4.

IPCC (2012) 'Summary for Policymakers', in Field, C. . *et al*. (eds) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press, pp. 1–19.

IPCC (2014a) 'Summaries, Frequently Asked Questions, and Cross-Chapter Boxes. A Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change', in Field, C. . *et al*. (eds) *Climate Change 2014: Impacts, Adaptation, and Vulnerability.* Geneva: WMO, p. 190pp. Available at: https://www.ipcc.ch/report/ar5/wg2/.

IPCC (2014b) 'Summary for policymakers', in Field, C. . *et al*. (eds) *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, pp. 1–32. Available at: https://www.ipcc.ch/report/ar5/wg2/.

IPCC (2014c) *Working Group II Questions about the Report*. Available at: https://www.ipcc.ch/site/assets/uploads/2018/03/IPCC_WG2AR5_Questions.pdf.

IPCC (2019) *Working Group II, Impacts, Vulnerability and Adaptation*, *Intergovernmental Panel on Climate Change*. Available at: http://www.ipcc-wg2.org (Accessed: 29 August 2019).

Jabbour, J. and Flachsland, C. (2017) '40 years of global environmental assessments: A retrospective analysis', *Environmental Science and Policy*, 77, pp. 193–202. doi: 10.1016/j.envsci.2017.05.001.

Jasanoff, S. and Martello, M. (2004) *Earthly Politics : Local and Global in Environmental Governance*. The MIT Press.

Jay, S. *et al.* (2007) 'Environmental impact assessment: Retrospect and prospect', *Environmental Impact Assessment Review*, 27(4), pp. 287–300. doi: 10.1016/j.eiar.2006.12.001.

Jeschke, J. M. *et al.* (2019) 'Knowledge in the dark: Scientific challenges and ways forward', *Facets*, 2019(4), pp. 423–441. doi: 10.1139/facets-2019-0007.

Jetzkowitz, J. *et al.* (2018) 'The significance of meaning. Why IPBES needs the social sciences and humanities', *Innovation*. Taylor & Francis, 31, pp. S38–S60. doi: 10.1080/13511610.2017.1348933.

Kenter, J. O. (2018) 'IPBES: Don't throw out the baby whilst keeping the bathwater; Put people's values central, not nature's contributions', *Ecosystem Services*, pp. 40–43. doi: 10.1016/j.ecoser.2018.08.002.

Kerley, G. *et al.* (2017) 'Livestock predation in South Africa: The need for and value of a scientific assessment.', *S Afr J Sci.*, 113(3/4). Available at: http://dx.doi.org/10.17159/sajs.2017/a0198.

Kerley, G. I. H. *et al.* (2019) 'Building assessment practice and lessons from the scientific assessment on livestock predation in South Africa', *South African Journal of Science*, 115(5), pp. 4–7.

Kerley, G., Wilson, S. and Balfour, D. (2018) *Livestock Predation and its Management in South Africa : A Scientific Assessment*. Port Elizabeth: Nelson Mandela University. Available at: https://predsa.mandela.ac.za/.

Klein, J. T. *et al.* (2001) 'Transdisciplinarity: joint problem solving among science, technology, and society. An effective way for managing complexity', in *Transdisciplinarity: joint problem solving among science, technology, and society. Proceedings of the International Transdisciplinarity 2000 conference (Zurich: Haffmans sachbuch Verlag, 2000)*. doi: 10.1007/978-3-0348-8419-8.

Klenk, N. and Meehan, K. (2015) 'Climate change and transdisciplinary science: Problematizing the integration imperative', *Environmental Science and Policy*, 54, pp. 160–167. doi: 10.1016/j.envsci.2015.05.017.

Kovács, E. K. and Pataki, G. (2016) 'The participation of experts and knowledges in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)', *Environmental Science and Policy*, 57, pp. 131–139. doi: 10.1016/j.envsci.2015.12.007.

Kowarsch, M. (2016) *A Pragmatist Orientation for the Social Sciences in Climate Policy*. doi: 10.1007/978-3-319-43281-6.

Kowarsch, M. *et al.* (2016) 'Scientific assessments to facilitate deliberative policy learning', *Palgrave Communications*, 2. doi: 10.1057/palcomms.2016.92.

Kowarsch, M. and Jabbour, J. (2017) 'Solution-oriented global environmental assessments: Opportunities and challenges', *Environmental Science and Policy*, pp. 187–192. doi: 10.1016/j.envsci.2017.08.013.

Kunelius, R. and Yagodin, D. (2017) 'Attention, Access and the Global Space of Interpretation: Media Dynamics of the IPCC AR5 Launch Year', in Risto Kunelius, Elisabeth Eide, Matthew Tegelberg, D. Y. (ed.) *Media and Global Climate Knowledge: Journalism and the IPCC*. First. New York: Springer Nature, pp. 59–80. doi: 10.1057/978-1-137-52321-1_3.

Lacey, J. *et al.* (2018) 'Understanding and managing trust at the climate science–policy interface', *Nature Climate Change*, 8(1), pp. 22–28. Available at: https://www.nature.com/articles/s41558-017-0010-z.

Langer, L. and Nduku, P. (2019) 'South Africa's "new dawn" should be built on evidence-based policy', *The Conversation*, June. Available at: https://theconversation.com/amp/southafricas-new-dawn-should-be-built-on-evidence-based-policy-118129?__twitter_impression=true.

Larigauderie, A. and Mooney, H. A. (2010) 'The Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services: Moving a step closer to an IPCC-like mechanism for biodiversity', *Current Opinion in Environmental Sustainability*, pp. 9–14. doi: 10.1016/j.cosust.2010.02.006.

Larigauderie, A., Stenseke, M. and Watson, R. . (2016) 'IPBES reaches out to social scientists', *Nature*, 532, p. 313.

Larivière, V., Gingras, Y. and Archambault, É. (2009) 'Brief communication the decline in the concentration of citations, 1900-2007', *Journal of the American Society for Information Science and Technology*, 60(4), pp. 858–862. doi: 10.1002/asi.21011.

Lindsay, J. A., Boghossian, P. and Pluckrose, H. (2018) 'Academic Grievance Studies and the Corruption of Scholarship', *Areo*, October. Available at: https://areomagazine.com/2018/10/02/academic-grievance-studies-and-the-corruption-of-scholarship/.

Ling, M. A. *et al.* (2015) *An Introduction to Environmental Assessment 2*.

Löfmarck, E. and Lidskog, R. (2017) 'Bumping against the boundary: IPBES and the knowledge divide', *Environmental Science and Policy*, 69, pp. 22–28. doi: 10.1016/j.envsci.2016.12.008.

Lubchenco, J. (2017) 'Environmental science in a post-truth world', *Frontiers in Ecology and the Environment*. doi: 10.1002/fee.1454.

Lundquist, C. J. *et al.* (2015) 'Engaging the conservation community in the IPBES process', *Conservation Biology*, 29(6), pp. 1493–1495. doi: 10.1111/cobi.12630.

Mach, K. and Field, C. B. (2017) 'Toward the Next Generation of Assessment', *Annual Review of Environment and Resources*, 42(18), pp. 18.1-18.29. doi: 10.1146/annurev-environ.

Mach, K. J. *et al.* (2016) 'A multistage crucible of revision and approval shapes IPCC policymaker summaries', *Science Advances*, 2(8). doi: 10.1126/sciadv.1600421.

MacMillan (2019) *MacMillan Dictionary*. Available at: https://www.macmillandictionary.com/dictionary/british/effectiveness (Accessed: 1 July 2019).

Marais, H. C. and Pienaar, M. (2010) 'Evolution of the South African Science , Technology and Innovation System 1994-2010 : An Exploration', *African Journal of Science, Technology, Innovation and Development*, 2(3), pp. 82–109.

Masood, E. (2018) 'Battle Over Biodiversity', *Nature New Feature*, 560, pp. 423–425. Available at: https://www.nature.com/articles/d41586-018-05984-3.

McKim, C. A. (2017) 'The value of mixed methods research: A mixed methods study', *Journal of Mixed Methods Research*, 11, pp. 202–222. doi: 10.1177/1558689815607096.

McKitrick, R. (2011) *What is Wrong With the IPCC? Proposals for Radical Reform*. London.

McMahon, R., Stauffacher, M. and Knutti, R. (2016) 'The scientific veneer of IPCC visuals', *Climatic Change*, 138(3–4), pp. 369–381. doi: 10.1007/s10584-016-1758-2.

MEA (2005) *Millennium Ecosystem Assessment (MEA) Ecosystems and human well-being: Current* *state and trends: Findings of the Condition and Trends Working Group*. Washington D.C: Island Press. Available at: http://www.unep.org/%0Amaweb/en/Global.aspx.

Miller, C. A. and Wyborn, C. (2018) 'Co-production in global sustainability: Histories and theories', *Environmental Science and Policy*, (June 2017). doi: 10.1016/j.envsci.2018.01.016.

Minx, J. C. *et al.* (2017) 'Learning about climate change solutions in the IPCC and beyond', *Environmental Science and Policy*, 77, pp. 252–259. doi: 10.1016/j.envsci.2017.05.014.

Mitchell, R. . *et al.* (2006) *Global environmental assessments: information and influence*. MIT Press.

Monroy, P. (2017) *Call for volunteers and in-kind support for the IPBES-6 stakeholder day and IPBES-6 Plenary*, *FutureEarth Open Network*. Available at: https://network.futureearth.org/communities/community-home/digestviewer/viewthread?GroupId=13&MessageKey=6546255d-8118-44a4-ba8b-eac9d5843704&CommunityKey=d7962aaa-f3a9-4ae2-8cae-71fe4d69c7e3&tab=digestviewer (Accessed: 14 November 2019).

Montana, J. (2016) *How IPBES Works: The Functions, Structures and Processes of the Intergovernmental Platform on Biodiversity and Ecosystem Services*, *SSRN*. doi: 10.2139/ssrn.2778701.

Montana, J. and Borie, M. (2016) 'IPBES and Biodiversity Expertise: Regional, Gender, and Disciplinary Balance in the Composition of the Interim and 2015 Multidisciplinary Expert Panel', *Conservation Letters*, 9(2), pp. 138–142. doi: 10.1111/conl.12192.

Morgan, E. (2014) 'Science in sustainability: A theoretical framework for understanding the science-policy interface in sustainable water resource management', *International Journal of Sustainability Policy and Practice*, 9(2), pp. 37–54. doi: 10.18848/2325-1166/CGP/v09i02/55421.

Morin, J. F. *et al.* (2017) 'Boundary organizations in regime complexes: A social network profile of IPBES', *Journal of International Relations and Development*, 20(3), pp. 543–577. doi: 10.1057/s41268-016-0006-8.

Morrell, R. (2019) 'The global South is changing how knowledge is made, shared and used', *The Conversation*, March, pp. 1–3. Available at: https://theconversation.com/the-global-south-is-changing-how-knowledge-is-made-shared-and-used-113943.

Nakashima, D. (2015) *Local and indigenous knowledge at the science–policy interface*, *Revue d'ethnoécologie*. doi: 10.4000/ethnoecologie.2229.

Nature (2015) 'Editorial: The IPCC news circuit', *Nature Climate Change*, pp. 281–281. doi: 10.1038/nclimate2603.

Nielsen, W. *et al.* (2017) 'Gender diversity leads to better science', *PNAS*, 114(8), pp. 1740–1742. doi: 10.1073/pnas.1703146114.

Noor, K. B. M. (2008) 'Case study: A strategic research methodology', *American Journal of Applied Sciences*, pp. 1602–1604. doi: 10.3844/ajassp.2008.1602.1604.

NPC (2012) *National Development Plan 2030 (NDP 2030) Available at*. Pretoria. Available at: https://www.poa.gov.za/news/Documents/NPC National Development Plan Vision 2030 -lo-res.pdf.

NRC (2007) *Analysis of global change assessments:Lessons learned*. Washington, D.C.: The National Academies Press. doi: https://dx.doi.org/10.1159/000365353.

O'Neill, B. C. *et al.* (2017) 'IPCC reasons for concern regarding climate change risks', *Nature Climate Change*, 7(1), pp. 28–37. doi: 10.1038/nclimate3179.

O'Neill, S. *et al.* (2015) 'Dominant frames in legacy and social media coverage of the IPCC Fifth Assessment Report', *Nature Climate Change*, 5(4), pp. 380–385. doi: 10.1038/nclimate2535.

Obermeister, N. (2018) 'Local knowledge , global ambitions : IPBES and the advent of multi- scale models and scenarios', *Sustainability Science*. Springer Japan, 8. doi: 10.1007/s11625-018-0616-8.

Okahana, H. and Zhou, E. (2018) *Graduate Enrollment and Degrees: 2007 to 2017*. Washinton DC. Available at: https://cgsnet.org/ckfinder/userfiles/files/CGS_GED17_Report.pdf.

Okereke, C. (2017) 'A six-component model for assessing procedural fairness in the Intergovernmental Panel on Climate Change (IPCC)', *Climatic Change*, 145(3–4), pp. 509–522. doi: 10.1007/s10584-017-2106-x.

Oliver, K. and Cairney, P. (2019) 'The dos and don'ts of influencing policy: a systematic review of advice to academics', *Palgrave Communications*. Springer US, 5(1), p. 21. doi: 10.1057/s41599-019-0232-y.

