On Non-epistemic Values in Climate Science for Decision Support

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ABSTRACT

Climate change is an ever-increasing threat to humanity, making the need for decision relevant, actionable climate science more and more pressing. With this need comes pressure to articulate what constitutes responsible practice in climate science for decision support. This requires in part understanding the role that values should play in socially relevant science. My aim in this thesis is to develop a deeper understanding of the role of non-epistemic values in climate science for decision support. To achieve this, I bring philosophical discussions of values in science into conversation with elements that are particular to climate science as a practice.

I begin by drawing on work by philosophers of science to argue for three ways in which values can be good for science: they can help scientists meet their moral obligations through managing inductive risk; they can promote the multiple aims of research; and the presence of diverse values can promote objectivity. I apply these arguments in the context of climate science for decision support and present a range of examples to show where in the scientific process values can appropriately inform choices that climate scientists make.

I then identify and examine three important value-related conflicts that can arise, even when conditions seem right for values to influence choices in science. These conflicts, which have been largely overlooked in philosophical work, include conflicts between epistemic and social values; conflicts related to the multiple roles that scientists might occupy in society; and conflicts between personal values and community values taken to regulate scientific practice. I argue that these conflicts have the potential to make value-based choices difficult to resolve.

Some commentators have recently raised the possibility that when value-based disagreements arise climate science could be more like medicine in its management of risk. I take this suggestion seriously and conclude by proposing that climate scientists ought to explicitly embrace some non-epistemic values, such as human security, as constitutive of their field. I respond to potential objections to this proposal, arguing that it would not be a radical change to science, that it would not undermine science's epistemic integrity, and that it need not result in the promotion of politically contentious values. I then discuss how embracing non-epistemic values as constitutive of the field could have implications for practice and could contribute to the development of a code of ethics for climate scientists.

DECLARATION

I, *Jessica Lee*, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Date: 29 July 2021

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Prior to embarking on this PhD, I was forewarned by many that it was going to be a lonely journey. While there have certainly been moments where it has felt this way, I have been anything but alone. This dissertation would not have been possible without the company, help, and support of so many.

I am extremely grateful to the friends and colleagues at CSAG who I have worked closely with over the past few years. My relationship with CSAG began when, as a master's student in the philosophy department, I found myself sitting with many questions that needed the input and engagement of climate scientists. Aware that the CSAG existed on the other side of campus in the science faculty, I walked on over and knocked on Bruce Hewitson's door. In true philosophical style our engagement started with me telling him all the reasons I thought climate scientists needed to do things differently. Perhaps many busy professors at this point would have sent me on my way; Bruce did not. He invited me to staff coffee hour, and from that point onward CSAG became my university home.

I would like to thank my CSAG colleagues for their company and engagement. I am grateful to them for allowing a philosopher to infiltrate their research group, for answering my many questions, and asking me valuable ones too. A special thanks to Alice McClure and Anna Steynor for your continued encouragement. My extended gratitude goes out to Chris Jack for the many helpful discussions we have had in corridors, over coffee and in a pandemic world, over Slack. I am grateful for the extensive time he has always given me and his genuine interest and insight in the work that I do.

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It should not go unmentioned that the presence of women in philosophy of science has had a profound impact on me. As an undergraduate I was painstakingly aware of the lack of female philosophers represented in our curriculum. One exception, however, was in philosophy of science. My decision to pursue philosophy of science was in part because many of the first papers that I read in this field were written by women. The path was set out by philosophers such as Wendy Parker, Katie Steele, Nancy Cartwright, Helen Longino, Naomi Oreskes, Katie Steele, Kristen Intemann, Elisabeth Lloyd, and Erin Nash, to name just a few . I am ever grateful to these women and many more, for their contributions to philosophy, and for being beacons of possibility to the women who follow in your footsteps.

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CHAPTER ONE

INTRODUCTION

Climate change and climate variability are posing ever-increasing risks to humanity and ecosystems. Some of these risks include injury, ill-health, and death from extreme events, food insecurity and a breakdown of food systems, loss of livelihoods and income, and loss of marine and terrestrial biodiversity and the ecosystem goods, functions, and services they provide. Moreover, these risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all levels of development (Intergovernmental Panel on Climate Change [IPCC], 2014). Effective adaptation plays a key role in mitigating these risks. Thus, the need for decision relevant, actionable climate information is becoming more and more pressing.

Climate science for decision support[1] plays a key role in adaptation to climate variability and change. Broadly, it involves the development of science-based climate information at local, regional, national, and global scales for planning, policy, and practical decision making that is directed toward minimising the harmful impacts of climate change. As a practice, climate science for decision support encompasses a range of scientific activities and products. Some examples include: the development of international reports, such as the Intergovernmental Panel on Climate Change (IPCC) assessment reports which contain a synthesis of the latest science intended for policy makers globally; national documents produced annually that provide country specific information on projected changes in the local climate and the risks, impacts and vulnerabilities associated with these changes (e.g., South Africa's Annual Climate Change Reports); or conducting tailored research for the local government to support specific decision making (e.g., producing rainfall projections to support water supply infrastructure planning). Climate science for decision support also includes activities that are more engaged with stakeholders and users of climate information. For instance, climate scientists might work together in collaboration with local communities in ongoing activities, such as workshops and in-person meetings, sometimes over several years, to produce tailored decision relevant climate information, and together with stakeholders integrate that information into their broader decision-making agenda.[2]

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[1] In this thesis I use the terms 'climate science for decision support', 'decision relevant climate information' and 'climate science for decision making' interchangeably.

[2] For an example of this kind of work see the Future Resilience and Lands Project at: http://www.fractal.org.za

The target audiences for such activities and products can include decision makers across multiple levels within governments, private industries, and communities. For instance, the IPCC reports are aimed at a global audience of decision and policy makers, especially those involved in international policy making. More locally, scientists might develop and present climate scenarios to a local government that are intended to inform decisions in budget allocation. Or climate scientists might develop future rainfall projections for small-scale farmers in a drought-stricken region. In recent years there has been rapid growth in a particular type of climate science for decision support known as climate services (Adams et al., 2015). These are institutions or services that aim at providing tailored climate information and knowledge for users and include national or regional climate services, as well as non-government run organisations. They typically entail the production of tailored climate information, effective communication of the science, and the integration of this information into decision support (Jones et al., 2014).[3]

With the growth of climate science for decision support there is a pressing need for a clearly articulated account of what constitutes responsible practice in the provision of decision relevant climate information. This need is recognised and highlighted in the 2015 White Paper "Toward an Ethical Framework for Climate Services" in which the authors state that "there is a time imperative to articulate a set of ethical principles to guide this emerging field (Adams et al., 2015, p2). The White Paper was endorsed by the Global Framework for Climate Services (GFCS), an initiative involving the World Meteorological Organisation and inter- and non-governmental regional, national, and local stakeholders, reflecting wide agreement on its call for responsible climate science.

Discussion of what constitutes responsible practice of climate science for decision support is only just beginning. However, there is a growing recognition that responsible practice requires not just attention to epistemic matters – the standards and norms of good scientific practice – but also social and ethical considerations. A central question is how 'non-epistemic' values – concern for human health, or environmental quality, or economic growth – should shape climate science for decision support.

When considering the influence of non-epistemic values, climate scientists may, at least initially, find themselves facing a kind of tension. On the one hand, climate science for decision support is

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[3] Climate science for decision support includes climate services; however, it should be understood as a broader set of activities that need not include the *integration* of the science into decision making but is always aimed at supporting decision making.

clearly directed towards promoting social ends such as improving people's lives and protecting them from the harms imposed by climate change. So, in this way, social and moral values, or extra scientific considerations, seem relevant to the practice. On the other hand, climate scientists may hold the widespread view that science is at heart an epistemic endeavour and should be protected from the influence of social, political, and other non-epistemic values. Those who hold this view might have the worry that if we allow values to influence science, this would be sure to undermine its epistemic integrity. It could lead to the suppression of important ideas or accepting hypotheses when there is not sufficient evidence.

In fact, it has been suggested that the idea that climate science should be value neutral is reinforced by the politicisation of the field. In her latest book, *Why Trust Science?,* Naomi Oreskes (2019) argues that climate scientists have retreated into value neutrality as a means of distancing themselves from the attacks of denialists and sceptics who accuse climate scientists of pushing a political agenda. These denialists and sceptics challenge the credibility and legitimacy of climate scientists and the science they produce, Oreskes argues, because its findings threaten contemporary capitalist life. By insisting on value neutrality, scientists believe that the public can perceive science as "fair, objective and dedicated to the pursuit of truth" (2019, p154)[4]. Indeed, the need to present climate science as value neutral is so strong that the authors of the IPCC felt compelled to explicitly say in their opening statement on the front page of their website, that the "IPCC reports are neutral, policy relevant, but not policy prescriptive" (IPCC, 2021).

This tension related to values is perhaps most clearly captured in a comment by an IPCC author interviewed on the role of values in their practice (Gundersen 2010, p104-105):

> It is really important that [climate scientists] don't have agendas, we, who are objective and neutral, at least as best we can be, research this. Otherwise, there is a clear [cost] for all sorts of fanatics and for politicians with arguments than could be completely wrong, right.

The same interviewee later said however,

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[4] Oreskes draws links between climate scientists today and Merton's (1938) evaluation of scientists' efforts to distance themselves from the political issues of that time.

> As a climate scientist I feel I have a very big responsibility. I almost have nightmares about it, what the next generation will say about us. You had all this knowledge and what did you do? Did you try to influence people? It doesn't look like it. What were you doing? I worry about this.

So, how should climate scientists doing socially relevant research understand the relationship between the epistemic goals of their work and the important social ends these goals are directed toward?

Philosophers have been working on the issue of values in science for decades, with a notable recent resurgence of interest. A strong case has been made for the appropriateness of value influence in science under certain conditions (for example, see Douglas, 2000, 2009; Steel, 2017; Hicks, 2014; Intemann, 2015; Elliott and McKaughan, 2014). Nevertheless, there remain many open questions, such as whose or what values should be playing a role in science and, further, what challenges or tensions might scientists face when incorporating values into their practice.

Several arguments and debates on the role of values in the context of climate science have been developed. Eric Winsberg, Wendy Parker, and others have argued for the various ways in which climate science is unavoidably influenced by non-epistemic values (Winsberg, 2012; Biddle and Winsberg, 2010; Lenhard and Winsberg, 2010; Parker, 2014; Parker and Winsberg, 2018). Parker and Winsberg (2018) identify many ways in which non-epistemic values shape both various choices and priorities in model construction. Moreover, they argue that because these models stand in for background knowledge the values that informed them ultimately influence evidence evaluation. Other arguments focus on the risk of error and the value relevant consequences associated with these errors in a number of choices that climate scientists make, such as choosing probability distributions (Steel, 2015), and assigning probabilities to scientific statements (Parker, 2014 Steele, 2012). These arguments have been challenged by a few who maintain that climate scientists can avoid the influence of value judgments by hedging their claims, or providing coarser probabilities (Betz 2015 & John 2015).

Putting descriptive arguments for values in science aside, a number of scholars have gone on to develop normative accounts for the presence of values, identifying and justifying legitimate or appropriate conditions under which values can and should inform climate modelling and climate science (Intemann,2015 & Steel, 2016). More recently, Parker and Lusk (2020) have attended, in part, to the issue of whose values should be playing a role in climate science by clarifying the ways in which user values can be incorporated into climate services.

My contributions in this thesis will go beyond this existing work in several respects. I will explore in greater detail how values could be brought into climate science at decision points throughout the research process and in a way that is positive for the practice. However, I will also show that climate scientists embracing these roles for values are likely to sometimes face value-related conflicts, which make value-based choices difficult. One way to resolve some of these kinds of conflicts, I will suggest, is to consider some non-epistemic values, such as human security, to be constitutive of climate science for decision support.

Chapter Two begins by defending positive roles for values in science. By synthesising existing philosophical work on values in science, I argue that there are three ways in which non-epistemic values can play an appropriate and even helpful role in scientific research. First, drawing on the work of Heather Douglas (2000; 2009), I argue that values can inform scientists' choices in ways that manage inductive risk and, in doing so, help scientists to meet their moral obligations. This is known as the Argument from Inductive Risk or the inductive risk view.[5] Secondly, many scientific practices, particularly decision- and policy-relevant science, have both epistemic and non-epistemic aims: non-epistemic values can inform choices in these practices in so far as the choices promote these multiple aims of research (Elliott and McKaughan 2014; Intemann, 2015). This is known as the Aims Approach. Lastly, the presence of diverse values helps scientists to identify problematic background assumptions and dominant values, thus promoting a distinctly social form of objectivity (Longino, 1990; 1996; 2004).

Though the arguments in Chapter Two provide clarity on how values can be positive for science, they are presented at a level of abstraction that may make it difficult for climate scientists and practitioners to see how the arguments apply to their own scientific field. Thus, in Chapter Three, I apply the three arguments from the previous chapter in the context of climate science and illustrate many of the ways in which values can play appropriate roles in climate science for decision support. I structure this chapter by analysing the scientific process as having three phases: the pre-research phase, the research phase, and the post-research phase. For each phase, I provide examples to show where values can inform scientists' methodological choices. The examples presented in this chapter are not intended as an exhaustive list of roles for values, but it is an

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[5] I use these interchangeably.

extensive one. My aim is, in part, to convey to climate scientists that values can play an appropriate role in many of the choices that they make.

In Chapter Four, I identify and examine three important value-related conflicts that can arise, even when conditions seem right for values to influence choices in science – such conflicts have been largely overlooked in philosophical work. Considering them is important because they can precipitate disagreements and tensions amongst scientists that can make value-based choices difficult to resolve. To illustrate this, I discuss a case study from climate science where a new method for extreme event attribution was introduced. This case study was identified by Elisabeth Lloyd and Naomi Oreskes (2018) as an example where non-epistemic values can play an appropriate *role* in informing a methodological choice, in particular an inductive risk choice, and yet led to considerable controversy. I propose three distinct value conflicts that can arise for scientists managing such inductive risk choices. The first is a conflict between epistemic values – such as truth or avoidance of false positives – and social values like human security. The second is a conflict between the multiple roles that scientists might occupy in society, in particular their moral obligations as scientists and the values they hold as citizens of society. Lastly, the regulatory function of community norms, together with the politicisation of sciences like climate science, can result in scientists' personal values, such as those related to their careers, pulling in a different direction than societal values that they also embrace. I suggest that a potential explanation for disagreements over such methodological choices is that scientists resolve these value conflicts differently.

In their analysis of the event attribution case, Lloyd and Oreskes (2018) briefly suggest that perhaps – contrary to the norm – climate science should be more like medicine in its management of risk: medical research tends to prioritise avoiding false negatives over false positives. In Chapter Five I mount a serious defence of their suggestion. I propose that climate scientists *should* explicitly regard some non-epistemic values, such as human security, as constitutive of climate science for decision making. I begin by considering three possible objections to my proposal: that it would be a radical change to science, that it could undermine epistemic integrity, and that it could lead to the promotion of politically contentious values. I provide rebuttals to each of these objections. Following this, I develop the proposal in further detail, expanding on the notion of human security, and arguing that it is already an implicit commitment of climate science for decision support. I then discuss several important implications that adopting this proposal would have in practice. I argue that climate scientists might well make different methodological choices, that they might give more priority to certain geographical areas where human security is at risk, and that the proposal might assist scientists in resolving some of the value conflicts identified in the previous chapter. Lastly, I argue that this proposal comes at an appropriate time for scientists and practitioners in the field who are increasingly looking to develop a code of ethics for their practice.

I conclude in Chapter Six by providing a summary of the chapters and discussing potential further avenues for research.

A final note: this is an interdisciplinary thesis. It straddles pertinent questions in both philosophy and climate science. Some of the chapters that follow, such as Chapters Four and Five, speak more to a philosophical audience, whereas Chapter Three is primarily geared toward scientific practitioners. However, all the chapters, both individually and jointly, are meant to be useful for a broad audience interested in questions related to values in science and, especially, climate science.

CHAPTER TWO

THREE WAYS VALUES CAN BE GOOD FOR SCIENCE

Introduction

At first glance, ethical and social values seem to have an important and appropriate role to play in many aspects of scientific practice. For example, societal values typically guide our judgments about what research scientists ought to pursue: we think it is important that a considerable proportion of research should be dedicated to pursuing science that is beneficial to society, such as developing a new vaccine, better predicting the future climate, or finding a cure for cancer. Values are also important in determining acceptable ways of conducting experiments: we ought not to harm human test subjects by giving them dangerous chemicals, even though doing so might facilitate medical research.

However, there are also many ways in which the influence of values in science is problematic. For example, it can lead to suppression of important ideas, cherry picking data, or accepting hypotheses when there is not sufficient evidence (Douglas, 2009; Oreskes and Conway, 2010). Saying that values should play a role in science is not enough; it is important to ensure that *appropriate values* are influencing science in *appropriate ways*. This includes determining where along the scientific process values should have an influence, what kind of influence they should have, and importantly, which or whose values should play a role. In an age where science plays an increasingly central role in decisions that matter for humanity (for example, in addressing contentious climate change issues, or protecting humanity from life-threatening diseases), and where the impacts of scientific research can be far-reaching, the need to think carefully about values in science has never been more pressing. Whilst in the past philosophy of science's central focus was on the relationship between evidence and theory and the nature of confirmation and explanation, increasingly now philosophers of science are addressing the relationship between science and society. A central aim is to achieve greater clarity, both descriptively and normatively, on the place of social and ethical values in science.

In what follows, I begin by providing some background to these values in science discussions by introducing the value free ideal (VFI), a thesis on which many values-in-science discussions hinge, as well as some terminology used in these debates (*Section 2*). According to the value free ideal, the internal workings of science should, as much as possible, remain independent from the influence of values. Debates over the value free ideal have waned in the past few years, with many philosophers agreeing that social and ethical values may play roles in all aspects of science. Almost no philosophers, however, give values free rein, acknowledging that there are certain constraints on the kinds of values that may influence science as well as the kind of influence they may have (Hicks, 2014). As a result, attention has now turned to address more specific questions about how to distinguish between legitimate and illegitimate value influence. This chapter brings together three distinct yet important arguments for why value influences of the sort that the VFI would prohibit make for better science. The first shows that, under certain conditions, value influence helps scientists to fulfil their ethical responsibilities *(Section 3*). The second shows how value influence can help science to better meet the aims that it sets for itself (*Section 4*). The third shows how diverse value perspectives can promote objectivity (*Section 5*). In presenting these arguments, I will make salient the ways in which the roles for values that are articulated meet both the ethical and epistemic standards that comprise 'good' science.

Before doing this, it is important to clarify the scope of this chapter, as well as some limitations. First, this chapter will not delve deeply into historical examples of how values have infiltrated science. We already know that in practice science is not value free, and a great deal of work in science studies has shown that, historically, non-epistemic considerations have influenced science (Oreskes and Conway 2010; Jasanoff et al., 2001). The central question being addressed in this chapter is why and under what conditions is it *appropriate* and even *helpful* for non-epistemic values to play various roles in the production of science. In other words, the focus here is normative: *should* scientific research aim to be value free? This question is worth considering regardless of whether science is or could be value free. Even if value-free science is attainable, it might not be something we should want. If it is not attainable, then it might still be argued that science should strive for it. Second, the arguments presented here espouse legitimate value *roles*; they do not address the question of which values are legitimate. That is, this chapter offers an account of where and how values can legitimately influence or inform the choices scientists make, without offering an account of what these values should be. The latter will be addressed in Chapter Five.

2.1 The nature of values in science

Understanding values in science is a vast, multifaceted undertaking, stretching across disciplines such as sociology of science, social psychology, science studies, and philosophy of science.

Research in these various fields involves understanding the relationship between science and society, how values drive decision making and what personal and institutional norms influence inquiry. Within philosophy of science these discussions include both descriptive research, which is aimed at identifying and understanding how values have played a role in science, and normative projects, aimed at determining the role of values in ensuring *good science*. Scholars have put forward various norms or ideals that scientific practice and scientists themselves should be committed to. In his influential essay "The Normative Structures of Science" (1942),[6] Robert Merton outlines a set of norms that he argues are the ethos of science: *universalism*, which asserts that all scientific claims should be held to a set of preestablished, impersonal criteria; *communism* (or communality) which states that the findings in science are products of social collaboration; and *disinterestedness,* which holds that because of the institutional structures of science, scientists do not allow their personal or ideological motives to influence their inquiry. Not too dissimilarly, the philosopher Hugh Lacey (2018) discusses three ideals for science: *impartiality*, which asserts that scientific claims are or should be evaluated in light of evidence and should not be value-laden; *neutrality* which is the ideal that scientific knowledge ought to be inclusive and equal – not privileging the values of some over others; and *autonomy*, a political stance arising as a reaction to external influence and control of science. This ideal maintains that scientists and scientific institutions ought to be free from political intrusions and that science should be left to the scientists. Lacey rejects neutrality and autonomy, espousing impartiality as the core norm and the basis for his defence of value freedom.

While freedom is regarded as a core value in science, responsibility is also recognised as a central tenet. Feminist philosophers of science, such as Janet Kourany (2010), have emphasised the need for more socially engaged and socially responsible science, which is undertaken more explicitly in the service of social goods. This two-part value foundation is expressed in the following quote by the American Association for the Advancement of Science in their statement on Scientific Freedom and Responsibility (2017):

> Scientific freedom and scientific responsibility are essential to the advancement of human knowledge for the benefit of all. Scientific freedom is the freedom to engage in scientific inquiry, pursue and apply knowledge, and communicate openly. This freedom is

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[6] This essay was originally published under the title "Science and Technology in a Democratic Order".

> inextricably linked to and must be exercised in accordance with scientific responsibility. Scientific responsibility is the duty to conduct and apply science with integrity, in the interest of humanity, in a spirit of stewardship for the environment, and with respect for human rights.

In the philosophy of science literature, discussions that speak to the norms of science and its social responsibility have arisen out of a relatively narrow focus on what constitutes a good scientific theory and whether values should have any role specifically in decisions about theory and hypothesis selection.

Generally, a value is understood as something desirable or worthy of pursuit to be promoted or realised (Kincaid et al 2007; Elliott 2017). They are factors that can motivate an individual's decision in a particular way and tend to be positively regarded either by an individual, a community, or population (Steel, 2010). In the values in science literature, values are typically categorised into two distinct groups: *epistemic values*, also constitutive values,[7] or epistemic criteria; and *non-epistemic values*, also called contextual values. Epistemic values are values related to the attainment of truth and knowledge.[8] They are often articulated as qualities that we want a scientific hypothesis to exhibit because those qualities are understood as truth promoting (McMullin, 1982). In other words, hypotheses or theories that instantiate these epistemic values are taken to be more worthy of belief than those that do not display them. They are usually understood to be constitutive of the knowledge and truth-seeking goals of science (Rooney, 1992), or values that help scientists think through the evidential and inferential aspects of theories or data (Douglas, 2009).

Philosophers tend to disagree on which values should be included in the list of epistemic values. Thomas Kuhn (1977) proposes five values for scientific theory choice: accuracy, simplicity, internal and external consistency, breadth of scope, and fruitfulness. Some philosophers include explanatory power and predictive accuracy, whilst others argue that some values on Kuhn's list are not values at all. John Norton (2018), for example, argues that epistemic values are surrogates for background knowledge. Heather Douglas (2013) further distinguishes between classes of

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[7] The term 'constitutive values' is used differently by different authors. Importantly, constitutive values are those that are taken to be *core to scientific practice*. For many, specifically advocates of the value free ideal, constitutive values are limited to epistemic values. However, some argue that constitutive values include a broader set of values. I will elaborate on the notion of constitutive values in later chapters.

[8] Or in the case of anti-realist interpretations of science, something weaker like empirical adequacy. The subtleties of the realism-anti-realism debate need not concern us here.

epistemic values themselves.[9] She maintains that internal consistency and empirical adequacy are not values per se but rather minimal criteria, qualities that any theory must have in order to be a candidate for truth. By contrast qualities such as explanatory power, accuracy, or simplicity are epistemic values; they cannot guarantee truth, but are desiderata, in that theories that have them are more likely to "home in on truth" (ibid., p.800).

Disagreements on the nature of epistemic values, though interesting, are not central to our concerns in this thesis. What is key for our purposes is that epistemic values are typically viewed as distinct from non-epistemic values.[10] Non-epistemic values include 'everything else'. They include, for example: social, political, economic, personal, cultural, and ethical values.[11] Debates on value-ladenness in science generally entail determining what role these apparently distinct sets of values should and do play in science. A long-held view about values in science centres on this distinction. It holds that while epistemic values play a key role in scientific reasoning, non-epistemic values should have no part to play in internal parts of science. This view is known as the value free ideal.

The value free ideal

To aid these discussions, philosophers tend to identify different moments or decision points in science where non-epistemic values can potentially have an influence. It should be noted that the schemata I use below is an idealisation: in some cases, the phases cannot be clearly distinguished from one another, and in practice these phases are often non-linear in that they do not always strictly follow in this order (Hicks, 2014). For example, a scientist might have access to some data and so develop a research question relevant to the data. Or a scientist may decide to go back and adjust a research question when she realises that the evidence doesn't support her initial hypothesis. Nevertheless, for the purposes of setting out the debates this framework offers structural clarity. The schemata used by philosophers of science vary, but all share similar divisions along the following lines:

1. *The pre-research phase,* in which research programmes are identified, research questions are chosen and framed, and the aims of inquiry are set out.

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[9] Douglas calls these cognitive values.

[10] Some philosophers such as Helen Longino (1996) have challenged this distinction.

[11] There are many other kinds of non-epistemic values, such as religious values, or aesthetic values. I have left these out as they do not play a significant role in this discussion.

2. *The research phase,* further divided into the *setting up stage*, which includes selecting particular methodologies, gathering and characterising data and interpreting data, and the *evidence-evaluation stage* in which hypotheses are evaluated in relation to evidence.
3. *The post-research phase,* which includes framing, communicating, and applying findings.

According to advocates of the VFI, non-epistemic values should only inform choices in external phases 1 and 3 (advocates include Hugh Lacey, 1999 and Isaac Levi, 1960). Non-epistemic values play a role in identifying which research avenues are important to pursue, and what kind of questions scientists should be asking. Values are also relevant where there are explicit policy and social related decisions about the application of scientific knowledge.[12] That said, though it is uncontroversial that non-epistemic values can legitimately play a role in these activities, there exists a host of contentious philosophical issues even within these phases. Phillip Kitcher for example addresses questions concerning where science should direct its efforts, and who should decide what research questions are pursued (Kitcher, 2003; Kitcher, 2011; Reiss and Kitcher, 2009). Recently, Heather Douglas (2018) has emphasised the need for further examination of the institutional structures that guide science and the impact this has on the promotion of certain values. This chapter will not address these topics however, as it focusses primarily on the research phase, which is at the heart of the values in science debate.

It is in phase 2 that the presence of non-epistemic values is regarded by defenders of the VFI as pernicious.[13] This phase is referred to as the 'internal part of science' or the 'core of scientific reasoning'. There is some ambiguity as to what scientific activities are actually included in this phase, or specifically which activities proponents of the VFI take issue with. Sometimes the VFI is construed narrowly (e.g., Hicks, 2014 and Lacey, 2018) where the research phase or epistemic phase includes only evaluating hypothesis in relation to evidence. Other scholars adopt a broader conception of the VFI, in which various methodological choices, such as those involved in gathering and analysis of data, are also viewed as internal or core to science (e.g., Intemann, 2015 and Elliott and McKaughan, 2014). For the purposes of this chapter, and throughout the thesis, I adopt a broad conception.

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[12] Of course, which values should be operating in the pre- and -post-research phases remains an open question – I am merely making the claim that their presence alone is not problematic.

[13] According to the VFI non-epistemic values – in particular, ethical values - are only acceptable in the research phase in so far as they play a constraining role, such as setting constraints on experimentation (Brown, 2013).

