1

Introduction

The Plight of the Environmental Scientist

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This is a book about how environmental knowledge is used in policy, and how it is transformed to be useful for public problem solving. It is also about how such processes sometimes fail, or are based on misguided conceptions of science, of policy, or of public concerns about environmental matters. We will describe the problems environmental professionals encounter in the interaction between knowledge, policy, and society, on a practical as well as deeper, conceptual levels. Ultimately, this books aims to offer guidance on how experts can play a productive role in the governance of current environmental challenges, while respecting the diversity of perspectives and knowledge claims, and taking into account the concerns of a democratic society.

To do so, the book builds on the knowledge and experience of both social and natural scientists, and tries to combine these insights without reducing them to the lowest common denominator. Rather than providing simple rules of thumb, we want to explain the logic behind them. This chapter explains why and how the book addresses these issues.

1.1 Science and the Environment

Environmental scientists have their work cut out for them, as humanity faces daunting environmental challenges. Climate change is endangering the livelihood of millions, overfishing and plastic pollution are threatening our oceans, while fertile land and biodiversity are under pressure. In turn, environmental problems lead to conflict, scarcity leads to a global scramble for natural resources, and the combined effects of environmental degradation disproportionally impact poor and vulnerable communities. The expectations for environmental sciences to help us understand and solve these problems are high.

To help us comprehend and cope with such challenges, we clearly *need* the sciences. We will also need wisdom, ingenuity, dogged environmental activism, political commitment, solidarity, and probably a bit of luck, but the sciences will remain an essential element in solving environmental problems. Without science, it is impossible to trace pollution that is too small to observe directly, or to establish causal connections between environmental processes that occur on a planetary scale.

One such connection is the link between CFCs (chlorofluorocarbons) and the depletion of the ozone layer. Until the 1980s, CFCs were a main ingredient in spray cans and cooling liquids, and they caused a dangerous degradation of Earth's protective ozone layer, especially over the Antarctic. Only scientific research, with its satellite measurements, its understanding of atmospheric chemistry, and its global research networks, could have established the relation between kitchen-fridge coolant and the atmosphere high above a remote and inhospitable continent. And the world actually listened: 30 years after an international convention, shored up with technological alternatives and regulatory commitment, the ozone layer finally seems to be 'healing'. When nature fails to speak to us unambiguously, we need scientists to provide a translation.

1.2 The Challenges for Environmental Professionals

Yet clearly, the authority of scientists to speak for the environment is not self-evident. Often, environmental scientists express concern or even despair over 'governments who do not listen', or 'the public who do not understand the facts', or even politicians who no longer even seem to *care* about facts. One reason could be that environmental scientists are often the bearers of bad news, and that shooting the messenger may be easier than actually addressing the problem. The case of the L'Aquila earthquake (see example given below) illustrates the difficult position of environmental experts. Luckily, the consequences are rarely as extreme as in this case, but the example does indicate how difficult the position of the expert can become.

The L'Aquila Earthquake: A Trial Against Science?

ESTHER TURNHOUT

The case of the 2009 L'Aquila earthquake in Italy is a useful illustration of some of the thorny issues and dilemmas that experts face. This earthquake not only ended up taking hundreds of lives and destroying historic

buildings, it also became important in redefining the relation between expertise and society. In the aftermath of the earthquake, experts were put on trial. The seven members of the national committee for major risks were charged with involuntary manslaughter, on the basis that they had unjustifiably reassured the public and downplayed the risks of the expected earthquake. In 2012, these experts were found guilty and sentenced to six-year prison terms. In 2014, the appeals court reduced the sentence of one of the experts to two years and acquitted the other six. Nevertheless, scientists worldwide were shocked at the thought they could end up in jail for failing to deliver proper advice.

The case triggered a variety of responses in the news media. Most coverage of the case was quick to side with the scientists, comparing their fate with that of Galileo and claiming that it was unreasonable to send scientists to jail for failing to predict the earthquake (Fox News, 2012; Kington, 2012; Davies, 2012). Coverage also focused on the implications of the verdict for the independence and autonomy of science, and on how the verdict might affect the willingness of scientists to sit in policy committees and offer advice (Davies, 2012; Brown, 2012). However, a closer look shows that there was more to this case than simply a matter of the rationality of science being threatened by ignorance and interests. Rather, several lessons can be learnt from the case, with wider significance for the connections between science, policy, and society.

