

of green growth and provide early warning signs of emerging risks and vulnerabilities in the face of changing climate and land use. Robust economic valuation of natural capital and ecosystem services would help identify the trade-offs that deliver the greatest net benefits to society.

Natural capital is the foundation of all human wellbeing, yet its degradation is largely unreported and important public and private sector decisions are routinely made without regard for its value. Government and industry should join efforts to require companies to disclose their dependence on, and also their impact on, natural capital. This requires transparent qualitative and quantitative accounting and reporting. The story of ExxonMobil's stranded assets reflects both what is good and what is bad in natural capital accounting. Shareholders clearly recognize the importance of accounting for the value of natural assets in light of potential climate related risks. But fossil fuel companies remain confident that their reserves are safe from depreciation,

particularly given the impotence of global climate policies. Measuring the impact of climate change on natural capital in monetary terms can help improve public and private sector decision-making.

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## COMMENTARY:

# Five ways to enhance the impact of climate science

David Christian Rose

Embracing an 'evidence-informed' rather than 'evidence-based' attitude to policy-making should result in more effective action on climate change, recognizing that evidence must be used in such a way as to interact persuasively with other factors.

Policy-making is rarely driven by evidence alone. Thus, climate scientists who adopt an 'evidence-based' mindset, expecting more science to lead automatically to better policy, are likely to be disappointed. Consider, for example, the following statements:

"Anyone who needed convincing about the scale of the [climate change] problem need only have watched the recent [BBC] 'Panorama' programme on the floods." (Former UK government minister Chris Mullin, 2000)<sup>1</sup>

"Colleagues across the House can argue about whether [flooding] is linked to climate change or not. I very much suspect that it is." (UK Prime Minister David Cameron, 2014)<sup>2</sup>

Both statements comprise responses to Parliamentary questions in which ministers

in the UK Government have been asked to explain recent extreme natural events. In both cases, flooding is clearly linked to climate change, and this reflects a wider tendency to make a connection between environmental change and the increasing frequency of extreme events. Yet, despite continuing high-profile claims about the urgency and gravity of the threat of climate change, policy seems to lag behind, and climate-based disasters gradually fade from media headlines. So why does meaningful policy not result, even when policymakers appear to accept that climate change is causing problems? Put simply, it is because policy-making is rarely 'evidence-based'.

Using the Fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) as inspiration, I argue

that climate scientists would do well to consider five ideas and ultimately embrace an evidence-informed approach to advising policymakers.

### 1. Reject an 'evidence-based' mindset

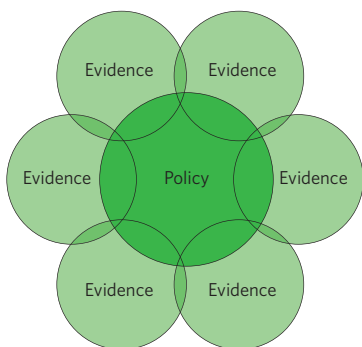
Growing confidence in climate science and observable impacts of climate change have led many policymakers to believe that climate change is a serious issue; however, considering the lack of meaningful action on climate change, this logic does not readily translate into policymakers believing that it is politically possible to act. Theorists of the policy process would not be surprised that evidence fails to influence policy in a direct fashion (rejecting Fig. 1)<sup>3</sup>, instead finding that scientific rationality must interact alongside other factors.

Indeed, the critical factor in Kingdon's<sup>4</sup> analysis of government agenda-setting refers to the influence of political conditions on scientific evidence, stating that if an idea does not fit prevailing conditions, then politics can supersede even the most pressing and well-researched science. For many environmental controversies, therefore, no amount of scientific evidence can influence policy and solve problems<sup>5,6</sup>, even if policymakers understand that the evidence is convincing. Policy-making in the climate realm is no exception, with many authors finding overwhelming evidence to suggest that policy responses "reflect a political balance of power rather than any firm direction derived from science"<sup>7</sup>. Indeed, Hulme<sup>8</sup> has argued that as a result of the IPCC's tacit loyalty to an evidence-based agenda, it (particularly the First Working Group's focus on the physical science basis) is "no longer fit for purpose," because a continued focus on producing 'more' science fails to understand that policy is not formulated in the way described in Fig. 1.