Another ambiguity that is sometimes present in discussions on values in science is whether the VFI is supposed to be prohibiting the use of values in motivating, justifying, or merely causally influencing certain aspects of science. (Ward, 2020). This ambiguity stems from a conceptual confusion on what is meant when authors say that values either should or shouldn't 'influence', 'inform', 'drive' or 'contribute' to scientific choices. Ward (2020) makes a convincing case that the VFI should not be interpreted as restricting a causal influence because this would rule out too much scientific practice. Many choices in science are influenced by values in so far as earlier value-laden choices made in the pre-research phase (about what is important in the non-epistemic sense to study), causally effect these later choices made in the research phase. This kind of influence is obvious and so philosophically uninteresting. The VFI is best understood as arguing that choices in the research phase should be neither directly motivated, nor directly justified by non-epistemic values.[14]

Rather then, in the research phase, the rules of inquiry are understood by many as a function of the *epistemic values* of science, which themselves are a function of the goal of science – to develop an accurate understanding of the world (Longino, 1990)[15]. Advocates of the VFI such as Isaac Levi (1960) maintain that the scientist, in virtue of being a scientist, "commits himself to certain scientific standards of inference" that restrict him to the use of epistemic values only (p356). That is, it is only epistemic values that provide appropriate grounds for choices in the research phase.[16] This exclusion is viewed as imperative for protecting science from the *problem of wishful thinking* (Lacey, 1999). The worry is that if non-epistemic values are free to influence the internal workings of science, science opens itself up to the possibility that scientists might rig the game in favour of their desired values and steer scientific inquiry toward predetermined conclusions, rather working to find out what is true and what is false (Brown 2013). Hugh Lacey, a strong defender of the value free ideal, argues that without this ideal we "lose all prospects of gaining significant knowledge" (1999, p216).

This external model of value-free science, which is the idea that science should be free of non-epistemic values in its internal stages, is viewed by those who espouse it as necessary for upholding the epistemic integrity of science and, in virtue of this, its ethical integrity too. On this view the goal of science is to uncover facts – a purely epistemic project. Anything (like value influence) that

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[14] For a deeper discussion on the distinction between motivation, justification, and causal influence see Ward's (2020) fourfold distinction on the nature of value influence.

[15] Not all philosophers share this view of the goals of science (e.g. van Fraassen).

[16] Though there remains disagreement about which values should be included in this list, defenders of the VFI all agree that non-epistemic values must be excluded.

inhibits science's ability to do that is problematic in two senses. First, it is epistemically problematic because it undermines the epistemic standards of science. Second, it might be viewed by some as ethically problematic because it involves contravening what the scientist has – in virtue of being a scientist – committed to pursuing. Thus, allowing values to play a role would be a bad thing, both epistemically as well as ethically. In the sections below, I will present three arguments that challenge this view and argue instead for appropriate roles that values can play in science. To provide an adequate analysis, each account must address both the ethical and epistemic dimensions of what constitutes good science. That is, each must jointly satisfy both epistemic and ethical standards for science.

2.2 Values help scientists fulfil their ethical responsibilities

One of the strongest arguments for the incorporation of values into science is the Argument from Inductive Risk, first presented by Carl Hempel (1965), Richard Rudner (1953), and C. West Churchman (1948), and later expanded by Heather Douglas (2000; 2009). According to the Argument from Inductive Risk, non-epistemic value judgments can appropriately influence choices in the internal phases of science where there are risks of error that have non-epistemic (i.e., social or ethical) consequences. It its classic form the argument runs as follows: When accepting or rejecting a hypothesis, scientists face two potential errors: accepting a hypothesis that is actually false (type 1 error) or not accepting a hypothesis that is actually true (type 2 error). When scientists are choosing whether to accept a hypothesis, the standard for acceptance should vary according to the severity of the consequences of error (Rudner, 1953; Douglas, 2000; 2009). For instance, scientists should require more evidence before accepting the claim that a certain medical product is not carcinogenic than they would before accepting the claim that a particular shampoo softens hair. They should require more evidence because the consequences of being wrong about the former are very serious, whilst the consequences of being wrong about the latter less so. Thus, the scientist's decision as to whether the evidence is strong enough is " a function of the *importance*, in the typically ethical sense, of making a mistake in accepting or rejecting the hypothesis" (Douglas, 2009,p2).

It is worth noting here that there are two versions of the inductive risk arguments, each making different claims.[17] There is the argument that values *must* (in a non-moral sense) play a role in

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[17] Ward (2020) discusses two other versions of the Inductive Risk Argument which are not central to my discussion. They are: (a) Scientists *can* (in the morally permissible sense) consider values when managing inductive risk; (b) Scientists have (in the descriptive sense) invoked values when making inductive risk choices.

choices about whether to accept a hypothesis when doing so runs an inductive risk. This version is defended by Rudner (1953) and Biddle and Kukla (2017). I share Ward's (2020) position on this 'must' version of the Argument from Inductive Risk: A scientist does not *unavoidably have to* consider non-epistemic consequences when managing choices. No matter how significant the consequences, a scientist can still choose to ignore these non-epistemic dimensions related to inductive risk choices and make decisions on account of epistemic reasons alone (Ward, 2020). The argument that I am defending here is the normative version, which claims that under certain conditions non-epistemic values *should* be considered. This is the argument put forward by Douglas (2000; 2009) and Steel (2010; 2015; 2016).

Douglas extends the 'should' version of the inductive risk argument by pointing out that inductive risk considerations do not occur solely at the point of hypothesis acceptance, as Rudner pointed out, but that 'micro-inductive risk problems' occur in methodological decisions throughout the research process.[18] To illustrate her argument, Douglas discusses methodological choices made by scientists conducting research on the effect of dioxins, where the research has a significant application: results are used to set regulatory standards for the chemical. Douglas emphasises methodological difficulties that researchers face when they encounter unexpected ambiguities in data sources. In the study, rats are dosed with a chemical called dioxin for two years, following which biopsies are carried out to determine the presence of cancer. However, in the study there is significant ambiguity as to whether some of the tumours seen in the tissue samples are benign or malignant. This is evidenced by the disagreement amongst pathologists across three studies using the same biopsy slides (the same data). In cases like this, Douglas argues, scientists should evaluate the possible consequences of error when deciding how to classify the tumour. If scientists decide to classify ambiguous cases as benign, they decrease the likelihood of false positives, but increase the likelihood of false negatives. This will risk an underestimation of malignancies and thus underestimation of the harms posed by dioxins. At a regulatory level this kind of error could lead to a relaxation of regulations which could threaten human health. Alternatively, if scientists decide to classify ambiguous cases as malignant, this would reduce the likelihood of false negatives while increasing the likelihood of false positives, risking in an overestimation of dioxin's harms. The likely consequence of such an error would be regulation that is more stringent than necessary. Each option risks errors with different consequences: overregulation better protects human health;

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[18] I have borrowed this term from Stephen John in *Scientific Deceit (forthcoming),* who cites Kukla (2012) as the originator of the term.

however, it comes at a significant economic cost.[19] Importantly, values should only play a role in managing inductive risk when the following three conditions are met: (1) the choice is *genuinely* underdetermined by epistemic factors (2), the various choices must have different potential non-epistemic outcomes associated with making an error, and (3) it must be foreseeable to the scientist that the outcomes associated with these errors are problematic/bad (2000; 2009).

A well-known response to the Argument from Inductive Risk, proposed by Richard Jeffrey (1956), is that "scientists qua scientists" should not accept or reject hypotheses; rather a scientist's job is to assign probabilities to hypotheses in light of the currently available evidence. At first gloss, much scientific practice seems to reflect this. For example, the IPCC Working Group One Report includes scientific statements about the state of the future climate with probability intervals attached to each of them. According to the Jeffreyian line of argument, probabilities like these indicate credences or degrees of belief in hypotheses and should be arrived at according to Bayes' rule, which requires no appeal to non-epistemic value judgments (Parker and Winsberg, 2018; Winsberg, 2018). By assigning probabilities, scientists avoid value judgments, instead leaving it to policy or decision makers to decide whether to take action or not in light of the probabilities presented to them, thus freeing the scientists from needing to consider the social consequences of a particular choice (Jefferey, 1956). Similarly, for micro-inductive risk choices, a Bayesian should determine the probability of a hypothesis being true, given the error tendencies of the methods chosen (see also Betz, 2013).

The Jeffreyian response to inductive risk faces a number of challenges. Firstly, even if scientists ascribe probabilities to hypotheses, do they not still have to decide whether to accept or reject the probability itself? If so, then the argument can be repeated: the standard for accepting or rejecting the probabilities should vary according to the severity of the consequences or error. Jeffrey is only pushing the problem back further, not escaping it (Rudner, 1953; Douglas, 2009). That is, scientists still face second order uncertainty about the probabilities themselves and so should consider non-epistemic values when deciding what probabilities to assign. This challenge doesn't stand up to some Bayesians, however, who would reject it on account of what they take probabilities to be: degrees of belief. Such Bayesians maintain that probabilities are not things that an agent can be uncertain of and therefore estimate; rather they are psychological states of mind that agents simply *have* (Parker and Winsberg, 2018).

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[19] For further examples of inductive risk in methodological choices such as choosing levels of statistical significance and interpreting results, see Douglas (2000).

However, when we look at most modern sciences, including complex model-based sciences like climate science, the Bayesian counter-response doesn't seem very plausible. As Steel (2015) argues, real world scientists don't really have precise degrees of belief (especially in the case of climate science) that can be used as inputs for priors and likelihoods in Bayesian updating calculations. Rather, he contends scientists *decide* how to represent probabilities by choosing distributions like Poisson, normal, or binomial etc, and these decisions themselves are subject to inductive risk considerations. What is more, probabilities arrived at in climate science don't seem to fit well with Bayesian notion of a probability as an individual agent's credence or degree or belief (Winsberg, 2018). Firstly, as is the case in the IPCC, probabilities often reflect the consensus of a *group* of scientists. Secondly, they are imprecise probabilities that are clearly offered as rough estimates, that plausibly could be somewhat different to what they are. That is, they are not precisely justified but are decided on with some scope for alternative choices. What these responses show us is that it doesn't seem right to think of the kinds of probabilities used in modern science as credences that scientists simply *have*: rather scientists have to take into account a host of complex information as well as a range of expert opinion to *decide* what probabilities to ascribe to hypothesis or set of hypotheses. These decisions should involve the consideration of non-epistemic consequences of error.

Others have attempted to defend the value free ideal from inductive risk arguments in different ways. Gregor Betz (2013) argues that scientists can avoid assigning probabilities altogether and instead 'hedge' their hypothesis by providing detailed exhaustive descriptions of all the background assumptions and relevant uncertainties underlying their statements. Like Jeffrey, Betz argues that by doing this the scientist can leave it up to the decision maker to decide on whether they want to act on that information. Betz does not argue that scientists should proceed this way, but that they could, and that it would be acceptable for them to do so.

In response to Betz the following can be said. Firstly, in some sciences, climate science in particular - to which Betz directs his argument - it is not clear that such a task is practical or even possible. To provide details of all the background assumptions and uncertainties would be a massive endeavour. This is especially difficult in the cases of climate projections which incorporate multiple lines of evidence often gathered and interpreted by different scientists. Moreover, current climate models are typically built on previous modelling decisions that are often not accessible or known to the current scientist (Lenhard and Winsberg, 2010). In such cases it would not be possible for the scientist or group of scientists to explicitly list all the decisions (Steel, 2016). A more sympathetic response to Betz might grant that, yes, scientists cannot always list *all* of the assumptions and uncertainties, but they could still provide detail to the recipients to the best of their ability.

A last option an advocate of the VFI might suggest would be to say that scientists could avoid value judgments by abstaining from accepting or rejecting the hypothesis and not assigning any probabilities. They could wait either until further evidence becomes available so that they can make claims that are more confident, or in cases where it is not reasonable to expect more evidence to become available, they could sit on the fence and leave it to the policy and decision makers to decide. I will respond to each of these suggestions below.

Normative response to arguments against inductive risk

I maintain that even if it were possible for scientists to avoid making ethical judgements by hedging their hypothesis to their best ability, or by withholding judgment, this would not be morally desirable in the first place. The primary justification stemming from proponents of the value free ideal – such as Jeffrey (1956) or McMullin (1982) – is that it is not the job of the scientist to consider the non-epistemic outcomes of their work. Scientists are responsible for carrying out the science and are not qualified to make a judgment on whether a particular consequence is or is not socially or ethically valuable. As McMullin states, "such utilities are irrelevant to theoretical science proper and the scientist is not called upon to make value judgments in their regard as part of his scientific work" (McMullin 1982, p8). This justification is problematic for a number of reasons.

The first, argued by both Douglas and Elliott, is that all moral agents, including scientists, have a basic ethical responsibility to consider the intended consequences of their choices as well as some of the unintended consequences and to take steps to reduce the harmful outcomes their choices may have. Failure to do so would amount to negligence on the part of the scientist (Elliott 2011; Douglas, 2003, 2009). Driving the point home, Douglas rightly emphasises that scientists hold "broadly authoritative" positions in society and hence their statements carry significant authority too (2009, p83). In virtue of this authority scientists have an even greater responsibility to consider the consequences of error as these errors can have more far-reaching consequences than they would for non-scientists. Of course, one might argue that scientists are not omniscient, and it is unreasonable to expect them to have perfect foresight into all the non-epistemic consequences of their work. Douglas acknowledges this caveat and agrees that scientists are under no special burden to have this special foresight. Nevertheless, we can expect *reasonable* foresight. In some cases, it is quite plausible that scientists can anticipate the outcome of a particular error. For example, if a scientist erroneously rejects a hypothesis that a particular drug causes cancer, two readily foreseeable consequences are that there is less chance that the drug will be rejected by regulators and, if it is approved, that it will lead to patient harm. It is not difficult to conclude that the latter is an undesirable outcome. Certainly, there are cases where the outcomes are not as clear cut. However, this does not undermine the overall normative argument Douglas is espousing, which is that there is a moral justification for scientists - to their best ability - to consider the consequences that might arise from their errors. Therefore, in such cases when there is significant uncertainty, scientists ought to consider non-epistemic values in making methodological choices and reaching conclusions.

Another justification is offered by Kevin Elliott (2011), who argues for what he calls the *No Passing the Buck Principle,* which holds that it is often harmful or impractical for scientists to respond to uncertainty by withholding judgment or providing uninterpreted data to decision makers and that scientists cannot always leave the difficult choices about how to interpret evidence up to decision makers. Carl Cranor, who is in agreement with Elliott and Douglas, sums up the reasoning for this succinctly (1990, p139):

> For one thing, anecdotal evidence suggests that risk managers may have considerable difficulty in interpreting the most objective interpretations of data for they are complicated and somewhat difficult to understand. In addition, there is some evidence that courts which review regulatory decisions may invalidate agency decisions, if the data on which agencies act present too many alternatives or present too much uncertainty... If the failure of risk managers or courts to understand the presentation of the objective data will frustrate more effective regulation, this is a consideration for not shifting the interpretive discretion from scientists to risk managers.

Finally, suspending judgment can itself be harmful in the policy and decision making related contexts. For example, if climate scientists suspend judgement about whether humans are contributing to climate change policy makers will be less likely to implement policies that aim to reduce carbon emissions. It is often unreasonable and irresponsible to suspend judgment when a particular action in question has pressing consequences (Steel, 2016).

Restrictions and limitations

Crucially, the Argument from Inductive Risk endorses a constrained role for non-epistemic values. They must play a secondary role in decisions, granting lexical priority to evidence, whereby non-epistemic values should inform a choice only after evidence has "done as much work as it could" (Hicks, 2014, p3281). Kevin Elliott (2010) calls this The Uncertainty Principle. By granting lexical priority to evidence the problem of wishful thinking is largely avoided in so far as values are only considered after we take all the evidence into account (Douglas, 2009, Brown 2013). This guarantees that "even in value-laden science, values do not compete with evidence even when the two compete"(Brown, 2013,p834). This constrained role aims to ensure that the epistemic standards of science are not undermined.

One limitation for the inductive risk view is that, while it can discern legitimate from illegitimate *roles* for non-epistemic values to play, it cannot pick out whether the values themselves are legitimate. Some philosophers have raised the worry that this leads to problematic ramifications (Hicks, 2014). This is best illustrated through the following example: on the inductive risk view a pharmaceutical company seems justified in demanding extremely high standards for accepting the hypothesis that a particular medical product is harmful. This is because in this case the pharmaceutical company might regard the consequences of error of a false negative (i.e. decreased profits), as worse than the consequences of a false negative (harming some people who use the product). They might base this on the value judgement that generating profit in large amounts is more valuable than protecting human health from a given level of harm. Clearly there is something wrong with this outcome. In this sense the inductive risk view is incomplete, only taking us part of the way in determining when value influence is appropriate. A complete account of legitimate values in science will have to offer some way of discerning which values ought to take priority in managing inductive risk (Varghese, 2019).

Despite this limitation, the inductive risk view still makes a considerable contribution to understanding how non-epistemic values can be good for science. It shows how values play an important role in managing the risk of error. When scientists are uncertain as to whether they are correctly accepting or rejecting a hypothesis, or when they are uncertain as to which methodological choice will yield the most accurate results, they should consider the non-epistemic consequences associated with that error and make a decision that takes account of those consequences. Doing so will help scientists meet their basic ethical responsibilities to consider the consequences of their choices and to take steps to reduce harmful outcomes.

In the next section I discuss another argument for appropriate value influence that is based on the multiple goals of science. On this account we are able to see a broader, more encompassing understanding of the role that values can play in science.

2.3. Values promote the multiple goals of scientific inquiry

The aims approach offers a different, yet complementary framework to the inductive risk view for identifying opportunities for appropriate value influence. According to this view, the influence of non-epistemic values in science is sometimes justified in so far as it promotes the aims of the research (Intemann, 2015; Fernandez Pinto and Hicks, 2019; Elliott, 2013; Elliott and McKaughan, 2014). To fully comprehend this approach, we need a broader understanding of the goals of science.[20]

While it is reasonable to assume that the aim of science is to produce reliable knowledge, it would be wrong to think of all scientific programmes as having purely epistemic goals; rather, scientific inquires can have both epistemic and practical goals. Epistemic goals concern broadening our knowledge of the world, while practical goals are tied up with achieving broader social and ethical objectives which can be described as broad social goods or values (Fernandez Pinto and Hicks, 2019). Socially relevant science, which includes policy support science, regulatory science, or decision support science, very clearly bears these two distinct kinds of goals. Practical goals for socially relevant science might include broad social goods or values such as promoting human health; alleviating the burden of disease and injury posed by climate change; and protecting human and environmental well-being. Science, however, rarely achieves these social goods directly, instead it has more immediate epistemic aims, which are to produce accurate beliefs about the world, and to use this knowledge to achieve these goods (Fernandez Pinto and Hicks, 2019; Steel, 2017). What this means is that in both epistemic and practical goals must be considered together when making methodological choices and evaluating hypotheses.

Judgments required in assessing hypotheses or theories will often involve weighing the relative importance of a range of different considerations that often stand in tension (Elliott and

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[20] I use the terms ‘goals’ and ‘aims’ interchangeably.

McKaughan, 2014). Kuhn made this point in his discussion on theory choice in “Objectivity, Value Judgment and Theory Choice” (1977), where he shows that rival theories exemplifying different characteristics (arguably we can take these to be epistemic values) leave scientists having to decide which criteria should be given more weight than others in different contexts. For instance, Kuhn discusses theory choice between Ptolemaic astronomy, which was more consistent with existing background knowledge, and Copernican astronomy that was simpler, another. There is no logical rule telling scientists which choice they ought to make. Elliott and McKaughan (2014) remind us of a recent analysis of modelling that argued a similar point. When constructing models, it is often the case that improving one feature of a model (e.g., precision) results in other features (e.g., breadth) being reduced (Matthewson and Weisberg, 2009), forcing scientists to make a choice about which epistemic features they want to prioritise. What Kuhn failed to elaborate on, add Elliott and McKaughan, is that the choices that scientists are required to make between different values depend on what the goals of inquiry are. That is, they might favour breadth over precision if they want their model to apply to a number of systems. Alternatively in a different context they may want the model to be really precise for predicting one particular system, because the question at hand depends on such precision.

Giere (2004) and Van Fraassen (2008) show that representations can be assessed along two different lines: the relationship they bear to the world and the uses to which the representations are put. Consider a commuter rail map. This map might be a poor representation of the rail system in the sense that it does not accurately represent the distance between stops, however it is very easy to use because it captures all the stops along the line and displays them in a simple layout. Similarly, the representational success of a model can be evaluated in terms of its fit with the world, but also its suitability to its practical purposes. When assessing the success of models, we can ask questions related to the model’s fit to the world such as: “Is this model accurate?”, “Does this model refer to entities that exist in the world?” and we can also ask practical questions: “Is this model easy enough to use?”, “Can it provide results inexpensively and timeously?” (Elliott and McKaughan, 2014). Giere and Van Fraassen emphasise that this point applies to hypotheses and theories in general: any proposition that represents something else can be analysed both in terms of its fit to the thing it is representing and in terms of the practical purposes for which is it required. Thus, if theories should be evaluated in terms of their ability to meet both the practical and epistemic aims for which they are required, then these goals, or aims of scientific inquiry, play an important role in the rules and standards that define legitimate scientific activity within that inquiry (Fernandez Pinto and Hicks,2019). That is, decisions made in scientific inquiry, such as methodological choices and research design, are legitimate in so far as they promote the epistemic *and* practical aims of inquiry (Intemann, 2015). This is known as the aims approach.

Recognising that science has multiple goals that shape scientific activity is crucial in helping us think about the role of non-epistemic values in scientific reasoning. Non-epistemic values should at least sometimes inform decisions about what the aims of research should be (for example social, political, or economic aims). From these goals, the choices made in all phases of the scientific research are appropriate in so far as they promote these aims. These choices include, for example, choices about how to frame research questions, choices about which features of a model to represent, and choices about what evidence to include in a set. These examples, along with others, will be expanded on in Chapter 3.

The aims approach raises an important challenge to the notion of value free science in virtue of its justification of certain kinds of trade-offs that scientists should sometimes make. In particular it shows us how scientists can sometimes sensibly prioritise non-epistemic considerations over epistemic ones. To illustrate this Elliott (2018) and Elliott and McKaughan (2014) refer to a case study carried out by Carl Cranor that looks at methods employed by those conducting risk assessments of toxic substances. The study found that traditional methods used by governments for regulating toxic chemicals are highly accurate, but they are slow and resource intensive. They can also be manipulated by regulated entities to slow the research process down even further (Michaels, 2008; Cranor, 2011). In this instance of regulatory science, the burden of proof fell on the regulatory agencies to show that the substances were toxic in order for them to be recalled or banned. However, due to the cost and time of the traditional method, few substances were being assessed despite the fact that many of them could be carcinogenic. To overcome this problem the California Environmental Protection Agency developed an alternative expedited method. This expedited approach is simpler, less expensive, and quicker to use, but less accurate than the traditional method. It over-predicted the toxicity 12% of the time and under predicted it 5% of the time. Through his analysis Cranor found that *if* the goal of the regulatory agencies was to minimise social costs, then the expedited approach was a better approach than the traditional method. Whilst some chemicals are overregulated, which imposes a cost on society due to decreased economic activity, when toxic chemicals go unregulated, there is a severe cost imposed on society in the form of healthcare, illness and even death.

As discussed earlier, scientific investigations have both epistemic and practical goals. In general, what is captured within 'epistemic goals' is what Fernandez Pinto and Hicks (2019) refer to as the *conclusive evidence standard,* which is to produce "evidence for or against a hypothesis according to a high epistemic standard, such that a scientist only asserts claims when those claims are extremely unlikely to be false". In the case of the regulatory agencies, the traditional method would meet this standard better than the expedited approach, and so in terms of meeting the epistemic aims, the traditional method is more desirable. Elliott and McKaughan (2014) argue that regulatory science however is policy orientated; in fact, its primary goal is not to produce conclusive evidence but to provide information that facilitates policy action (in the case above it is reasonable to assume that one of the practical goals of regulatory science is to reduce social costs), and so its goals are *both* epistemic and practically orientated. What advocates of the aims approach maintain is that when the epistemic goal of conclusive evidence is in conflict with the practical aims, regulatory science should "abandon the conclusive evidence standard" (Fernandez Pinto and Hicks, 2019, p127). The expedited approach serves the practical goals of regulatory science better than the traditional method, despite it not reaching the evidence standard to the same capacity. What this case study illustrates is that when regulatory bodies are choosing methods for regulating chemicals with the aim of reducing social harms, a method that can produce results quickly is of a higher priority than a more accurate approach (Elliott and McKaughan, 2014).

What kind of challenge does such an argument present to the idea that non-epistemic values should not inform choices in the research phase of science? A notable one, it seems. Cranor's example seems to show us that non-epistemic values can play a legitimate role in choices in the internal phase of science, and moreover in some circumstances it is appropriate for non-epistemic values to take priority over epistemic ones. One objection to this argument, brought to attention by Elliott and McKaughan themselves, is that while non-epistemic considerations are playing a role in developing methodologies, it would be wrong to think that non-epistemic values are *taking priority* over epistemic ones. How so? In the regulatory example above there are two different reasoning steps. First, the scientists determine the goals of the research – i.e., to minimise social costs/harms. Following this the scientist chooses the method that best achieves the goal identified, in this case it is the expedited approach. In the first step non-epistemic values are playing a legitimate role in setting the goals of inquiry. In the second instance non-epistemic values are not playing a role per se; deciding on a method that will best reduce social costs is an epistemic decision. It is quite easy to tease out the value influence here: yes, values are guiding goal selection, however, the choice of how to achieve those goals is an epistemic endeavour.

Elliott and McKaughan (2014) maintain that this objection unfairly shifts the focus of the original argument they put forward. It is true that once we allow non-epistemic values free rein in setting the goals of inquiry, then it becomes an epistemic undertaking to determine which method best achieves those goals. Reverting to the example: once we decide that reducing social cost through regulating chemicals is the aim, then a method that best reduces social cost is developed. The authors do not dispute this. But the focus of their debate is on how to *prioritise* the various qualities instantiated in the representation. The argument Elliott and McKaughan are making is that scientists often have goals that are not only epistemic and so when they are choosing which representation will best allow them to achieve their goals, they can legitimately prioritise qualities that are not epistemic. They are making a simple, yet important point. Scientists do and should consider non-epistemic factors when making methodological decisions, and moreover, sometimes this will lead to favouring methods that produce weaker conclusive evidence standards than they would if the goals were simply epistemic. This is a crucial argument to convey to those who are thinking about what role values should be playing in science.

Nevertheless, the objection does steer toward a point to be made about the strength of the aims approach pitted against the value free ideal. The kind of value-ladenness defended by the aims approach is not as deep as some challengers of the value free ideal appear to claim it is. Intemann and de Melo-Martin (2015) for example argue that the aims approach reveals to us many cases in which non-epistemic values appropriately influence the content of scientific statements and conclude that this deeply undermines the value free ideal. They illustrate their point with an example about the value-ladenness of normative concepts. In climate change impact studies, the decision to regard a decline of cultural tradition *as a loss* clearly depends on a value judgment about what we take to be worthy of protection. Thus, the scientific statement: '*one of the potential harms imposed by climate change will be loss of cultural tradition*', is a descriptive claim about the world that "involves normative concepts". Therefore, argue Intemann and de Melo-Martin, these kinds of cases show us that some scientific claims are not simply descriptive, but "normative values about what ought to be are indeed sometimes relevant to what is the case" (2015, p514).

While I agree that Intemann and de Melo-Martin have provided an example of value influence in science, I think that they exaggerate how deeply undermining cases like these are for the value free ideal. Yes, in their example the scientific statement contains value-laden talk, but it doesn't mean that values determine whether the evidence supports the statement. Suppose the scientists or the stakeholders that are conducting the research value cultural heritage, and so in the study the scientists define its eradication as a loss or harm. They then carry out their research to determine if climate change will lead to such a loss. Clearly, their claims will contain statements referring to the things they care about (in this case cultural heritage). The claims may have value-related content, but it's a separate epistemic question to whether the scientists have evidence for the claim. That is, we can still make a distinction between the phenomena we are trying to find out about and what the best means for finding out about those phenomena are. This is quite different from the kind of value influence that occurs in inductive risk cases. In inductive risk cases, a scientist might come to accept the hypothesis that a certain amount of chemical exposure is safe because of the methodological choices that she made, whereas if she had made different value-laden choices, she might have rejected that same hypothesis. The acceptance or rejection of the claim is in some sense dependent on value judgments. By contrast, in the cultural heritage example judgments about the truth or falsity of the claim "climate change will damage cultural heritage" is not sensitive to value choices, but rather in articulating or investigating the statement we rely on certain values in the first place.

It is in this sense that I argue that this kind of influence justified by the aims approach is not as deep as Intemann and de Melo-Martin claim, because it is easy to disentangle the value judgments from the epistemic choices into clearly defined steps. Similarly, with Cranor's study, while values influenced methodological decisions, it is likewise possible to separate their influence from the epistemic agenda of the research. If we want to achieve social aim *x,* then we should favour method *y*. We choose method *y* because epistemically it is the best method for achieving social aim *x*.