First, the court case was not about scientific predictions and calculations; it was about the communication of risk and uncertainty. In the period leading up to the earthquake, the area had experienced a number of small quakes, known as seismic swarms. While experts disagree about the extent to which such swarms influence the probability of a big earthquake, there is consensus that it cannot be seen as a deterministic precursor. However, one of the experts who was put on trial – De Bernardinis, a government official, and the only one whose sentence was not overturned – had said in an interview that such a swarm was actually a good sign. He claimed that swarms release energy, a statement that is widely considered scientifically false. He also called the situation ‘normal’, and encouraged the inhabitants of L’Aquila to go home and spend the night indoors. In a subsequent meeting of the expert committee and a related press conference, a different message was expressed, emphasising that earthquakes cannot be predicted and that in a high-risk area such as L’Aquila nothing could be ruled out. However,

De Bernardinis' statements were not refuted, nor were precautionary measures discussed. The main argument of the prosecution was not that the experts did not predict the earthquake, but that they were negligent in their assessment and communication of risk and uncertainty. Also, the main argument for overturning the six other experts' verdicts was that they could not be blamed for the statements made by De Bernardinis. In other words, the appeals court did uphold the view that De Bernardinis' statements were a decisive factor in causing casualties by influencing the behaviour of the residents so that they remained indoors (Cartlidge, 2015).

Second, the advice of the expert committee was not the only source of information available in L'Aquila. Local inhabitants had adopted a number of precautionary measures, including spending nights outdoors after seismic tremors. One inhabitant admitted that De Bernardinis' reassurances had led him to break with this tradition (Hall, 2011). A local resident, Guiliani, had been making his own earthquake predictions using radon gas levels, and he had warned that a major event was on the way. Although his ideas were controversial, they were picked up by the local community. According to some commentators, this created discussion in the expert committee and subsequent moves to silence Guiliani and avoid panic (Hall, 2011). As a consequence, public communication focused on whether or not there would be an earthquake, which drew attention away from communication about preparedness and about what preventive and precautionary measures could be taken.

There are several lessons in this case for risk communication, which requires a clear division of labour. It needs to be clear who is communicating about earthquake expectations and who makes policy decisions based on them. Experts are expected to state their assessment of the situation and avoid spinning the facts for political convenience. However, in a local context, local customs and knowledge about handling risks should not too readily be discarded as 'unscientific'. In fact, it may be counterproductive to get bogged down in discussions about whether dangers are sufficiently proven or not, at the expense of practical measures for coping with environmental hazards. Throughout this book, we will provide further examples of this difficult balancing act between sticking to independent experts' standards and keeping an open mind towards other forms of knowledge and other approaches to handling danger.

The L'Aquila case illustrates how hard it can be for experts to advise on public decision making, especially under conditions of high stakes and uncertainty. But even when nature does express itself loudly and without scientific intermediary, with environmental disasters, dwindling rain forests, or large pollution accidents, it may not automatically be clear where to locate the original cause, how to attribute responsibility, or how to identify optimal solutions, even with the help of scientists.

Environmental problems hence require more than just scientifically validated facts. They require deliberation over which values are at stake and which causal connections involve obligations to act. For example, should we blame ill-informed consumers for the pressure on the world's fish stocks, or hesitant regulatory agencies, under pressure from fisheries ministers worried about jobs in the fishing industry? Or should we blame Western consumption patterns for exhausting marine resources in southern oceans? Should the protection of fisheries involve edible species primarily, or find some balance with the protection of marine biodiversity, even if it cannot be harvested? Scientists' factual observations are mixed with questions about what should be valued in the environment, or about who has access to environmental resources, and when and how. Depending on how we answer such value-laden questions, different facts become relevant for our understanding of the environment, perhaps involving different forms of scientific expertise, or facts from sources other than professional scientists. Even if everybody paid attention to scientists all the time, experts would not be able to answer these questions just by providing facts based on the standard methods of their field.