Oreskes, Noami (2015) 'Meeting Report: IPCC Expert Meeting on Potential Studies of the IPCC Process Meeting Report', in Sokona, Y. *et al*. (eds). Geneva, pp. 1–41. Available at: https://cgsnet.org/ckfinder/userfiles/files/CGS_GED17_Report.pdf.

Oubenal, M., Hrabanski, M. and Pesche, D. (2017) 'IPBES, an inclusive institution? Challenging the integration of stakeholders in a science-policy interface', *Ecology and Society*, 22(1). doi: 10.5751/ES-08961-220111.

Owen-Smith, N. *et al.* (2006) 'A scientific perspective on the management of elephants in the Kruger National Park and elsewhere: elephant conservation.', *South African journal of science*, 102(9–10), pp. 389–394.

Painter, J. (2015) *The effectiveness of the IPCC communication : a survey of (mainly) UK-based users*, *Joint Programming Initiative (JPI) AR5 in Europe*. doi: 10.1016/j.ymeth.2015.12.008.

Parrish, S. (2020) *Double Loop Learning: Download New Skills and Information into Your Brain*, *Farnham Street Blog*. Available at: https://fs.blog/2018/06/double-loop-learning/ (Accessed: 27 April 2020).

PBL (2019) *Report on the workshop 'From visions to scenarios for nature and nature's contributions to people for the 21st century'.* The Hague. doi: PBL publication number: 3756.

Pearce, W., Mahony, M. and Raman, S. (2018) 'Science advice for global challenges: Learning from trade-offs in the IPCC', *Environmental Science and Policy*, 80, pp. 125–131. doi: 10.1016/j.envsci.2017.11.017.

Petersen, A., Blackstock, J. and Morisetti, N. (2015) 'New leadership for a user-friendly IPCC', *Nature Climate Change Commentary*, 5, pp. 909–911. doi: 10.1038/nclimate2766.

Peterson, G. D. *et al.* (2018) 'Welcoming different perspectives in IPBES: "nature's contributions to people" and "ecosystem services"', *Ecology and Society*, 23(1). doi: 10.5751/ES-10134-230139.

Pielke Jr, R. A. (2007) 'The honest broker: making sense of science in policy and politics'. Cambride University Press.

Pielke, R. (2018) *Disasters & Climate Change*. Second. Tempe, Arizona: Consortium for Science, Polciy and Outcomes. Available at: https://www.cspo.org.

Pielke, R. J. (2018) 'Opening Up the Climate Policy Envelope', *Issues in Science and Technology*, 34(4).

Pinker, S. (2018) *Enlightenment now: the case for reason, science, humanism, and progress*. New York: Viking.

Poister, T. (2010) 'Performance measurement.', in Wholey, J., Hatry, H., and Newcomer, K. (eds) *Handbook of Practical Program Evaluation, 3rd edition.* San Francisco: Jossey-Bass, pp. 100–124.

Pope, J. *et al.* (2013) 'Advancing the theory and practice of impact assessment: Setting the research agenda', *Environmental Impact Assessment Review*, 41, pp. 1–9. doi: 10.1016/j.eiar.2013.01.008.

Powell, R. R. (2006) 'Evaluation Research: An Overview', *Library Trends*, 55(1), pp. 102–120. doi: 10.1353/lib.2006.0050.

Raustiala, K. and Victor, D. G. (1996) 'Biodiversity since Rio: The future of the convention on biological diversity', *Environment*, 38(4), pp. 16–45. doi: 10.1080/00139157.1996.9929252.

Riede, J. O. *et al.* (2016) 'What's on the 5th IPCC report for West Africa?', in *Adaptation to Climate Change and Variability in Rural West Africa*, pp. 7–24. doi: 10.1007/978-3-319-31499-0_2.

Riousset, P., Flachsland, C. and Kowarsch, M. (2017) 'Global environmental assessments: Impact mechanisms', *Environmental Science and Policy*, 77, pp. 260–267. doi: 10.1016/j.envsci.2017.02.006.

Ritchie, H. and Roser, M. (2018) *Now it is possible to take stock - did the world achieve the Millennium Development Goals?*, *Our World in Data*. Available at: https://ourworldindata.org/millennium-development-goals (Accessed: 19 July 2019).

Rosa, I. M. D. *et al.* (2017) 'Multiscale scenarios for nature futures', *Nature Ecology & Evolution*, 1(10). doi: 10.1038/s41559-017-0273-9.

Rothman, D. S. *et al.* (2009) 'How to make global assessments more effective: lessons from the assessment community', *Current Opinion in Environmental Sustainability*, pp. 214–218. doi: 10.1016/j.cosust.2009.09.002.

Roué, M. *et al.* (2015) *Indigenous & Local Knowledge of biodiversity and ecosystem services in Africa: Outcomes from the African Dialogue Workshop 14–16 September 2015*, *Knowledges of Nature 8.* Paris. Available at: http://climatefrontlines.org/sites/default/files/ipbes/IPBES_in_Africa_2015.pdf.

Rowley, J. (2002) 'Using case studies in research', *Management Research News*.

Sarewitz, D. (2016) 'Saving Science', *The new Atlantis: A Journal of Technology & Society*, (Spring / Summer), pp. 6–40.

Sarkki, S. *et al.* (2014) 'Balancing credibility, relevance and legitimacy: A critical assessment of trade-offs in science-policy interfaces', *Science and Public Policy*, 41(2), pp. 194–206. doi: 10.1093/scipol/sct046.

Sarkki, S. *et al.* (2015) 'Adding "iterativity" to the credibility, relevance, legitimacy: A novel scheme to highlight dynamic aspects of science-policy interfaces', *Environmental Science and*

Policy, 54, pp. 505–512. doi: 10.1016/j.envsci.2015.02.016.

Satterthwaite, D. (2014) 'Getting local governments, residents and enterprises to respond to the new IPCC assessment', *Environment and Urbanization*, pp. 3–10. doi: 10.1177/0956247814522386.

Schiermeier, Q. (2014) 'Climate Policy: IPCC Report Under Fire', *Nature News*, 508, p. 298.

Schleussner, C.-F. *et al.* (2016) 'Science and policy characteristics of the Paris Agreement temperature goal', *Nature Climate Change*. Nature Publishing Group, a division of Macmillan Publishers Limited. All Rights Reserved., 6, p. 827. Available at: https://doi.org/10.1038/nclimate3096.

Schmeller, D. S. and Bridgewater, P. (2016) 'The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES): progress and next steps', *Biodiversity and Conservation*, 25(5), pp. 801–805. doi: 10.1007/s10531-016-1095-9.

Schmeller, D. S., Niemelä, J. and Bridgewater, P. (2017) 'The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): getting involved', *Biodiversity and Conservation*, 26(10), pp. 2271–2275. doi: 10.1007/s10531-017-1361-5.

Scholes, R. . and Mennell, K. G. (2009) *Elephant management: A scientific assessment for South Africa.* Johannesburg.: Wits University Press.

Scholes, R. J. *et al.* (2013) 'Multi-scale and cross-scale assessments of social-ecological systems and their ecosystem services', *Current Opinion in Environmental Sustainability*. Elsevier B.V., 5(1), pp. 16–25. doi: 10.1016/j.cosust.2013.01.004.

Scholes, R. J. *et al.* (2016) *Shale Gas Development in the Central Karoo: A Scientific Assessment of the Opportunities and Risks*. Edited by R. J. Scholes *et al*. Pretoria: CSIR. Available at: http://seasgd.csir.co.za/scientific-assessment-chapters/PREFACE.

Scholes, R. J., Schreiner, G. O. and Snyman-Van der Walt, L. (2017) 'Scientific assessments: Matching the process to the problem', *Bothalia*, 47(2). doi: 10.4102/abc.v47i2.2144.

Schreiner, G. . *et al.* (2018) 'Evidence-based and participatory processes in support of shale gas policy development in South Africa', in Whitton, J. *et al*. (eds) *Governing Shale Gas: Development, Citizen Participat ion and Decision Making in the US, Canada, Australia and Europe*. First. Oxon: Routledge, pp. 149–168. Available at: https://www.routledge.com/Governing-Shale-Gas-Development-Citizen-Participation-and-.

Schreiner, G. O. and Snyman-Van der Walt, L. (2018) 'Risk modelling of shale gas development scenarios in the Central Karoo', *International Journal of Sustainable Development and Planning*, 13(2), pp. 294–306. doi: 10.2495/SDP-V13-N2-294-306.

Schulte-Uebbing, L. *et al.* (2015) 'Chapter scientists in the IPCC AR5-experience and lessons learned', *Current Opinion in Environmental Sustainability*, 14, pp. 250–256. doi: 10.1016/j.cosust.2015.06.012.

Science-Metrix (2019) *Classification*, *Science-Metrix*. Available at: http://science-metrix.com/?q=en/classification (Accessed: 7 October 2019).

Skodvin, T. and Alfsen, K. H. (2010) 'The Intergovernmental Panel on Climate Change (IPCC): Outline of an assessment'. Blindern, Norway: Centre for International Climate and Environmental Research, pp. 1–14. Available at: http://www.cicero.uio.no.

Soberón, J. and Peterson, A. T. (2015) 'Biodiversity Governance: A Tower of Babel of Scales and

Cultures', *PLoS Biology*, 13(3), p. 8pp. doi: 10.1371/journal.pbio.1002108.

Spencer, T. and Lane, S. N. (2017) 'Reflections on the IPCC and global change science: Time for a more (physical) geographical tradition', *Canadian Geographer*, 61(1), pp. 124–135. doi: 10.1111/cag.12332.

Steffen, W. *et al.* (2011) 'The anthropocene: From global change to planetary stewardship', in *Ambio*, pp. 739–761. doi: 10.1007/s13280-011-0185-x.

Stenseke, M. and Larigauderie, A. (2018) 'The role , importance and challenges of social sciences and humanities in the work of the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES)', *The European Journal of Social Science Research*. Taylor & Francis, 31. doi: 10.1080/13511610.2017.1398076.

Stewart, R. *et al.* (2019) 'The evidence ecosystem in South Africa: growing resilience and institutionalisation of evidence use', *Palgrave Communications*. Springer US, pp. 1–12. doi: 10.1057/s41599-019-0303-0.

Stocker, T. F. and Plattner, G.-K. (2014) 'Rethink IPCC reports', *Nature Comment*, 513, p. 163165. doi: 10.1108/02621711011039259.

Stocker, T. F. and Plattner, G.-K. (2016) 'Letter to the Editor - Making use of the IPCC's communication tool', *Nature Climate Change*, 6. doi: 10.1038/nature.2015.18543.

Struck, B. (2017) *Team diversity widget: how do you measure up?*, *Science Metrics*. Available at: http://www.sciencemetrics.org/team-diversity-widget-measure/ (Accessed: 4 October 2019).

Subramanian, M. (2019) 'Anthropocene now: influential panel votes to recognize Earth's new epoch', *Nature*. doi: doi: 10.1038/d41586-019-01641-5.

Sutherland, W. J. and Burgman, M. A. (2015) 'Policy advice: Use experts wisely', *Nature*, pp. 317–318. doi: 10.1038/526317a.

Swilling, M. (2014) 'Rethinking the science – policy interface in South Africa : Experiments in knowledge co-production', *South African Journal of Science*, 110(5), pp. 1–7.

Timpte, M. *et al.* (2018) 'Engaging diverse experts in a global environmental assessment: participation in the first work programme of IPBES and opportunities for improvement', *Innovation: The European Journal of Social Science Research*, 31, pp. S15–S37. doi: 10.1080/13511610.2017.1383149.

Tinch, R. *et al.* (2016) 'Science-policy interfaces for biodiversity: dynamic learning environments for successful impact', *Biodiversity and Conservation*, 27(7), pp. 1679–1702. doi: 10.1007/s10531-016-1155-1.

Tol, R. S. J. (2011) 'Regulating knowledge monopolies: The case of the IPCC', *Climatic Change*, 108(4), pp. 827–839. doi: 10.1007/s10584-011-0214-6.

Tol, R. S. J. (2016) 'The impacts of climate change according to the IPCC', *Climate Change Economics*, 07(01), p. 1640004. doi: 10.1142/S2010007816400042.

Tomich, T. P. *et al.* (2016) *The California Nitrogen Assessment: Challenges and Solutions for People, Agriculture, and the Environment*. University of California Press.

Toth, F. L. (2003) 'State of the Art and Future Challenges for Integrated Environmental Assessment', *Integrated Assessment*, 4(4), pp. 250–264. doi: 10.1080/1389517049051540$16.00.

Tunón, H., Kvarnström, M. and Malmer, P. (2015) *Indigenous and local knowledge in a scoping* *study for a Nordic IPBES assessment.*, *Naptek, Swedish Biodiversity Centre*. Uppsala: Naptek, Swedish Biodiversity Centre. doi: 10.13140/RG.2.1.4030.6004.

Turnhout, E., Neves, K. and De Lijster, E. (2014) '"Measurementality" in biodiversity governance: Knowledge, transparency, and the intergovernmental science-policy platform on biodiversity and ecosystem services (ipbes)', *Environment and Planning A*, 46(3), pp. 581–597. doi: 10.1068/a4629.

Twin, A. (2019) *Delphi Method*, *Investopedia*. Available at: https://www.investopedia.com/terms/d/delphi-method.asp (Accessed: 15 January 2020).