Thus, the argument put forward by Elliott and McKaughan, that values can appropriately play a role in the research phase in science in so far as they promote the aims of the research, and the objection raised against it, which argues that the non-epistemic value are actually only guiding goal selection are speaking past each other. The aims approach shows us a role for values in the internal phase of science that we may not have previously recognised or acknowledged, while the latter – which argues that there are two different reasoning steps involved and thus values are not influencing important epistemic processes – rightfully points out that this argument is not as radical as some may think, as we can still partition this kind of influence from the epistemic rules of inquiry.

Limitations for the aims approach and its relationship to the inductive risk view

A weakness of the aims approach, however, is its failure to stipulate epistemic constraints. Daniel Steel (2017) makes a case for this through the use of both hypothetical and real case examples of what he calls Ibsen Predicaments: where a community or group scientists have certain non-epistemic goals and corrupt the science so that they can achieve their aims. According to an unconstrained version of the aims approach such actions are legitimate because the corruption of science helps promote the aims of the research.

The Ibsen predicament tells the story of a group of townsfolk whose primary income comes from tourists visiting their local baths. One day a scientist makes a discovery that the baths have become contaminated and wants to publish these concerning findings. When the townsfolk find out about the scientist's discovery, they turn on him destroying his data and driving him out of town (adapted from Steel 2017). In the story the community members value something and this provides an incentive for them to corrupt the science to achieve the things that they value. Of course, such a story is not unlike cases found in the pharmaceutical industry. The notorious Vioxx case is one such example which entailed scientists hiding and manipulating data supporting the hypothesis that Vioxx is harmful to humans (Biddle 2007; Ross, 2008). Here the pursuit of non-epistemic aims (i.e., getting their pharmaceutical product approved by the FDA) conflicted with the epistemic aim to advance new knowledge about the harmful effects of pharmaceuticals, and the scientists involved chose to corrupt the science to achieve their non-epistemic aims (see Biddle, 2007). Both examples entail communities who, due to their values, are incentivised to act in ways that "run roughshod over epistemic values" to maintain a hypothesis in the face of conflicting data (Steel, 2017, p51). As it stands the aims approach cannot provide a reason as to why these cases are problematic; these actions are justified as long as they are promoting the aims of inquiry.

One response might be that the aims provided in the above examples are themselves problematic, we need to have *legitimate aims*. This is what Intemann (2015) proposes. She argues that the influence of values is justified in so far as it promotes democratically endorsed aims. However, this does not resolve the predicament. We can imagine a community holding worthwhile aims such as protecting the environment or promoting gender equality and still succumbing to an Ibsen predicament. For example, we can imagine a community who aim to achieve gender equality in the workplace. This group would be justified in manipulating evidence so that the findings show women to be more intelligent than men. Epistemically corrupt science could be used to promote a worthwhile aim. The real problem with these Ibsen style predicaments, argues Steel (whether the aim is legitimate or not) is connected to the fact that they don't meet some criteria of epistemically adequate science. This is what is missing from the aims approach: non-epistemic values can appropriately inform choices that scientists make in so far as they promote the aims of research, provided the choices still meet the basic criteria for epistemically adequate science (Steel, 2017, p58).

Any scientific inquiry that is manipulated or designed to achieve a pre-determined result is prohibited (Anderson, 2004). This is a basic requirement for Heather Douglas' inductive risk view: "the core value of science – to produce reliable knowledge – which requires the possibility that the evidence produced could come out against one's favoured theory" (2009, p100). For Steel and Whyte (2012) science should meet the *weak severity criterion* which holds that "a test counts as evidence if it was likely to issue a negative result if the hypothesis were indeed false" (p58). Science that does not meet this criterion can pre-empt Ibsen predicaments. What goes wrong in the Ibsen cases, argues Steel, is that the actions taken violate the weak severity criterion. If scientists ignore or hide certain data that shows that a pharmaceutical product is harmful, the hypothesis is no longer being held up against the severity criterion, a criterion that science must meet in virtue of its immediate aim of *advancing knowledge*.

Another limitation is that, like the inductive risk view, the aims approach does not provide a complete picture of legitimate value influence. While it shows us how values can play an appropriate role in many scientific choices, it cannot tell us which values are the right values. This remains an open question.

Lastly, a couple of points about the relationship between the aims approach and the inductive risk view should be made clear. The aims approach and inductive risk view are not entirely distinct. In one sense, we can interpret the inductive risk argument as illustrating the aims approach. That is, the aims view can entail some inductive risk preferences. For example one aim of a particular piece of research might be to avoid underestimation. However, they are distinct in the sense that the aims approach presents a much broader role for values. It is not just claiming that aims can shape inductive risk choices, but rather many other choices in the scientific process that are not to do with risk of error but have to do with aims more broadly. A further way in which they are distinct is that each approach has a different justification for why values are appropriate. On the inductive risk view values are appropriate because scientists have a *moral responsibility* to take care when making choices that could have bad consequences. For the aims approach, value influence is *justified in relation to the aims*. Value influence plays an appropriate role in informing certain choices because it will promote the aims of the research.

In summary, the aims approach offers another framework for thinking about how non-epistemic values can play an appropriate role in the internal stages of science. What the aims account brings to our attention is that the goals of many sciences are not purely epistemic, but that they have practical aims that promote non-epistemic goods. These goals play an important role in determining the rules and standards that define legitimate scientific activity. That is, the choices that scientists make throughout the research process must endeavour to meet both of these aims, provided they always meet the basic criteria for epistemically adequate science. Values play a positive role in science in so far as they help scientists promote the aims of the research.

The aims approach is a crucial argument in the values discussion; firstly, because it presents a challenge to the idea that epistemic values should always be prioritised over non-epistemic ones, and secondly, because it sheds light on the ubiquitous role of non-epistemic considerations throughout the research phase of science, even if this influence is not as deep as some may claim, insofar as it often occurs indirectly during the research stage, as scientists make choices to achieve research aims selected on non-epistemic grounds.

2.4 Diverse value perspectives promote objectivity

A third argument for why values can be good for science is put forward by Helen Longino (1990,1996). Longino builds her argument on feminist critiques of science, and while it is a different line of reasoning from the two arguments discussed above, I regard her thesis as crucial for understanding how values can play a positive role in science. Longino's argument straddles both the descriptive and normative aspects of the value free ideal – that is, she regards the inevitable presence of values in science as a reason to endorse and include diverse value perspectives, regarding this as necessary to achieve objectivity.

Longino's argument starts with a version of the underdetermination thesis, which shows us that no amount of empirical data can ever completely close the gap between evidence and theory. That is, no amount of data determines a theory choice. Proponents of the value free ideal respond to the problem of underdetermination by claiming that only epistemic values are (or at least should be) operating in this gap. Longino, however, takes the general lesson of underdetermination to show that all empirical reasoning takes place against a background of assumptions and auxiliary hypotheses that themselves are "neither self-evident nor logically true". Moreover, when linking data to hypotheses scientists rely on assumptions or auxiliary hypotheses that can sometimes reflect value commitments or biases that scientists may have (Longino, 2004, p 132). Longino (1996) calls this view of science 'contextual empiricism'. On this view the relevance of data is secured by background assumptions, where the same data serves as evidence for different hypotheses in different contexts.

A well-known example that illustrates this is the case of sperm-egg fertilisation theories discussed by Okruhlik (1994). Outdated models which showed that the sperm played an active seeking role, and the egg played a passive role, seemed to align with certain patriarchal ideas and values about the roles of men (i.e., as active) and women (i.e. as passive). Rival feminist theories, however, challenged this thesis. They suggested that the egg is more active than previously assumed. Electron microscopy found that the sperm does not just burrow into the egg but that the egg has microvilli that clasp the sperm and draw it in, supporting the feminist hypothesis. Okruhlik's example aims to illustrate how values and beliefs – in this case concerning gender roles are embedded or reflected in background theoretical assumptions. Furthermore, these assumptions inform the questions scientists ask, which hypotheses they investigate, and which data they decide to ignore (Okruhlik, 1994).

Another way that values infiltrate science, argues Longino, is through epistemic values themselves. Longino (1996) maintains that the distinction between epistemic and non-epistemic values is not always clearly defined but rather in some cases epistemic values carry with them or at least reinforce, certain political or social agendas. To illustrate this, she describes two sets of epistemic (she refers to them as theoretical) values from different scientific communities. The first are Kuhn's list of epistemic values (empirical adequacy, internal and external consistency, simplicity, breadth of scope, and fruitfulness), an exemplar of traditionally accepted values that are constitutive of scientific practice.[21] These are contrasted with a set of alternative theoretical values arising from feminist critiques (empirical adequacy, novelty, ontological heterogeneity, applicability to human needs, diffusion of power and mutuality of interaction). Longino (1996) then illustrates how theoretical values in *both* sets can promote or hinder non-epistemic aims.

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[21] These values are taken to be constitutive of science, in that they are frequently invoked as cognitively virtuous features of scientific theories.

For example, using simplicity as a criterion for theory choice can support the development of theories that fail to consider the interests of minorities such as women or different racial groups, and thus lead to the support of oppressive patriarchal or racial structures. How so? A simple theory is one that is more parsimonious, positing fewer fundamental entities. A theory that achieves simplicity supposes that the world is comprised of fewer entities, and through this allows ways of erasing the differences among persons. Persons from an underprivileged class, or a different gender, will be treated either as members of a generic class, in which their own individuality is not recognised, or perhaps as permutations from the norm that should be ignored (Longino, 1996, p52). By contrast, a theory that displays ontological heterogeneity– a value endorsed by feminists – does not erase differences among entities under study or does so to a much lesser extent. These theories help to make minorities more visible, recognising for example gender relations or activities of gendered females.

What Longino shows through her analysis is that what are often considered epistemic values (in this case both the traditionally accepted values and feminist values) are not *purely* epistemic.[22] When used in certain contexts, epistemic values have particular social and political undertones or 'valence', or at least can have social and political implications (Longino, 1996).

While some argue that epistemic values are there to facilitate scientific reasoning and guide epistemic processes, Longino's arguments show us that sometimes what they are also doing is reinforcing background values held by the individual scientist or a scientific community. There is no hierarchy or algorithmic formula for prioritising epistemic values. How a value is interpreted, and its weighting against other competing values, depends on what is desired from that specific community and could vary in different social, political, and historical contexts (Longino, 1990, p77). When the boundaries between epistemic and non-epistemic values are blurred, non-epistemic features permeate into the inductive gap. To be clear, Longino is not claiming that in practice this is always the case, but that at least some of the time, values are at work - in a deeply embedded sense - at the core of scientific reasoning.

What do Longino's arguments mean for how we understand the role of values in science? Longino (2016) argues that contextual factors (values and interests) have a bearing on the knowledge that is produced in the scientific community, and once we accept the idea that non-epistemic values can enter into scientific reasoning in this veiled sense, either through the employment of certain

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[22] For additional examples see Longino (1996).

epistemic values, or via various background assumptions, the worry is that certain ideologies and values will be espoused (even unconsciously) through science more than others, in virtue of the predominant values held by those conducting the science.

Importantly, up to this point the feminist concern seems only to show a pernicious role for values, however, this is not Longino's conclusion. Rather she argues that given that values play this inevitable role, in order to prevent an arbitrary dominance of subjective preferences it ought to be *a diverse set of* values that shape the process of justification (1990; 2019). Introducing diverse perspectives into the process can help scientists and researchers recognise crucial theoretical assumptions that might conflict with their own values. For instance, the challenging of earlier sperm-egg theories discussed above demonstrates the role that feminist values played in developing rival reproduction theories. Feminist values helped recognise sexist assumptions, leading them to challenge outmoded models of the sperm-egg fertilisation. Okruhlik highlights that it matters less whether the rival theories are more correct, but rather that their existence leads to the interrogation of questionable assumptions in the older model.

Thus, argues Longino, objectivity requires criticism from diverse perspectives that carry with them different values and interests. Effective criticism requires open discussion and critical engagement between scientists where they are able to interrogate theoretical assertions, hypotheses and background assumptions, the use of various epistemic values, and uncover non-epistemic values and other non-evidential standards.[23] Types of criticism vary. Evidential criticism is well acknowledged in scientific practice; it entails questioning the accuracy, extent, or conditions of performance of the experiment to determine the degree to which the evidence supports the hypothesis. However, it is a certain type of *conceptual* criticism that Longino regards as particularly dependent on diverse values. This criticism interrogates the relevance of evidence presented in support of a hypothesis. It amounts to questioning the background beliefs or assumptions in light of which certain objects or states of being *count as evidence in the first place.* Criticism at this level uncovers the influence of values at the level of background beliefs. Criticism becomes what Longino calls transformative when background assumptions are either defended, modified, or abandoned either by the original scientist engaging in the inquiry, or by another scientist who enters into the relevant discourse (2004, p 73).

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[23] For Longino this can be anyone with the "appropriate background, education, and interest" (1990, p70).

Transformative criticism requires that all members of the scientific community are taken seriously, and that scientists should not marginalise the views and criticism of certain members of the community like women, or racial groups. It should be responsive to criticism from a diverse community and in doing so will weed out ideas that are not supported by evidence (Longino, 1990). This contextual empiricism, Longino claims, is the closest we can get to objectivity. She summarises this succinctly in the following passage (1996, p79):

> Thus understood, objectivity is dependent upon the depth and scope of the transformative interrogation that occurs in any given scientific community. This communitywide process ensures (or can ensure) that the hypothesis ultimately accepted as supported by some set of data do not reflect a single individual's idiosyncratic assumptions about the natural world.

In summary, Longino views scientific knowledge as the product of both non-epistemic and epistemic values, and thus offers a third and important role that non-epistemic values can appropriately play in scientific reasoning. Background assumptions and auxiliary hypotheses, required for closing the gap between data and theory, can often reflect values commitments or biases that scientists may have. These can determine what hypotheses scientists test and how scientific inquiry is carried out (for instance what is regarded as evidence in the first place). Moreover, non-epistemic values can also operate in science in a veiled sense as epistemic values. Because of this deeply embedded role that values can play, it is important that a diverse range of value perspectives are present in science. Crucially the scientific community should be responsive to criticism that arises out of diverse representation, allowing open discussion and critical engagement. Moreover, it should be tolerant of science that is explicitly elaborated with different values and background beliefs, because even if these beliefs are wrong they can contribute to greater objectivity.

Conclusion

Traditional views of science hold that science is or should strive to be value free. Most philosophers working on values in science now agree that values can play a legitimate role in science, even in the heart of research. This chapter has presented three different arguments for why under certain conditions non-epistemic values can play an appropriate role in scientific inquiry and can even be good for science. The inductive risk view shows us how non-epistemic values play an important role in managing the risk of error. When scientists are uncertain as to whether they are correctly accepting or rejecting a hypothesis, or when they are uncertain as to which methodological choice will yield the most accurate results, they should consider the non-epistemic consequences associated with making an error. Doing so will help scientists meet their moral responsibilities. The second argument, the aims approach, shows us that non-epistemic values can appropriately influence a number of choices that scientists make in all phases of scientific activity, in so far as these choices promote the goals of the research. Socially relevant science has both epistemic and practical goals and satisfying these goals will sometimes require prioritising non-epistemic considerations over epistemic ones, at least to some extent. Lastly diverse values can play a positive role in science by helping to identify and criticise the arbitrary dominance of subjective background assumptions, auxiliary hypotheses and the concealment of non-epistemic interests behind a veil of epistemic values, thus promoting a distinctly social form of objectivity.

CHAPTER THREE

NON-EPISTEMIC VALUES IN CLIMATE SCIENCE

Introduction

Chapter Two offered a synthesis of a wide range of discussions on the role that values can appropriately play in science. It illustrated how under certain conditions non-epistemic values can play a positive role in science by informing some of the choices made by scientists throughout science. Drawing on work by philosophers of science, I argued that values can make a positive contribution to science in three distinct ways.[24] Values help scientists meet their moral responsibilities through the management of inductive risk. When scientists face a choice between methodological options and there is significant scientific uncertainty as to which option will obtain the most accurate results, the scientist should consider the non-epistemic consequences of error associated with each option and make a choice in light of those consequences. Values judgments should also inform some of the choices made in science in so far as they promote the non-epistemic aims of the research. The aims themselves are determined by values, i.e., what society, the users, or the scientists themselves care about. Lastly, a diverse scientific community is good for science in so far as diverse values promote objectivity by identifying, interrogating, and criticising theoretical assertions, hypotheses and background assumptions.

While the discussion of Chapter Two was fruitful for thinking about how values are good for science in general, the case has been made at a high level of abstraction; it is not necessarily easy for climate scientists and practitioners to see exactly how these arguments apply to their own scientific field. This chapter intends to remedy this by showing, through a range of examples, how non-epistemic values can appropriately inform a number of scientific choices in the production of climate science for decision making. Some of the examples are taken from existing literature in philosophy of science, but many are novel.

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[24] I use the terms 'appropriate' and 'positive' interchangeably. I assume that values are making a positive contribution to science if they either play a role in managing inductive risk or promote the aims of research under the conditions set out in Chapter Two.

To be clear, this chapter is not intended to provide a complete list of *all* the possible choices that can involve value judgments; rather it offers a synthesis of what I take to be some key examples that will contribute toward a more complete understanding of values in climate science. Moreover, the focus is on appropriate *roles* for values. Values can of course play inappropriate roles in climate science for decision making. For instance, imagine a climate scientist is concerned about the adverse consequences associated with future climate change. Because of this concern he wants the results of his study to support the claim that the earth is warming so that global action will be taken to reduce carbon emissions. He therefore deliberately favours models that show extreme increases in global mean surface temperature (GMST) though there is strong evidence suggesting that these models tend to overestimate GMST, and ignores other models available, even though they don't show evidence of overestimation. This is an example of wishful thinking and is clearly not acceptable because the scientist is allowing values to override evidence (namely, the evidence that these models are inaccurate or of low quality). The very least the scientist could have done was include the models that are thought not to overestimate GMST. Examples that show pernicious value influence are not the focus of this chapter. Rather the aim is to illustrate how values can play a positive role in choices climate scientists make. It should also be noted that it is still possible for values to be used in appropriate roles but for the values themselves to be problematic. For instance, while it is appropriate for values to inform choices about what to research, it would be unethical for a scientist to choose to promote problematic values such as political destabilisation. To keep the focus on understanding appropriate roles, this chapter will seek to avoid using examples where the values themselves are problematic.

The chapter is structured as follows. I begin by providing further clarity on some of the concepts and categories relevant to values in climate science *(section 3.1*). I then offer examples of scientific activities where values can appropriately inform choices that climate scientists make. These examples are divided according to the schema outlined in Chapter Two: the pre-research phase (s*ection 3.2*); the research phase, which includes the setting up stage (*section 3.3)* and the evidence evaluation stage (*section 3.4);* and the post-research phase (*section 3.5).*[25] In each of these sections I will draw on the aims approach and inductive risk view to provide examples of positive roles for values. At the end of each section (sections 3.2 – sections 3.5) I will provide a table summarising the examples. Lastly, I discuss the importance of diverse perspectives in ensuring good epistemic and non-epistemic outcomes (*section 3.6*). I finish with some closing remarks.

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[25] As mentioned in Chapter Two, the schema used is a simplification; scientific activities are not always chronological, nor can they always be so clearly delineated. However, it is at least useful for the structural purposes of this chapter to use this schema.

Some of the examples below could be framed slightly differently and be used to illustrate values informing choices in another stage. For example, values might play a role in choosing how a research question is framed, which in turn will influence the choice about which methodology to use to answer that particular question. Thus, one could frame such an example as one where values are influencing question framing, or as an example where values inform methodological choices. Because part of the aim of this chapter is to illustrate the ubiquitousness of opportunities for values to play appropriate roles in climate science, I am purposefully including examples at each stage even though for some examples one could argue that it could be framed differently. This structural ambiguity is a result of the different kinds of relationships values can have to a choice and different interpretations of that relationship, which will be attended to in this chapter.

3.1 A little more clarification on values

Prior to delving into examples, it will be helpful to provide further clarity on some of the concepts, categories, and terms relating to values in climate science that will be referred to or discussed in more detail in the chapter.

What and whose values are at play, and what are they informing?

This chapter focusses on the role of values in *choices made by climate scientists*. These are choices about how to carry out research, such as choosing appropriate methodologies, or deciding on a parameterisation scheme. They are choices that **individual scientists** might make, as well as choices made by **groups of scientists** (for example authors of the Working Group One IPCC Sixth Assessment Report). These choices can be appropriately informed by a range of different kinds of non-epistemic values. The different kinds of non-epistemic values this chapter is concerned with include the following: (**1) social and ethical values** are the values that members of society hold.[26] They are estimations that society at large regard as valuable in a social or ethical sense, such as global environmental health, human safety, and justice. Social and ethical values can also be those held by **users of climate information** in a particular context. For instance, a group of farmers might value food security and so require information from climate scientists that can be used to promote food security. **(2)** Scientists' choices can also be informed by **personal and professional values**, such as career success, financial stability, or prestige. Scientists might choose

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[26] In line with Eric Winsberg's (2018) categorisation, I do not distinguish between social and ethical values.

to pursue a particular research avenue because it has low hanging fruit and so promises easy publications that will promote their career interests. **(3)** Lastly, scientists' choices can also be informed by **institutional values and norms**. These are distinct from scientists' personal and professional values in that they are a broader set of values held by a scientific community in which the scientist operates. For instance, the scientific community might value truth and public trust, among many other things. These values can be reflected in norms, i.e., rules or standards that govern behaviour. All three of these kinds of values could overlap or coincide. For instance, scientists could make choices in light of institutional norms in order to promote their own personal values, such as prestige or career success, and these institutional norms could reflect broadly held social values. Sometimes these values will not overlap. This is discussed in detail in Chapter Three.

In this chapter I will sometimes refer to non-epistemic values simply as values. In cases where more specificity is needed, I will distinguish between the different kinds of non-epistemic values as I have done above. In the instances where I discuss epistemic values, I will call them such.

Furthermore, it should be noted that choices can also be made for **pragmatic reasons.** Pragmatic reasons aren't paradigmatic examples of either social or epistemic value choices. For example, a scientist might face a choice between using model *A* or model *B* and have no good epistemic reasons to favour either. She might therefore decide to use model *A* because it was developed by her own research group and so she has easy access to it. Here the scientist is not making this choice because it directly promotes certain values, but because she has pragmatic reasons for doing so. There is some sense in which we could think of choices made for pragmatic reasons as indirectly promoting epistemic and even non-epistemic aims, insofar as they advance the scientific process. Choosing a model that is easily available assists the scientist in continuing with her work – ultimately promoting epistemic ends.[27] But these choices do not promote truth in the same way that say, choosing a model that has stronger predictive power does. Many choices in climate science, and science more generally, are made for pragmatic reasons.

How do these values relate to choices in climate science?

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[27] Steel (2016) would call these extrinsic epistemic values, because they instrumentally (albeit not intrinsically) promote truth-related aims.

There are various ways in which values can bear on choices in science. Values can serve as **reasons** for scientists' choices insofar as values either *motivate* a scientist to make a particular choice or *justify* a choice. Values also can stand in a **causal relation** to scientists' choices. They can be *causal effectors*, when they causally impact a choice, and values can also be *affected goods*, i.e., choices made by scientists can promote or undermine values (Ward, 2020). Sometimes choices can involve a combination of more than one of these relationships. For instance, a choice could be both motivated and justified by values, and causally impact additional choices down the line.

In practice, it is not always evident what kind of relationship holds in a given case, and it is often no small task for the outside observer to determine either. For instance, to determine if a choice was motivated by values we would need – amongst other things – knowledge of a scientist's mental states when making the choice. To keep things simple, no such claims about scientists' mental states will be made in this chapter. The reader should understand the examples that follow as ones where, at least, the choices might be *justified by* appeal to values.

3.2 The pre-research phase

Values play a clear and uncontentious role in the pre-research phase; most obviously non-epistemic values help scientists identify which research projects and programs ought to be pursued.[28] There are however other choices in the pre-research phase where values appropriately inform choices. They play a role in choosing how to frame research questions and which methodological frameworks to adopt.

3.2.1 Choosing and framing a research question

It is uncontroversial to claim that values play an important and appropriate role in choosing which problems to address (Biddle 2013; Hicks; 2014).[29] Scientists often research topics that society values. Public funding for climate research is typically aligned with values that the public hold. For example, water scarcity is a primary issue in sub-Saharan Africa (Chievenga et al., 2015). Climate change is expected to further exacerbate this scarcity and reduce crop productivity (Niang et al., 2014). This makes rural communities in this region – whose livelihoods depend on crop yield –

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[28] As stated in Chapter Two, there can still be instances where the values themselves are contentious, however *that* they play a role in informing choices about which projects ought to be pursued is not contentious.

[29] I acknowledge that there are some instances that practical elements guiding or constraining these choices, for example the given expertise in a research centre or the resources available often determine what research will be carried out in that centre. Generally, however, societal values often guide decisions about what to research.

extremely vulnerable. Climate scientists working in sub-Saharan Africa might therefore choose to research future precipitation patterns and the potential impacts these patterns will have on crops specific to that region. In this instance non-epistemic values are informing or driving their choice about what to research. Of course, there are likely also epistemic and pragmatic reasons for these choices: a scientist might be interested in the research for its own sake, not its social application, or she may simply choose to research the topic because it has been proposed by her research group. Nevertheless, non-epistemic values very often play a key role in identifying what is important to research.

Perhaps less obviously, values can also play an appropriate role in framing research questions. This will be illustrated in two case studies. The first case is a relatively straightforward instance showing how the aims of the research should determine whether the framing of the research question is appropriate. In particular this example shows how the 1.5°C – 2°C framing adopted by the IPCC is suitable for promoting one set of non-epistemic aims, but not for another. The second case study, taken from extreme event attribution, is an example of how two different framings of a research question leads to different inductive risk profiles, and thus requires appealing to non-epistemic value judgments to determine which framing is appropriate.

3.1.1. Time periods vs 1. 5° C – 2° C framing

Climate change information promotes various aims. Two that are of relevance here are (a) to drive mitigation efforts, and (b) to aid in adaptation. Below I show how research framing can be suitable for one aim and not for another. The appropriate framing should be that which promotes the aims of the research in the particular context in question.

Traditionally, the IPCC has framed future climate change by providing projections for future time periods based on a set of scenarios of anthropogenic forcing known as Representative Concentration Pathways (RCPs). This framing shows a range of changes over certain time period; typically, near term projections from present to the mid-century (2016-2050) and long-term projections which are for the end of the century (2081-2100). We can see this in a figure taken from the IPCC report (Figure 1), which shows changes in global annual mean surface temperature for the end of century relative to 1986-2005. Under this framing some research questions that could be asked include the following:

1. What changes in extreme temperatures can we expect in the near-term future?
2. How will global mean surface air temperatures change for the period 2081-2100, and what impact will this have on regional temperatures over this time frame?
3. Can we expect changes in rainfall seasonality in the tropics?

Answers to these kinds of questions include *ranges of possible changes* over a given time interval, such as ranges in temperature increase, precipitation patterns, sea level rise etc. Climate scientists then typically apply downscaling methods to provide projections at higher resolutions.

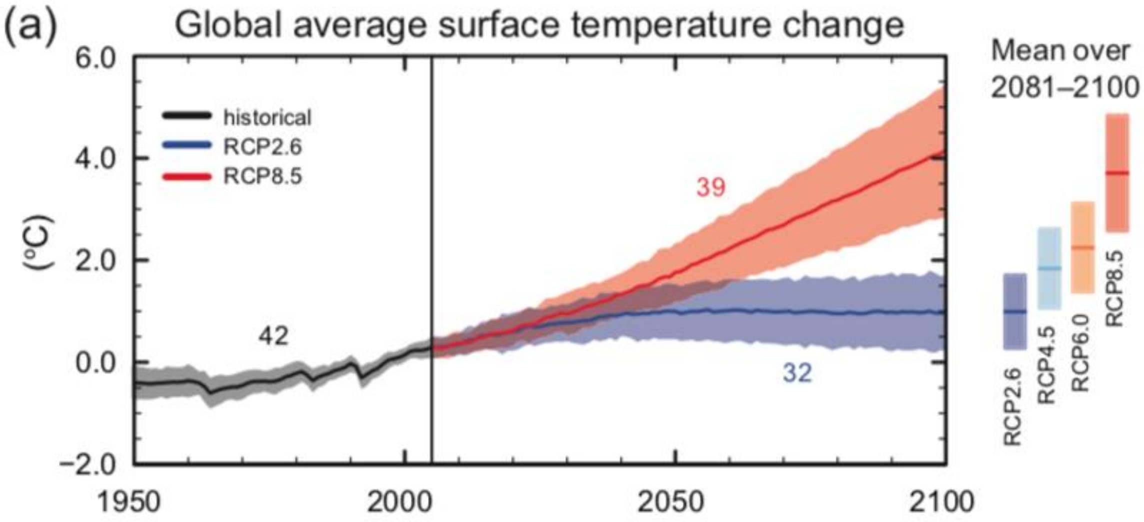

Figure 1. CMIP5 multi-model simulated time series from 1950 – 2100 showing change in global annual mean surface temperature relative to 1986-2005 (Stocker et al., 2013, p21).