To complicate matters further, in many environmental issues the facts are less than absolute. High levels of uncertainty are rife in environmental affairs: there are things we do not yet know, things that are too costly to measure precisely, scientific disagreement about how best to measure or model the environment, and chaotic processes that are inherently too indeterminate to model. In addition, the environmental sciences are multiple: a toxicologist will have a different approach to pollution than an ecologist or an environmental engineer, even if they do agree on facts. Also, scientists are not the only actors in society who speak for the environment: environmental movements, governments, companies, citizens, and the media also make claims about what is going on. Citizens concerned about local soil pollution may present worries over shaky facts presented by official sources. Or maybe these same citizens have dug into the technical details of pollution measurement, hired expertise of their own, and are about to make a strong case that goes against the dominant understanding of soil pollution risks. (Concerned citizens will do that, if they have the resources.)

A multitude of voices, partly contradictory and often displeased, is the norm rather than the exception in environmental issues, especially with new and emergent concerns. Shale gas drilling ('fracking'), river and sea pollution by (micro-)plastics, and the socio-environmental consequences of biofuels are examples of issues that spark fierce debates. The resulting controversies can land even the best-intentioned environmental scientist in dire straits. In the case of biofuels, many environmental scientists had expected environmental NGOs to support rapid introduction, only to find that NGOs expressed serious doubts, questioning the promise of carbon emission reduction and the predicted impact on food production from biofuels. These scientists faced unexpected levels of distrust, differing understandings of the problem (livelihood concerns, rather than carbon cycling), and suspicion over affiliations with the oil industry, as well as doubts over presented facts and challenges to established methods. Under such conditions, simply presenting more facts or insisting on the validity of standard methods rarely silences the critics. In issues that touch on peoples' concerns and livelihoods in such fundamental ways, the job of an environmental scientist is truly complex.

Our key message in this book is that the simple juxtaposition between 'sound, scientific fact' and value-laden advocacy provides inadequate guidance for environmental professionals. In addition to sound scientific work that lives up to expert standards, environmental professionals need to understand how to recognise variation in problem definitions, understand sources of distrust in policy or expert institutions, and appreciate the importance of acknowledging and communicating uncertainties. This requires an understanding of the variety of roles experts play in environmental issues, beyond merely providing accurate facts, however crucial these may be.

1.3 The Book

This book will help you prepare for, or reflect on, the challenges of a job in the incendiary world of environmental affairs. Specifically, it will suggest ways to prevent surprises, identify and recognise deeper sources of disagreement over environmental issues, communicate about uncertainties and limitations of knowledge, and position yourself in times of environmental controversy. This book is not about methodology or about how to get your facts straight. Rather, it is a book that explains how facts and values are entwined and how controversy can often arise not just from disagreement about the facts, but also from debate about which facts are to be considered relevant. Our main goal is to offer guidance on how experts can play a productive role in the governance of

current environmental challenges, while respecting the diversity of perspectives and knowledge claims and taking into account the concerns of a democratic society.

While these goals are relatively practical, we offer more than just hands-on instructions. Our book is rooted in decades of social science research on the role of science in environmental decision making, mostly connected to the scholarly fields of science and technology studies (STS) and policy studies, but also public understanding of science and the social science side of environmental studies. Our account is informed by the theoretical reflections this research has produced: rather than simple dos and don'ts, we want to convey the deeper insights of this research. Rather than rules of thumb, we want to explain the logic behind them.

We therefore take time to explain some of the theoretical debates in these fields of study, including the philosophical problem of whether science can be distinguished from other forms of knowing. We also provide pointers to relevant academic literature, thereby allowing the reader to dig deeper, or suggest materials that could be used in academic courses or seminars. However, we also put these theoretical insights to work and show their practical relevance for the work of an environmental professional. For this same reason, we combine the discussions of theory and general insight with extensive case studies to show how general patterns and processes can be observed in concrete environmental issues.