UN (2015) *The millenium development goals report*. New York. Available at: https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG 2015 rev (July 1).pdf.

UNEP (1987) *The Montreal protocol on substances that deplete the ozone layer*.

Vadrot, A. B. M. (2014) 'The epistemic and strategic dimension of the establishment of the IPBES: "epistemic selectivities" at work', *Innovation: The European Journal of Social Science Research*. Taylor & Francis, 27(4), pp. 361–378. doi: 10.1080/13511610.2014.962014.

Vadrot, A. B. M. *et al.* (2018) 'Why are social sciences and humanities needed in the works of IPBES? A systematic review of the literature', *Innovation*, 31, pp. S78–S100. doi: 10.1080/13511610.2018.1443799.

Vadrot, A. B. M., Jetzkowitz, J. and Stringer, L. C. (2016) 'IPBES disciplinary gaps still gaping', *Nature Correspondence*, 530, p. 160.

Vardy, M. *et al.* (2017) 'The Intergovernmental Panel on Climate Change: Challenges and Opportunities Mark', *Annual Review of Environment and Resources*, 42(3), pp. 55–75. doi: 10.1146/annurev-environ.

Vasileiadoua, E., Heimeriks, G. and Petersen, A. . (2011) 'Exploring the impact of the IPCC assessment reports on science.', *Environ Sci Policy*, 14(8), pp. 1052–1061.

van der Veer, L. *et al.* (2014) 'Innovating the IPCC review process—the potential of young talent', *Climatic Change*, 125(2), pp. 137–148. doi: 10.1007/s10584-014-1145-9.

Victor, D. G. (2015) 'Embed the social sciences in climate policy', *Nature*, pp. 27–29. doi: 10.1038/520027a.

Vohland, K. *et al.* (2011) 'How to ensure a credible and efficient IPBES?', *Environmental Science and Policy*, 14(8), pp. 1188–1194. doi: 10.1016/j.envsci.2011.08.005.

Vohland, K. and Nadim, T. (2015) 'Ensuring the success of IPBES: Between interface, market place and parliament', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 370(1662), pp. 1–6. doi: 10.1098/rstb.2014.0012.

Warren, R. *et al.* (2016) 'Chapter 2: Approach and context', in *UK Climate Change Risk Assessment 2017: Evidence Report*. London: Adaptation Sub-Committee of the Committee on Climate Change., pp. 1–50.

Warren, R. F. *et al.* (2018) 'Advancing national climate change risk assessment to deliver national adaptation plans', *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376(2121). doi: 10.1098/rsta.2017.0295.

Watson, R. T. (2005) 'Turning science into policy: Challenges and experiences from the science-policy interface', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(1454), pp. 471–477. doi: 10.1098/rstb.2004.1601.

Webb, J. (2011) ‘Making climate change governable: The case of the UK climate change risk assessment and adaptation planning’, *Science and Public Policy*, 38(4), pp. 279–292. doi: 10.3152/030234211X12924093660471.

Wikipedia (2019) *List of countries by GNI (nominal) per capita*, *Wikipedia*. Available at: https://en.m.wikipedia.org/wiki/List_of_countries_by_GNI_(nominal)_per_capita (Accessed: 7 October 2019).

Wilber, K. (2018) *Trump and a post-truth world: An evolutionary self correction*. Deep Dive e-Book.

Wilby, R. . and Wigley, T. M. . (1997) ‘Downscaling general circulation model output: a review of methods and limitations’, *Progress in Physical Geography: Earth and Environment*, 21(4), pp. 530–548. doi: https://doi.org/10.1177/030913339702100403.

Winberg, C. (2006) ‘Undisciplining knowledge production: Development driven higher education in South Africa’, *Higher Education*, 51, pp. 159–172. doi: 10.1007/s10734-004-6378-5.

Woodward, A. *et al.* (2014) ‘Climate change and health: On the latest IPCC report’, *The Lancet*, 383, pp. 1185–1189. doi: 10.1016/S0140-6736(14)60576-6.

Yamineva, Y. (2017) ‘Lessons from the Intergovernmental Panel on Climate Change on inclusiveness across geographies and stakeholders’, *Environmental Science and Policy*, 77, pp. 244–251. doi: 10.1016/j.envsci.2017.04.005.

Yin, R. K. (2009) *Case study research: Design and methods*. Fourth. Thousand Oaks, California: Sage.

Young, J. C. *et al.* (2013) *The SPIRAL synthesis report: A resource book on science-policy interfaces*.

Young, J. C., Watt, A. . and van den Hove, S. (2013) *Effective interfaces between science, policy and society: the SPIRAL project handbook.*

Ziman, J. (2000) *Real science: What it is, and what it means*. Cambridge: University Press.

APPENDICES

Appendix 1: Survey Statements and Participant Responses

Table 1: Case study and demographic information of survey participants

Which assessment process did you participate in?	**n**	**%**							
IPCC	274	42							
LDA	84	13							
Africa	74	11							
ECA	109	17							
SGSA	86	13							
CCRA2 ER	28	4							
What was your primary role in the assessment process?		**n**	**%**						
Authors		353	54						
Govt		28	4						
Managers		21	3						
External		253	39						
What is your knowledge background?			**n**	**%**					
A, N & H S			449	69					
E&SS			136	21					
A&H			11	2					
ILK			8	1					
Other			51	8					

Which sector do you work in?				**n**	**%**				
Research				473	72				
Private				33	5				
NGO				44	7				
Govt				89	14				
Other				12	2				
How old are you?					**n**	**%**			
<40					125	19			
>40 <60					374	57			
>60					149	23			
Were you born in a low, middle or high-income country?						**n**	**%**		
Low						53	8		
Low-Middle						85	13		
High-Middle						107	16		
High						403	62		
Do you live in a low, middle or high-income country?							**n**	**%**	
Low							33	5	
Low-Middle							75	11	
High-Middle							114	17	
High							426	65	
What is your gender?								**n**	**%**
Woman								224	34
Man								422	64

Table 2: Participant responses to survey statements

	Strongly Agree	Agree	Neutral or Unsure	Disagree	Strongly Disagree
Participants were able to co-develop (i.e. participate together in knowledge production)	164	316	119	51	5
There was a wide range of expertise among participants	237	306	88	23	1
Government/s actively participated in various roles during the assessment	66	221	246	107	15
The process was open to all interested stakeholders	108	260	171	103	13
Non-scientific knowledge was adequately considered	37	221	266	113	18
Biophysical, social and economic issues were considered in a balanced fashion	111	312	151	73	8
Experts were sufficiently knowledgeable and competent	229	318	73	31	4
Adequate financial resources	43	126	253	167	66
There were sufficient human resources	85	286	169	99	16
There was continuity in personnel through the process	120	332	167	35	1
Information systems were available to participants	146	313	141	49	6
Time was made available for compromises	57	290	247	53	8
Objectives were clearly communicated to all participants	152	363	91	42	7
Imminent policy changes were considered during the process	42	162	332	106	13
The different scenarios were adequately assessed	90	306	196	57	6
The assessment process was asked for, or 'mandated', by government/s	169	232	203	45	6
The scope of the issues assessed, was clearly defined	168	366	73	43	5
Questions were posed by a diversity of stakeholders	62	237	255	93	8
The process you participated in was free from bias	122	298	124	97	14
The process was free from manipulation	208	294	116	32	5
Personal, political and organisational interests were transparent	87	268	223	70	7
The process was trustworthy	205	326	107	14	3
Conflict among participants was mediated	61	237	315	38	4

	Strongly Agree	**Agree**	**Neutral or Unsure**	**Disagree**	**Strongly Disagree**
Procedures for negotiation were transparent	59	220	322	49	5
The assessment process was procedurally fair	170	339	125	18	3
Media communication was prioritised	41	165	329	105	15
Scientists and policy-makers had opportunities to engage with one another	63	219	213	138	22
Young people were developed for future assessment processes	75	187	263	121	9
Participation opportunities were provided to marginalised stakeholder groups	15	124	350	136	30
The process was able to adapt to change	37	272	269	67	10
The assessment process managed uncertainty in an organised fashion	98	300	199	51	7
The process was iterative i.e. did things repetitively to promote improvement	124	338	141	50	2
The outputs (e.g. reports, policy documents, maps etc.) will enrich public debate	277	302	56	16	4
During the process, important new research issues were assessed	156	302	119	72	6
The outputs addressed the questions raised by stakeholders	95	301	222	32	5
The outputs were of adequate technical quality	220	348	65	19	3
The outputs were made available in different formats	124	298	184	48	1
Expert judgement was suitably applied in the findings	165	359	100	27	4
The outputs have been / will be useful for decision-making	231	302	95	25	2
The outputs have been / will be used in future assessments undertaken at a finer scale	168	300	161	21	5
The process and outputs have made some contribution toward the resolution of the problem	132	338	148	32	5
You would willingly participate in future assessment processes	252	295	70	32	6
Totals	**5271**	**11699**	**7557**	**2600**	**383**