An alternative framing has recently been adopted by the IPCC in response to an invitation contained in the Decision of the 21st Conference of the Parties of the UNFCCC to adopt the Paris Agreement, which was to provide a special report in 2018 on the impacts of global warming of 1.5°C – 2°C above pre-industrial levels. This 1.5°C – 2°C framing essentially asks a different kind of question to the traditional framing. Instead of asking what various features of the climate will look like over a certain time period, it asks *when* we will reach a particular global temperature (of 1.5°C or 2°C above pre-industrial levels) and what will the regional changes be at that time, conditional on that warming. This is illustrated in Figure 2, which shows the timing of global warming of 1.5°C – 2°C degrees under different RCPs.

Though the aim is not explicitly expressed, the authors of the special report state that it was "prepared in the context of strengthening the global response to the threat of climate change, sustainable development and efforts to eradicate poverty" (Allen et al., 2018, p4). It is plausible to infer from this that the practical aim of the report is to galvanise and bolster a global response to climate change. This framing aims to achieve this by providing compelling evidence that failure to mitigate will result in global warming between 1.5°C – 2°C and that there will be many adverse impacts associated with this level of warming.[30]

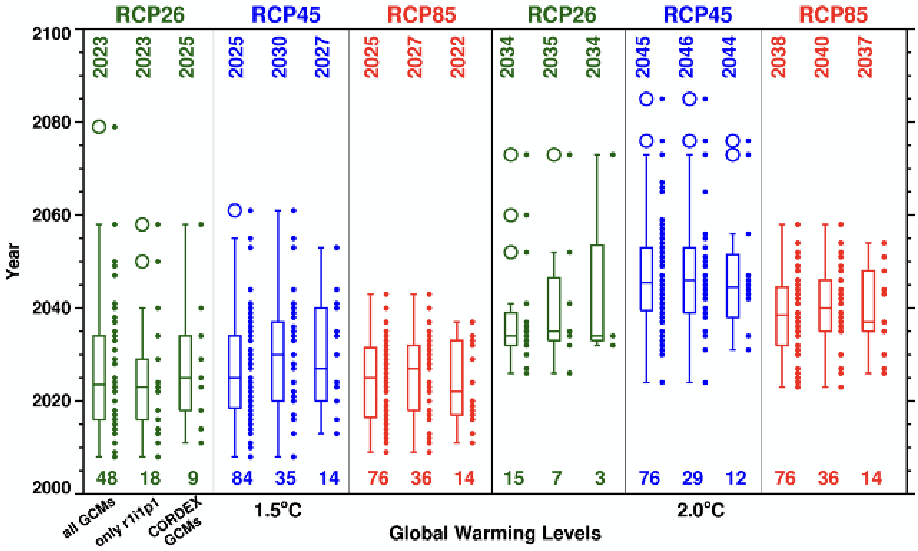

Figure 2. Timing of 1.5°C and 2°C global warming (Nikulin et al., 2018)

While this framing appears appropriate for the aim at hand, it is unsuited for supporting adaptation decision support at a local scale. Failure to integrate climate risk information into decision making and local planning processes has been identified as a major barrier to effective adaptation (Kok et al., 2008; Funfgeld, 2010). In part, integration requires that knowledge about local changes in hazard exposure and climate change vulnerability is linked to existing management policies and practice (Dovers, 2009), land use planning (Lindley et al., 2007), political agendas, and development priorities (Storbjork, 2007). Failing to consider the implications of climate change within policies and planning decisions can lead to increased maladaptation and lock-in of irreversible development trajectories (Ranger and Garbett-Shiels, 2012). The 1.5°C – 2°C framing is inappropriate for supporting local adaptation because decision making in this context requires

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[30] These include higher risk of extreme weather events, species loss and extinction, damaged ecosystems, a reduction in the productivity of fisheries and aquaculture, and an increase in heat related morbidity and mortality (IPCC, 2014)

climate information about regional climate change and the impacts and risks associated with such change *within particular development timeframes,* so that decision makers are able to integrate climate information into their broader development planning agenda (Jack et al., 2020). For instance, planning long lived infrastructure for a coastal city requires knowledge of sea level estimates from present onwards. Establishing or improving a country's agricultural sector requires information on the possible changes in climate over the next decade to determine which crops will be suitable. Traditional framing is better suited to adaptation because it provides information on a range of changes within various development timeframes.

In summary, choices about which framing to use should be informed by the aims in a given research context. If supporting local adaptation is the aim, then traditional framing is appropriate. If it is to convince decision makers to mitigate climate change, then 1.5°C – 2°C framing is better suited. These framing choices are value laden in the sense that they ought to promote the aims of the research, the selection of which are motivated or justified by values.

The next example illustrates how different framing results in different inductive risk profiles – providing an appropriate opportunity for scientists to appeal to values to resolve their choice.

3.1.2. Framing extreme event attribution questions

In the detection and attribution community there are two different methods used in extreme event attribution studies. For each method the research question is framed differently and, as I will illustrate below, has different inductive risk profiles.

The risk-based approach is a probabilistic technique that involves examining an event as a member of a class of extreme weather or climate events. It uses models to compare the probability of an event occurring under current factual conditions (p1), with the probability of it occurring under counterfactual conditions (p0) in which the climate did not undergo greenhouse gas warming and anthropogenic changes. This approach establishes probabilities, determining what fraction of the risk (FAR) is attributable to climate change (FAR = $1 - p0/p1$) (Stott et al., 2016).

FAR estimates are however highly uncertain. Extreme events are determined by both dynamical and thermodynamical factors yet changes in dynamics often are not easy to discern because of the small signal to noise ratio (Trenberth, et al 2014). Because of this the risk-based approach faces a notable challenge when analysing extreme events that are strongly influenced by dynamical processes. If an extreme event was caused by dynamical conditions, any risk analysis must consider whether the model's simulated likelihood is credible. And, as stated, because dynamical processes are difficult to discern, once plausible uncertainties are placed on the simulated changes it is likely that the result will be 'no change detected'; the null hypothesis cannot be rejected (Shepherd, 2014). This is problematic because, "the absence of evidence is not evidence of absence" (Shepherd, 2016, p32). Thermodynamic processes by contrast are well understood and easy to attribute to climate change. Climate scientists *are* very confident that greenhouse-gas-driven thermodynamic changes are occurring and could increase event intensity (see Fischer and Knutti, 2016). This suggests that the risk-based approach – insofar as it often finds 'no change detected' – is getting it wrong at least some of the time. In other words, in the absence of adequate understanding of dynamical processes, the risk-based approach has a propensity for false negatives.

There is also an alternative method called the storyline approach.[31] This approach proposes a conditional format that seeks to explain the origin and causes of *a single* extreme event, and how the event was influenced by climate change. It assumes the weather event and its circulation regime to have occurred, thus not assessing any change in likelihood, and investigates instead whether the event was affected by thermodynamic changes, such as changes in sea surface temperature or atmospheric moisture content, for which there is high confidence (Trenberth et al., 2015). This approach has been recommended by those who developed it as one that can be used in instances where dynamic process cannot be captured well.

Lloyd and Oreskes (2018) suggest that one way to think about the difference between these two methods is that they frame their research questions differently. The risk-based approach asks: 'What is the *probability of an event in a specific class*, given our world with climate change, relative to a world without climate change?' The storyline approach by contrast is conditional. It asks: 'Conditional on the weather event, how did thermodynamic processes change that event?' Lloyd and Oreskes illustrate this difference using an example from the Boulder Colorado flood. Under the storyline approach, a research question might be: "*how did climate change alter the Boulder CO flood of 2013?*" This question assumes that the flood did happen and asks the question, 'given the same dynamical event, does the flooding get worse because of anthropogenic warming leading to more atmospheric moisture content?' The risk-based approach asks a different question. In the Boulder

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[31] This approach was developed by Kevin Trenberth and co-authors, John Fussalo and Theodore Shepherd (2015).

case the question is, "*Was an event like the Boulder flood made more likely by climate change?*" This question is concerned with a class of events, rather than a singular event (ibid., 2018).

Importantly, each method has the propensity to make different errors.[32] As discussed, the risk-based approach tends to produce false negatives. The storyline approach has a propensity for false positives because it focuses solely on thermodynamic features and ignores dynamical features, which can play a role in the changing probability of an event. In some cases, dynamical effects might actually *decrease* the overall risk of the extreme event occurring, despite thermodynamic processes contributing to the intensity of singular events in these cases (Otto et al., 2016). There are ongoing debates in the D&A community about the scientific defensibility and appropriateness of each method (see for example, Otto et al., 2016; Shepherd, 2016; Stott et al., 2017, 2016, 2013; Mann et al., 2017). I am setting these discussions aside however, focussing instead on what this example illustrates about the role of values in question framing.

A scientist might be concerned with the risk-based framing because false negatives, which the approach is more likely to accept, could result in missed warnings about the effects of climate change on extreme events. Missed warnings could lead to a failure to mitigate and adapt to climate change, resulting in serious environmental and societal harm. By contrast, a scientist could also be concerned about the false positives generated by the framing used in the storyline approach. False positives could harm the reputation of climate science as a credible scientific field. They could be used as ammunition for climate deniers and sceptics, to justify mistrust of climate scientists. This could lead to negative outcomes both for the scientists and the scientific community, such as the withdrawal of funding. It could also lead to societal harm. If the reputation of the climate science community is damaged and the public no longer trust what climate scientists claim, then again, they may fail to take action to mitigate and adapt to climate change.

There may be a number of epistemic or scientific reasons why climate scientists might choose one framing over another. However, in the absence of sufficient reasons of that sort, when choosing which framing to adopt scientists should consider the non-epistemic consequences associated with each error.

3.2.2 Choosing a methodological framework

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[32] In fact, for the Boulder flood each approach reached different answers. For a detailed explanation of how this happened and why these answers do not actually contradict each other see Lloyd and Oreskes (2018)

Values can also play an appropriate role in the selection of methodological frameworks. A methodological framework or research strategy is a structure that determines how the research phenomena under question will be investigated.[33] It identifies which entities are relevant to the investigation, and the relationship these entities have to the phenomena under question. It also sets the rules for what kinds of theories can be investigated, as well as the kinds of concepts that can be used (Lacey, 1999).

Choices about which research strategy to adopt should be informed by the aims of the research, as different strategies are suitable for different aims. Suppose a climate services provider is tasked with providing scientific information to a rural community whose primary livelihood is small scale agriculture. This particular project has a narrow aim which is to improve the skill of a downscaled climate model to better predict seasonal rainfall for this area. In this case it would be appropriate to adopt what Lacey calls a *decontextualised research strategy.* A decontextualised strategy is one that is constrained to understand only certain phenomena through measurement and typically using quantitative categories. In particular it dissociates phenomena (in this case climatic processes) from the relationship they have to "social organisation, human lives, and experience" (Lacey, 2018 p607), i.e., from their human and social context. This strategy is concerned with producing model outputs: measurable projections about the state of the future climate for a geographical location. These climate model outputs are typically integrated into impact models where projections of seasonal rainfall for a specific region will be used as a variable for hydrological models that will capture run-off to determine, for instance, the effect the changes in rainfall might have on the area.

In some cases, research aims may be broader. Suppose the aims of a research project were to support the same rural community to adapt to and better prepare for seasonal shifts in precipitation but in this case the aims of the research are not simply to produce defensible climate science, but to produce climate science that can be integrated into the context in which it is being used. In this case scientists should choose a different research strategy. Lacey refers to contextualised strategies as those in which the phenomena under question (in this case seasonal rainfall patterns) are studied in relationship to the social context in which they exist, and therefore other phenomena (i.e., social phenomena) and their relationships should also be investigated. This kind of contextualised strategy is based on the premise that climate science is one dimension in a complex multidisciplinary research endeavour. It assumes that contextually important phenomena

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[33] Hugh Lacey has written extensively on the role of research strategies in understanding the role of values in science (1999). For the purpose of this chapter the concept is useful for thinking about how aims and values determine which phenomena will be included in a study.

such as governance structures, economic and resource limitations, development pathways, and local capacity will affect the uptake of climate information, and so the research program should broaden its domain of phenomena under question. Sometimes projects of this nature call for more transdisciplinary modes of inquiry where researchers from multiple disciplines, together with other stakeholders and citizens carry out the research together.

UK Aid (DFID) funded a four-year research project that serves as a good example of decision relevant climate science that adopts a contextualised research strategy. Future Resilience for African Cities and Lands (FRACTAL) was a research project coordinated by the Climate System Analysis Group at the University of Cape Town. The aim of FRACTAL was to

> ...advance scientific knowledge about regional climate responses to anthropogenic forcing, and to enhance the integration of this knowledge into decision making at the co-dependent city-region scale that responsibly contributes to resilient development pathways.

To achieve this FRACTAL identified three fundamental phenomena that need to be investigated: i) physical climate processes, ii) the decision-making space, iii) and the city specific context which includes in terms of their climate change risks and impacts and the cities resilience. Unlike a decontextualised strategy, which may have just focussed on physical phenomena, FRACTAL identifies a wider domain of phenomena as relevant to investigate to advance their research aims. Social processes such complex decision making that occurs under specific governance structures, as well as context specific features of the region in question are seen as key to understanding how to integrate regional climate knowledge into decision making.

Here we see how the aims approach can be applied in climate science. Scientists' choices about which methodological structure to adopt, and thus which phenomena will be included in the study, should be informed by or made in light of, the aims of the research.

Table 3.2 A list of positive roles for values in climate science for decision making in the pre-research phase

.	Choice	Examples	Philosophical defence

1	Choosing a research question	IPCC time period projection framing which produces adaptation relevant information vs 1.5°C – 2°C framing, which is less suited to adaptation aims, promotes action to mitigate climate change.	Promotes the aims of research
2	Framing research	Choosing how to frame extreme event attribution questions: the risk-based method vs the storyline approach; each have different inductive risk profiles.	Managing inductive risk
3	Choosing a methodological framework	Choosing between a contextualised strategy that includes incorporation of a broader range of phenomena over a decontextualised approach. An example of a project that adopts a contextualised approach is the FRACTAL project.	Promotes the aims of research

3.3 The research phase – setting up stage

The research phase, sometimes called the internal part of science, is the phase in science where the presence of non-epistemic values is viewed by some as problematic. This section will show that in fact the presence of non-epistemic values is ubiquitous in the research phase of climate science, and that there are many cases where their presence alone should not warrant concern, but is, in fact, justified. I have further separated this phase into two stages: the setting up stage and the evidence evaluation stage.

3.3.1.Identifying impacts

Obviously, what counts as a climate related impact depends on what we care about. In this regard identifying impacts requires appealing to non-epistemic values. Suppose that a climate scientist is working on a project that aims to determine the potential risks of drought in sub-Saharan Africa. Her report needs to compare the impact of the drought on communities across provinces. The results of her research will be used to draft a climate adaptation strategy for the country. The typical approach for this research is to take the population density of a given area and overlay it with a hydrological map. This determines the total number of people impacted by hydrological drought in a given area. Through consultation with community members in both provinces, the scientists are aware that communities in one of the provinces have to walk great distances to collect clean water. In sub-Saharan Africa collection of water falls disproportionately on women and girls, which puts them at risk of a variety of negative health outcomes (Graham et al., 2016). When carrying out her study the scientist faces a choice then to either include in her analysis how many people have to walk more than thirty minutes to collect water, or to leave this impact out. It is possible that, while in province A more people per square kilometer are impacted by drought than in province B, if you consider distances travelled to collect water, more women are impacted in province B than they are in province A. If promoting gender equality is a key concern in implementing adaptation strategies for the country, then she could choose include this impact because it provides information on how climate related drought could exacerbate gender inequality.

3.3.2. Selecting/conceptualising measurements

Values should inform the selection of measures in so far as the measures scientists select can better promote certain goods/aims over others. Take drought index selection, for example.

Drought indices are used in drought assessments, monitoring, and forecasting by providing a quantitative estimate of drought severity. Whether or not data supports the claim that drought will occur, has occurred, or the extent to which it occurred, in part depends on how scientists measure drought, i.e., which indices they choose to adopt. There are more than 150 drought indices that have been developed, each with various strengths and weaknesses (Vincent-Serrano et al., 2010). Different indices are suitable for promoting different aims. For instance, consider two common drought indices: the Standard Precipitation Index (SPI) and the Palmer Drought Severity Index (PDSI).

SPI is a probability index that considers only precipitation (the probability of precipitation for any time scale). It was designed to quantify precipitation deficit and its impact on the availability of different water sources such as ground water, reservoir storage, soil moisture and stream flow (McKee et al., 1993). SPI is easy to use and is suitable for monitoring drought. However, because it does not take temperature into account – which is important for determining water balance – SPI is not suitable for determining the impact drought will have on agriculture. By contrast PDSI is a water balance index; it uses precipitation and temperature to estimate moisture supply and demand. PDSI considers water supply (precipitation), demand (evapotranspiration), and loss (runoff). This index is more effective for measuring the impact drought will have on agriculture because it is more sensitive to soil moisture conditions (Willeke et al., 1994).

Thus, scientists' choices about which index to use depends on what they want the information to be used for, which in turn can depend on non-epistemic values. According to the aims approach, non-epistemic values thus should inform choices about how to measure certain phenomena.

3.3.3 Model construction

Climate models play an integral role in decision-relevant climate science by providing quantitative predictions of the future climate. There is, however, uncertainty as to how these models should best be built. Model uncertainty stems from structural uncertainty, which is uncertainty about the auxiliary assumptions, approximations, and parameterisations used in the model, and parameter uncertainty, which is uncertainty about which parameter values to use (Winsberg, 2012, p116). To cope with this uncertainty a variety of models are built with different structures, parameters, and initial conditions. This requires climate scientists to make choices about how to include these features in each model; non-epistemic values can play an important role in some of these choices.

Aims and priorities will influence model construction

Models are often selected for particular purposes, of which some are prioritised more than others (Winsberg and Parker, 2018). For example, a model might be built with the aim of projecting seasonal rainfall under a specific emission scenario, while another model might be built to understand the relationship between surface temperature and the urban heat island effect over a metropolitan region to determine the health risks urban citizens face as global temperatures increase. These aims generally reflect interests of certain groups, such as governments or communities or even scientists, and these interests in turn reflect values.

Aims and priorities will influence a number of choices when constructing models. They will shape which features and processes are represented and also determine *how* they are represented. That is, which simplifications, idealisations, and distortions are acceptable depend, in part, on what the scientist is trying to achieve with the model. Parker and Winsberg (2018) outline a number of ways in which this can occur: (i) modellers might decide whether to include a particular variable or not, depending on whether they think it is important to include for the particular purpose at hand. For example, scientists who are interested in understanding upper atmosphere dynamics might leave out certain land surface features like small lakes which they deem to have a negligible effect on the process they are concerned with modelling.[34] Including such features takes time and effort, and so they might leave it out if they are confident that it will not undermine the overall ability of the model. (ii) Aims and priorities will also determine which level of detail is important. For instance, scientists might require that a model accurately predicts certain processes at short time scales and therefore reject models that fail to do so, even if these models can make robust projections at coarser resolutions (Parker and Winsberg, 2018).

(iii) Aims and priorities influence how models are tuned which can lead to epistemic trade-offs. In practice model evaluation and model construction cannot be easily separated (Parker and Winsberg, 2018). Models are often evaluated through the construction process and then 'tuned' or 'calibrated' to improve the overall functioning of the model. Tuning entails adjusting a few key numerical values (usually defended physically) that are associated with sub-grid parameterisations to obtain a better match between model output and observations of the phenomena that is being prioritised. For instance, if scientists are concerned with producing a better fit for changes in global surface temperatures they might adjust the auto-conversion threshold radius, which determines the size at which cloud water droplets fall as rain. Increasing the radius increases cloudiness thereby affecting the radiation balance and surface temperatures (Frisch, 2015)

Importantly, due to both computational limitations as well as limitations in knowledge, improving the model in one sense often means that it will not represent other features as accurately. In these cases, scientists will sometimes face epistemic trade-offs. For example, Mauritsen (2015) shows how models tuned to better represent the distribution of tropical precipitation across land and ocean in Maritime Southeast Asia may poorly represent tropical inter-seasonal variability. The choice about whether to tune the model in one way over another depends on which predictions are regarded as more important to make. In this case, it is a choice between generating more accurate seasonal rainfall predictions, or better predicting extreme events such as monsoons.[35]

Inductive risk and model construction

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[34] Sometimes variables are left out or simplified because there is uncertainty regarding how best to represent them – e.g. UKMet office high resolution model C4 leaving out sandy soil.

[35] This example was taken from Intemann (2015)

Inductive risk concerns will also impact model construction, where values play an appropriate role in scientists' management of uncertainty. Parker and Lusk (2018) offer a hypothetical example where a climate scientist is tasked with providing climate information on possible changes in water supply under different emissions scenarios for a lake that supplies a local town. The manager does not want to spend unnecessary money on infrastructure, however her primary concern is to ensure that the locals have sufficient water supply. Suppose in this project the scientist is building a hydrological model that connects rainfall to other factors that flow into streams and rivers eventually feeding into the lake. There might be significant uncertainty as to what numerical values should be assigned to certain land surface parameters that affect surface runoff.[36] In this case the scientist might choose to assign numerical values near the low end of the plausible range, knowing that doing so will result in the model output displaying lower dam water levels. By doing this the scientist reduces the risk that the model will overestimate water supply, which is the manager's primary concern (Parker and Lusk, 2019).

Model entrenchment and values

Another feature of model construction that is important for expanding our understanding of value influence is its historical character. In practice models are generally produced in a layered way whereby current models are built by adjusting and adding to existing ones (Parker and Winsberg 2018). In this sense climate models show path dependency where the choices that scientists make at one time to solve certain problems (i.e., how a model is tuned as discussed above), have an effect on the model output and what options are available at a later stage. A very clear illustration of this is offered by Parker and Winsberg (2018, p129),

> Suppose process A was represented in the model in a particular way at an earlier time in the model's development because of priorities at that time. That A was represented in that way might well have shaped how some other processes were subsequently represented in the model; perhaps process F was represented in a way that helps to compensate for some errors introduced by A's representation. Or perhaps the way in which A was represented makes it impractical, or impossible, to represent F in an otherwise desirable way, because those two methods of representation do not work in harmony with each other. A decade later in the model's development, priorities may have shifted somewhat, but modellers

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[36] The uncertainty might be due to not knowing which developments – which have different land surface profiles – might arise in the area in the future.

> often will not bother to change the way A is represented, unless there is a good reason to do so.

This historical feature is referred to as generative entrenchment (Winsberg and Lenhard, 2010).[37] A structure is generatively entrenched when it "has many other things depending on it because it has played a role in generating them" (Wimsatt, 2007, p133). The decisions made in earlier model development determine, or causally implicate current model outputs. That is, if the purposes and priorities (i.e., the values) had been different in the past then the models that exist now, and the results they produce, would be different too (Parker and Winsberg, 2018). Though priorities might change later down the line, modellers usually will not adjust the way things are already represented because this can disturb the "balance of approximations" and affect its overall performance (Mauritsen, 2012, p14). Furthermore, while disentangling this entrenchment is possible in principle, it is not really a viable option in practice because even in moderately complicated cases it would be highly complicated and time consuming, and information about past choices may not be documented (Winsberg and Lenhard, 2010). So, while there is little that scientist can do to change the course of this kind of causal influence of historical values, its existence should still be recognised. It should be apparent that this kind of value influence is distinct from the other examples in this chapter. Here values are causal effectors of later choices, they are not reasons for those latter choices. Generative entrenchment also provides another illustration of the significance of pragmatic choices. Scientists don't want to change the models because doing so can cost time money and effort.

3.3.4 Resolving trade-offs between epistemic and non-epistemic desiderata

As I have argued, climate science for decision making is not solely concerned with achieving epistemic ends such as determining whether a hypothesis about the world is correct, or whether a model accurately represents the world. Practical aims are important too. Scientists may want a model to be easy or fast enough to use, or they may want it to be inexpensive to run. Sometimes in the design of the study, to meet non-epistemic considerations scientists have to make trade-offs between epistemic and non-epistemic desiderata, where the latter can be legitimately prioritised over the former.[38] For example, Haasnoot et al (2014) developed and evaluated an integrated

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[37] This concept was first introduced by William Wimsatt (2007).

[38] It is worth noting here that there is a debate between Elliott and McKaughan (2014) and Steel (2016) about whether we should consider values like speed to be epistemic or not. Unlike Elliott and McKaughan (2014),

assessment metamodel intended to facilitate the exploration of adaptation pathways in the Rhine Delta. The development of adaptation plans requires the exploration of different possible futures together with assessments of the impacts associated with these futures and the possible adaptation actions taken. According to the authors their model had two requirements. (1) It needed to be an integrated model, in order to assess the impacts of environmental changes and policy actions on relevant outcome indicators. (2) Secondly, the model also needed to be fast, in order to simulate a large number of potential decisions. The appropriate model in this case, therefore, was one that represented the dominant processes, natural variability, and the relevant policy actions and outcome indicators for decision making but left out many details judged less significant so that it could simulate quickly (Haasnoot et al., 2014). While even greater accuracy and detail are qualities that the researchers may have liked the model to have had, an expeditious model in this case was a greater priority and so they deliberately designed a model that prioritised speed (non-epistemic desideratum) over detail (epistemic desideratum).

3.3.5 Selecting climate information sources

Inductive risk can also arise when choosing climate information sources. There are a range of sources that climate scientists can use. However, there is often uncertainty about which are the most accurate. That is, there may be a range of model projections or observational data sets that a scientist could choose from, and no epistemic reason to favour one over another. In such cases, the scientist could make a choice in light of which error to avoid. For example, suppose the consequences of a drought for a particular city are really adverse. The city's municipality, who has employed a group of climate scientists to provide them with climate information, has made it clear to the scientists that their primary concern is to be adequately prepared for drought. Suppose further that there is significant uncertainty about which set of projections will yield the most accurate results. In such circumstances, the scientists might select the models that show more frequent and severe droughts under each RCP rather the mean or median of the model projections (Parker and Lusk, 2019).

Table 3.3 A list of positive roles for values in climate science for decision making in the research phase: setting up stage

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Steel (2016) argues that speed is an extrinsic epistemic value, i.e., one that instrumentally promotes the achievement of epistemic aims.

	Choice	Examples	Philosophical defence
1.	Identifying impacts	Choosing to include a gender relevant drought impact in a drought assessment (e.g., walking time to collect water) in an assessment of drought impacts.	Promotes the aims of research
2.	Selecting measurements	Choosing between two drought indices such as SPI index or PDSI index; each of which are better suited to different aims.	Promotes the aims of research
3.	Model construction	Choosing to include a particular variable or not. e.g., excluding small lakes from a model	Promotes the aims of research
4.		Choosing which level of detail is important. e.g., choosing a model that makes accurate predictions at shorter time scales	Promotes the aims of research
5.		Choosing how to tune a model depending on which predictions are important to make. E.g., tuning a model to better predict seasonal rainfall rather than extreme events.	Promotes the aims of research
6.		Choosing to assign lower numerical values to land surface features that affect runoff because users are particularly concerned with avoiding underestimation	Managing inductive risk
7.		Generative entrenchment of models: models have path dependency where the choices made earlier, which are sometimes value informed choices, effect the model output at a later stage. **	Promotes the aims of research *or* managed inductive risk at the time the choice was made
8.		Resolving trade-offs between epistemic and non-epistemic desiderata. E.g., choosing a fast integrated assessment model over a model that has more detail but takes longer to run	Promotes the aims of the research

9.	Selecting climate information sources	Uncertain about which climate information sources are more accurate a scientist selects sources that show frequent and severe drought rather than mean or median of projections to avoid underestimation	Managing inductive risk
** Here values are only serving as causal effectors. See section 3.3.3 (p 60)			

3.4 The research phase - evidence evaluation stage

3.4.1 Model evaluation

This point follows on from the earlier argument made in the discussion on model construction. Aims and priorities will also impact formal evaluation of models. A model will produce outputs for a range of different variables. Which metrics are relevant for evaluation – that is, which model results scientists compare with observations – depend on what variables the scientists wants the model to best represent (Parker and Winsberg, 2018). For example, if the primary aim of a modelling study is to accurately predict changes in the number of hot days (days above x degrees Celsius), then the fact that the model may not perform well in another aspect, such as capturing precipitation, might not be that problematic. The decision about which aspects the model should perform well on is based on the purpose of the model and priorities of the research, which in turn are often based on non-epistemic values.