**2. Think 'evidence-informed'**

Climate scientists could address the question posed by Schön, in which he characterizes messy policy arenas as 'swampy lowlands'<sup>9</sup>: "Shall ... [scientists] descend to the swamp ... forsake technical rigor [and] deliberately involve themselves in messy but crucially important problems?"

In climate change negotiations, progress is often hampered by competing economic interests and issues of environmental justice, not by lack of evidence — questions such as: Who wins? Who loses? Who decides? Solomon and Manning<sup>10</sup> might discourage the IPCC and climate scientists more widely from making a shift towards harnessing a greater awareness of political processes, arguing that they "must maintain ... rigor,"



**Figure 1 |** Is policy usually 'based' on evidence alone? Even if evidence was the only factor in the policy-making process, this would not automatically mean that decision-makers were in a position to accept it.

as this is the "foundation for the most appropriate next steps in ... climate policy". However, just as foundations are useless unless something is built on them, providing 'the facts' to policymakers is wasted if no meaningful policy results from doing so. Instead, climate scientists should embrace an 'evidence-informed approach'<sup>11</sup> to policy-making, typified by Fig. 2.

This term recognizes that evidence can only ever be one factor in the policy-making process, and thus must interact with a number of other variables. Consequently, while technical rigor remains vital, it can be productive to enter the 'swamp', seeking to understand the nature of competing interests and learning how to deploy evidence alongside these other considerations.

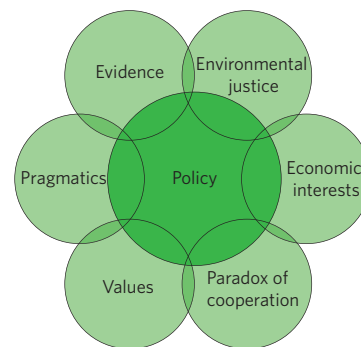
**3. Do not overrate certainty**

An overemphasis on the continued reduction of scientific uncertainty can be misguided. The IPCC's Fifth Assessment Report (First Working Group<sup>12</sup>) emphasized that the body was 95% certain that humans were responsible for climate change, a 5% increase from the Fourth Assessment report. While it should be acknowledged that in some disciplines a 95% confidence level would be significant (this can reject the null hypothesis), it is unwise to consider that this approach to certainty is adopted by policymakers. So is it probable that a 95% confidence level or more will be influential when we acknowledge that their decisions are influenced by much more than science?

To argue in the affirmative would reinforce an assessment of the policy process that only comprehends 'direct hits'<sup>13</sup> between evidence and policy, arguing that more science leads to better decisions. In contrast, some complex environmental controversies can never be solved by an infinite amount of science, as the prevailing conditions are not right for that evidence to be influential. Thus, if we reject this direct relationship between science and policy, then we must also start to question the value of continuing with efforts to focus constantly on improving scientific certainty, particularly in problems where 100% certainty is impossible.

**4. Tell 'good news' stories**

Telling good news stories is essential. Although climate change is undoubtedly serious, do climate scientists have to present doom-laden evidence much of the time? Even some climate scientists have vociferously argued that they are weary of apocalyptic discourses, exemplified by the following reaction to the Second Working Group report within the IPCC's Fifth Assessment Report:



**Figure 2 |** Evidence of climate change must interact with other factors in the policy-making process and thus can only ever 'inform' policy. Understanding the nature of these other influences on policy-making is an important determinant of how evidence can be deployed alongside other factors persuasively<sup>19</sup> ('paradox of cooperation'<sup>20</sup>).

"The message in the first draft was that ... these were manageable risks... This has completely disappeared from the [final] draft ... which is all about the impacts of climate change and the four horsemen of the apocalypse." (Richard Tol, 2014)<sup>14</sup>

While the wider media reaction to the report of the Second Working Group generally recognized a shift towards a position that argued that adaptation to climate change was possible, the public withdrawal of Tol from the report indicates that an opportunity was missed to create a pervasive positive narrative. There is plenty of evidence that telling good news stories works. Flyvbjerg<sup>15</sup>, for example, shows that policymakers often like to see something 'work' on the ground before they consider whether to enact policy, and other disciplines have illustrated the value of communicating success stories<sup>16</sup>.