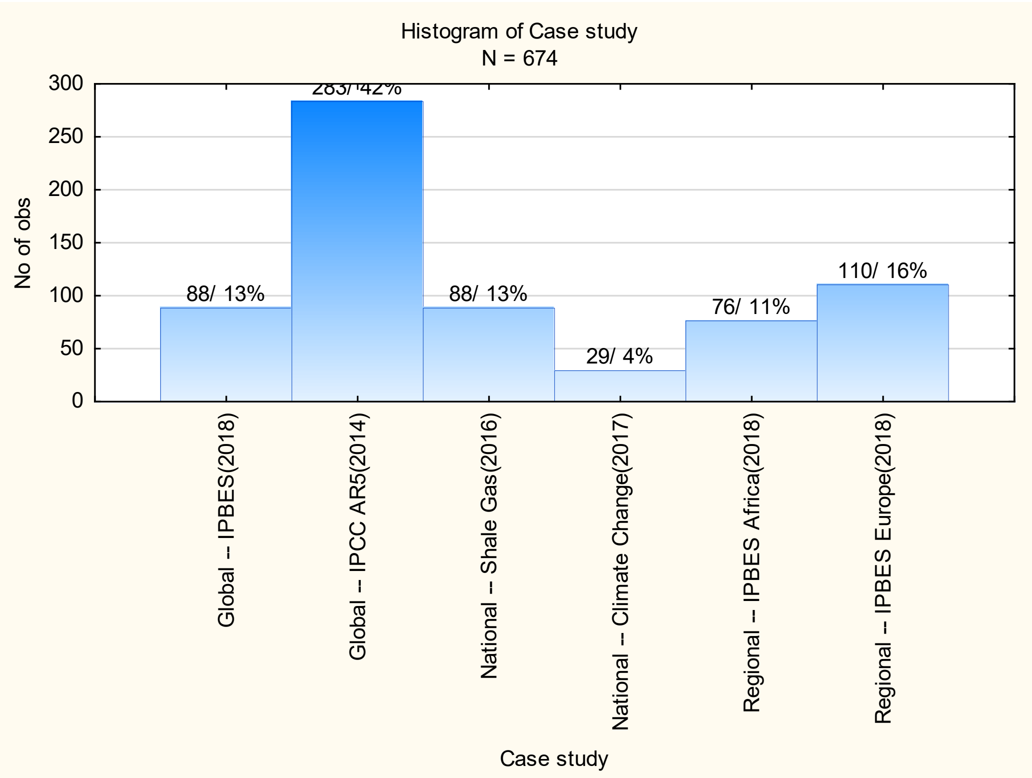


Figure 1: Survey response distribution across case

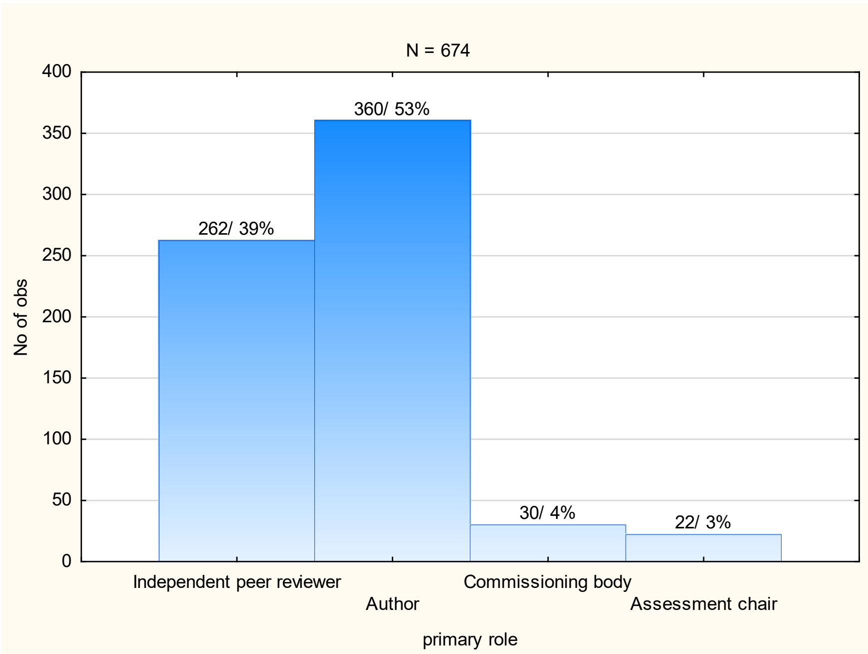


Figure 2: Survey response distribution across primary role

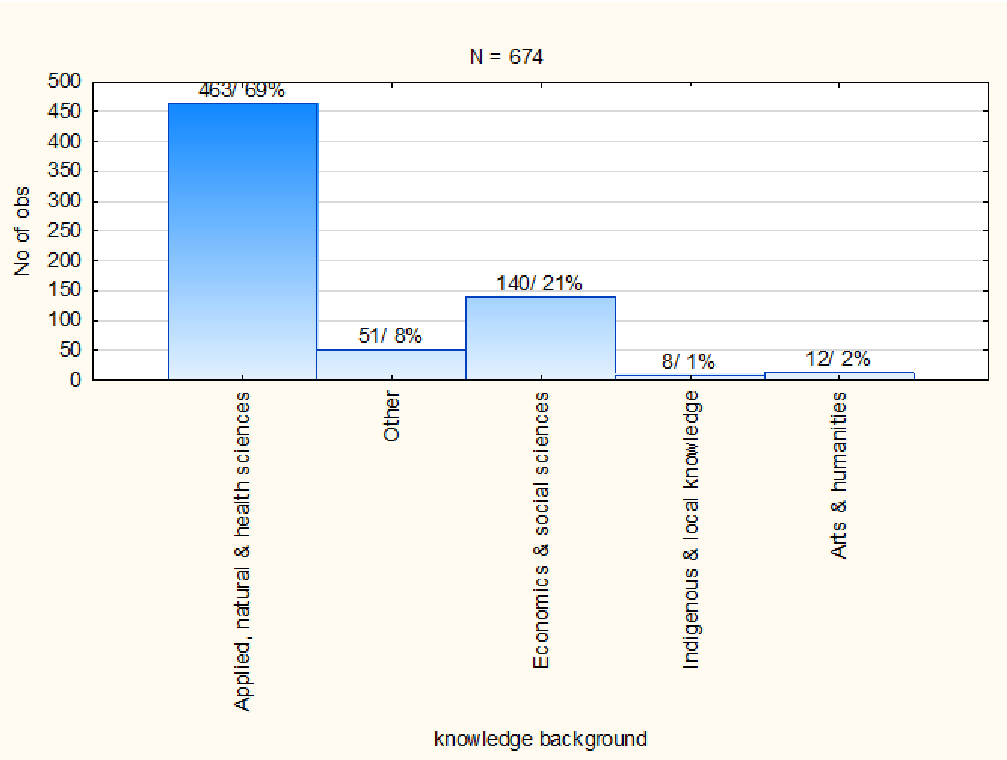


Figure 3: Survey response distribution across knowledge background

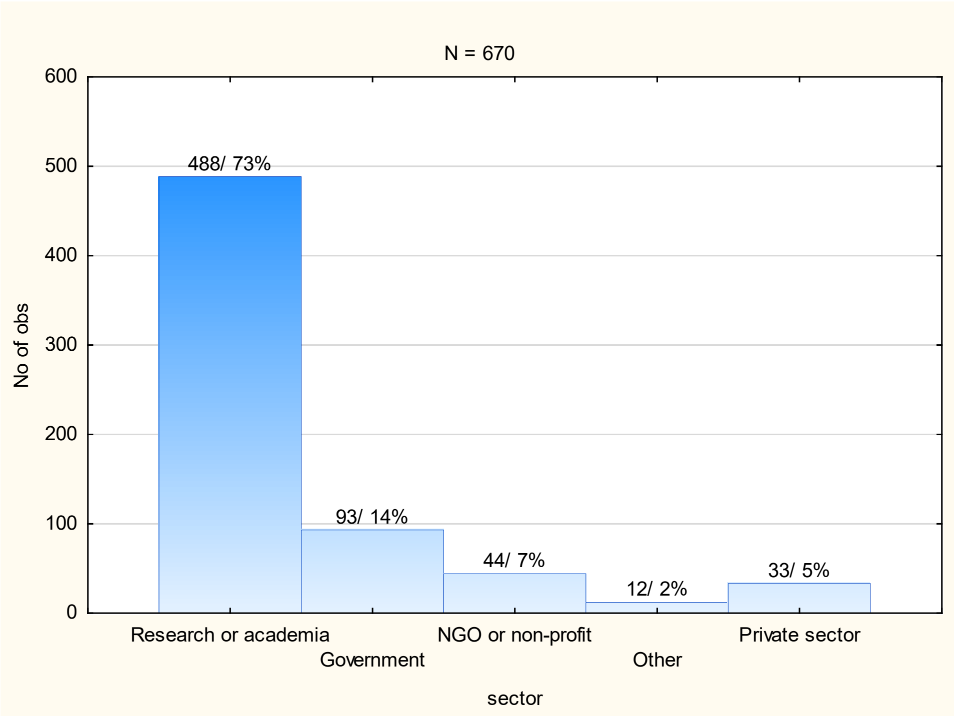


Figure 4: Survey response distribution across sectors

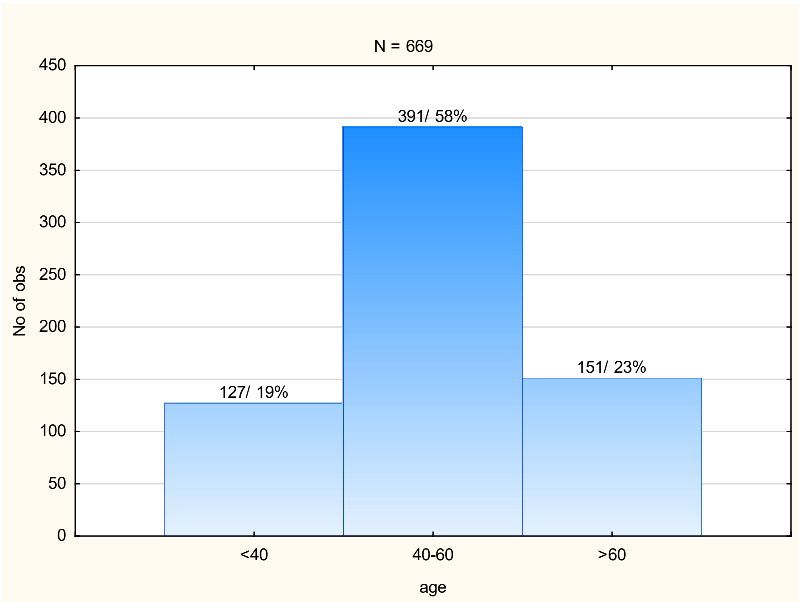


Figure 5: Survey response distribution across age differences

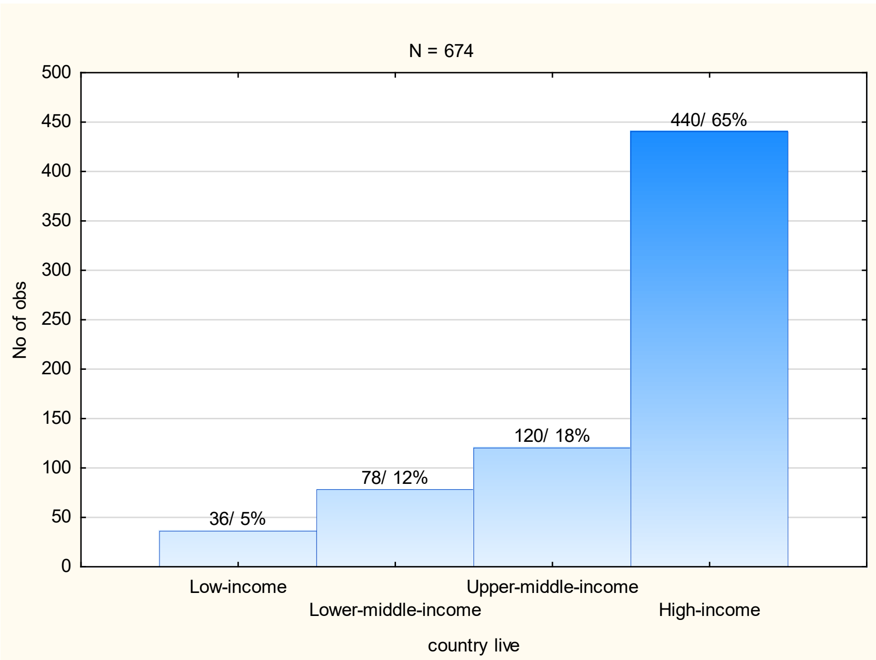


Figure 6: Survey response distribution across age differences

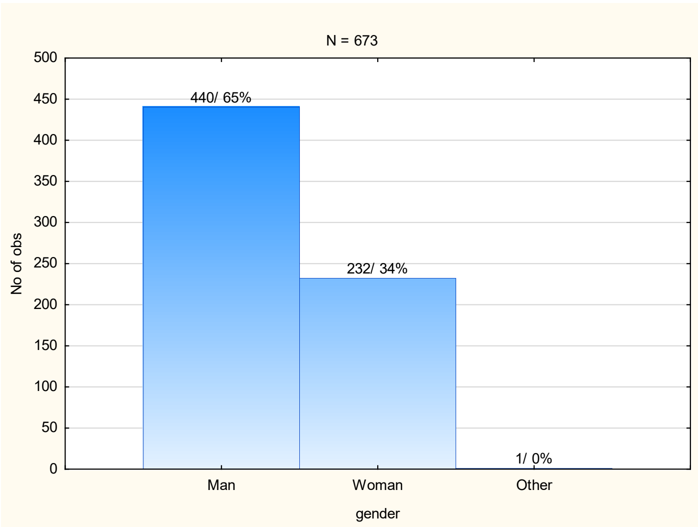


Figure 7: Survey response distribution across gender

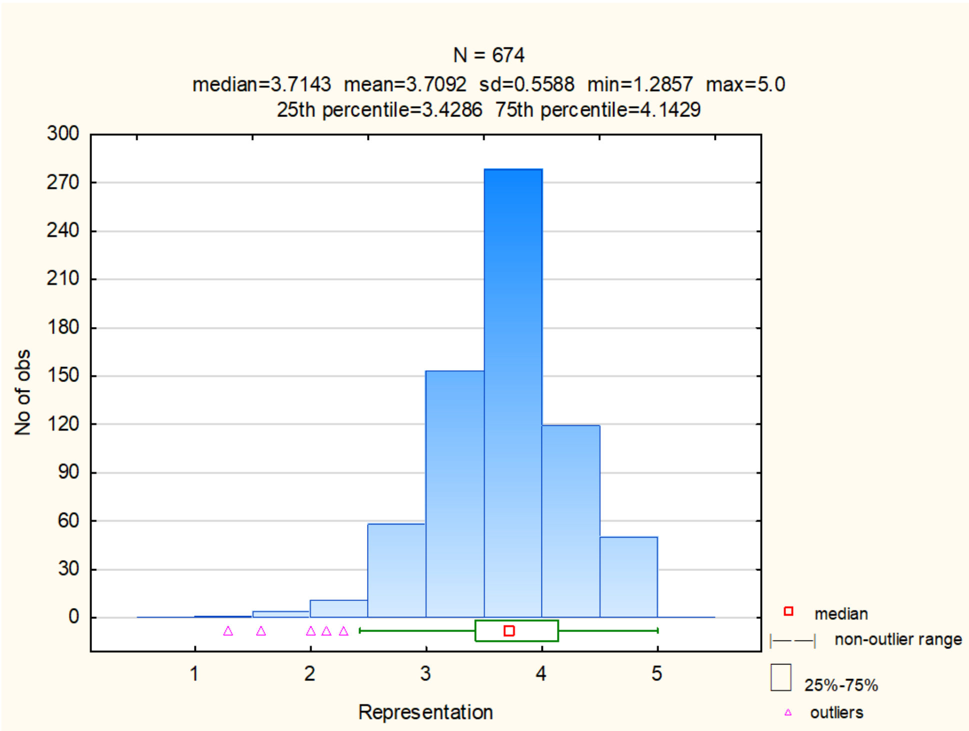


Figure 8: A summary of the responses for subcategory construct representation.

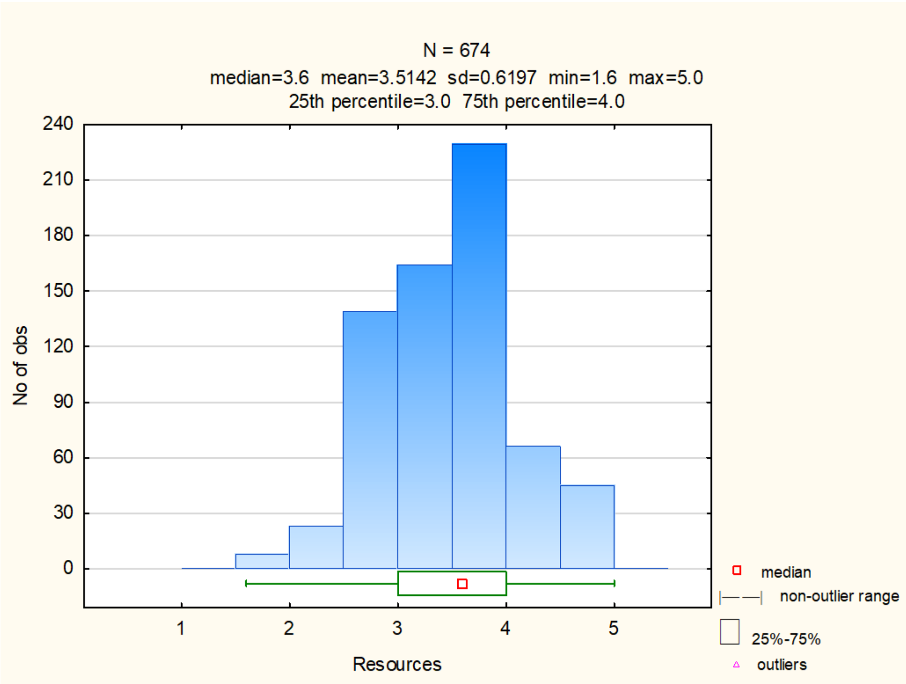


Figure 9: A summary of the responses for subcategory construct resources.