3.4.2 Choosing probability models

The selection of probability models can also run inductive risk, presenting another opportunity for scientists to consider consequences of error associated with their choices (Steel, 2015). Take the case of constructing a perturbed physics ensemble (PPE). PPEs are a typical method employed by climate scientists when they are uncertain about various parameters in a model. PPEs entail multiple runs of the same model, with variations in uncertain parameters. [39] When constructing a PPE, climate scientists often select probability distributions for the uncertain parameters. There are a range of possible options. For instance, scientists can choose between Uniform, Binomial, Poisson, Gamma, Beta, Normal among others. They could also choose how wide or narrow the distribution will be. Sometimes scientists might not have good physical reasons for thinking one probability model is closer to the truth than another. Moreover, these choices could have

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[39] The structure of the model stays the same while parameters vary for each run (Parker, 2011).

consequences for how likely certain errors will be – how likely the ensemble is to overestimate or underestimate a projected quantity, for example. In these cases, values can play an appropriate role: scientists should consider the non-epistemic consequences of errors that are made more or less likely in light of the selection of a different reasonable probability models.

3.4.3 Assessing evidence regarding model ensembles

Both multi-model and perturbed physics ensembles are often employed in an attempt to estimate the degree of uncertainty arising from structural and parameter uncertainty. However, Eric Winsberg (2018) argues that there are a number of reasons why ensemble methods are not a conceptually coherent way of producing objective probability estimates. First, ensemble methods assume that all models are equally good or that they can be ascribed equal weighting. Second, they assume that the set of models in the ensemble are a random sample of independent draws from all possible model structures. Third, models have shared histories that cannot be easily untangled. Lastly, climate modellers have herd mentality about what constitutes success. Many of the variables in climate models are highly tuneable and so to avoid being the odd one out there is pressure on climate scientists to tune their models in accordance with others. Putting these conceptual issues aside, scientists are still required to make choices about how to weight models within the ensemble and can often be uncertain about how best to do so. Such choices run inductive risks. For instance, a scientist might have only weak evidence that two of the models are going to produce more accurate results than the other models in the ensemble. The two models in question however tend to project larger changes in temperatures. In this instance the scientist might appeal to non-epistemic values to inform her choice regarding weighting. If the user of this climate information is particularly concerned with avoiding overestimation of temperature change, then a scientist might choose to weight the models equally, since that will carry a smaller risk of overestimating the changes (Parker and Lusk, 2019).

3.4.4 Deciding on the boundaries of relevant evidence

Errors can also be made about what evidence should be included in a set, from which uncertainty estimates will be inferred (Parker and Lusk, 2019). For example, scientists will sometimes have to make decisions about whether or not to include models that fall on the tails of a distribution. Including these models would widen the uncertainty bar. These kinds of choices can be made in light of non-epistemic values, as illustrated below.

Suppose that a city is building an underground rail system. For health and safety, they need to ensure that temperatures in the tunnels are moderated appropriately, i.e., that the tunnels are neither too cold in the winter months, nor too hot in the summer months. They consult a group of climate scientists for information about future temperatures for the city. The scientists run various models and produce a range of projections. While the scientists are confident about the projections that fall toward the centre of the distribution there is significant uncertainty about whether the end member projections are plausible. In this instance, in light of the intended use of the climate information, the climate scientists could include a wider range of plausible future temperatures, including models that fall on the tails of the distribution (i.e., models that show the highest the temperature could go, and models that show how low the temperature could go).

Table 3.4 A list of positive roles for values in climate science for decision making in the research phase: setting up stage

No.	Choice	Examples	Philosophical defence*
1	Model evaluation	Choosing which metrics are relevant for evaluation	Promotes the aims of the research
2	Selecting probability models	Choosing a probability model in light of the risks of error	Managing inductive risk
3	Assessing evidence regarding model ensembles	Choosing how to weight models in an ensemble.	Managing inductive risk

3.5 Post-research phase – communication and application

Once scientists have finished their research, typically their work has not yet come to an end. There are usually post-research activities which involve the communication, dissemination, and application of their findings.

3.5.1 Application of findings

Usually, discussions on the role of values in the post research phase centre around exploring how scientific applications can promote or undermine certain values, i.e., how choices in science affect goods (Ward's (2020) fourth kind of value-ladenness). In the field of genetics for instance, there is concern that while genetic editing has promising applications such as reducing disease prevalence, there is also asymmetrical access that could exacerbate global inequality (Cribbs and Perera, 2017). Thus, in the interest of avoiding potentially unethical outcomes where only the privileged would benefit, scientists working on genetic editing might choose to keep their research methods and findings confidential or ensure that they are not made available to the public. These kinds of choices therefore are guided by moral values, they are appropriately informed by or made in light of values.

In the climate science for decision making context, scientists often are conducting research with a specific application in mind. For instance, a climate scientist develops a set of downscaled climate projections with the awareness that these products will be used to inform a set of adaptation decisions. These adaptation decisions invariably promote certain non-epistemic values such as human security, well-being, or equality. Because climate science for decision making is so directly linked to application, I will not discuss this further. The main point to be made here is that climate scientists should try to be aware of possible ways in which their findings could be used to promote good versus problematic ends.

3.5.2 Dissemination of findings

Another activity occurring in the post-research phase is the dissemination of findings. Climate scientists are often required to communicate their findings to the public or to decision makers. Of course, there are some instances where this is not required, such as when scientists are publishing for scientific journals, but these are not the kinds of cases that we are interested in here. Climate science for decision making is aimed at informing or supporting decision makers and so communication constitutes a key activity in this practice.

A crucial step that scientists typically have to take when communicating findings is to communicate scientific uncertainty. Climate science is inherently uncertain, with this uncertainty stemming from a range of sources. To cope with this uncertainty scientists often assign probabilities to their statements. Below I will discuss the ways in which uncertainty quantification legitimately requires value judgments. Before continuing it is important to note that conceptually uncertainty quantification does not strictly have to be described as a part of the post-research phase. One could argue that it falls under the evidence evaluation stage in the research phase because it involves evaluating evidence. On the other hand, one might say assigning probabilities is a step taken to communicate findings. This ambiguity is captured by in the IPCC guidance note on the treatment of uncertainties, wherein they express that the guidance is intended to be used for both "evaluating and communicating the degree of certainty in findings" (2010, p1). It does not make any significant difference which phase this activity is placed under; the key aim is to illustrate another instance in climate science where scientists can appropriately appeal to values to inform their choices.

Probabilities attached to statements about the climate often are best understood as subjective probabilities. They indicate scientists' estimated degree of belief that a statement is true, in light of the evidence and relevant background knowledge.[40] Scientists' estimations of uncertainties, however, are always themselves to some degree uncertain. This is known as *second order uncertainty*. That is, there is always the chance that the uncertainty statement itself could be wrong. Thus, statements about uncertainty require scientists to weigh their second order uncertainty; to decide whether their estimation is accurate enough (Douglas, 2004). Here the argument goes that the choice to accept a particular statement of the extent of uncertainty (such as a probability statement) indicates that the scientist judges her second order uncertainty to be insignificant or unimportant (Douglas, 2009; Parker, 2014). This judgment at least implicitly involves recourse to values; it reflects an evaluation of how bad the consequences of error would be if the probabilities are wrong in one way or another (e.g., too high or too low). Plausible consequences for incorrect probabilities include failure to take policy action or making incorrect adaptation choices. Climate scientists, therefore, should consider these consequences of error when assigning probabilities.

As set out in Chapter Two, this argument sometimes takes a descriptive form (e.g., Rudner, 1953), in which the claim is that scientists necessarily must appeal to values to settle on probabilities. Others make a normative argument which states that scientists *should* be considering non-epistemic values when making these choices (e.g., Douglas, 2009). Here I am making the latter argument that when scientists are ascribing probabilities to statements, they *should* consider the consequences associated with potential errors. I defended the normative argument in Chapter Two.

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[40] There is significant disagreement in philosophical literature about what personal probabilities represent. Richard Jeffery argued that probabilities reflect degrees of belief, while Richard Rudner maintains that personal probabilities are things that a scientist accepts. I adopt Dan Steel's understanding of acceptance "as accepting a statement *S* in a given context to be a decision to make *S* available as a premise for reasoning in that context" (Steel, 2015, p 82).

In practice however, it is rare for climate scientists to assign precise probabilities to statements.[41] More commonly they use coarser or imprecise probabilities. We can see this kind of practice adopted by the IPCC, who employ a likelihood scale to measure their uncertainty, as indicted in Figure 3 (Mastrandrea et al., 2010). Each probability band reflects a probability range and has associated terminology. These expressions are then attached to claims made about the climate. For example,

> It is ***very likely*** that anthropogenic forcings have made a substantial contribution to increases in global upper ocean heat content (0–700 m) observed since the 1970s.

Here 'very likely' indicates a probability of between 90-100%. At this point it would be correct to conclude that coarse probability bands reduce the need for value judgments in managing inductive risk because they reduce the likelihood of error; scientists can be more certain about coarse probabilities. It does not however remove this risk completely. Scientists still have to decide whether to accept *those* uncertainty estimates. Coarse probabilities can still be incorrect – the actual probability might lie outside the reported range – and so they too carry inductive risk. Scientists have to decide whether a given probability interval is accurate enough, which again could depend on how bad the consequences would be of erring (Parker, 2014).

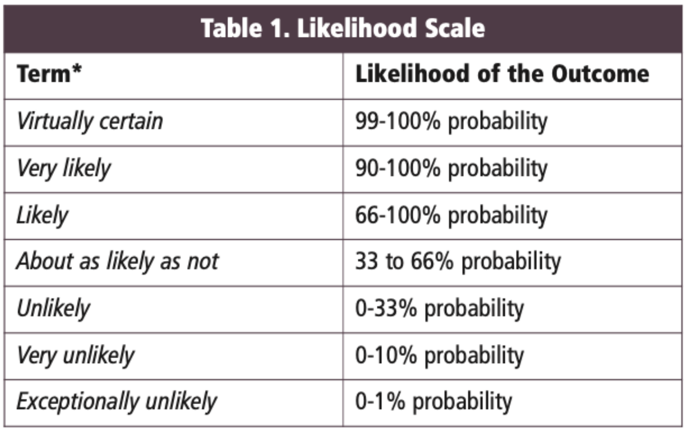

Table 1. Likelihood Scale

Term*	**Likelihood of the Outcome**
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

Figure 3. IPCC likelihood scale for treatment of uncertainties (Mastrandrea et al., 2010)

Furthermore, uncertainty estimation for both precise probabilities and coarse ones – though the latter less so – are also be impacted by the historical role that values played in model construction.

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[41] The UKCP09 report stands as one case where precise probabilities were provided, but it received wide criticism for doing so.

Estimating the probability of a statement is conditional on the evidence as well as the background knowledge that the scientist has about that statement. This background knowledge is based on basic physical theory, observations, simple energy balance models, and importantly climate models themselves which often serve as a kind of stand-in for or embodiment of scientific background knowledge of how the climate system works. Generative entrenchment, however, means that these climate models will include distortions such as simplifications, idealisations, and omissions that were made on account of the aims and priorities that shaped earlier layers of the model's development (Winsberg and Parker, 2018). What this means is that when models stand in as background knowledge the distortions in these models deviate in a way that reflects earlier value judgments and are difficult to correct for when making probability estimates (Parker and Winsberg, 2018). As noted above, while there is little that can be done to minimise this impact, it is worth recognising that such an influence is present.

Table 3.5 A list of positive roles for values in climate science for decision making in the post-research phase

	Choice	**Examples**	**Philosophical defence**
1	Application of findings	Considering the possible ways in which research findings might be applied to promote or undermine various ends	Considering how choices affect goods
2	Dissemination of findings	Assigning precise or coarse probabilities to statements.	Managing inductive risk

3.6 Diverse perspectives

The previous chapter argued for three ways in which values can be good for science. The examples laid out so far in this chapter are based on the first two arguments. I have discussed how values can inform climate scientists' choices in so far as they promote the aims of their research and contribute toward managing inductive risk. Chapter Two also discussed how diverse values can be good for science. Diversity is important because it improves the likelihood that at each of the stages outlined above arbitrary dominant background assumptions can be interrogated and through a process of transformative criticism the relevant knowledge and values will inform those choices.

If climate scientists working on a particular problem lack diverse representation they could, for instance, make incorrect assumptions about which impacts or variables matter, or they might overlook some aspect of the science that might be particularly important. Climate scientists from the Global North for example, who sometimes conduct climate research in the Global South, do not necessarily have knowledge of the relevant information for the Global South context, and therefore may approach scientific problems with their own set of assumptions and values that are not necessarily relevant to the context in which they are working. This is the case for both the relevant epistemic and non-epistemic elements of the research. Importantly, the climate science community should be responsive to criticism arising from diverse representation insofar as the community allows open discussion and critical engagement between scientists where they are able to interrogate theoretical assertions and background assumptions, and uncover non-epistemic values.

There are a multitude of ways that diverse perspectives could inform the various choices outlined in this chapter. For instance, in the pre-research phase diversity could contribute toward identifying important aims and framing relevant research questions. In the research phase diversity could help scientists identify evidential categories, such as relevant impacts and indicators that scientists might otherwise overlook. Diverse values could also contribute toward identifying both the consequences of error and inductive risk preferences. To be clear climate science would not only benefit from diversity amongst climate scientists, but also other relevant stakeholders.

While there are efforts are being made to improve diversity in climate science, there is evidence that more work needs to be done. There remains a need for multiple perspectives in the climate science and climate adaptation space both in terms of relevant stakeholders (Byskov et al., 2021), and within the scientific community (Gay-Antaki and Liverman, 2017; Pearson and Schuldt, 2014). STEM (science, technology, engineering, and mathematics) fields notoriously lack gender and racial diversity (Bernard and Cooperdock, 2018; Botella et al., 2019). In the US employment statistics for STEM occupations highlight that climate related fields face a unique challenge of underrepresentation of minority groups. This is particularly strong in academia where, although the gender gap has narrowed, environmental fields remain low in racial and ethnic diversity (Pearson and Schuldt, 2014). Concern has been raised about the lack of diversity in the IPCC authors, specifically the dominance of scholars from the Global North (Gay-Antaki and Liverman, 2017). Several studies on demographics of IPCC authors have shown that authorship is dominated by developed countries, non-indigenous voices, and men (Corbera et al., 2015; Ford et al 2012; Carey et al., 2016; Ho-Lem et al., 2011; Cortina, 2008). These trends are not only present in bodies such as the IPCC; globally the majority of climate services are funded and supported by developed nations (Reinecke, 2015; Vogel et al., 2019). Appraisal of international climate scientists also appears to be heavily skewed. In 2021 Reuters published a 'Hot List' of "the world's top climate scientists" (Reuters, 2021). In this list climate scholars are ranked according to how 'influential' they are, which is determined by the number of research papers related to climate change the scholars have published in 2020, how often those papers are cited by other disciplines, and how often they are referenced by the lay press. An analysis carried out by Schipper et al (2021) found that of the 1000 climate scientists on the list, only 122 were women and 111 scientists were based in institutions from countries in the Global South. Of the 111, 88 scientists were based in China, and *none* were based at institutions in Africa outside of South Africa.[42] This analysis reveals a stark imbalance of gender and geographical diversity in the climate change field.

Nevertheless, it should be acknowledged that in recent years the IPCC has made some effort to improve multi-country and developing nation representation as well as gender diversity in their assessments. A 2018 analysis of the nominated authors for the IPCC AR6 found that 44% of the authors are from developing countries and countries in economic transitions, an improvement from the 37% in the AR5. Gender gaps have also narrowed from 75% male, 21% female in the AR5 to 67% male, 33% female in the AR6 (McSweeney, 2018). We should be careful however when using geographical location as a proxy for diversity. It is possible that scientists who differ in geographical location still share certain gender, racial or other features and therefore do not hold a diverse range of perspectives and values. Thus the issues of how to ensure real diversity is more complex than simply, for example, including scientists from the Global South. Regarding the IPCC, evidently some kind of attendance to diversity is being undertaken, though it might still be insufficient.

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[42] Only four are from South Africa; all of them men.

Table 3.7. A list of positive roles for values in climate science for decision making

No.	Choice	Examples	Philosophical defence*
The Pre-research Phase			
1	Choosing a research question	IPCC time period projection framing which produces adaptation relevant information vs 1. 5°C – 2°C framing, which is less suited to adaptation aims, promotes action to mitigate climate change.	Promotes the aims of research
2	Framing research	Choosing how to frame extreme event attribution questions: the risk-based method vs the storyline approach; each have different inductive risk profiles.	Managing inductive risk
3	Choosing a methodological framework	Choosing between a contextualised strategy that includes incorporation of a broader range of phenomena over a decontextualised approach. An example of a project that adopts a contextualised approach is the FRACTAL project.	Promotes the aims of research
The Research Phase: Setting up stage			
4	Identifying impacts	Choosing to include a gender relevant drought impact in a drought assessment (e.g., walking time to collect water) in an assessment of drought impacts.	Promotes the aims of research
5	Selecting measurements	Choosing between two drought indices such as SPI index or PDSI index; each of which are better suited to different aims.	Promotes the aims of research
6	Model construction	Choosing to include a particular variable or not. e.g., excluding small lakes from a model	Promotes the aims of research
7		Choosing which level of detail is important. e.g., choosing a model that makes accurate predictions at shorter time scales	Promotes the aims of research

9		Choosing how to tune a model depending on which predictions are important to make. E.g., tuning a model to better predict seasonal rainfall rather than extreme events.	Promotes the aims of research
10		Choosing to assign lower numerical values to land surface features that affect runoff because users are particularly concerned with avoiding underestimation	Managing inductive risk
11		Generative entrenchment of models: models have path dependency where the choices made earlier, which are sometimes value informed choices, effect the model output at a later stage. **	Promotes the aims of research *or* managed inductive risk at the time the choice was made
12		Resolving trade-offs between epistemic and non-epistemic desiderata. E.g., choosing a fast integrated assessment model over a model that has more detail but takes longer to run	Promotes the aims of the research
13	Selecting climate information sources	Uncertain about which climate information sources are more accurate a scientist selects sources that show frequent and severe drought rather than mean or median of projections to avoid underestimation	Managing inductive risk
The Research Phase: Evidence evaluation phase			
14	Model evaluation	Choosing which metrics are relevant for evaluation	Promotes the aims of the research
15	Selecting probability models	Choosing a probability model in light of the risks of error	Managing inductive risk
16	Assessing evidence regarding model ensembles	Choosing how to weight models in an ensemble.	Managing inductive risk

17	Deciding on the boundaries of relevant evidence	Including evidence that falls on the tails of the distribution because decision makers want the range of plausible possibilities	Managing inductive risk
The Post Research Phase			
18	Application of findings	Considering the possible ways in which research findings might be applied to promote or undermine various ends	Considering how choices affect goods
19	Dissemination of findings	Assigning precise or coarse probabilities to statements.	Managing inductive risk
*In all inductive risk cases scientists should make a choice in light of non-epistemic consequences *only* when there are no good scientific reasons to choose one option over another ** Here values are only serving as causal effectors. See section 3.3.3			

Conclusion

It has been well established by philosophers of science that non-epistemic values can make a positive contribution to science by playing an appropriate role in some of the choices that scientists make when conducting research and producing scientific information. Nevertheless, it is not always obvious how these arguments bear out in specific scientific practices. In this chapter I applied these arguments to climate science for decision making and, through the use of case studies and examples, illustrated the various ways in which non-epistemic values have an appropriate role to play a role in the choices that climate scientists make.

For structural and analytical purposes, I distinguished three phases in the scientific process, the pre-research, research, and post-research phase, and provided examples in each. At each of these stages I provided examples where values can appropriately inform scientists' choices in so far as they either help manage inductive risk or promote the non-epistemic aims of research. I offered a summary of these choices and their examples in Table 3.7

Where possible, scientists should be explicit about how and why values informed a particular choice. Failure to be open about value judgements or insisting that science is value-free is likely to perpetuate misunderstandings about the role of values in science (Elliott and Resnik, 2014). Transparency could take the form of discussing value-informed choices in the methodological section of a report or journal paper, or it could be communicated in other forms directly to the decision maker. Either way, in climate science for decision making, scientists should strive to make value judgments explicit to the decision maker, who can then make their decision with awareness of how values informed the nature of the information presented to them. Of course, it is not always possible to be fully transparent, specifically in cases where value judgments are unconscious; the requirement is just to strive for transparency.

In the selection of examples in this chapter I have tried to strike a balance between on the one hand avoiding trivial instances of value influence, and on the other hand providing a thorough list of value influence in climate science. In doing so my intention was to find a middle ground between two opposing views about value-ladenness. : on the one hand, there are those who claim that the presence of values in science is pernicious. To remedy this, I provided a range of examples which show that many instances of value-ladenness in climate science are not complex or contentious (arguably many of the aims approach examples are of this nature). On the other hand, there are those who reduce value-ladenness to trivialities. As noted by Ward (2020) "any action that affects things that are values is value-laden" (p4). In other words, many of the choices that scientists make could, out in the world, promote or undermine some goods over others. Scholars such as Michael Scriven (1972), use this argument to trivialise claims about science being value laden. Ward rightfully points out Scriven misses the point however, because it would be incorrect to conclude that *all* claims about scientists' choices affecting goods are necessarily trivial. In climate science there are a number of scientific choices that will advance values that might be surprising. Many of the examples in this chapter intend to be interesting in this way.

In all of these phases it is important that there are diverse perspectives both within the scientific community and the relevant stakeholders. The presence of diverse perspectives improves the likelihood that at each of the stages outlined above the relevant knowledge and values inform these various choices, and that dominant background assumptions are critically interrogated.

Importantly this chapter provided examples where values can play appropriate *roles* in scientific choices. It has not argued for which values are the *right* values. Nor has it discussed the problem of value conflicts that can arise even when values are playing appropriate roles. These issues will be attended to in the next two chapters.

CHAPTER FOUR

VALUE CONFLICTS IN CLIMATE SCIENCE

Introduction

In Chapters Two and Three I argued that values can, under certain conditions, play an appropriate role in the decisions that climate scientists make when producing climate information. Attention to values can help scientists meet their moral responsibilities (Douglas 2009), as well as promote the aims of science (Intemann, 2015; Elliott and McKaughan, 2014). I further argued that this doesn't only occur in "external" phases of science, as scientists consider which problems to investigate or how to communicate findings, but that values can appropriately inform many choices made in the research phase, such as choices about model construction and the evaluation of evidence. However, while values may play appropriate roles, there is also room for value commitments to come into conflict.

Existing literature addressing value conflicts usually centres on illegitimate value influences, such as values leading to the suppression or manipulation of data in pharmaceutical studies (Biddle, 2007; Hicks, 2014; Elliot, 2018; Ross et al., 2008; Jureidini et al., 2008).[43] Little attention has been given to the potential for conflicts to arise when values are operating in their *appropriate* roles. Scientists who accept that non-epistemic values can sometimes appropriately influence methodological choices, and who have identified situations where such influences are appropriate, may still find themselves in situations where scientific, personal, ethical and societal values do not all pull in the same direction. Acknowledging the potential for, and recognising the presence of, value conflicts is crucial if we are to give an account of how, whose, and which values should operate in climate science, especially if these conflicts can problematise current recommendations. For example, some philosophers have argued that scientists' choices should be informed by democratically-endorsed values, whilst other have argued that, in climate services, the users' values should often take centre stage (Parker and Lusk, 2018). However, it is not immediately clear what scientists should do if user values do not align with scientists' values (Schroeder, 2017), or if users in a particular context hold values that conflict with democratically-endorsed ones.

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[43] Debates on value conflicts between *epistemic* values is theory choice are however well established in philosophy of science.

In this chapter I identify three types of value conflicts that can be present for climate scientists when managing inductive risk and discuss how these can lead to difficult tensions that scientists may struggle to resolve. I begin in Section 4.1 by sketching a recent disagreement that occurred between climate scientists in the detection and attribution community over the introduction of a new method for extreme event attribution.[44] Adopting Lloyd and Oreskes' (2018) analysis, I explain how what occurred was in essence a value-based disagreement about how the risks of error should be weighted. I present this as an example in climate science where scientists are confronted by a methodological choice where values can play an appropriate role, yet there is disagreement amongst scientists related to this choice. Then, in Section 4.2, I move beyond this specific example to propose three kinds of value conflicts that can be present for scientists working in decision relevant climate science as they attempt to manage inductive risk with the help of values: conflicts between epistemic and social values, along with different attitudes about how these values should be weighted; conflicts between different moral values associated with the different roles scientists have; and conflicts between scientists' personal values and societal values. I argue that choices to resolve these value conflicts differently can give rise to disagreements like those seen in the extreme event attribution case. To be clear: the aim is not to peer into the minds of attribution scientists, but to use the attribution case study to concretise a more general analysis of value conflicts that can make methodological choices difficult to resolve, even when value influence is appropriate.

4.1 Case study: a disagreement about methods

In its Fifth Assessment Report, the IPCC concluded that "human influence on the climate system is clear"(2014, p15) and that "changes in many extreme weather and climate events have been observed since about 1950" (2014, p5) Extreme events are of great societal concern due to their (mostly) adverse effects on human lives. Yet detecting changes in their occurrence is challenging, given that they by definition occur infrequently (Stott et al., 2016). When extreme events occur, a common public question is whether anthropogenic greenhouse gases, through their effects on the climate system, are in some way responsible for, or played a role, in such events. Extreme event attribution aims to detect and quantify such anthropogenic contributions to extreme weather events. We will see below, however, that there are different ways of conceptualising the nature of these effects.

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[44] This case was presented in the Chapter Three as an example of how values can appropriately inform choices about how to frame research questions. Some of the material in this section was covered in Chapter Three. It will be repeated here because it is central to the discussion. However additional information about the disagreement that ensued is included.

As discussed in Chapter Two, the standard method used to attribute extreme events, often referred to as the risk-based approach,[45] was developed by a group of scientists at Oxford and the UK Met Office, including Peter Stott, Myles Allen, and Frederikke Otto. It is a probabilistic technique that compares the frequency of a certain class of events in a model simulation with increasing greenhouse gas emission (p1) (i.e., under current factual conditions) with the frequency of that event in a model simulation with greenhouse gas emissions at pre-industrial level (p0) (i.e., under counterfactual conditions.) These probabilities are used to estimate what fraction of the risk of occurrence of the extreme event type is attributable to climate change ($FAR= 1 - p0/p1$), as well as a risk ratio ($RR = p1/p0$) (Stott et al., 2016).

The risk-based approach faces a notable challenge when analysing events that are strongly influenced by dynamical processes. Extreme events are determined by both dynamical and thermodynamical factors, however, anthropogenic changes in dynamics are often difficult to discern because of their small signal to noise ratio (Trenberth, et al 2014). Consequently, FAR estimates are often highly uncertain; 'no increase in risk' cannot be ruled out. This finding could be interpreted as meaning that the event has no link with climate change, even though such a link might actually be present.

In response to the limitations of the risk-based approach, climate scientists Kevin Trenberth, John Fussalo, Theodore Shepherd, and others have argued that attribution scientists should employ additional, complementary methods (Hannart et al., 2016a; 2016b; Shepherd, 2014; 2016; Trenberth, 2011; 2012; Trenberth et al., 2015; Lloyd and Oreskes, 2018). They propose the storyline approach, a method that adopts a conditional format that seeks to explain the origin and causes of *a single* extreme event, and how the event was influenced by climate change. The storyline approach focusses on thermodynamic processes (changes in heat and heat's effect on moisture content in the atmosphere), which are easier to analyse and attribute than dynamical processes. That is, it assumes that the weather event and its circulation regime (dynamical factors) have occurred – not assessing its change in likelihood – and investigates whether the event developing in those circumstances was affected by thermodynamic changes, such as changes in sea surface temperature or atmospheric moisture content, which scientists can attribute to anthropogenic causes with high confidence (Trenberth et al., 2015).

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[45] Shepherd (2016) and Lloyd and Oreskes (2018) both use this term.