So where are all the climate success stories? In making this point, I do not imply that there are few examples of effective climate action, instead arguing that there should be greater communication of successful projects. Currently, from the point of view of someone who conducts research in climate science, I struggle to think instantly of a range of examples where there have been successful climate interventions. Thus, it would be useful if success stories were highlighted more in climate reports so that references to these examples could be commonplace, acting as a model for best practice. Climate scientists would do well to extend the sentiment that was present at times within the Second Working Group report (that adaptation is possible), showing those policymakers who aren't currently making meaningful climate change policies that action on climate change can work.

## 5. Be policy-relevant

Attaching the project to a politically salient issue has increased the influence of many ideas among policymakers; for example, 'ecosystem services' (which include climate-based services) in nature conservation can show that doing the right thing for nature doesn't necessarily mean doing the worst thing for the economy (perhaps a Faustian bargain, nevertheless). A useful example of astute framing of evidence can be viewed by analyzing the campaign of the Royal Society for the Protection of Birds (RSPB) against the trade in wild birds. The RSPB was able to 're-frame' their evidence against wild bird trading when they sensed an opportunity to package it in a politically salient way. They had campaigned for a long period of time to achieve a European Union ban, presenting clear evidence that the trade was ongoing. Initially, this evidence was framed on animal welfare grounds, but this line of argument failed to impact on policy. However, when the bird flu crisis struck, the RSPB were able to show that the trade in wild birds was a serious issue for human health, potentially providing an avenue for spreading the disease further. This salient framing of the same evidence had an immediate influence on policy<sup>17</sup>.

Where possible, climate science should be communicated in a policy-relevant way (the IPCC is meant to be 'policy relevant' after all), showing that doing the right thing for climate is not always alien to other political priorities. Of course, this will not always be possible, but climate scientists can productively seek a better understanding of current political priorities,

and consequently package their evidence in a more influential way.

## Winning the battle

I have argued that when presenting climate science to policymakers, it is rarely adequate for evidence to be merely 'correct'; it must also be persuasive. Thus, climate scientists would do well to pay more attention to understanding how policy negotiations work, what could be done to ameliorate differences between decision-makers, and how science could be presented in persuasive form. Because, at times, researchers "are informing battles," but are often "not providing the knowledge needed to win the war," and thus they must start to work "outside [their] comfort zone"<sup>18</sup>.

The battle to protect the world from climate change will not be won by firing a single canon repeatedly at decision-makers, loaded with a slightly larger cannonball each time, proving that humans are responsible for climate change or expecting extreme climate events to convince policymakers to take sudden action. Rather the battle may be won by firing a broadside shot at policymakers, loaded with targeted information about how policy systems work and which issues are particularly prominent in holding up meaningful action, as well as containing astutely framed practical solutions. In directing these efforts wisely, climate scientists can win battles. Otherwise, in several years' time, policymakers might again be vociferously blaming another extreme event on climate change and leave climate scientists wondering why little attention was paid to the accumulating evidence. □

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## COMMENTARY:

# A better currency for investing in a sustainable future

Michael Carbajales-Dale, Charles J. Barnhart, Adam R. Brandt and Sally M. Benson

Net energy analysis should be a critical energy policy tool. We identify five critical themes for realizing a low-carbon, sustainable energy future and highlight the key perspective that net energy analysis provides.

Most energy planning efforts consider primary energy production by countries, industries, companies or projects. This focus on gross production of primary energy does not reflect the reality that some fraction of this gross production must be invested in sustaining

and growing the energy system itself, as well as in processing and transforming energy to provide the useful energy services we desire. Put simply, we need to 'spend' energy to 'make' energy. If the fraction of energy used by the energy system is constant, tracking and forecasting the evolution of the energy

system without considering the energy reinvestment may be adequate. However, new energy resources, new energy conversion and storage devices, and new global supply chains will affect the fraction of energy reinvestment required to support societal energy demands. Given the large changes required in coming