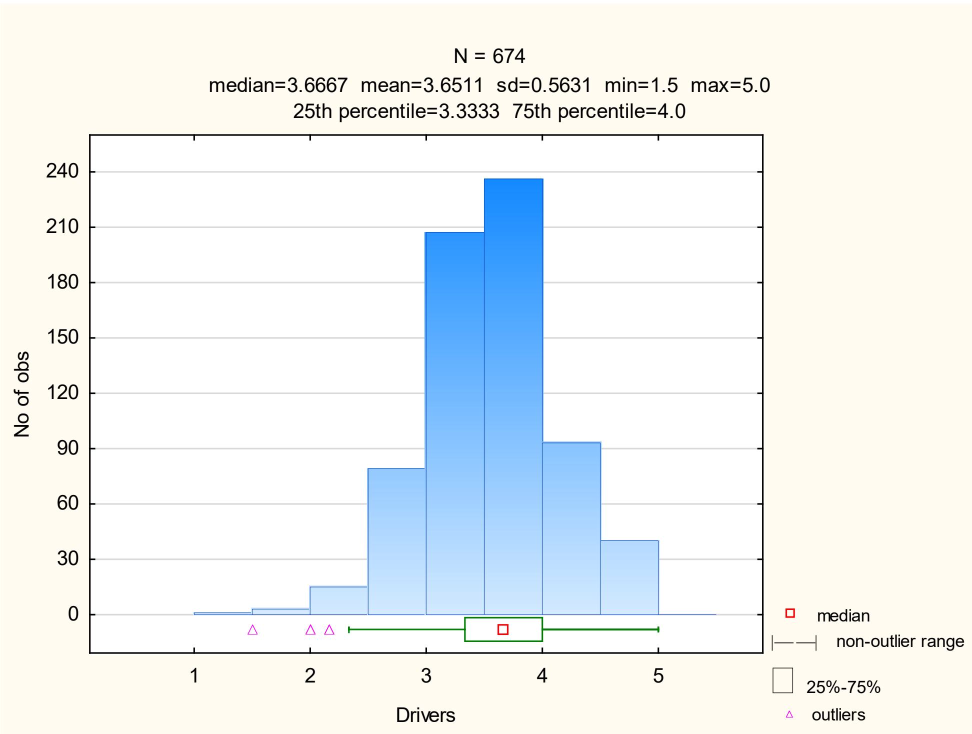


Figure 10: A summary of the responses for subcategory construct drivers.

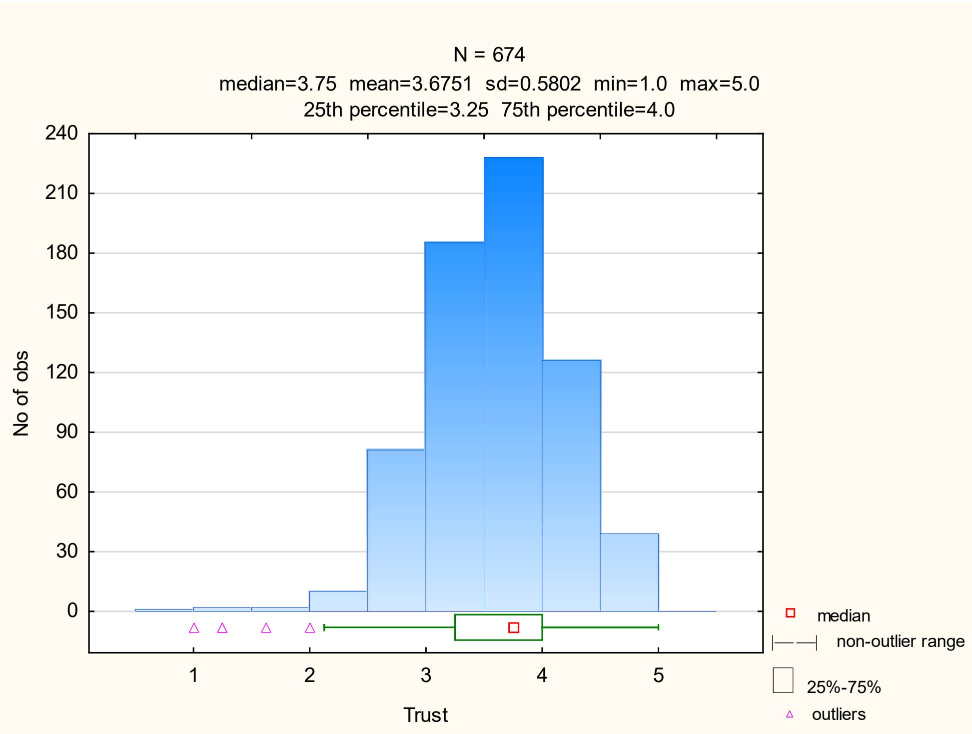


Figure 11: A summary of the responses for subcategory construct trust.

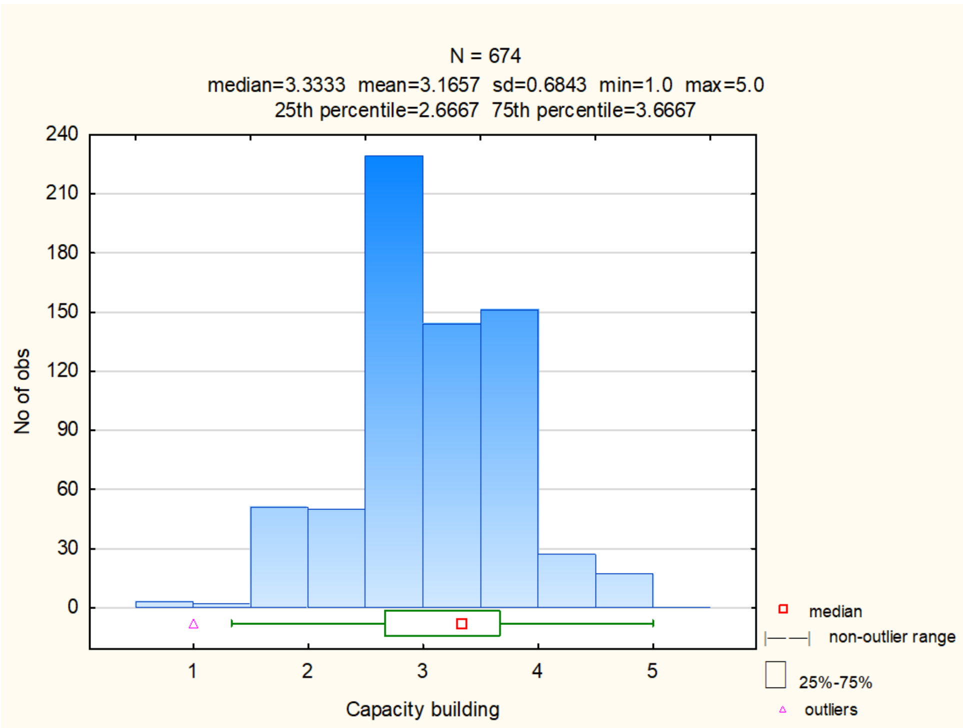


Figure 12: A summary of the responses for subcategory construct capacity building.

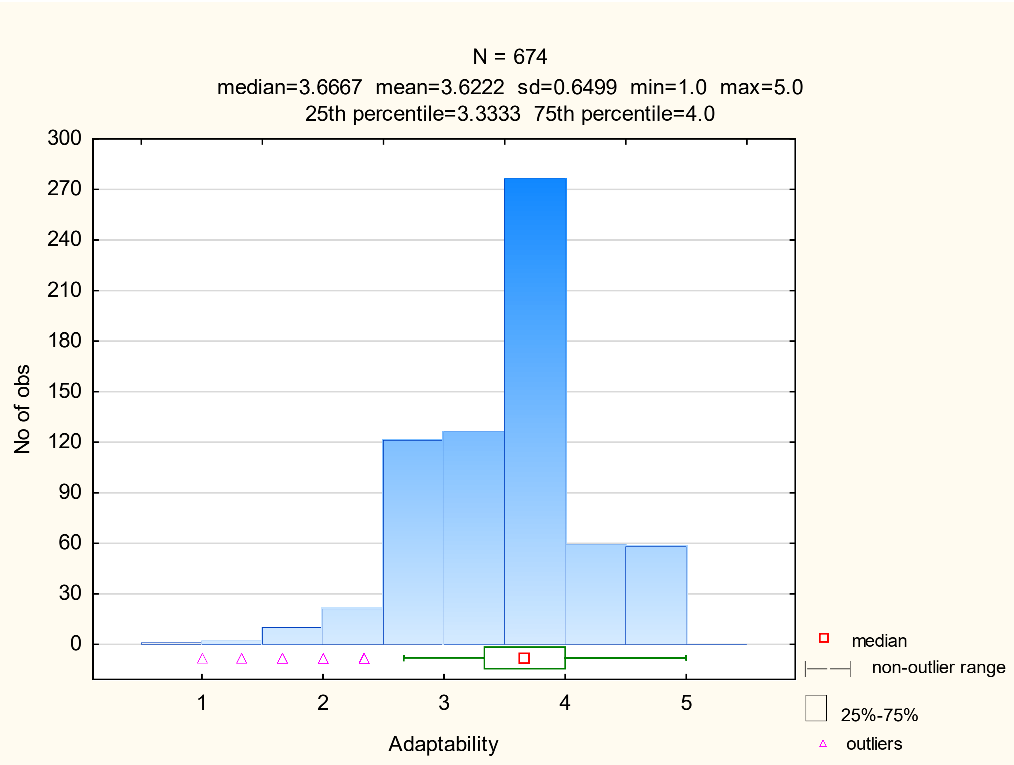


Figure 13: A summary of the responses for subcategory construct adaptability and uncertainty.

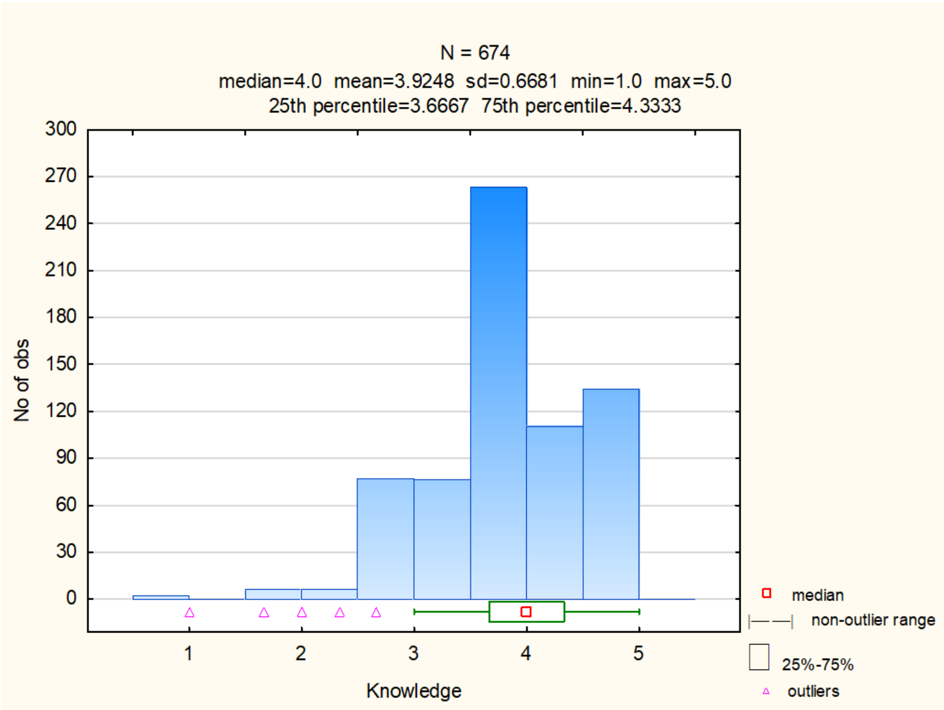


Figure 14: A summary of the responses for subcategory construct knowledge.