In a comprehensive analysis, Lloyd and Oreskes (2018) discuss in detail how and why the proposal to include the storyline approach in extreme event attribution research sparked considerable controversy in the attribution community. Some scientists explicitly criticised the approach on the grounds that it focuses solely on thermodynamic features and ignores dynamical features; this is problematic because both features can play a role in the changing probability of an event (Stott et al., 2016). In fact, in some cases dynamical effects might actually *decrease* the overall risk of the extreme event type occurring, despite thermodynamic processes contributing to the intensity of the particular event (Otto et al., 2016). In such cases, argue Otto et al., "it would be confusing to blame anthropogenic climate change, even partially, for an observed pluvial flood if the actual impact is to make such flood events in that region less likely to occur" (2016, p814). This statement captures the core of the scientists' concern. They argue that the storyline approach could *overstate* the role of anthropogenic climate change. In other words, they are worried that it risks Type 1 errors, or false positives (Lloyd and Oreskes, 2018). Stott et al. write,

> By always finding a role for human induced effects, attribution assessments that only consider thermodynamics could overstate the role of ACC, when its role may be small in comparison with natural variability, and do not say anything about how the risk of such events has changed. (2016, p33)

Scientists like Stott et al (2016) and Otto et al (2016) object to the storyline approach because they believe that it has a tendency towards producing false positives.

By contrast, proponents of the storyline approach appear to have the opposite worry. Their concern with the risk-based approach is that they think it could lead to an *underestimation* of the role of anthropogenic climate change (Lloyd and Oreskes, 2018). This is expressed in the following quote from Shepherd:

> If an extreme event was caused in part by extreme dynamical conditions, then any risk-based analysis that uses a climate model also has to address the question of whether the simulated change in the likelihood or severity of such conditions is credible... And if plausible uncertainties are placed on those changes, then *the result is likely to be 'no effect detected'*. This is indeed what tends to be concluded in event attribution studies of dynamically driven extremes. [31] But absence of evidence is not evidence of absence." (2016, p32, own emphasis)

In summary, the worries held by both sides concern the tendencies for the other approach to err in particular ways. It is a worry about inductive risk. Deciding which consequences associated with the two types of errors are 'worse' is a value judgment. In this case there are a range of plausible non-epistemic consequences associated with the errors each approach is prone to make. These will be explored in the coming sections, as we consider a range of underlying value conflicts that could give rise to disagreements like that seen in the extreme event attribution case study.

Philosophers who accept that values can play an appropriate role in such cases put forward various suggestions as to which or whose values ought to be applied when making value-informed methodological choices. The Democratic View for example, argues that democratically endorsed values, or values that meet democratically endorsed ends, should be used (Intemann, 2015; Douglas, 2005; Kitcher, 2011). This view is defended on grounds of democracy and political legitimacy. If values are going to influence policy, through policy relevant science, then the public should be able to choose those values (Schroeder, 2017). In the case of climate services provision, Parker and Lusk (2019) state that in inductive risk cases it is usually user values that should be employed. Take the following example. A climate service provider is asked by a particular city to provide projections of future rainfall patterns in the city catchment area to help them determine whether they should invest in further dam infrastructure. The city's primary worry is that they will not have enough water to cope with urbanisation in the coming years. When faced with a methodological choice (such as deciding how to weight an ensemble of models or choosing parameterisations) where the climate service providers are unsure of which method will yield the most accurate results, Parker and Lusk would argue that they ought to choose a method that risks underestimating future rainfall over and above methods that risk overestimating rainfall. By doing so the climate service provider is drawing on user values to manage inductive risk.[46]

While these suggestions seem quite reasonable, they gloss over some important issues. Climate scientists are doing socially-relevant science work in a particular context where scientific norms and regulatory structures impose constraints on the value choices that they can make. What is more, scientists are human beings too, and they are members of society, with their own interests and values that should be acknowledged. In the following sections I attend to these factors and draw out three types of underlying value conflicts that can be present for climate scientists when they are making value-influenced choices. These value conflicts have the potential to precipitate

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[46] It should be noted that in some circumstances these values could converge, i.e., if the user is a government of some kind then it ought to represent the values of the electorate. But in other circumstances these values might diverge.

disagreements of the kind we see in the event attribution case study. They also make value-based choices more complex to resolve than the suggestions offered by Intemann or by Parker and Lusk.[47]

4.2 Epistemic and social values

There are good reasons why the attribution scientists making inductive risk choices might be concerned with an approach that they regard as being prone to false positives, i.e. prone to indicating that false hypotheses can be accepted. Many would agree that truth, or the advancement of knowledge, is the core goal of science, and accepting falsehoods is antithetical to that goal. The content of knowledge varies across disciplines of course, but in climate science we can broadly say that the epistemic aims are to advance knowledge about the climate system and its impacts on socio-economic and environmental systems. Given this aim, scientific practice, including climate science, is guided by epistemic norms -- standards of behaviour and practice that reflect widely agreed upon beliefs about how members of the scientific community ought to behave. Values usually provide the justification for norms. In the climate science field, a number of scholars have written about the presence and impact of a particular epistemic norm that serves the value of truth: conservatism.

Scientific conservatism holds that scientists should not accept hypotheses too readily and should be cautious, rather than bold or conjectural, with their claims. Hypotheses should be met with scepticism and should be severely tested before they are accepted (Mayo, 1996; Popper, 1963). This norm is also sometimes referred to as scientific "restraint" (Anderegg, 2014), "reticence" (Hansen, 2007) or "erring on the side of least drama" (Brysse et al., 2013). One of the ways that it can manifest is as a preference for avoiding false positives over avoiding false negatives – not yet rejecting a false null hypothesis, rather than accepting a substantive hypothesis that is false.

One of the clearest instantiations of conservatism is found in statistical significance testing. In many fields, scientists only accept a claim (reject the null hypothesis of no causal relationship) in the context of an experiment if it is shown that the odds of the observed pattern is very low. For example, in psychology typically a result is only judged significant if there is a less than 5%

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[47] For the purpose of this discussion I set aside discussion some important open questions related to these views. For instance, how are democratic values elicited? How should these values be accommodated in the research process? What should one do if different stakeholders or users have conflicting values, or their values are morally dubious?

probability of the result having occurred on the assumption the null hypothesis is true.[48] There is no objective epistemic reason to set the significance level to this value; it is a convention and reflects a value judgment that "the worst mistake a scientist could make is to think an effect is real when it isn't" (Oreskes, 2016).[49]

Traditional risk-based approaches in extreme event attribution adhere to these conservative norms via their adoption of conventional statistical significance levels. They assume a null hypothesis of 'no effect' and proceed by determining the probability of a specific class of events given anthropogenic climate change compared to a counterfactual climate where there is no human-caused GHGs. The propensity for the risk-based approach to commit false negatives lies in the inclusion of dynamical factors in attribution models whose contributions, as discussed above, are often difficult to discern, given their small signal-to-noise ratio and uncertainties associated with modelling. Consequently, in many cases, scientists employing the risk-based approach don't have enough evidence to reject the null hypothesis. Note, however, that concluding that there isn't enough evidence to reject the null is not the same as concluding that there is evidence to accept it. In such cases, the risk-based approaches are not showing that the extreme event was *not* caused by climate change; rather, they are concluding that there is not enough evidence to positively attribute the event to anthropogenic climate change. They remain agnostic.

By contrast, Risk-based scientists regard the storyline approach as one that fails to adhere to conservative norms, because they think that by excluding dynamical processes the storyline approach will almost always find that human-induced climate change had an effect, even in cases where, were dynamical contributions apparent, such a conclusion would be called into question (or even incorrect). In this sense they believe that the storyline approach is not appropriately cautious. In fact, some scientists who criticised the storyline approach argued that it "flipped the null" or "nullif[ied] the null hypothesis" and "turned 400 years of scientific thought on its head" (Bryce and Day, 2014, p 1029; Curry, 2011; Allen, 2011). In reality, the storyline approach does not have a null hypothesis and so it does not actually flip the null. One could say, though, that because it is prone to false positives it is analogous to flipping the null.

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[48] In data rich sciences like particle physics, the significance level is much higher

[49] Some scholars draw on a Kuhnian conception of conservatism to explain climate scientists' preference for Type 1 errors (Oreskes, 2016; Brysse et al., 2013). Kuhn's (1962) depiction of science holds that science is resistant to change. Established knowledge is the default position, and the burden of proof is placed on those scientists who want to challenge prevailing views. This idea of conservatism is conceptually distinct from the kind I discussed previously, which holds that scientists should not accept claims without very strong evidence.

Conservatism serves an important function in science; it protects both scientists and the public from believing in falsehoods, thus indirectly serving the epistemic value of truth. Moreover, there is ample evidence to suggest that conservatism is prevalent in climate science (see Brysse et al., 2013; Hansen, 2007; Anderegg et al., 2014; Allen, 2011).

In this light we can understand why a climate scientist faced with an inductive risk decision might choose the option that is less prone to false positives: because she believes that by doing so, she is making methodological decisions in accordance with a core epistemic value in her scientific field. Nevertheless, it is important to consider that climate science, especially climate science intended to support decision making, might not only have epistemic aims; it also has important social aims that are underpinned by social values. These social and epistemic values can sometimes conflict with one another, with different methodological options serving at the expense of the other. When this happens scientists might weight these values differently, judging some to be more important or foundational than others.

Helen Longino's concept of constitutive values in science provides a useful framing for thinking about values specific to areas of science. Constitutive values are values that are generated from a shared understanding of the goals of scientific inquiry (Longino, 1990). They are the values that belong to the scientific community within the social and cultural environment where the science is done (Rolin, 1998; Longino, 1990). Typically, constitutive values are understood as including epistemic values such as predictive accuracy or explanatory power (which Longino describes as cognitive features that characterise a good scientific explanation), as well as values that promote good scientific practice, such as honesty and collaboration. But in some scientific fields constitutive values are also understood as including social or ethical values. In medicine, for example, ethical values concerning the health and well-being of patients are regarded as fundamental to the field. Indeed, the first promise doctors undertake when taking their Hippocratic Oath is to 'do no harm'. Upholding this value is part of what it means to be a good doctor; it is constitutive of the practice in their field. Crucially, it has an impact on how research in some areas of medicine is conducted – specifically in the management of inductive risk. In cancer screening, for instance, false positives are often tolerated more readily than false negatives, because of the very serious risks associated with failing to diagnose a patient with cancer. To reduce these risks, screening tests are specifically designed to be highly sensitive, resulting in a relatively high rate of false positives (Lloyd and Oreskes, 2018). Prioritising avoidance of false negatives is in line with one of the fundamental values of medicine. This is not to say that epistemic values like truth or accuracy are not still extremely important but just that, in some circumstances, non-epistemic values can be constitutive of scientific practices too, affecting inductive risk preferences.[50]

Climate scientists working in decision relevant climate science like extreme event attribution and adaptation do not undertake an oath, nevertheless, many would agree that these scientific efforts do have some distinctively social aims. In broad terms, these might include helping people to avoid harms that matter to them by adapting to and mitigating climate change. Some climate scientists do seem to understand particular social values to be constitutive of their practice. For example, a prominent white paper on ethics of climate services – compiled by a group of authoritative climate scientists under the auspices of the Climate Service Partnership – identifies human security and minimisation of risk to be key 'outcomes' that climate services seek to support (Adams et al., 2015). More generally, however, explicit discussions by climate scientists on the constitutive values of climate science are extremely rare, and even more so discussions on the possibility of constitutive social or ethical values.

The extent to which climate scientists consider certain values, including social values, as being constitutive of their field can impact how they manage value conflicts when they arise. In the case of managing inductive risk, for example, scientists face two choices, each promoting different values. A desire to avoid false positives serves the epistemic value of truth, which few climate scientists would deny is a core value in their field; conservatism observed in practice confirms this. Avoiding false negatives in this context, by contrast, has the ability to promote human security. Some climate scientists might accept that social values are in some way important in their work but regard these values as tangential rather than constitutive of their practice. A second camp may regard social values as constitutive, yet still strongly feel that epistemic values should still take preference. In such instances they might still choose approaches that avoid false positives. A third camp might adopt positions similar to the medical profession, viewing societal values as inherent and paramount to their field. As such, when faced with a choice between promoting truth or human security, they might in some cases give societal values more weight and therefore choose an approach that avoids false positives, than one that avoids false negatives.

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[50] As discussed in Chapter Two, Elliott and McKaughan (2014) draw on the notion that science has multiple goals, both epistemic and non-epistemic, to explain of how scientists can legitimately prioritise non-epistemic values over epistemic ones in some circumstances. Steel (2016) however might reframe this as a tension between two different epistemic values because some of the values that Elliott and McKaughan call social, Steel regards as "extrinsic epistemic" values.

In practice, of course, scientists need not neatly fall into these three camps. A scientist might be uncertain about how to apply constitutive values of her field and be unsure which of the camps to join. Such a scientist might experience a tension internally. What is clear, however, is that climate scientists can experience instances where the epistemic value of truth pulls in a different methodological direction to that of human security. When this does occur, managing inductive risks is likely to be challenging for the scientists in question.

4.3 Multiple moralities

One explanation for why scientists adhere to norms such as conservatism is that doing so falls under the role morality of a scientist. This points to the next conflict I will discuss, a conflict between role moralities. A role is defined as a position within a society, whether professional or non-professional, where those who hold the position are expected to act and even feel in particular ways (Andre, 1991; Johnson, 2000).[51] Role morality refers to the set of morals and principles a person adopts when they take on a specific role; it defines what behaviour is appropriate or acceptable within that role. For instance, a mother is expected to take extra care of her child over and above other children and a psychologist is expected to uphold confidentiality. Role morality is often contrasted with general morality because under some circumstances role moralities involve additional responsibilities over and above general ones, or can excuse people from general responsibilities.[52]

The role of a scientist brings with it distinct normative expectations. Some are responsibilities regarding the treatment of test subjects, such as retaining their anonymity or not imposing harm on them, others concern obligations seen as essential to the functioning of science, such as honesty when reporting data, sharing of important results, and responding to valid criticism (Douglas, 2003). These responsibilities align with the norms established by the scientific community. Conservatism is one of these long-held norms in science, enacted in many scientific disciplines. It is reasonable therefore to argue that a climate scientist might regard adherence to conservatism as one of their obligations as scientists. That is, they might think being a good scientist requires a sceptical, questioning attitude and so adopting more conservative approaches. Suppose that climate scientists do not question the appropriateness of conservatism in the context of climate

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[51] Not all roles are assumed voluntary; assuming a role as a doctor is, while usually one's role as a sister is not.

[52] For example, while it is our general responsibility not to drive recklessly and speed. Police officers and paramedics, however, are often excused from this responsibility because of the urgent nature of their circumstances.

science, and instead think that even in the context of decision relevant climate science conservatism – manifesting as a preference for avoiding false positives – ought to be adhered to.

How might such a scientist view the introduction of the storyline approach? She might decide that while false negatives in climate science can have some negative consequences for society, her role as a scientist requires that she chooses approaches that err on the side of caution, and thus favours the risk-based approach. This is similar reasoning to a clinical psychologist, for instance, who will uphold client confidentiality in a variety of cases even if there are other good moral reasons to share that information, because it is her role obligation to do so.[53] Moreover, a climate scientist might adhere to conservatism not only because they see that their profession requires it. Identity Theory asserts that individuals define themselves, in part, by the roles they take on in society, including in their professional sphere (Robertson, 2009; Hunt, 2003). Roles, and the expectations governing them, are often internalised to become part of an individual's identity. Hence, a scientist's role forms part of her moral identity; it can provide an explanation for how individuals navigate moral dimensions of their lives and work (Reed and Aquino, 2003).

Scientists, however, like many other individuals, do not only occupy one role in society. Most people adopt a number of roles simultaneously, each of which is accompanied by its own set of principles and norms. According to role morality, individuals ascribe to different moralities depending on the roles they adopt; effectively, people can wear different moral hats (Gibson, 2003).[54] These differing moralities have the potential to give rise to conflicting moral obligations that can lead to internal conflicts for the individual (Leavitt et al., 2012), a phenomenon well-documented by social scientists (Gibson, 2003).

For example, in inductive risk cases in climate science, where there are societal consequences associated with missed warnings, a crucial tension can surface between the scientist's professional role as a scientist and her role as a *citizen*. When using the term 'citizen' I am not specifying a member of a particular state, but rather I use the term to pick out someone who is a member of society – who has an interest in the well-being of their neighbours and a right to promote their interests through voting and other activities. The scientist-qua-citizen may recognise that acceptance of each event attribution method could influence policy outcomes in different ways. Conservative approaches could lead to less stringent mitigation and adaptation policies and

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[53] There are some exceptions where psychologists are not obligated to uphold confidentiality, such as when the psychologist can foresee that their patient is likely to harm themselves or someone else.

[54] By using the term 'adopt' I am not implying that it is a choice. Some roles are not explicitly chosen.

actions, while an approach that often concludes that anthropogenic climate change is making extreme events worse may help to galvanise public support for stricter mitigation and adaptation policies. As a citizen she may feel it is her moral obligation to make choices that help to safeguard and promote the well-being of her society, i.e., choices that protect the future of the society in which she lives. For the scientist-qua-citizen the *consequences* of error, in particular the consequences for society, may take the moral foreground. Thus, insofar as she takes on her role as a citizen, she may judge an approach like the storyline approach to be more appropriate than the risk-based approach. This is quite different from the scientist-qua-scientist, whose moral focus may be on the *kind* of error each approach tends toward: false positives in science are bad, consequences aside. These kinds of conflicts present a complication for those who argue that scientists ought to abide by democratically endorsed values or user values. In policy relevant science, scientists are sometimes also stakeholders or decision makers themselves, and thus can find themselves in situations where they have to promote or make value choices that they don't necessarily agree with and have a right to speak on (Schroeder, 2017).

A recent study by Gundersen (2020) on value perceptions held by climate scientists working on the IPCC suggests that at least some climate scientists in fact do experience moral conflicts between their perceived obligations as scientists and their notions of social responsibility. [55] The climate scientists interviewed acknowledge a discrepancy between their role as 'value-neutral' scientists and their sense that they have a moral responsibility to warn the public of the risks imposed by climate change. This is captured in the following quote from an interviewed scientist (2020, p105):

> And I think all scientists know in their bone marrow that we are not supposed to take sides. We're supposed to enhance scientific knowledge and then someone else has to make the decisions. And that's definitely how I am as well, but often I've also questioned this: Don't we believe the results? So, if we believe in the results on the first page of the IPCC that CO2 is a problem caused by humans that will have enormous consequences unless we do something about it—we have reached this conclusion some four or five times by now—then I think it is our *social responsibility* to take that into consideration. Otherwise there is no meaning in science if we don't believe in our own results. (Interviewee 4) [emphasis added]]
> 14.

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[55] I say 'perceived' because I am not making the case that these are in fact scientists' moral obligations.

Gundersen explores the discrepancies between a scientist's personal values and the normative standards imposed on them by their professional role (2020, p105). The interviewee strongly holds that they have a normative obligation as a scientist to be 'value neutral' and so should not be prescriptive in any sense, yet also seems to express that they have a social responsibility – one distinct from science – to do more.

As early as the 1980's, Stephen Schneider explored the moral tensions that climate scientists experience in virtue of their dual identities as both scientists and 'human beings'. He states:

> On the one hand, as scientists we are ethically bound to the scientific method, in effect promising to tell the truth, the whole truth, and nothing but — which means that we must include all the doubts, the caveats, the ifs, ands, and buts. On the other hand, we are not just scientists but human beings as well. And like most people we'd like to see the world a better place, which in this context translates into our working to reduce the risk of potentially disastrous climatic change (Interview with Discover magazine, October 1989)

Schneider was specifically concerned with how this duality leads to a "double ethical bind" (1989) for climate scientists communicating through the media. The two contexts have different modes of communication: science requires all caveats and doubts are clearly stated; media conventions, by contrast, demand brevity and conviction, and so scientific norms would be ineffective for public communication. Though communication is not the focus of the discussion in this chapter, the concept of a double ethical bind is appropriate. Schneider calls attention to the ways in which climate scientists confront or experience conflicting norms and values in virtue of the dual roles that they hold, and the difficulties that can arise from them pulling in different directions.

Tensions between role moralities for scientists are not necessarily restricted to the two roles described above. Even within their occupation, scientists assume many sub-roles. Philosophers of science have explored some of the normative differences between scientists-qua-scientists and scientists-qua-advisors or experts, particularly concerning the treatment of non-epistemic values in these roles (Douglas, 2009; Steele, 2012; Gundersen, 2018). Climate scientists are often also supervisors, public intellectuals, or lecturers (Gundersen, 2018, p55). Outside of their professional roles, they might identify not just as citizens but as environmentalists or social activists.

Accompanying each of these roles are specific sets of normative rules and expectations, which can result in multi-layered cross-cutting demands of differing moralities (Gibson, 2003).

Naturally, several questions arise concerning how these kinds of conflicts ought to be resolved. Do professional obligations override other role obligations in some cases? Are professional obligations morally significant at all? Are there basic universal obligations that ought to override all others? These issues have been and continue to be addressed by moral philosophers and ethicists. I am bracketing these debates here, as my aim is to show how the conflicts arise in the first place and how they can be manifest in scientific practice. Moral considerations aside, the descriptive aspects of role morality provide insight into ways in which a scientist might experience an internal tension in her efforts to manage inductive risk. It also offers a potential explanation of disagreement across scientists, as in the event attribution case; scientists may resolve these internal tensions differently.

It should be clear that the conflict between epistemic and social values in climate science discussed in the previous section is distinct from the conflict between scientists' role moralities. The first concerns a conflict that arises as scientists grapple with the question of which values are constitutive of their practice; at issue is whether social values are constitutive values and, if so, how they are to be pursued alongside epistemic ones. The second concerns a scientist experiencing a conflict between her perceived moral obligations as a scientist (assuming she operates in a scientific community where conservatism is a norm) and her responsibilities and rights as a citizen or member of society, which are understood as clearly distinct from her obligations-qua-scientist. Both conflicts have the potential to impact how inductive risk is managed in climate science.

4.4 External constraints and personal values

A third type of conflict involves tension between societal values and scientists' personal values. Scientists as individuals are constrained by methodological standards and norms in their scientific community that make it difficult for them to diverge from these conventions, even if they view the established norms and conventions as problematic (Steel, 2015). Conservatism has been identified as bringing with it conventions (such as those used in statistical significance level in hypothesis testing) that have such a regulating function (Brysse et al., 2016). Some have also argued that climate scientists undergo a kind of anchoring effect, a systematic bias toward conservatism, where they do not want to stray too far from the mean, i.e., from what is judged acceptable practice by most members of their community (Garnaut, 2011).

Going against these conventions and norms can have implications for a scientist's career, such as having their work ignored and their papers rejected (Steel, 2015). There is anecdotal evidence to suggest that climate scientists who are less conservative are judged to be 'alarmist' in their claims can face some backlash and difficulties from their scientific community. James Hansen (2007) argues that in the climate science community (particularly the IPCC) scientists who are more conservative in their claims, and err on the side of underestimating rather than overestimating the effects of climate change, are given more authority, are more likely to receive funding, and are more likely to get their papers published. All of these are paramount to a successful academic career. Hansen (2007) recounts his own experience of having his funding cut, claiming that the U.S. Department of Energy reversed a decision to fund his research because he and his colleagues had just published a paper (Hansen,1981) describing the likely impact of fossil fuel use on climate change – research, he claims, that did not downplay the dangers of climate change.

These constraining factors too can create a conflict of values for climate scientists when they are making inductive risk choices. A scientist may very well want to choose an approach that prioritises avoiding false negatives because she believes that doing so will promote human security. She may be aware of the conventions in her field but strongly hold that, in this particular instance, methodologies that are prone to false negatives could undermine human security and thus she might feel a social and personal responsibility to choose a less conservative approach. However, by doing so, she would depart from the established norms in her community, and so could put a number of other personal values at risk, such as career success, financial security (through her career) or credibility in her field. It would be reasonable for her to be concerned about these personal risks.

Even at a community level, climate scientists could face such value conflicts if they shifted conventions to prioritising avoidance of false negatives. For the climate science community itself operates within a broader social and political context, in which they seek to maintain credibility. Climate denialism and scepticism have already done much to undermine that credibility (Brysse et al., 2013; Garnaut, 2011; Oreskes and Conway, 2010). Climate scientists have been accused of exaggerating claims, despite evidence to the contrary (Brysse et al., 2013). In a set of interviews conducted in 2009, one scientist expressed concern about the spate of reputational attacks on scientists by the fossil industry, including the vilification of an IPCC chapter lead author, Ben Santer (discussed in Brysse et al., 2013). More recent research shows that science denialism remains prevalent and that there has been an increase of direct attacks on the integrity of climate scientists (Cann and Raymond, 2018). In the face of this political context, a central concern for climate scientists is that false positives, and even appearing to risk false positives, could lead to a loss of credibility for the climate science community (Brysse et al., 2013; Lloyd and Oreskes, 2018). This worry is explicitly expressed by Myles Allen in his consideration of the storyline approach:

> …type two errors do no particular harm to climate scientists as a group. An individual might miss out on a high-profile paper, but that would be a small price to pay compared to the reputational harm of claiming a positive result that subsequently turns out to be false. (2011, p931)

Indeed, the reputational harm might accrue not just to the individual scientist but to the climate science community as a whole.

Loss of credibility for the climate science community could lead to a number of adverse outcomes that, again, could jeopardise various values that scientists might hold. Firstly, it could undermine the social aims of climate science if much of the public no longer regards scientific findings of climate science as credible. Scientists are wary that committing false positives will result in being accused of "crying wolf" (Brysse et al., 2013). This happened to scientists working at NASA who overpredicted a potentially alarming outcome resulting from Antarctic Ozone depletion; they were heavily criticised and accused of exaggerating; their credibility was strongly questioned (Ibid). The worry is that if policy makers and the public do not regard the scientific claims made by climate scientists as credible, then they may fail to take future warnings seriously, which would put human security at risk.[56]

Secondly, reputational harm of the scientific community is not only potentially harmful for society, but would impact climate scientists personally too. If the climate community lose funding this puts the careers of scientists in that community at risk. Thirdly, science as a form of inquiry claims a level of epistemic authority or credibility that many scientists would argue distinguishes it from other forms of inquiry. Credibility is something that scientists are likely to value highly in and of

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[56] Brysse et al (2013) highlight a concern with this worry: what is the use of preserving scientific credibility if it actually comes at the cost of missing warnings?

itself. Scientists may worry that making methodological decisions that increase the likelihood of false positives puts this credibility in jeopardy.

It is crucial to acknowledge the impact inductive risk choices could have on scientists' personal values and how these values are intimately tied to the methodological standards and norms of their scientific community. Those who propose that democratically endorsed values, or user values should be used in managing inductive risk, should recognise the potential for such values to conflict with scientists' personal values as well as the values held by the scientific community. Scientists faced with inductive risk choices might choose to resolve these value tensions in different ways, which could explain disagreements in some cases.

Conclusion

Many philosophers of science now agree that non-epistemic values can play an appropriate role in science in a number of important ways. These discussions have expanded into the climate science field, and there is a nascent body of literature on the appropriate roles for values in climate science. Philosophers are now turning to the question of which or whose values should guide scientific research. Little attention, however, has been given to the potential for value-related conflicts to arise. Considering these conflicts is important, because they can precipitate disagreements and tensions amongst scientists that make value-based choices difficult to resolve.

This chapter explored the potential for value conflicts to arise in the appropriate management of inductive risk. The disagreement that ensued between event attribution scientists on the introduction of the storyline approach is an example of how methodological choices that require value judgments can lead to tensions amongst scientists. I proposed three distinct value conflicts that could arise for scientists managing inductive risk choices of this kind and suggested that a potential explanation for disagreements over such methodological choices is that scientists resolve these value conflicts differently.

First, there can be a conflict between epistemic and social values, with different methodological options serving one at the expense of the other; how these conflicts are resolved depends in part on how these values are weighted and the extent to which scientists regard certain social values as constitutive of their field. Second, scientists occupy multiple roles in society and so could experience a conflict between their perceived moral obligations as scientists -- to adhere to scientific norms like conservatism – and the values they hold as citizens of society. Lastly the regulatory function of community norms, together with the politicisation of sciences like climate science, can result in scientists' personal values, such as those related to their careers, pulling in a different direction than societal values that they also embrace.

The impact regulatory frameworks have on individual scientists' choices raises important questions for further research: if the conventions and methodological standards of a scientific community appear to be failing to meet the social aims of their research program, then their relevance or appropriateness should be questioned. However, the extent to which the climate science community itself could change these norms is limited. Science as an institution lacks autonomy insofar as it is dependent on external sources like governments and private industry for funding (Steel, 2015). This highlights the need for explicit and open discussion between scientists and between the scientific community and funding bodies about the epistemic and social aims of their research and the extent to which conventions and standards in the field serve the various aims.