The book moves from more fundamental issues about the nature of scientific knowledge, and of how to understand problem definitions or (more generally) 'frames', to more practical suggestions for communication and organisation of expertise. It ends with a more normative discussion of expertise in a democratic society. At the end of many of the chapters you will find case descriptions that illustrate how the general patterns described in the main text may pan out in practice. We have chosen our case studies to cover a wide range of environmental matters, from fisheries to climate change or the regulation of pesticides. This is not just to illustrate the general difficulties of environmental professionals' work, but also because, as lecturers, we know the value of case stories as a 'memory hook' for general principles.

Hence we start (Chapter 2) with a more fundamental understanding of why a simple distinction between science and politics, and between science and other forms of knowing, provides insufficient handles for environmental advisory work. Our goal for this chapter is not to deny the unique value of scientific work, nor the importance of sticking to scientific standards, but to explain why referring to such standards alone fails to resolve debates, especially if environmental issues are heavily contested. The problem of how to define science is

much more than finding a smart phrase to express its unique features, and it raises fundamental questions about how policy makers and citizens can trust expert knowledge, and about what knowledge will come to bear, and how, on public deliberations.

Chapter 3 makes these complications more concrete, with the introduction of *framing*. This concept helps us to comprehend and analyse differing understandings of environmental problems, which may point to varying sets of facts or assessments of uncertainty. As participants in an environmental debate define problems differently, or have radically different understandings of how the environment or environmental institutions work, complex misunderstandings may develop. A case discussion of climate change sharply illustrates these points. The chapter suggests ways for environmental professionals to recognise contrasting frames, and suggests that an awareness of frame differences can be a first step to more meaningful deliberation.

Chapter 4 focuses on environmental controversies and the particularly difficult dynamic that arises when environmental issues become polarised or if disagreement 'heats up'. These are the circumstances in which environmental professionals are confronted with hypercritical opponents who may scrutinise and question every assumption (as illustrated in the 'Climategate' case), or even accusations of partisan positions, potentially accompanied by heavy emotions (as becomes clear in the case study of shale gas or 'fracking').

Chapter 5 discusses the 'The Limits to Knowledge', providing an overview of forms of uncertainty and how these play a role in environmental deliberations. The chapter provides pointers for how uncertainties can be identified, as a tool for both clarification of environmental debate and for problem finding. Uncertainties are illustrated for the case of the flower industry, which describes the debate over what constitutes an adequate understanding of pesticide hazards.

This brings us to the next logical question of what constitutes usable knowledge, the central question of Chapter 6. If society expects more from environmental professionals than just a stream of facts, and if a stream of facts alone clearly does not help to advance environmental decision making, then what more can be expected? The chapter describes how environmental professionals can better understand the context in which their knowledge has to operate, assisting with providing timely, trustworthy, and relevant knowledge in full respect of scientific standards. The difficulties of combining such principles in the practice of policy advice are illustrated by a description of European fisheries policy.

One way environmental experts have tried to resolve contrasting accounts of environmental issues is by speaking with one voice through 'integrated

environmental assessments'. Chapter 7 describes such efforts with examples from air pollution modelling and the Millennium Assessment, but also points out the downsides of integration, as some of the wealth of cognitive diversity is sacrificed for a unison account.

Lay knowledge, the topic of Chapter 8, is an important example of such cognitive diversity. Citizen science, knowledge gathered in activist opposition to policies, and knowledge of enthusiasts (such as volunteer biodiversity observers) may present valuable knowledge that is not produced or maintained by professional scientists. However, the successful use and fostering of lay knowledge requires care and tailored institutions, to address concerns over, for example, data access or the validity of such knowledge. The chapter provides illustrations of such problems for lay involvement in botanical gardens and nature conservation.

Chapter 9 translates knowledge of these processes into a description of the kinds of tasks experts perform for environmental policy, expanding beyond the narrow and instrumental job of providing 'scientifically sound facts'. The analysis of a variety of expert roles in environmental policy is illustrated with a case about the complex debate over the advantages and disadvantages of carbon storage.

Chapter 10 investigates the responsibility of environmental professionals and their expert organisations not just to scientific standards, but also to their wider role in democratic societies. The chapter takes a more normative stance and proposes some crucial virtues for the presentation of expert environmental knowledge in society.

We sincerely hope our book will prove useful for environmental professionals, in training or as reflection on their work, and look forward to continue the challenging but exciting conversation with those of us who study environmental expertise in action.

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