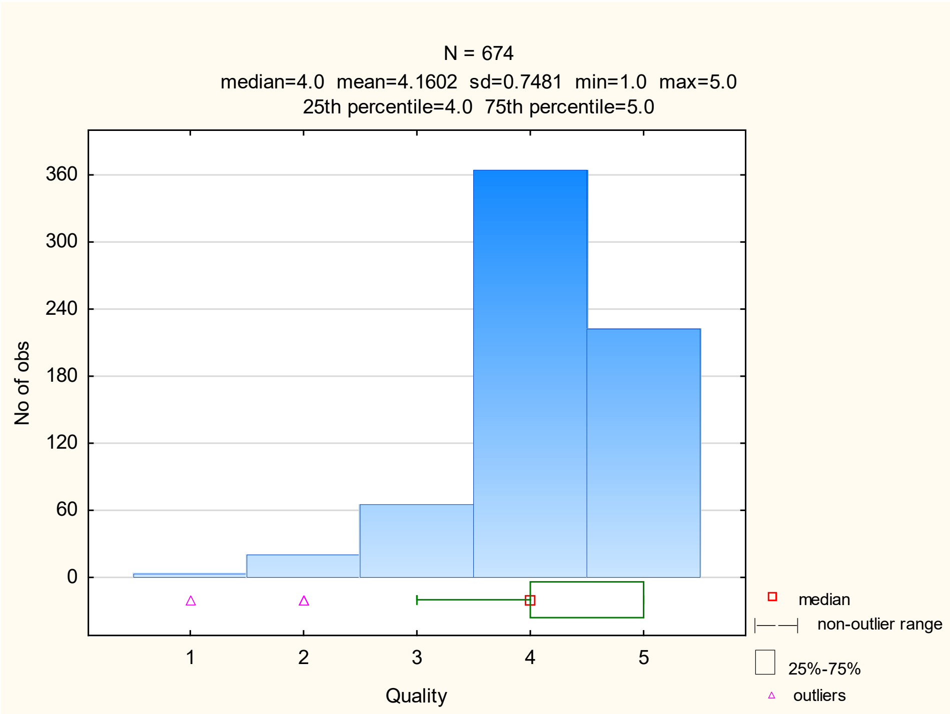


Figure 15: A summary of the responses for subcategory construct quality

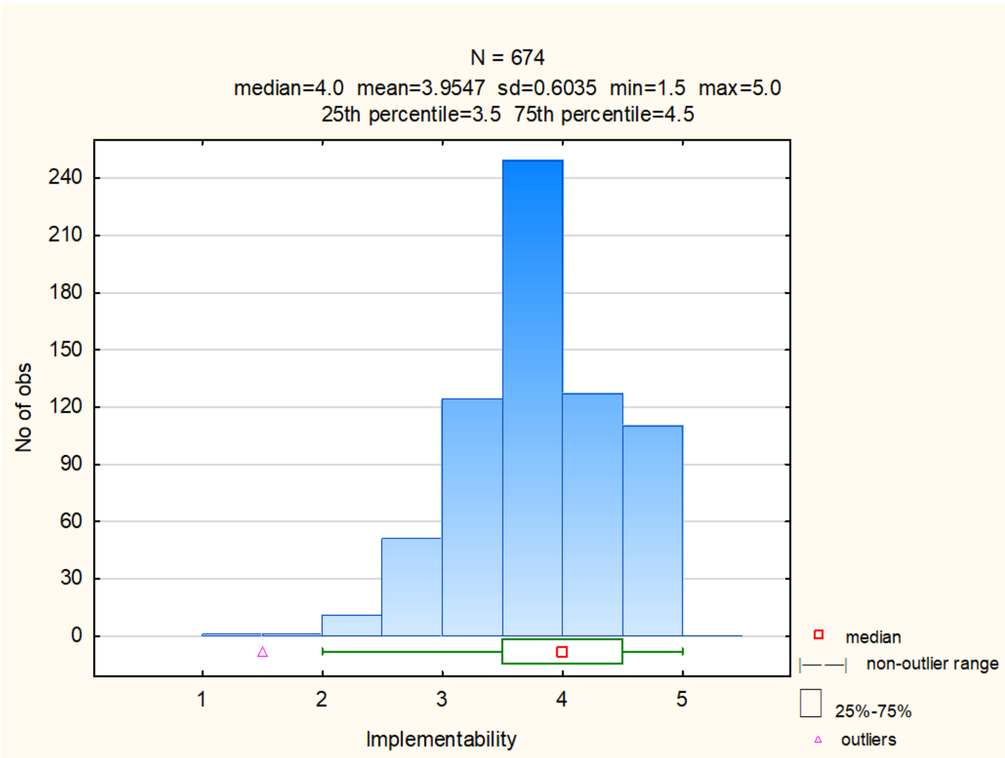


Figure 16: A summary of the responses for subcategory construct implementability.

Appendix 2: Systematic Review Data

Table 3: Literature inventory from the systematic review

	Platform / case study	Indicators / content	Authors	Year
1	IPBES	Background	Bridgewater & Schmeller	2018
2	IPBES	Background	Granjou *et al.*	2013
3	IPBES	Background	Montana	2016
4	IPBES	Background	Opgenoorth & Faith	2013
5	IPBES	Background	Opgenoorth & Hotes	2016
6	IPBES	Capacity building	Gusstafsson	2018
7	IPBES	Capacity building	Hanssen *et al.*	2014
8	IPBES	Expertise	Gustafsson & Lidskog	2018
9	IPBES	Expertise	Heubach & Lambini	2017
10	IPBES	Expertise	Hochkirch	2014
11	IPBES	Expertise	Kovács & Patakib	2016
12	IPBES	Expertise	Montana & Borie	2016
13	IPBES	Expertise	Timpte *et al.*	2017
14	IPBES	Government involvement	Balvaneraetal *et al.*	2017
15	IPBES	Impact	Tinch *et al.*	2016
16	IPBES	Comparative to IPCC	Beck *et al.*	2014
17	IPBES	Comparative to IPCC	Brooks *et al.*	2014
18	IPBES	Comparative to IPCC	Larigauderie & Mooney	2010
19	IPBES	Knowledge diversity	Borie & Hulme	2016
20	IPBES	Knowledge diversity	Borie	2016
21	IPBES	Knowledge diversity	Briggs & Knight	2011
22	IPBES	Knowledge diversity	Diaz *et al.*	2018
23	IPBES	Knowledge diversity	Diaz-Reviriego *et al.*	2019
24	IPBES	Knowledge diversity	Hulme *et al.*	2011
25	IPBES	Knowledge diversity	Kenter	2018
26	IPBES	Knowledge diversity	Löfmarck & Lidskog	2016
27	IPBES	Knowledge diversity	Nakashima	2015
28	IPBES	Knowledge diversity	Peterson *et al.*	2018
29	IPBES	Knowledge diversity	Roué *et al.*	2015
30	IPBES	Knowledge diversity	Soberón & Peterson	2015
31	IPBES	Knowledge diversity	Sutherland *et al.*	2013
32	IPBES	Knowledge diversity	Tunón *et al.*	2015
33	IPBES	Knowledge diversity	Turnhout *et al.*	2014
34	IPBES	Knowledge diversity	Turnhout	2012
35	IPBES	Natures Contribution to People	Diaz *et al.*	2018
36	IPBES	Natures Contribution to People	Harris & Kotiaho	2018
37	IPBES	Natures Contribution to People	Kenter	2018
38	IPBES	Natures Contribution to People	Masood	2018

	Platform / case study	Indicators / content	Authors	Year
39	IPBES	Suggestions to the platform	Díaz Reviriego *et al.*	2017
40	IPBES	Suggestions to the platform	Schmeller & Bridgewater	2016
41	IPBES	Suggestions to the platform	van den Hove & Chabason	2009
42	IPBES	Suggestions to the platform	Vohland & Nadim	2015
43	IPBES	Suggestions to the platform	Vohland *et al.*	2011
44	IPBES	Scale	Hof *et al.*	2017
45	IPBES	Resources	Stokstad	2017
46	IPBES	Scenarios	Rosa *et al.*	2017
47	IPBES	Science-policy	Balian *et al.*	2016
48	IPBES	Social sciences	Jetzkowitz *et al.*	2018
49	IPBES	Social sciences	Morin *et al.*	2017
50	IPBES	Social sciences	Stenseke & Larigauderie	2018
51	IPBES	Social sciences	Vadrot *et al.*	2018
52	IPBES	Stakeholders	Esguerra *et al.*	2017
53	IPBES	Stakeholders	Lundquist *et al.*	2015
54	IPBES	Stakeholders	Oubenal *et al.*	2016
55	IPBES	Stakeholders	Schmeller *et al.*	2017
56	IPBES	Trust	Hotes & Opgenoorth	2014
57	IPCC	Authors	Corbera	2015
58	IPCC	Authors	El-Hinnawi	2011
59	IPCC	Authors	Ford *et al.*	2011
60	IPCC	Authors	Ho-Lem	2011
61	IPCC	Authors	Hughes & Paterson	2017
62	IPCC	Authors	Schulte-Uebbing *et al.*	2015
63	IPCC	Comments on IPCC	Carraro	2014
64	IPCC	Comments on IPCC	Field & Baros	2015
65	IPCC	Comments on IPCC	Geden	2015
66	IPCC	Comments on IPCC	Griggs	2014
67	IPCC	Comments on IPCC	Hulme	2010
68	IPCC	Comments on IPCC	Mckitrick	2011
69	IPCC	Comments on IPCC	Minx *et al.*	2017
70	IPCC	Comments on IPCC	Petersen *et al.*	2015
71	IPCC	Comments on IPCC	Schiermeier	2014
72	IPCC	Comments on IPCC	Smith & Porter	2018
73	IPCC	Comments on IPCC	Solomon & Manning	2018
74	IPCC	Comments on IPCC	Spencer & Lane	2017
75	IPCC	Comments on IPCC	Stocker & Plattner	2014
76	IPCC	Comments on IPCC	Woodward *et al.*	2014
77	IPCC	Effectiveness evaluation	Fearnside	2015
78	IPCC	Effectiveness evaluation	Okereke	2017
79	IPCC	Effectiveness evaluation	Ravindranath	2010
80	IPCC	Effectiveness evaluation	IAC	2010

	Platform / case study	Indicators / content	Authors	Year
81	IPCC	Effectiveness evaluation	Sokona *et al.*	2015
82	IPCC	Effectiveness evaluation	Vardy *et al.*	2017
83	IPCC	Gender	Gay-Antaki & Liverman	2018
84	IPCC	Gender	Nhamo & Nhamo	2017
85	IPCC	Gender	Perry	2018
86	IPCC	General	Beck & Mahoney 2018	2018
87	IPCC	General	Beck *et al.*	2014
88	IPCC	General	Chan *et al.*	2016
89	IPCC	General	Cochrane	2016
90	IPCC	General	Drouet *et al.*	2015
91	IPCC	General	Edenhofer & Minx	2014
92	IPCC	General	Gleditsch	2015
93	IPCC	General	Howarth *et al.*	2016
94	IPCC	General	Mach *et al.*	2016
95	IPCC	General	O'Neill *et al.*	2016
96	IPCC	General	Pearce & Hollin	2015
97	IPCC	General	Pearce *et al.*	2016
98	IPCC	General	Pielke	2018
99	IPCC	General	Rosen	2015
100	IPCC	General	Tol	2016
101	IPCC	General	van deer Geest & Warner	2015
102	IPCC	General	Viner & Howarth	2014
103	IPCC	Groupthink	Booker	2018
104	IPCC	Indigenous & local knowledge	Ford *et al.*	2016
105	IPCC	IPCC & policy	Doukas *et al.*	2018
106	IPCC	IPCC & policy	Fawcett *et al.*	2015
107	IPCC	IPCC & policy	Sterner	2015
108	IPCC	Knowledge	Connell *et al.*	2017
109	IPCC	Knowledge	Devès	2018
110	IPCC	Knowledge	Fløttum	2016
111	IPCC	Knowledge	Hesse	2016
112	IPCC	Knowledge	Klenk & Meehan	2015
113	IPCC	Knowledge	Tol	2011
114	IPCC	Media & comms	Barkemeyer	2016
115	IPCC	Media & comms	Black	2015
116	IPCC	Media & comms	Brick *et al.*	2016
117	IPCC	Media & comms	Eide	2016
118	IPCC	Media & comms	Harold	2016
119	IPCC	Media & comms	Hickman	2015
120	IPCC	Media & comms	Hollin & Pearce	2015
121	IPCC	Media & comms	Jacobs *et al.*	2015
122	IPCC	Media & comms	Kunelius & Yagodin	2017