The analysis presented in this chapter has implications for how we understand the role of values in science; we need to consider not just that value-influenced choices can sometimes be appropriate, but that scientists can face tensions or conflicts among legitimate values that can make choices difficult to resolve to resolve. Proposals for which or whose values should influence science, such as the democratic view or the user values view, take a step in the right direction. However, as I have shown, it is important that we consider the potential for value conflicts and how they can and should impact scientists' choices.

CHAPTER FIVE

HUMAN SECURITY AS A CONSTITUTIVE VALUE

Introduction

Non-epistemic values have appropriate roles to play at the heart of scientific reasoning. Nevertheless, even in these appropriate roles there is still potential for values to come into conflict with one another and lead to tensions for scientists during their reasoning processes. One kind of conflict that was explored in the previous chapter was a conflict between social values, like human security, and epistemic values or goals, like truth and avoidance of false positives. In climate science for decision making, these values can sometimes pull in different directions. For example, in the case study discussed in the previous chapter, scientists disagreed about the appropriateness of two different methods used in extreme event attribution because of their tendencies to err in different ways, with different societal consequences. A suggestion that grew out of discussions on event attribution in the scientific and philosophical literature was that perhaps – contrary to the norm – climate science should be more like medicine in its management of risk, often preferring false positives to false negatives (Lloyd and Oreskes, 2018). This inductive risk preference in medical practice, they argue, is grounded in an underlying value that is fundamental to, or constitutive of medical science – patient health.

Is it reasonable to suggest that climate science for decision making could include non-epistemic values as constitutive of its practice? In their white paper on climate services ethics, Adams et al (2015) identify human security as a 'commitment' or 'goal' of climate services. This suggestion, however, is unusual. Discussions among climate scientists, at least in the published literature, typically circumvent any explicit consideration of what, or even whether, non-epistemic values are central to their practice. Values such as human security are clearly related or linked to climate science for decision making, which provides information to facilitate local adaptation to climate change and mitigation of future global warming. However, it is usually only epistemic values that are considered *constitutive* of scientific practices (Longino,1996; Kuhn, 1977), including the practice of climate science; environmental and social values are understood to be *contextual* – part of the context in which scientific research occurs.

The distinction between constitutive and contextual values was introduced by Helen Longino (1990; 1996). As discussed in Chapter Two, on her analysis, constitutive values are "values that are generated from an understanding of the goals of science...they are the source of rules determining what constitutes acceptable practice" (1996, p4). It is fair to say that the standard view among both scientists and philosophers is that these are epistemic values, which relate closely to science's epistemic goals. Though there is some debate as to which values count as epistemic values, there is much overlap between various proposals (Longino, 1996), and the generally accepted idea is that constitutive values in science are those that guide scientists toward truth or knowledge when they are choosing among theories and models and reaching conclusions. While constitutive values are internal to science, contextual values, by contrast, are usually understood as part of the social and cultural context within which the science is done (Lloyd,1996, p245).

Daniel Hicks (2014), however, offers an alternative way to understand what counts as constitutive versus contextual values for science, thinking of science *as a practice* in the sense suggested by Alastair MacIntyre (1984). Just as chess, or sport, is a practice, so too is science. Practices have constituent activities whereby communities engage in collective projects toward shared ends; constitutive values are derived from these ends (MacIntyre,1984; Hicks and Stapleford, 2016). The goals of science, Hicks argues, or the constitutive ends of science, are both epistemic and practical (or non-epistemic): they are aimed at both advancing knowledge and at practical actions, though different scientific fields have different emphasis on these two kinds of ends.[57] For Hicks, the values that constitute science therefore are not restricted to epistemic ones; they can include both epistemic values such as truth or empirical adequacy, and other values or aims such as practical knowledge or socially useful technology that promote practical ends (2014). Hicks provides the example of biomedical research, where developing *socially useful* pharmaceuticals is a constitutive aim of that practice.[58]

In this chapter, like Hicks, I suggest that we should adopt a broader view of constitutive values for scientific practices. In particular, I develop the following proposal: *non-epistemic values such as human security should be explicitly recognised as constitutive of climate science for decision making.* These values do not replace epistemic ones but sit alongside them as part and parcel of this practice, determined by the goals of the practice.

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[58] Hicks uses the terms values and goals interchangeably.

To build my case, I will first present and rebut three objections that might lead someone to reject the proposal out of hand. These objections relate to how radical the proposal is, its epistemic implications, and its political contentiousness. Following this, I will develop the proposal in more detail and then discuss several important implications that its adoption would have for practice. In particular, I will argue that it could change the direction that research takes, provide ethical guidance to difficult ethical/epistemic problems, and inform ethical codes of practice in the climate science for decision making field.

5.1 Clearing away anticipated objections

In this section I address three anticipated objections to my proposal to consider non-epistemic values like human security to be constitutive of climate science for decision support. The first objection is that embracing the proposal would be a radical change to science, which is something we should avoid unless there are very clear benefits. Secondly, one might object that making non-epistemic values constitutive of climate science for decision support will undermine the epistemic integrity of the research. Thirdly, one might worry that putting the proposal into place will inevitably involve the endorsement of politically contentious values. I will rebut each of these initial worries in turn.

5.1.1 Too radical a change to science

This objection begins from the assumption that science is at its heart an epistemic endeavour; to include non-epistemic values would be a radical change to the way science operates. Science has been, and continues to be for the most part, a very successful enterprise, and we would not want to change the way it is done unless there are, at the very least, clear benefits for doing so.

Indeed, there are some scientific activities where the suggestion to include non-epistemic values as constitutive would seem misplaced, or even inappropriate. Fields like x-ray astronomy have predominantly epistemic aims; they are focused on advancing knowledge with no obvious connection to any social considerations. However, many other areas of research are more directly related to decisions and applications that have distinct social relevance. In many of these, there is a clear case to be made that non-epistemic values are in some sense core to the practice. Below I offer five professions involving scientific activities where people do invoke these values.

The clearest examples where we see non-epistemic values explicitly invoked are in the context of professions such as engineering and medical practice. In engineering, human safety and environmental sustainability are directly acknowledged as important values in the field. Almost all engineering codes of ethics include a paramountcy clause which calls on engineers to "hold paramount the safety, health and welfare of the public" (Code of Ethics for Engineers, 2019) (See for example the National Society for Professional Engineers or the American Society for Mechanical Engineers). The environment/sustainability clause, which pertain to environmental sustainability is less common, though still present in many engineering codes. The code of the American Institute for Chemical Engineers (2015), for instance, includes in its paramountcy clause the "protection of the environment" alongside the safety, health, and welfare of the public, whilst the AIChE code (2020) calls on engineers to consider environmental impact in their work.

It has been argued that many of these ethical principles in engineering are preventative, rather than aspirational (Harris, 2013). That is, that the goal of engineering is not to ensure the safety and health of the public nor the environment, but rather that engineers should ensure that harms related to humans and the environment are prevented when carrying out their practice. With the exception of a few engineering disciplines, such as environmental engineering, this seems like a fair observation. That said, some professional engineering bodies have codes that sound aspirational. The ASCE code (2020), for example, states that engineers should "enhance the quality of life for humanity". Nevertheless, *even* when playing only a preventative role, we might argue that such non-epistemic values are in fact seen as constitutive of engineering practices. If this is not persuasive enough, it is not difficult to find other scientific practices where it is reasonable to regard certain non-epistemic values as constitutive, *aspirational* values.

Most obviously, in medicine, patient health is a core goal of the practice. Regarded as the contemporary successor to the Hippocratic Oath (Parsa-Parsi, 2017), the declaration of Geneva, which was adopted by the World Medical Association at the second General Assembly in 1948, outlines the professional duties and ethical principles of the medical profession. The pledge binds physicians with the words that "the health of my patient will be my first consideration" (World Medical Association Declaration of Geneva, 2006). This promise is evident in medical codes of ethics too. The International Code of Medical Ethics, for instance declares that "a physician shall act in the patient's best interest when providing medical care" (World Medical Association, 2006). The UK General Medical Council code of ethics says to "make care of your patient your first concern" (General Medical Council, 2021). While medical codes vary in form and length, undeniably it is regarded as the duty of the physician to promote and safeguard the health and well-being of patients (Masic and Mulic, 2014).

Patient health is not only a core value for practising physicians, but also a driving goal of medical research (Masic and Mulic 2014). Unlike the work of physicians who apply scientific knowledge in their care of patients, medical research is orientated towards advancing knowledge itself, in order to promote patient health. In this sense medical research has stronger epistemic aims; importantly however, these aims are instrumental for the overall goal of patient health. Research questions are directed toward development of vaccinations, disease cures, and prolonging or improving health of patients. For instance, much cancer research is geared toward finding cures, and the pharmaceutical industry is geared toward developing drugs that improve patient health (Hicks, 2014). Patient health does not only direct research questions, it also plays a critical role alongside epistemic values in certain methodological decisions, in order to manage inductive risk. As noted in the previous chapter, cancer screening typically prioritises false positives over false negatives. In the pharmaceutical industry, scientists are required to demonstrate that a new proposed drug is both effective and safe. To demonstrate that it is safe (i.e., has no adverse effects) they adopt a null hypothesis of "(adverse) effect" placing the burden of proof on the scientist – which in this case is the pharmaceutical developer – to show that the drug is not harmful. To demonstrate its effectiveness, they adopt a hypothesis of "no effect" requiring scientists to show that the drug is effective before allowing it to be used. These choices reflect a value judgment that protecting patient health is a priority. Another example where patient health is prioritised would be when ambiguous results do not lead a researcher to reject the hypothesis that a new therapy could work, because it would be bad (for patients' health) to miss out on a cure.

One might accept the examples above as instances where non-epistemic values are constitutive of a practice, but object that they are 'professions' that seem more focused on applying existing knowledge than developing new knowledge, in contrast to those practices that we paradigmatically think of as 'sciences' (medical research is likely excused here). In response to this, I will offer two last examples.

The first includes biochemistry and microbiology, where it is made clear in the profession's existing codes that non-epistemic values are constitutive of the practice. Both the American Society for Biochemistry and Molecular Biology and The International Union of Biochemistry and Molecular Biology have codes of ethics which state that the ultimate goal for its members is to advance human welfare. In each, there are lines which indicate that scientists are expected or obligated to "promote and follow practices that enhance public interest or well-being", and to "ensure the current and future welfare of both human and non-human subjects and the protection and sustainability of the environment" (International Union of Biochemistry and Molecular Biology, 2006; American Society of Biochemistry and Molecular Biology, 2013).

The second is conservation biology. Conservation biology has long been described as a scientific field with inherent normative aims (Longino,1990; Noss, 2007; Takacs, 1996; Naess, 1990). Noss (2007) writes,

> The entire field rests on the value assumption that biodiversity is good and ought to be conserved. Human actions that protect and restore biodiversity are good; those that destroy or degrade biodiversity are bad. (p18)

Arne Naess (1990) likens this scientific practice to AIDS and cancer research, because it "uses certain goals and values as axioms" (p169). In conservation biology, the intrinsic value of diversity and saving certain life forms is taken for granted. In this sense, Naess (1990) argues that the field is not purely a descriptive science; it is intrinsically normative. In 2004, the Society for Conservation Biology published a code of ethics stating that their mission is "to develop the scientific and technical means for the protection, maintenance and restoration of life on Earth" (Society for Conservation Biology, 2004). This statement is an explicit declaration that protecting biodiversity is constitutive of conservation biology as a practice. Though there has been pushback from some scientists in the field who argue that the practice should be value neutral and should not advocate for any value position,[59] there are many who regard conservation biology as having non-epistemic values at its core.

From these examples, we can see that there are both science-related professions like engineering and medicine, as well as in fields that are more straightforwardly labelled "sciences", in which non-epistemic values appear to be regarded as constitutive of those practices.

I contend that climate science for decision making is similar to these practices in a crucial respect, namely, it has very clear social ends. This was not always the case. Historically, climate science was primarily concerned with characterizing climates and with understanding the climate system and

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[59] For some examples see Odenbaugh's (2020) entry in Stanford Encyclopaedia of Philosophy: https://plato.stanford.edu/entries/conservation-biology/

its components. While these fundamental epistemic aims remain very important, in the last fifty years the threat of anthropogenic climate change has to some extent changed the focus of research in the field, bringing in new kinds of practices that are making it much more outward (i.e., societally) facing.

Of course, there remain theoretical areas of climate science that have at best a very distant connection with societal concerns and where social values thus are not immediately relevant. The proposal does not apply to those areas. What I am calling "climate science for decision making" encompasses newer areas of practice, where the inclusion of non-epistemic values as c*onstitutive* appears to support the goals to which they are orientated. In fact, in preliminary efforts to sketch an ethical framework for these areas of climate science, such as the White Paper of the Climate Services Partnership Working Group on Climate Services Ethics (2015) (from here on referred to as 'the White Paper') noted above, practitioners explicitly identify human security as a goal. This shows that some climate scientists have begun thinking about – and have even appeared to embrace – some non-epistemic goals as being constitutive of their practice, suggesting that the proposal to consider some non-epistemic values to be constitutive in this context is one that already has plausibility to some practitioners.

Thus, the proposal to make non-epistemic values constitutive of climate science for decision making is not so radical after all. There are already scientific fields where non-epistemic values are regarded as constitutive. Climate science for decision making is similar to these fields in important respects, in particular in its having clear social aims. And indeed, non-epistemic values are already being invoked by practitioners in preliminary efforts to articulate a code of ethics in this context.

5.1.2 Undermines epistemic integrity

Another worry one might have is that if we elevate non-epistemic values to the status of epistemic ones in the sense of regarding them as constitutive of scientific practice, this would undermine the epistemic integrity of the science. People who have this worry might hold the following view: it is acceptable and sometimes even good for non-epistemic values to guide choices that are external to scientific reasoning; values like human security and sustainability are important to uphold when choosing what areas of science to research, guiding research questions, and deciding how to apply findings. But if we accept non-epistemic values as *constitutive* of climate science then it could lead to all kinds of epistemic corruption as scientists try to promote those non-epistemic values – at the expense of epistemic ones – when carrying out the research itself.

For instance, suppose that a developing country is applying for funding for adaptation for extreme events. To qualify for the funding package, they need to provide evidence that there is likely to be an increase in natural disasters in the region. The country, which is primarily rural, is already in a socio-economic crisis – overgrazing coupled with poor land management by small scale farmers means that even current precipitation levels result in flooding in the catchment areas, driving food insecurity and the spread of diseases such as cholera and malaria. The country would greatly benefit from aid. The national government approaches a research group of climate scientists and ask them to produce seasonal rainfall projections. If one of the core values of climate science is human security then one might worry that scientists will be motivated, or perhaps even obligated, to sway their findings in favour of an outcome that shows that extreme events, such as flooding, are going to increase. This move would ensure that the country receives the aid it clearly needs, however it would clearly constitute a corruption of the research. This would correspond to one of the kinds of scientific corruption that Daniel Steel notes can arise in value-driven science: scientists could suppress or bury unwanted conclusions and design studies in a way that avoids certain results (2017).[60] In sum, in an effort to promote human security, scientists might present climate data and modelling results in a misleading manner that ensures that development aid can be obtained.

This worry is unwarranted. Accepting non-epistemic values as constitutive of some scientific practice need not lead to such outcomes, and it would be deeply concerning if it did. An important feature of socially relevant science should now be made explicit: though I am arguing that science can have constitutive values that are not epistemic, the socially relevant science still must respect basic epistemic standards.

Clearly, the presence of non-epistemic goals alone is not sufficient for a particular practice to count *as science* at all. Advocacy groups like The Climate Reality Project or 350.ORG have similar goals to climate science for decision making, in that their objectives are to protect the environment and human security from the threats of climate change, but they are not scientific practices. At least some epistemic aims are necessary for a practice to be considered a science at all (Odenbaugh, 2003). In addition, the relationship among aims is important. Steel writes, "an essential feature of

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[60] The other two kinds of corruption Steel discusses are: attacking the reputations of scientists who publish such unwanted results and obstructing lines of enquiry that could produce unwanted information by "stonewalling" and "foot dragging" (2017, p52).

the social role of science has to do with *how* it promotes goals legitimately valued by society, namely, by advancing knowledge" (2017, p58). Climate science for decision making may have non-epistemic ends, but the way in which these are to be achieved is *by actualising the epistemic goals*, i.e., through generating knowledge about the climate system and its impact on humans and the environment. To put it slightly differently, a distinction must be made between the long terms aims of science, which include social and ethical aims like human security, and the way in which science is conducted to achieve those aims (Steel, 2017). Taking this into account, it would not be acceptable for non-epistemic values, even constitutive ones, to drive the outcomes of science if they undermine the basic criteria for epistemically adequate science.

A similar point is emphasised by Heather Douglas, in developing her arguments regarding non-epistemic values in methodological decisions in science:

> One cannot use values to direct the selection of a problem and a formulation of a methodology that in combination predetermines (or substantially restricts) the outcome of a study. Such an approach undermines the core value of science—to produce reliable knowledge—which requires the possibility that the evidence produced could come out against one's favoured theory. (2009, p100)

Conducting investigations in ways that leave open the possibility that the evidence produced runs contrary to one's favoured outcome is a core epistemic value in science, often referred to as The Severity Principle (Mayo, 2010; Steel and Whyte, 2012). It asserts that a test can give evidence for a hypothesis only if that test puts the hypothesis at risk of a contrary result (Steel and Whyte, 2012; Mayo, 1996; Popper, 1963). Many epistemic values are relevant to policy relevant science; however, the severity criterion is particularly important because it helps to identify instances where non-epistemic values have played an inappropriate role (Steel and White, 2012). Returning to the toy example, if the climate scientists producing climate information for the government chose to exclude certain models from an ensemble, for example, because those models indicated a decrease in severe weather events – and thus run contrary to the preferred outcome of the study – then their actions would violate the severity principle.

Therefore, while regarding non-epistemic values like human security as constitutive of science means acknowledging them as core to the practice, non-epistemic values should not undermine basic criteria for epistemically adequate science. While one may desire various social and ethical outcomes, pursuing those outcomes scientifically means doing so within the bounds of certain constraints that stem from epistemic values.

In summary, including non-epistemic values as constitutive need not result in epistemic integrity being undermined; philosophers have already identified certain rules, such as the severity principle, for identifying egregious value influence in science, which impose limitations on the influence these values can have.

5.1.3 Politically contentious values

A last concern is that, if one were to accept non-epistemic values as constitutive of climate science for decision support, this would inevitably lead to the endorsement and promotion of politically contentious values. Promoting politically-contentious values might be problematic for several reasons. In the instance of publicly funded climate science for decision making, one could argue that publicly-funded activities should be democratically representative (Intemann, 2015; Brown, 2013) and so it might be regarded as unfair or unjust if it systematically promoted certain political groups' values over others. More generally, one might be concerned that accepting non-epistemic values as constitutive of the practice could lead to climate science being used to an even greater extent as a tool for politics, e.g., in the environmental policy arena (Sarewitz, 2004).

Again, there is reason to think that this worry is unfounded. Examples like medicine illustrate that it is possible for practices to embrace non-epistemic values – like human health – that are not politically contentious. Patient health might well be a democratically endorsed value; even without surveying the public, we know that it is a widely held value that most people regard as very important. So, it seems at least possible in principle that a practice like climate science for decision support could have constitutive values that are not politically contentious in the way this objection suggests. Of course, this is not to say that no controversies or contentious questions will arise. I will discuss a few.

Constitutive values could come into conflict with other values, but this is not unlike in other practices. Patient health often comes into conflict with the pursuit of profit in the pharmaceutical industry (Hicks, 2014; Biddle, 2007; Brown, 2008). The controversy in this case is about how this conflict is resolved. In particular it surrounds the potential scientific corruption for financial gains *at the expense* of patient health and other values such as truth and scientific credibility. The presence of these conflicts however does not mean that health is a controversial value.

Some of the other values relevant to the scientific activity might also be widely held, which can make value-based choices difficult to resolve. For instance, deciding whether to keep someone on life support (which promotes longevity) versus voluntary euthanasia (which promotes the right to die) illustrates such a conflict (Finkel, 1993). In this instance, choosing actions that promote health is not as straightforward a decision as it could be in other circumstances. We can see how this could play out in climate science too. Scientists choosing how to manage inductive risk when making projections for future extreme events such as drought might not always know which errors to avoid. Avoiding false positives increases the chances of missed warnings – say of an increase in the frequency and severity of droughts -- which could lead to loss of human lives. However, preferring to risk false positives might lead to spending fiscal resources on preparing for a drought that never occurs, and in doing so wastes valuable financial resources. Again, this is an issue of value conflict. It does not support the idea that the values themselves, such as patient health or human security, are politically contentious.

Lastly there is the worry that certain uncontroversial social values could in practice align with more controversial political agendas, such the green agenda. This concern takes inspiration from Helen Longino's analysis of epistemic values in science (1990). Longino presents an example from primatology where the adoption of certain epistemic values when developing theories on primate behaviour inadvertently promoted patriarchal and sexist agendas.[61] Similarly, it is possible that what appears to be an unobjectionable value like human security could have intended or unintended implications or alignments with certain political agendas that themselves are contentious. This however does not undermine the appropriateness of human security as a value that is itself worthy of pursuit. An analogy from medical science may be helpful here. Pharmaceutical companies developing and selling vaccines and other medicines do so on the premise that these promote patient health. While the potential for pharmaceutical companies to make huge profits that exacerbate existing wealth inequalities may be contentious, this does not point to a problem with promoting patient health per se; it does not cast doubt on the idea that human health is something widely accepted as worthy of pursuit. The same goes for adopting an uncontentious value like human security in climate science for decision making. It might turn out that recognising human security as constitutive of the practice will give rise to investigations and outcomes that align with

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[61] For more detail on this case study, see Longino (1990).

some more contentious values, but human security itself nevertheless remains uncontentious as something that is worthy of pursuit.

To summarise: one might worry that by making non-epistemic values constitutive of climate science for decision support we will inevitably build into climate science values that are politically contentious. This is not the case. While there may be issues in the operationalisation of values, management of conflicts, and unintended alignment with other politically contentious agendas, none of these entail that non-epistemic values constitutive of a scientific practice must inevitably be contentious, as the example of human health in medicine and biomedical research illustrates.

5.2 Developing the proposal

In the previous section, I anticipated three objections to the sort of proposal I am making. Having cleared the ground by providing rebuttals to each of these objections, I will now proceed with developing the proposal in further detail. First, I will make some suggestions regarding which non-epistemic values could plausibly be regarded constitutive of climate science for decision support. Following this I will discuss some implications that adopting the proposal will have in practice.

5.2.1 Suggestions for constitutive values

Which non-epistemic values should be regarded as constitutive of climate science for decision making? This is a substantial and important question, though to answer it in full detail is beyond the scope of this thesis. It requires the attention of moral and political philosophers, climate scientists, social scientists and the public, among other disciplines and stakeholders. What I will suggest however is that human security is a plausible value to adopt. To be clear, I am not making the case that human security is the one and only value that climate science for decision making *should adopt, but I do offer it as a plausible candidate.* Rather I am picking it out as a value that aligns with the already-existing orientation of the practice. That is, human security is a value that is already implicitly, and sometimes almost explicitly, conceptualised as constitutive of climate science for decision making.

It is evident, both in the kind of activities carried out and from the statements made by governing bodies in climate science about their purpose, that climate science for decision support is fundamentally geared toward certain social ends. These ends have to do with producing and communicating scientific information in order to protect and promote the well-being of humans impacted by climate change. Commitment to these ends is made most explicit by the Global Framework on Climate Services (GFCS) who state that their core focus is to deliver services in five key priority areas to "*address issues that are core to the human condition* and present the most immediate opportunities *for bringing benefits to human safety and wellbeing*" (GFCS, 2020; own emphasis). These priority areas are agriculture and food security, disaster risk reduction, energy, health, and water (GFCS, 2020), each of which stand to be impacted by climate change.

Other organisations are less explicit about their social commitments, nevertheless the nature of the activities carried out, and the sorts of information produced by these organisations, are directed toward similar social ends that relate closely to human well-being. For instance, the IPCC, which was established to provide policy makers with regular scientific assessments on climate science and its potential for future risks (IPCC, 2021) produces an assessment report every five to eight years that is intended for a global audience and that includes information not only about projected future climate conditions but also about risks of harmful impacts on societies and the environment. Some of the risks the Fifth Assessment report outlines include: the risk of morbidity and mortality during periods of extreme heat; risks of food insecurity and breakdown of food systems linked to drought, flooding and rainfall variability, particularly for poorer populations in both rural and urban settings; biodiversity loss; the risk of death, injury and ill heath in low lying coastal areas and small developing islands due to storm surge, coastal flooding and sea level rise; risk of severe ill health and livelihoods in urban populations due to inland flooding; risk of conflict and insecurity and risk of human migration and displacement (IPCC, 2014).

Beyond the GFCS and IPCC, research activities in the field of climate science for decision making are directed toward protecting society from the various risks posed by climate change. Take for example a research project like FRACTAL (Future Resilience for African Cities and Lands), where scientists worked closely with stakeholders in a number of cities across sub-Saharan Africa to produce climate knowledge that supports resilient development pathways. The activities conducted in each city were directed toward reducing the risks posed by climate change. For the city of Maputo, scientists and stakeholders produced an online tool for estimating the risk of waterborne diseases as a function of climate variables. In Lusaka, they ran 'learning labs' where knowledge is exchanged and coproduced by scientists and stakeholders. During these labs, they identified water security as a key issue for the region and explored how climate change would impact it (FRACTAL, 2021). For the city of Windhoek in Namibia scientists produced climate projections for the city region while working closely with stakeholders to identify key impacts climate change would have on health, socio economic variables, and ecosystem services from the city region. They then identified various adaptation options to cope with these impacts (Janes, Taylor and Bharwani, 2020).

Other activities in the field include government-funded organisations like the UK Met Office and the South African Weather Services, which provide climate information to the public so that they can better prepare for future changes in climate, such as increased daily temperatures or severe weather events like drought, heat waves, or flooding.

In each of these examples the scientific activities are orientated toward similar social ends. Climate change poses a serious risk to humanity, and it is clear from the nature of the information produced and activities carried out that climate science for decision making is geared toward reducing these risks to protect– what I suggest falls under the value – *human security.*

The concept of human security is somewhat vague, with characterisations that range from narrow state-centred definitions to broad person-centred ones (Liotta and Owen, 2006). I am adopting the United Nations Development Program (UNDP) definition because it operates as a catchall value term for a set of values or ends – all of which the activities in climate science for decision support appear to be orientated toward promoting. According to the UNDP, human security covers seven core components (UNDP, 1994):

1) *Economic security*: poverty; vulnerability to global economic change
2) *Food security:* hunger and famine; vulnerability to extreme climate events and agricultural changes
3) *Health security*: injury and disease; vulnerability to disease and infection
4) *Environmental security*: resource depletion; vulnerability to pollution and environmental degradation
5) *Personal security*: violence; vulnerability to conflicts, natural hazards, and "creeping" disasters
6) *Community security*: violations of the integrity of cultures; vulnerability to cultural globalization
7) *Political security*: political repression; vulnerability to conflicts and warfare

While it is not possible to include in this chapter a full analysis of the ways in which climate science for decision making aligns with these component values, it should be clear from the discussion already that the activities and climate information products outlined above can plausibly be understood as geared toward promoting or protecting these various components or dimensions of human security. It is easy to find examples, for instance, in among the aims and products of FRACTAL: information on water-borne diseases and adaptation options, such as increasing available health care, relates to *health security*; identifying impacts on socio-economic activity, such as loss of tourism, relates to *economic security;* and understanding risks to water supply relates to *environmental security*. The risks identified by the IPCC also align with these components, including the risks that climate change poses for human migration, displacement, and conflicts (*community and political security*), threats to food systems *(food security),* and risk of death due to storm surge (*personal security*).

Moreover, that the White Paper (Adams et al., 2013) explicitly declares human security as a key goal to which climate services is directed, and adopts UNDPs definition of this term, further bolsters my argument that human security is a plausible constitutive value of climate science for decision making. To be clear, I am not proposing that this is *the value* that should be regarded as constitutive, nor that the dimensions that fall under the term are exhaustive of all the goals of climate science for decision making. Furthermore, there may be different ways to conceptualise the practice's social aims using different value concepts. There is certainly scope for this to be explored in further detail. Nevertheless, there is a strong case to be made that human security as construed above is already constitutive of the practice. Moreover, it seems reasonable to accept that human security is in and of itself is not a politically contentious value.

5.2.2 Some implications

At this point, one might accept the proposal that climate science for decision support could reasonably regard certain non-epistemic values as constitutive, while at the same time thinking the following: the proposal sounds more like a conceptual commitment, which is unlikely to amount to more than lip service to social responsibility in science. What difference will this really make in practice? Below I set out a number of implications that embracing the proposal would have, showing that it is more than just a conceptual shift.

5.2.2.1 Changes in methodological choices: including and foregrounding high-impact low-probability scenarios

If scientists were to take seriously the idea that human security is constitutive of their practice, it is plausible that they might, in some circumstances, make different methodological choices. One of these would be to include high-impact, low-probability scenarios into climate assessments. The controversial exclusion of the West Antarctic Ice Sheet (WAIS) from estimates of sea level rise in the Fourth IPCC Assessment Report (AR4) illustrates this point.

The potential rapid disintegration of WAIS and its impact on sea level rise remains the largest single source of uncertainty for projections of sea level rise (Robel et al., 2019). The uncertainty stems from limited understanding of both ice sheet processes and climate variability's forcing of ice sheets. In light of this uncertainty, the IPCC authors decided not to factor the potential near-term dynamical changes of the polar ice sheet contribution into their projections of future sea level rise, instead basing their conclusions only on phenomena that are well understood, such the melting of mountain glaciers, and thermal sea water expansion. In doing so the report provides ranges of sea level rise by 2100 that are lower than those reported in the earlier second and third report (Anderegg et al., 2014). The IPCC defended this choice by stating that "quantitative projections of how much [WAIS] would add to sea level rise cannot be made with confidence" (Bindoff et al., 2007, p409).[62]

Climate modeller James Hansen was explicitly critical of the IPCC, pinning their choice to exclude WAIS on their propensity for "scientific reticence", which he described as a tendency to be overly cautious in epistemic matters. This reticence was problematic, Hansen argued, because it prevented scientists from adequately warning society of the potential danger the collapse of the WAIS could have (Hansen, 2007). Granted, the authors of AR4 include a disclaimer, stating that "larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise" (Alley et al. 2007, p14). However, a media analysis found that media outlets failed to include or communicate the critical caveats regarding the upper bounds (Anderegg et al., 2014). Leaving the contribution of WAIS out of sea level rise projections, and insufficiently highlighting possible futures in which WAIS contributes significantly to sea level rise, could lead to significant societal consequences. It could limit or delay decision makers from adequately preparing for future impacts should WAIS in fact turn out to make a substantial contribution to sea level rise – impacts such as significant habitat loss, coastal

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[62] This decision was also criticised by some scientists (Oppenheimer et al 2007; Rahmstorf, 2010) for failing to adequately include and represent the available non-model based scientific material (as discussed in Brysse et al., 2013, p6).

flooding, erosion, and salination of the soil, ground, and surface water (Oppenheimer et al., 2019a), which would put human security at risk.

If the IPCC scientists accepted the proposal here to recognise human security as a constitutive value of their practice, they might have made different choices in their treatment of the WAIS. The IPCC authors might have included quantitative estimates of ice sheet contribution to their estimates of future sea level rise and attached to them a low or medium confidence label. They could have done this and included caveats that outlined limitations of its inclusion, instead of excluding its contribution with caveats about the limitations of its exclusion.

Looking more generally, Brysse et al (2013) argue that a preference for avoiding false positives in the IPCC has led to underestimations of climate change in earlier assessments. They cite studies (Rahmstorf et al., 2007 and Pielke, 2008) that compared projections from previous IPCC reports with observations (since 1973) and found that, overall, the reports underestimated global mean temperature change, sea level rise, and atmospheric carbon dioxide concentration. These findings are consistent with a report prepared by the US Climate Change Science Program published in 2009 that argued that the IPCC projections had been too conservative in a number of areas including surface temperatures, sea level rise and emissions (NRC, 2009). Anderegg et al (2014) agree that both climate science and assessments have focussed too strongly on avoiding false positives, neglecting to consider the potential harms associated with false negatives. Again, if human security were explicitly recognised as constitutive of climate science for decision support, then the IPCC authors might make various methodological choices that shift the balance of inductive risk toward avoiding false negatives and might choose to highlight plausible futures with high impact even if they cannot be given a quantitative likelihood.

There is no one-size-fits-all rule to apply to these methodological choices. There may be times where model projections are not well supported enough to support their plausibility and so including them as evidence would be unreasonable, or the risk is not great enough that it warrants risking overinterpretation by users. Or there may be times where including high-impact, low probability scenarios are not deemed necessary. Another worry which was raised in the previous chapter, is that false positives could undermine confidence in climate science. Climate scientists will have to appraise each situation individually. However, if the proposal were accepted there could be a systemic shift in decisions to manage inductive risk and in how findings are presented and communicated, where scientists might be more inclined not to miss out on reporting on low confidence conclusions that indicate substantial threats to human security.

5.2.2.2 Prioritising research in low-income countries

Accepting the proposal could also lead to more attention being given to research in low-income countries, where there are great risks to human security from climate change.

It has been argued that there is a lack of climate change information for many parts of the tropics (Gebrechorkos, 2019, Washington et al., 2013; Allen, 2011), especially compared to the midlatitude regions (Shepherd and Sobel, 2020; Allen, 2011). This is the case, argue climate scientists Ted Shepherd and Adam Sobel (2020), for expected precipitation over land. They illustrate this in Figure 4, where stippling – which indicates agreement between models (which is used as a proxy for confidence[63]) – occurs mostly in the higher latitudes. Similarly, Myles Allen notes that the few studies on the attribution of individual harmful weather events have primarily focused on midlatitude regions because these regions are well monitored, and their phenomena are better understood. (The studies that Allen refers to are Stott and Allen, 2004; Perlwitz et al., 2008; Pall et al 2000; Dole et al., 2011.)

Climate scientists report that this information gap is due in part to a lack of data availability (Washington et al., 2013; Allen, 2011). The midlatitude regions, Allen (2011) contends, are better understood because they are home to wealthy citizens whose taxes have paid for long data records and for which weather models were originally developed, so there is potential for stronger evidence on questions of interest related to climate change. Others have said that data does exist in some of countries in the tropics, however officials are not eager to share them or will only do so for a fee (Nordling, 2019). Some scientists have suggested that this paucity of data, which leads to significant uncertainties, coupled with conservatism (preference for avoidance of false positives) in climate science has led to a kind of "paralysis" in taking the research forward in these regions (Shepherd and Sobel, 2020).

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[63] This proxy for confidence is problematic however for a number of reasons. See Parker (2011); Frigg et al. (2015); Winsberg (2012); Tebaldi & Knutti (2007) for explanations as to why this is the case.

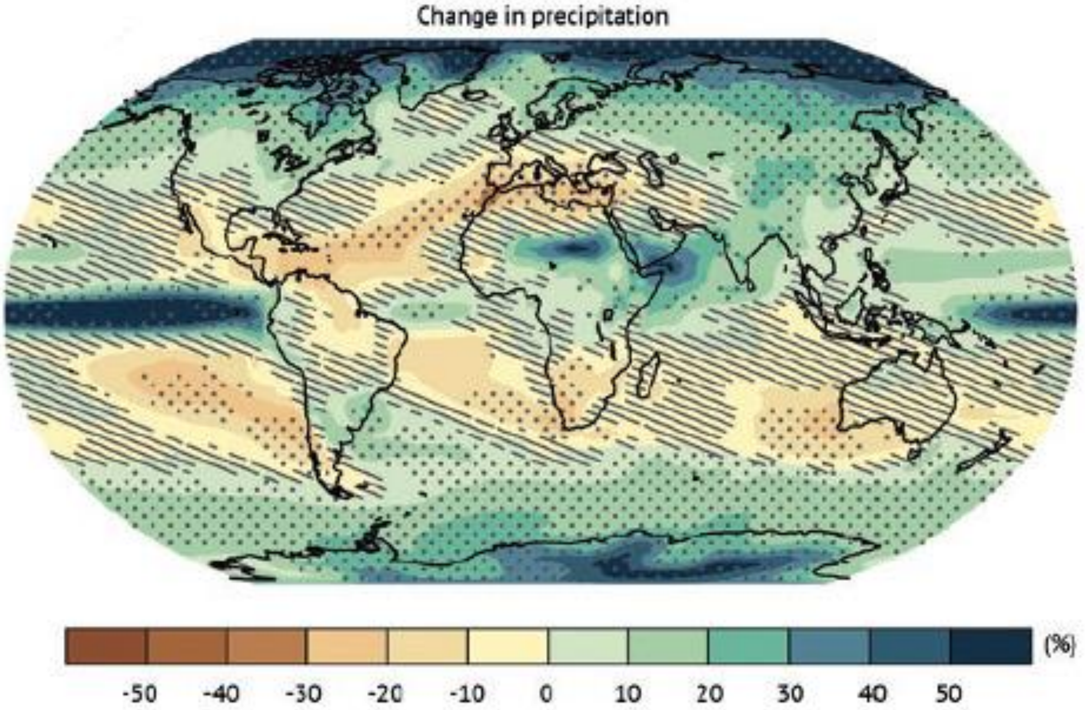

Figure 4. Changes in Precipitation. Predicted changes in precipitation over the 21st Century under RCP8.5. Stippling indicates where model predictions are robust. Otherwise, the models do not agree. (Stocker et al 2013).

From an epistemic perspective, it makes sense for scientists to focus on regions where there is better data; where there is more evidence available, there is a stronger basis for analysis and for reaching conclusions. However, from a non-epistemic perspective, focused on protecting and promoting human security, there is a real need for attention to be given to the tropics, despite the relative paucity of data. Many of the key risks imposed by climate change constitute significant challenges for developing countries in the tropics, due to their inability to cope (IPCC, 2014). Regions such as East Africa, for instance, are known to be extremely vulnerable to climate change (McDowell et al., 2016) and yet face challenges in availability and access to data and climate information (Gebrechorkos, 2019). Global climate models reliably show an increase in extreme weather events such as droughts, floods, tropical storms, and heavy rainfall for East Africa, indicating a strong need for adaptation (IPCC, 2007; Bates et al., 2008; IPCC*,* 2014), but locally tailored information would better facilitate adaptation decisions.

If human security were recognised as a constitutive value of climate science for decision making, it would provide grounds for greater effort to produce decision relevant information with whatever data that are available and to promote efforts to improve data collection and sharing. Scientists might present low-confidence, high-impact scenarios to decision makers. Another option would be to offer non-discountable envelopes of change . These are the range of future changes that could occur within a particular domain. They are non-discountable meaning that scientists should not disregard the possibility that the outcome could fall anywhere within the envelope. This does not mean that they should discount outcomes outside of the range. (Stainforth et al., 2007). Or they might adopt approaches like the storyline approach (Shepherd et al., 2018; Shepherd and Sobel, 2020) and narrative approach (Jack et al., 2020), which present physically self-consistent narratives or stories of past events or plausible future events or pathways. No probability is assigned to them, rather emphasis is placed on their plausibility. Such approaches could be used to aid in developing adaptation strategies.

In summary, if human security is taken to be a constitutive value of climate research for decision support, it would naturally push more attention to areas where human security is at risk.

5.2.2.3 Guidance on value conflicts

Another implication the proposal could have in practice would be to offer guidance for managing value conflicts by expanding on the institutional values that the scientist can draw from when making choices. To understand this, we have to consider that the choices that scientists (both individuals and research groups) make are to some extent guided and constrained by the norms and conventions of the scientific community within which they operate (Steel, 2016; Wilhout, 2009). As discussed in the previous chapter, it is not easy for scientists go against community norms. Those who stray from the norms often do so at the cost of having their work rejected or ignored (Steel, 2016). This can place scientists in a difficult position when faced with choices that have non-epistemic consequences. They may want to make choices that take account of their concern for non-epistemic consequences, but in doing so could run contrary to the norms and values of the climate science community.

For instance, some AR4 scientists may have felt that they could not include the WAIS into their sea level rise projections, because this would go against an institutional norm of their practice which, it has been suggested (Brysse, 2013; Hansen, 2007; Anderegg, 2014), is to err on the side of caution and be conservative in one's claims. While conservatism is important and valuable in scientific practice, it is an epistemic norm that may not be sensitive to non-epistemic factors. In this case, these factors are concerns about the disastrous consequences the disintegration of the WAIS would have on humanity (Hansen, 2007). Scientists producing the projections may have held human security as an extremely important value but not known how to incorporate it into their decision making, because it was not explicitly endorsed by the community as a constitutive value. I set out in Chapter Three the various value conflicts this could impose on the scientist.

If the climate science community explicitly recognises values like human security as constitutive of climate science for decision making, then scientists will have a broader set of institutional values to guide their choices. In particular, they would not only have epistemic values available to them, but non-epistemic ones too and so could more easily consider the non-epistemic aspects of their work when making choices. In the case of choosing whether to include WAIS in the future sea level projections, scientists would have been able to draw on human security as a value and may have made different choices. To be clear, I am not arguing that they should have made different choices, but rather that they might have felt open to doing so.

Accepting the proposal could make some other choices related to human security easier too. For example, scientists might find it easier to choose to foreground different information for stakeholders, as suggested above. Suppose a climate scientist is providing projections of maximum summer temperatures for farmers in a specific region. Common practice is to provide scenarios under different Representative Concentration Pathways (RCPs). How should results for each RCP be selected or produced from the various model-based estimates that are generated? One common practice is to highlight (either by a bold line in a figure or as the value reported in a table) for each RCP the mean or the median, often implicitly understood as a kind of best estimate. After in depth consultation with the farmers, however, the scientist might understand that the farmers in this region are particularly vulnerable to and concerned about extreme temperatures, because of the heat sensitive crops that they are farming. Aware of this vulnerability, and with human security acknowledged as a constitutive value of the practice, the climate scientist might feel more comfortable going against the tendency to show means or medians, choosing to foreground more extreme results instead, so that farmers do not miss out on this particular risk when consulting the science presented to them. To be clear, the same information is included in the report as would be if the mean were the focus; what is different is which information is foregrounded or highlighted.

Again, this does not mean that the scientist is forced into a particular choice, nor that there is a clear-cut answer for how to manage conflicts between constitutive norms and values. Rather, by expanding the constitutive values of the practice to include non-epistemic values, it would provide a backdrop from which scientists are able to more openly and comfortably consider social and ethical considerations in their decision making. Of course, this change could impact different scientists differently. Those that are not aware of the social and ethical aspects of their work might become attuned to considering social values in their choices, while those who are aware – as in the example above – have more freedom to make choices that are responsive to such values, since they are now recognised as being in alignment with constitutive values of their practice.

5.3 A code of ethics for climate science for decision making

A standard way to make the non-epistemic value commitments of a practice explicit is through the development of a code of ethics. The purpose of a code of ethics is to regulate the behaviour of professionals or practitioners. It does so by providing guidance for decision making, support for ethical action, and by providing a set of standards to aspire to (Martin and Schinzinger, 2010). At present no code of ethics has been adopted for practitioners of climate science for decision support. There has however been a growing interest to develop one, possibly due to the recent rapid growth of climate services globally, and recognition that there is little standardisation and regulation across the field (Adams et al, 2015). This interest is most notable in the development of the White Paper, which was developed and endorsed by various members of the climate science community, including the Global Framework on Climate Services, The Red Cross/Red Crescent Climate Centre, and the Climate Knowledge Brokers Group. Despite its wide endorsement, the White Paper failed to gain traction and has not been further developed since its release in 2015. In 2020 however, the topic surfaced again with two independent workshops held in different countries (South Africa and the United Kingdom), both aimed at developing a national code of ethics for climate services.[64] Neither group have yet produced completed codes.

Climate scientists who are interested in developing a code of ethics might – in addition to other things – want their code to provide guidance on the socially relevant elements of their work.[65]

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[64] The first was a series of workshops coordinated by the University of Cape Town in South Africa that aimed to develop a code of ethics for climate services for the country (The report can be accessed at http://www.csag.uct.ac.za/wp-content/uploads/2021/04/Ethical-challenges-in-climate-services-Final-Report.pdf). The second workshop was run by the University of Leeds and aimed to develop a code of ethics for climate services in the United Kingdom.

[65] In her book Philosophy of Science after Feminism (2013) Janet Kourany makes a case for reforming codes of ethics for scientists to include greater awareness of being socially responsible.

However, it is possible that they might be hesitant – or unsure of how – to include codes that engage with these non-epistemic elements. This difficulty could be because although climate scientists are aware of these socially relevant factors, they still adhere to some form of the value free ideal (Gundersen, 2020),[66] and so feel uncomfortable with trying to integrate these elements of their work into a code. This kind of hesitancy could result in a code of ethics that has a predominantly epistemological focus, where principles and guidelines are aimed at ensuring that epistemic standards are met but provide little guidance on how to manage non-epistemic concerns that are clearly relevant to climate scientists.

The proposal put forward in this chapter would be helpful in developing this non-epistemic dimension of a code of ethics. An explicit declaration that certain non-epistemic values, such as human security, are constitutive of climate science for decision support will provide the foundation from which guidelines referring to the management of non-epistemic aspects of the practice can be derived. We can see an example of this in medical codes of ethics, where patient health is stated as a constitutive goal of the practice, and from this there are lines within the code that capture and ensure that this value is upheld or promoted. For instance, in the American Medical Association Code of Ethics it clearly states at the start of the code that "a physician must recognize responsibility to patients first and foremost, as well as to society, to other health professionals, and to self" (2021). Following this, different chapters contain codes that cover various aspects of professional work from patient care, privacy, consent, and genetic testing, among others. Similarly, a code of ethics for climate science could have different chapters covering topics such as managing uncertainty, collaboration, communication, and intellectual property. In each chapter specifics about how to promote human security could be stated. Specific codes might state for example: "When communicating findings, the provider should present the information in a format and language that the user is able to comprehend"; or "when producing information, the scientist should consult indigenous knowledge producers". "or "scientists should include information that they regard as relevant to the users' safety and wellbeing".

Climate science providers could come across situations in their work where the inclusion of human security in a code of ethics could serve as explicit guidance or justification for managing social elements of their work. Take for instance a situation where a climate service provider has a client that is not being sensitive to broader stakeholder values. An investment company approaches a

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[66] In Gundersen's (2020) study, he found that this adherence was justified with two reasons: 1) scientists want to refrain from making moral and political judgments out of concern of losing their credibility, and 2) scientists see it as their role to be experts that are value free.

provider to acquire climate information for a specific municipality. The client wants to determine whether wind turbines are feasible in that area. For a good wind power site, wind speeds must fall between a range, not over certain speeds, and not under certain speeds (these figures vary depending on the turbines used). The client is specifically interested in wind patterns and wind speeds. They intend to use the information provided to them as part of their application to rent land from the local government in that region. The local government is under economic strain with the majority of the residents in the area living below the poverty line. If the wind farm is approved there would be considerable economic benefits for those living in the area.

In the analysis climate projections show that wind speeds will be suitable for turbines. However, in addition to this information the climate scientist makes some concerning findings that are unrelated to the investment company's interests. Their models suggest that during the winter months, due to heavy rainfall, there will likely be an increase in flooding in the low-lying areas of the region where a large town is located. This does not impact the wind farm in any way, but the flooding is likely to put the population living there at serious risk. The client has not requested information on climate-related impacts for the community, they have only asked for information related to their own interests. However, the provider might feel that the ethical thing to do would be to at least call to attention the risks the community faces. A code of ethics that specifies human security as a constitutive value of his practice would empower the provider to raise these worries or to document in their report that there are potentially harmful impacts relevant to the community.

Identifying non-epistemic values as constitutive in a code of ethics could also be useful for offering guidance on value conflicts. Codes of ethics rarely offer direct instructions about how to solve conflicts, however they can give some indication of how values in general can or ought to be prioritised. The American Society for Civil Engineers, for example, separates their code of ethics into five groups of responsibilities, each of which is directed toward different stakeholders: society, natural and built environment, profession, client and employers, and peers. For each group there is a different set of guidelines or obligations related to ethical treatment or engagement with those stakeholders. In terms of conflicts, the code states that when there is a conflict between ethical responsibilities, priority should be given in the order that the stakeholders groups are listed. That is, responsibilities to society always come first (American Society for Civil Engineers, 2020).

It must be acknowledged that the White Paper does state human security as a goal of climate services. Yet the extent to which the "principles of practice" and "principles of product" that are listed in the paper offer guidance on how to maximally promote(?) this goal, or on how to settle difficult conflicts between human security and other values, appears limited. The principles of practice and product primarily refer to epistemic behaviours. They are focussed on ensuring good *epistemic* practice. Even though there is awareness that human security that is core to the practice, it's an additional exercise to think about how to explicitly embed that into the code of ethics. Future codes could be more expansive in this regard and perhaps even offer some guidance on what practitioners should do when human security conflicts with other goals or values such as serving the client, economic growth, or career security. Climate scientists could look to codes of ethics that other scientific communities have developed to see examples of how these kinds of constitutive values are explicitly operationalised in a code of ethics. There is scope for enriching the code in ways that speak directly to non-epistemic values that are constitutive of the field.

Conclusion

It is clear that climate science for decision making is, at its core, directed toward certain social goals and commitments. In other words, non-epistemic values appear to be central to the practice. This chapter proposes that climate scientists, therefore, should explicitly regard certain non-epistemic values as constitutive of climate science for decision making. To do so would not constitute a radical change to science; there exist a number of scientific practices where non-epistemic values are regarded as constitutive. It would not result in the epistemic integrity of climate science being undermined as there are rules in place for how values can legitimately operate in the core parts of scientific reasoning. Moreover, including non-epistemic values in climate science practice does not necessarily entail the inclusion of politically contentious values; the values this proposal would include would be those that are widely held.

More work needs to be done to conceptualise which values adequately capture the practice's non-epistemic commitments. Such work requires input from a range of disciplines and stakeholders. There is a strong case to be made, however, that human security could be one such value, and perhaps the core value, as it appears to well represent the goals to which climate science for decision making is already orientated in practice.

This proposal is not simply a conceptual one. It would have a number of implications in practice. Climate scientists may make different methodological choices, such as presenting high-impact, low-confidence findings; they might give more attention to areas where human security is at greater risk, such as the tropics. It would also guide scientists in resolving value conflicts they may face when making certain choices in their work.

This proposal comes at an appropriate time for scientists and practitioners in the field who are increasingly looking to develop, or are already in the process of developing, a code of ethics for their practice. Including non-epistemic values like human security explicitly in a code of ethics will provide crucial direction for climate science practitioners who may look to the code for guidance on resolving non-epistemic matters.

CHAPTER SIX

CONCLUSION

In response to a growing need to articulate responsible climate science for decision making, this thesis further develops our understanding of the role of non-epistemic values in climate science. Specifically, I aimed to make salient the many ways in which non-epistemic values can appropriately inform climate scientists' choices. I also showed, however, that even when conditions are right for values to play a role, climate scientists might face value-related conflicts that make their choices difficult. I offered a proposal that could help resolve some of these tensions and has independent reasons in its favour as well: climate science for decision making could explicitly embrace some non-epistemic values, such as human security, as constitutive of the field.

In Chapter Two I synthesised the work of philosophers on values in science to argue for three distinct ways in which non-epistemic values can make a positive contribution to science. Firstly, values help scientists meet their moral responsibilities by playing an important role in managing the risk of error. Secondly, many scientific practices, especially decision- and policy-relevant science, have both epistemic and non-epistemic aims; non-epistemic value influence, at least sometimes, can promote these multiple aims of research. In both cases, the roles for non-epistemic values are constrained by epistemic criteria, i.e., choices still must meet minimal criteria for epistemically adequate science. Thirdly, having a diverse value representation in science can help scientists to identify problematic background assumptions and dominant values and in doing so promote a distinctly social form of objectivity.

Building on the groundwork in Chapter Two, Chapter Three applied these arguments for value influence in the context of climate science for decision making. The aim in this chapter was to make salient the bearing these philosophical arguments have on climate science in practice by moving beyond the abstract and general discussion of the previous chapter and providing a host of examples that illustrate for climate practitioners the sorts of choices that values might appropriately influence.

I structured the chapter by analysing the scientific process as having three phases: the pre-research phase, the research phase, and the post-research phases. For each phase I offered examples of scientific choices that climate scientists make where values could appropriately inform that choice. Though not exhaustive, the range of examples is extensive. It was intended to strike a balance between providing examples that are surprising and interesting – in response those who may argue that it is trivial that values relate to scientific practice – and demonstrating to climate scientists that the opportunities for values to appropriately inform their choices are ubiquitous in their practice – in response to those who maintain that the practice should be value free.

In Chapter Four I identified and examined three important value-related conflicts that can arise even when the conditions are right for values to influence choices in science. As a point of departure, I presented a disagreement that ensued between event attribution scientists on the introduction of a new method called the storyline approach. This case study served as an example where non-epistemic values can play an appropriate role in informing scientists' choices (in this case the management of inductive risk) and yet led to considerable controversy. I then proposed three distinct value conflicts that could arise for scientists managing inductive risk choices of this kind and suggested that a potential explanation for disagreements over such methodological choices is that scientists resolve these value conflicts differently. These conflicts have been largely overlooked in philosophical work.

The first is a conflict between epistemic and social values, with different methodological options serving one at the expense of the other. The epistemic value of truth, which manifests as a preference for avoiding false positives over false negatives, can pull methodological choices in a different direction to social values such as human security. How these conflicts are resolved depends in part on how these values are weighted and the extent to which scientists regard certain social values as constitutive of their field. The second is a conflict that stems from the multiple roles that scientists can occupy in society. A scientist could experience a conflict between their perceived moral obligations as a scientist – one of which I argued is to adhere to norms such as (epistemic) conservatism – and the values that they hold as citizens of society. Lastly, together with the politicisation of climate science, the regulatory function of community norms can result in scientists' personal values, such as those related to their careers, pulling in a different methodological direction than societal values that they also embrace.

In Lloyd and Oreskes' (2018) analysis of the extreme event attribution case, they briefly raised the possibility that climate science could be more like medicine in its management of inductive risk;

medical testing tends to prioritise avoiding false negatives (missed illnesses/diseases) over false positives. In Chapter Five, I mounted an extended defence of this idea and proposed that climate science for decision making ought to explicitly embrace some non-epistemic values, such as human security, as constitutive of its practice. I argued that to do so would not constitute a radical change to science; we can look to other similar scientific practices where non-epistemic values are clearly regarded as constitutive. It would not undermine the epistemic integrity of the science, because epistemic values should always be granted qualified epistemic priority. Lastly, I argued that it need not result in the promotion of politically contentious values.

While further research needs to be carried out to determine which non-epistemic values adequately capture the non-epistemic commitments of climate science for decision support, I argued that human security is a reasonable candidate for a core non-epistemic value, as it is already an implicit (and sometimes explicit – see Adams et al., 2015) commitment of climate science for decision support. My proposal is not just a conceptual one; it would have a number of implications in practice: a) climate scientists would likely make some different methodological choices when carrying out their research; b) they might well give more priority to geographical areas where human security is at risk; and c) they would be better equipped to avoid some value-related conflicts that currently arise, such as those between personal and societal values.

Moreover, this proposal to make human security a constitutive value of climate science for decision support comes at an appropriate time for scientists and practitioners in the field who are increasingly looking to develop – or are already in the process of developing – a code of ethics for their practice. It could ground the non-epistemic aspects of the code, which otherwise might be primarily geared toward epistemic issues. Recognising non-epistemic values like human security explicitly would provide the foundations from which specific practical guidelines could be derived. These would aid climate science practitioners who look to the code for guidance on how to approach non-epistemic considerations.

Indeed, in my view, the development of such a code of ethics, which pays due attention to non-epistemic value considerations, should be a priority for the field. Climate science for decision support is a rapidly growing field, with a wide range of practitioners, from government agencies to academics to private consulting firms. Like many other well established scientific practices and professions, it would benefit from having a code of ethics to guide the actions of practitioners and hold them accountable to fulfilling their responsibilities. Creating a code should be a multidisciplinary process. It would entail that climate practitioners work closely with stakeholders, ethicists, and experts who specialise in producing professional codes. Philosophers of science could provide key contributions to this project too, helping to identify issues that lie at the intersection of ethics and epistemology – the topic of value influence is one such component.

Another significant avenue for future research is to examine in detail the institutional structures of climate science and the bearing these have on climate scientists' ability to carry out socially relevant research. This thesis made a step in this direction in so far as it looked at the constraining role that community norms can have on climate scientists' ability to incorporate values into their work. However, I think that there is further work to be done to determine extent to which funding structures are enabling or inhibiting opportunities for climate scientists to promote or incorporate certain non-epistemic values, or social considerations, into their work. This research would not only be important for climate science but could be a fruitful new direction for philosophers working on values in science more generally too. Heather Douglas (2018) has called on both scientists and philosophers to move beyond examining value influence from the individual scientist's perspective, and to evaluate the "loom of science" – the institutional and cultural structures that shape scientific research. Climate science would provide an excellent case study for such an analysis.

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