	Platform / case study	**Indicators / content**	**Authors**	**Year**
123	IPCC	Media & comms	Kunelius *et al.*	2017
124	IPCC	Media & comms	McMahon	2016
125	IPCC	Media & comms	Newman	2016
126	IPCC	Media & comms	O'Neill	2015
127	IPCC	Media & comms	Painter	2015
128	IPCC	Media & comms	Roosvall	2017
129	IPCC	Media & comms	Sokona *et al.*	2016
130	IPCC	Media & comms	Stocker & Plattner	2016
131	IPCC	Participation	Klenk *et al.*	2015
132	IPCC	Participation	Riede	2016
133	IPCC	Participation	Yamineva	2017
134	IPCC	Risk & uncertainty	Adler & Hadron	2014
135	IPCC	Risk & uncertainty	Aven & Renn	2014
136	IPCC	Risk & uncertainty	Budescu *et al.*	2011
137	IPCC	Risk & uncertainty	Budescu *et al.*	2014
138	IPCC	Risk & uncertainty	Stoerk *et al.*	2018
139	IPCC	Scale	Devès *et al.*	2017
140	IPCC	Scale	Howarth & Painter	2016
141	IPCC	Scale	Satterthwaithe	2014
142	IPCC	Scenarios	Pielke	2018
143	IPCC	Social sciences	Carey *et al.*	2014
144	IPCC	Social sciences	Kowarsch	2016
145	IPCC	Social sciences	Stern & Dietz	2015
146	IPCC	Social sciences	Victor	2015
147	IPCC	Capacity development	Singh & Patwardhan	2014
148	IPCC	Capacity development	van der Veer	2013
149	Shale gas	Participation	Borchardt	2017
150	Shale gas	Assessment report	Scholes *et al.*	2016
151	Shale gas	General	Scholes *et al.*	2017
152	Shale gas	Risk & scenarios	Schreiner & Snyman-vd Walt	2018
153	Shale gas	Participation & governance	Schreiner *et al.*	2018
154	UKCCRA	Assessment report summary	Committee on Climate	2016
155	UKCCRA	Social justice	Benzie	2014
156	UKCCRA	Co-production	Howarth *et al.*	2018
157	UKCCRA	Shortcomings	Semenov *et al.*	2012
158	UKCCRA	General	Warren	2018
159	UKCCRA	Review of economics	Watkiss & Hunt	2012
160	UKCCRA	Risk	Webb	2011
161	UKCCRA	Policy frameworks	Wilby	2012
162	UKCCRA	General	Wood *et al.*	2015

Appendix 3: Project Manager's Survey

University of the Witwatersrand
1 Jan Smuts Avenue, Braamfontein,
Johannesburg, 2000
South Africa

Measuring the effectiveness of scientific assessment processes

PhD undertaken by Greg Schreiner
Research Ethics Clearance: H18/04/18

Questionnaire for Project Managers

	Background questions	**Answer** [Insert]
1	Your name	
2	Scientific assessment managed	
	Content questions	**Answer** [Insert]
3	Did the assessment have access to sufficient financial resources?	
4	What was the budget for the entire assessment?	
5	What was the duration of the entire assessment?	
6	Were there enough personnel dedicated to the assessment? i.e. within management, leadership, authorship, reviewers, structures.	
7	Was there continuity in personnel through the assessment duration?	
8	Were information systems such as websites, databases, maps etc. made available to people participating in the assessment? Are there any examples of this?	
9	Was there sufficient time allowed to produce the assessment?	
10	How much time in months was allocated between: i) ZOD to FOD ii) FOD to SOD iii) SOD to Final Assessment	
11	Were there any points where policy changes meant that	

	changes to the assessment approach or method were required? If so, please briefly explain this situation.	
12	Was there a scoping exercise at the outset of the assessment to gather the concerns and interests of wider stakeholders? If so, do you think the assessment was effective in delivering answers to those questions?	
13	Was there a process whereby assessment participants had to declare their political or personal interests?	
14	Were there established protocols for conflict mediation?	
15	Were there forums for experts to engage with policy-makers, and policy-makers to engage with experts?	
16	Were there initiatives to promote the participation of young people in the assessment?	
17	Was there initiative to promote the participation of marginalised groups in the assessment?	
18	Do you think the process was able to adapt to change? Can you think of an example of this?	
19	Did the assessment have a system for the management of uncertainty e.g. in the form of calibrated likelihood language?	
20	Were things done repetitively in order to promote content improvement?	
21	Were the outputs of the assessment focused on implementation practicality and the needs of policy?	
22	Has any of the assessment been used so far in policy formation or public dialogue (e.g. media, law, policy statements, protocols etc.)? Can you think of a few well-known examples?	
23	Was there an effort to produce material which would have an impact by guiding future assessments at smaller scale? Can you provide evidence of this?	

Appendix 4: Detailed Rationale for CRELE Indicators

STRUCTURE

REPRESENTATION

The quality of a scientific assessment depends on the quality and diversity of the participants (Young *et al*., 2013). Representation includes the indicators of knowledge co-production, diverse expertise, government involvement, openness to participants, indigenous and local knowledge, embedded social sciences, and knowledgeable experts.

Knowledge co-production

Rationale for inclusion	Co-production has the potential to increase legitimacy and relevance through advancing participant understanding and learning, increasing decision-making saliency and encouraging transparency (Mach and Field, 2017).
Example statement from the literature	*"Effectively designed and managed assessments provide the platform for the 'co-production of knowledge' – an iterative and collaborative process involving scientists, stakeholders and policymakers"* (Scholes, Schreiner and Snyman-Van der Walt, 2017: 1).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Participants were able to co-develop (i.e. participate together in knowledge production).

Diverse expertise

Rationale for inclusion	A wide coverage of expertise increases the knowledge base, legitimacy and credibility of a scientific assessment (Young *et al*., 2013).
Example statement from the literature	*"…[scientific assessment] must be demand driven and involve experts from all relevant stakeholder groups in the scoping, preparation, peer-review and outreach/communication"* (parentheses added) (Watson, 2005: 473).
Relationship to CRELE	Credibility: Moderate Relevance: Weak Legitimacy: Strong
Survey statement	There was a wide range of expertise among participants.

Government involvement

Rationale for inclusion	Cogenerating material with government increases the relevance of the outputs and leads to shared psychological ownership of the products, enhancing their effect in the policy domain.
Example statement from the literature	"…in order to help the assessment be accepted and land politically, it is vital that policy-makers be closely involved in the assessment" (Rothman *et al*., 2009: 216).
Relationship to CRELE	Credibility: Weak Relevance: Strong

	Legitimacy: Moderate
Survey statement	Government/s actively participated in various roles during the assessment.

Openness to participants

Rationale for inclusion	Increasing the openness and transparency of a scientific assessment process to all participants increase legitimacy in the eyes of the stakeholders (Watson, 2005). Creating a diversity of mechanism for participation e.g. through authorship, governance, peer review etc. enables the greatest scope and opportunity for this.
Example statement from the literature	*"The benefits of broadening participation in assessment processes almost certainly outweigh the costs"* (Rothman *et al.*, 2009: 216).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	The process was open to all interested stakeholders.

Local knowledge

Rationale for inclusion	Scientific knowledge is excellent at answering technical questions which affect large-scales e.g. global climate models. It is less useful in the domain of local adaptation and management strategies which may be influence by social and cultural values. Including local knowledge enables the incorporation of different values and increases the likelihood of policy/behavioural change.
Example statement from the literature	*"…the process should incorporate institutional as well as local and indigenous knowledge whenever appropriate"* (Watson, 2005: 473).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Non-scientific knowledge was adequately considered.

Embedded social sciences

Rationale for inclusion	Traditionally the natural sciences have dominated scientific assessments. Since human drivers inspire much of the global change and policy options are to be implemented at scale in society, the social sciences are viewed as increasingly important in scientific assessments (Stenseke and Larigauderie, 2018).
Example statement from the literature	*"…allow for genuine interdisciplinary interactions between social and natural sciences"* (van den Hove, 2007: 815)
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Biophysical, social and economic issues were considered in a balanced fashion

Knowledgeable experts

Rationale for inclusion	Including well-known, well-recognised experts increases the credibility of a scientific assessment. Experts don't necessarily have to be academics. They are knowledgeable people recognised by their peers and wider society as having knowledge relevant to the issue.
Example statement from the literature	*"Efforts to increase the technical credibility of an assessment may well want to secure participation of relevant experts in the assessment so that adequate and authoritative information can be brought to bear"* (Cash and Clark, 2001: 9)
Relationship to CRELE	Credibility: Strong Relevance: Moderate Legitimacy: Weak
Survey statement	Experts were sufficiently knowledgeable and competent

RESOURCES

Adequate financing and staffing capacity enables CRELE in all respects as implementation of CRELE principles are resource consuming (Young *et al*., 2013). Resources include financial resources, human resources, personnel continuity, information systems and sufficient time.

Financial resources

Rationale for inclusion	Most participation exercises in a scientific expensive are relatively expensive. Adequate sources of funding enable higher levels of participation which influences relevance (through government participation) and perceived legitimacy (through wider stakeholder participation).
Example statement from the literature	*"Resources are essential to the ongoing work of the SPI, and the sourcing and development of financial and human resources require time and iterative work"* (Sarkki *et al*., 2015: 10).
Relationship to CRELE	Credibility: Weak Relevance: Strong Legitimacy: Moderate
Survey statement	Adequate financial resources (e.g. funding, stipends, disbursements etc.) were made available

Human resources

Rationale for inclusion	Recruiting sufficient management staff and competent experts with peer-group respect impacts quality of process and product and hence credibility.
Example statement from the literature	*"SPIs depend on human and financial resources to achieve their objectives"* (Young *et al*., 2013: 44).
Relationship to CRELE	Credibility: Strong Relevance: Weak Legitimacy: Moderate
Survey statement	There were sufficient human resources (i.e. management, experts and reviewers) available to undertake the work.

Personnel continuity

Rationale for inclusion	Continuity enables the smooth running of processes and high-quality outputs.
Example statement from the literature	*"Continuity of policy support, communication, network building and maintenance, as well as a certain amount of continuity in membership and participation, are necessary to ensure smooth running of the SPI and to avoid erosion of CRELE"* (Young *et al*., 2013: 48)
Relationship to CRELE	Credibility: Strong Relevance: Weak Legitimacy: Moderate
Survey statement	There was continuity in personnel through the process.

Information systems

Rationale for inclusion	Accurate and accessible information systems for knowledge transfer increase technical accuracy of findings and also accessibility through useable, attractive interfaces.
Example statement from the literature	*"Develop and use existing information systems"* (Young *et al.*, 2013: 54).
Relationship to CRELE	Credibility: Strong Relevance: Moderate Legitimacy: Weak
Survey statement	Information systems were available to participants (e.g. websites, platforms, databases, maps etc.).

Sufficient time

Rationale for inclusion	Creating environments for deliberation and compromise, such as negotiation sessions between experts and policy-makers around SPMs, increases the legitimacy and relevance of the scientific assessment outputs.
Example statement from the literature	*"Projects must ensure there is sufficient time and resources set aside for interaction via personal meetings and larger events with policy-makers when the final results have been produced"* (Young *et al*., 2013: 58).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Time was made available for compromises

DRIVERS

Drivers move the assessment process forward from inception to conclusion. They are the energy driving and framing nature of the questions assessed. Drivers consist of the indicators of clear objectives, adaptation to policy changes, use of different scenarios, mandated process, delineated scope and questions from stakeholders.

Clear objectives

Rationale for inclusion	A clear set of objectives establishes the steps which demonstrate progression toward a vision which encourages legitimacy and relevance.
Example statement from the literature	*"A clear and shared vision helps to motivate SPI participants by showing what objectives are to be achieved and how this will be done. Clarity and transparency regarding vision were also considered important for increasing relevance"* (Sarkki *et al*., 2015: 6).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Objectives were clearly communicated to all participants

Adaptation to policy changes

Rationale for inclusion	Being adaptive to policy changes influences the usability of the outputs for policy- and decision-making and also affects quality. Being flexible can also affect timing of assessment outputs.
Example statement from the literature	*"To stay relevant, and also credible, SPIs need to implement processes to scout out the future policy and decision contexts, and science needs and trends. Horizon scanning includes various planning, scoping and knowledge-filtering activities"* (Young *et al*., 2013: 48).
Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	Imminent policy changes were considered during the process.

Different scenarios

Rationale for inclusion	Shared visions of the future make scientific assessments highly relevant to a diversity of stakeholders. Since they are frequently evidence informed, they also increase the credibility of the findings.
Example statement from the literature	*"…scenarios can nurture contemplation of futures that individuals, societies, and decision makers might want - and bolster understanding of how to achieve them. They can also involve evidence informed speculations about futures people might get and need to deal with"* (Mach and Field, 2017: 15).
Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	The different scenarios were adequately assessed

Mandated process

Rationale for inclusion	An authorising environment is essential for legitimisation of the process and outputs. Relevance is also established by allowing government to pose questions which relate to their specific decision-making needs.
Example statement from the literature	*"Legitimacy means that the assessment was asked for by a body which has a mandate to take action on the topic. This is called an 'authorising environment'. In its absence, there is a high likelihood that the findings will simply be ignored"* (Scholes, Schreiner and Snyman-Van der Walt, 2017: 4).

Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	The assessment process was asked for, or 'mandated', by government/s.

Delineated scope

Rationale for inclusion	A clearly defined scope increases the opportunity for co-production of meaningful outputs. Conversely, processes which become too wide in scope (while they may be interesting from a curiosity perspective), lose their decision-making relevance (Cash and Clark, 2001).
Example statement from the literature	*"A final characteristic of assessments that seems likely to shape their effectiveness is decisions regarding scope – what is included, and what is left out"* (Cash and Clark, 2001: 9).
Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	The scope of the issues assessed, was clearly defined

Questions from stakeholders

Rationale for inclusion	Allowing stakeholders and policy-makers to pose the questions for assessment stimulates in interest and increases the possibility of policy uptake. Most importantly, allowing stakeholder inputs during the framing of the assessment builds legitimacy.
Example statement from the literature	*"Deciding on the questions or topics is usually an iterative ('co-determined') process because they have to be both salient and amenable to scientific investigation"* (Scholes, Schreiner and Snyman-Van der Walt, 2017: 4).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Questions were posed by a diversity of stakeholders.

PROCESSES

TRUST

Trust is important for scientific assessments. Trust is required between experts, policy-makers, users and wider society. Trust includes the indicators of managed bias, freedom from manipulation, declaration of interests, trust, conflict mediation, transparent procedures, fairness and media relations.

Managed bias

Rationale for inclusion	Bias control mechanisms much as peer review advance legitimacy of process and credibility of content. There is a trade-off in that non-scientific forms of knowledge and value judgements can be subjectively biased, so increased inclusivity may not be

	associated with increased scientific credibility.
Example statement from the literature	*"…assemble knowledge in a scientifically and politically unbiased way with a view toward making it publicly available in a form intended to be useful for decision-making"* (Edenhofer and Kowarsch, 2012: 2).
Relationship to CRELE	Credibility: Moderate Relevance: Weak Legitimacy: Strong
Survey statement	The process you participated in was free from bias.

Freedom from manipulation

Rationale for inclusion	A scientific assessment process needs to be free of external control, which promotes legitimacy in the eyes of the users.
Example statement from the literature	*"Independence from external control and from vested interests enhances credibility"* (Young *et al*., 2013: 61).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	The process was free from manipulation.

Declaration of interests

Rationale for inclusion	Legitimacy and credibility are enhanced if potential conflicts of interest are transparently declared at the outset of the scientific assessment process.
Example statement from the literature	*"SPIs' credibility is enhanced if their structures are perceived as unbiased and existing dependencies or potential conflicts of interests are transparently communicated"* (Sarkki *et al*., 2015: 4).
Relationship to CRELE	Credibility: Moderate Relevance: Weak Legitimacy: Strong
Survey statement	Personal, political and organisational interests were transparent

Trust

Rationale for inclusion	Trust between policy-makers, experts and the wider stakeholder community creates effective communication (Young *et al*., 2013), mutual learning and enhances cooperation (Kowarsch *et al.*, 2016). Without trust, there is no legitimacy and credibility of process and outputs, drastically reducing the likelihood of impact in society.
Example statement from the literature	*"A common theme in the literature is that the uptake and application of new scientific knowledge by the end-users is largely underpinned by the level of trust that exists between the scientific 'producers' and 'users'"* (Lacey *et al*., 2018).
Relationship to CRELE	Credibility: Moderate Relevance: Weak Legitimacy: Strong
Survey statement	The process was trustworthy.

Conflict mediation

Rationale for inclusion	While some conflict may be necessary, and indeed a feature of co-production processes, too much conflict can be corrosive of trust and therefore legitimacy.
Example statement from the literature	*"Clearly stated and agreed methods for managing disagreements, including, for example, specific stages for recourse to internal and independent external conciliation, will help to avoid the potentially corrosive effects of conflict"* (Young *et al*., 2013: 48).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Conflict among participants was mediated

Transparent procedures

Rationale for inclusion	Transparent negotiation procedures build legitimacy in the eyes of the users and participating experts and stakeholders. Negotiation through conflict is essential for building and maintaining trust.
Example statement from the literature	*"…because of the multi-faceted complexity and interdependencies of these problems, ongoing and transparent deliberation on available knowledge and response options is essential"* (Kowarsch *et al*., 2016: 7).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Procedures for negotiation were transparent

Fairness

Rationale for inclusion	Perceived procedural and political fairness impacts the credibility and legitimacy of process and outputs. Fairness mainly applies to providing opportunities for participation and making inputs into content generation.
Example statement from the literature	*"…explicit attention to procedural fairness could mitigate or counter-balance the inevitable influences of political interests and epistemologies. In doing so, procedural fairness can help to bring about the outcome of good science, understood in terms of credible, relevant, comprehensive, and balanced assessment"* (Okereke, 2017: 512).
Relationship to CRELE	Credibility: Moderate Relevance: Weak Legitimacy: Strong
Survey statement	The assessment process was procedurally fair (i.e. it adhered to an established set of rules)

Media relations

Rationale for inclusion	Experts and policy-makers need the media in order to liaise with wider stakeholder communities. Developing a relationship with the media, collaborating on new forms of outreach mechanisms and materials, increase the prospects of social change (Young *et al*., 2013: 100).
Example statement from the literature	*"The media are powerful agents that translate information across the science–policy interface, framing it for audiences"* (O'Neill *et al*., 2015: 380)

Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	Media communication was prioritised

CAPACITY BUILDING

Capacity development means developing process insights, integration skills and developing topic knowledge (Kowarsch *et al*., 2016). It consists of the following indicators: capacity development, youth development and marginalised groups.

Capacity development

Rationale for inclusion	Scientific assessments should include on-going capacity development opportunities which involve spending time building trust, and developing capacities to understand other's positions, views, needs and constraints (Young *et al*., 2013). The greater the number of people familiar with and involved in the scientific assessment, the greater the levels of relevance for policy-making and wider society.
Example statement from the literature	*"…assessment process also has the potential to empower participating actors and actors groups and to build capacity among and beyond participants"* (Kowarsch *et al*., 2016: 14).
Relationship to CRELE	Credibility: Weak Relevance: Strong Legitimacy: Moderate
Survey statement	Scientists and policy-makers had opportunities to engage with one another

Focus on youth development

Rationale for inclusion	To achieve and maintain epistemic credibility through subsequent generations of knowledge producers, emerging young researchers need to be provided opportunities to grow their skill sets (van der Veer *et al*., 2014).
Example statement from the literature	*"As producers of environmental knowledge assessments, these expert organisations are epistemic authorities in their field of expertise. To achieve and maintain epistemic authority, expert organisations constantly need to reproduce and develop their expertise"*. (Gustafsson, 2018: 21)
Relationship to CRELE	Credibility: Strong Relevance: Weak Legitimacy: Moderate
Survey statement	Young people were developed for future assessment processes

Focus on marginalised groups

Rationale for inclusion	Focusing on empowerment, capacity development and access barriers for marginalised viewpoints will enhance legitimacy of the scientific assessment process (Kowarsch *et al.*, 2016).
Example statement from	*"…emphasizing empowerment through participatory scenario-building requires longer time frames, access to the expertise necessary to organize such exercises, as well as*

the literature	*mechanisms to motivate participation amongst marginalized groups"* (Kowarsch *et al*., 2016: 10).
Relationship to CRELE	Credibility: Weak Relevance: Moderate Legitimacy: Strong
Survey statement	Participation opportunities were provided to marginalised stakeholder groups

ADAPTABILITY

Scientific assessments must be able to adapt to changing policy contexts and be equipped to take advantage of new opportunities. It consists of the following indicators: it was adaptable, managed uncertainty and was iterative.

Adaptable

Rationale for inclusion	Being adaptable enables the scientific assessment to shift emphasis to align with societal or political interests, providing processes and outputs which are useable for decision-making within that context.
Example statement from the literature	*"…flexibility and adaptive management are needed as user needs and concerns change and evolve according to the changing policy landscapes and priorities"* (Young *et al*., 2013: 70).
Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	The process was able to adapt to change

Manages uncertainty

Rationale for inclusion	Many scientific assessments, such as the IPCC, require the quantification of uncertainties. This increases the credibility of the knowledge and allows for the expression of assumption upon which expert judgement is built.
Example statement from the literature	*"Effective approaches transparently acknowledge persistent uncertainties about future outcomes and contested priorities"* (Mach and Field, 2017: 23).
Relationship to CRELE	Credibility: Strong Relevance: Weak Legitimacy: Moderate
Survey statement	The assessment process managed uncertainty in an organised fashion

Iterative processes

Rationale for inclusion	Iterative scientific assessments rely on multiple face to face engagements (Kowarsch *et al.*, 2016) which help to develop trust and enhances capacities for communication on all sides (Young *et al.*, 2013).
Example statement from the literature	*"SPIs are likely to have more outcomes, when they facilitate iterative multi-directional dialogues between science, policy and stakeholders"* (Sarkki *et al*., 2015: 2).

Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	The process was iterative i.e. did things repetitively to promote improvement

OUTPUTS AND EFFECT

KNOWLEDGE

Building knowledge is an essential feature of scientific assessments. The following indicators for knowledge were developed: enhancing debate, covering emerging issues and delivering on social questions.

Enhances debate

Rationale for inclusion	Developing solutions to complex problems requires multiple inputs from multiple sources, across different cultures, worldviews and knowledge disciplines. Increasingly there are calls for greater levels of participatory processes. For these knowledge deliberations to succeed, they need to be underpinned by trustworthy processes and materials (Kowarsch *et al.*, 2016).
Example statement from the literature	Scientific assessments *"…can contribute to framing international coordinative discourses in intergovernmental negotiations. This can be achieved by widening, improving and/or maintaining the active participation of policy actors in the discussions of global environmental risks and by creating the scientific foundations for intergovernmental negotiations"* (Riousset, Flachsland and Kowarsch, 2017: 1).
Relationship to CRELE	Credibility: Weak Relevance: Strong Legitimacy: Moderate
Survey statement	The outputs (e.g. reports, policy documents, maps etc.) will enrich public debate

Covers emerging research areas

Rationale for inclusion	New areas of knowledge are essential for shaping technological and policy solutions, for example in the realm of climate change adaptation. The more current and effective these solutions are, the more they will find purchase in policy and social application.
Example statement from the literature	Scientific assessments *"…can provide a warning mechanism for policy makers to understand emerging and important issues"* (Young *et al.*, 2013: 64).
Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	During the process, important new research issues were assessed

Delivers on social questions

Rationale for inclusion	Focussing the scope of a scientific assessment on the salient questions posed by society greatly enhances public interest in the products emerging from it. Undertaking

	participation processes which seek to gather social concerns also assist in perceived public legitimacy and fairness.
Example statement form the literature	Scientific assessments answer *"…the pertinent questions and only the pertinent questions, fully and in the way the stakeholders pose them and understand them (as opposed to what scientists think stakeholders want to know)"* (Scholes, Schreiner and Snyman-Van der Walt, 2017: 4).
Relationship to CRELE	Credibility: Weak Relevance: Strong Legitimacy: Moderate
Survey statement	The outputs addressed the questions raised by stakeholders

QUALITY

Scientific assessment must be of high technical quality (Alcamo, 2017)

Of high quality

Rationale for inclusion	The credibility of scientific assessments is greatly enhanced if iterative processes to ensure quality, comprehensiveness, transparency and robustness are implemented, for example, transparent peer review (Young *et al*. 2013).
Example statement form the literature	*"…the results and analyses need to be technically accurate"* (Watson, 2005: 473).
Relationship to CRELE	Credibility: Strong Relevance: Moderate Legitimacy: Weak
Survey statement	The outputs were of adequate technical quality

IMPLEMENTABILITY

Scientific assessments must be useable (Cash and Clark, 2001). Coupled with high technical quality, the method of delivery to various audiences through reports, summaries, videos, scenarios etc. makes the findings implementable and therefore more policy relevant. Implementability consists of the indicators reaches target audiences, uses expert judgement, meets practical policy needs and guides assessments undertaken at smaller scale.

Reaches target audiences

Rationale for inclusion	Users of scientific assessments have different needs. This means that outputs need to meet the needs of multiple audiences, especially target audiences like policy-makers. Specified outputs for specified audiences have substantial relevancy and greater chances of uptake in society.
Example statement from the literature	*"SPIs must be fit for purpose, and able to reach their target audiences in timely and effective ways to maximise influence"* (Young *et al*., 2013: 42).

Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	The outputs were made available in different formats (e.g. summaries, videos, websites etc.)

Uses expert judgement

Rationale for inclusion	Since many scientific assessments are couched within the theoretical framework of risk and mitigation / adaptation, experts are required to make subjective judgements when estimating the consequence of impacts materialising (likelihood estimates are sometimes more empirically grounded). Undertaking risk assessments are extremely relevant for policy-making as they order and prioritise action items.
Example statement from the literature	*"Subjective expert judgements often required, but made explicit, along with statements of confidence"* (Scholes, Schreiner and Snyman-Van der Walt, 2017: 2).
Relationship to CRELE	Credibility: Moderate Relevance: Strong Legitimacy: Weak
Survey statement	Expert judgement was suitably applied in the findings

Meets practical and policy needs

Rationale for inclusion	The usability of the outputs generated through a scientific assessment process are perhaps the most critical element in ensuring its relevance to society.
Example statement from the literature	"Relevance is the perception of the usefulness of the knowledge brokered in the SPI, how closely it relates to the needs of policy and society, and how responsive the SPI processes are to these changing needs" (Young *et al*., 2013: 6).
Relationship to CRELE	Credibility: Weak Relevance: Strong Legitimacy: Moderate
Survey statement	The outputs have been / will be useful for decision-making

Guides assessments at smaller scale

Rationale for inclusion	Scientific assessments undertaken at a global or regional scale need to communicate with assessments undertaken at national or sub-national scale, and *vice versa*. This makes information more relevant to decision-making as it can be applied across scales by multiple governmental and non-governmental decision-makers.
Example statement from the literature	*"Assessments are typically carried out at particular scales: local, national, regional, or global, to name a few common ones. But they often rely on information collected at greater or smaller scales, or they must interface with assessments or decision-making processes at somewhat different scales, either larger or smaller"* (Ash *et al*., 2010: 124-125)
Relationship to CRELE	Credibility: Weak Relevance: Strong Legitimacy: Moderate
Survey statement	The outputs have been / will be used in future assessments undertaken at a finer scale (e.g. local or site-specific scale)