Orders of Social Science: Understanding Social-Scientific Controversies and Confluence on What "High-Quality" Knowledge and "Good" Adaptation Is

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Various scholars have noted—and experienced—tribal tendencies between social-scientific "schools of thought" or "paradigms." The intensity and fervor of such controversies has led some scientists to compare them with frictions between religious *orders*. In the research domain focused on the use of climate science for climate adaptation, such disputes revolve around the what "high-quality" climate knowledge and "good" adaptation is or should be. Emphasizing this diversity of *orders of social science and the humanities*, this article describes five distinct ways social scientists and humanities scholars have thought and written about climate adaptation: *descriptivists* aim to empirically portray climate adaptation as objectively as possible from an assumed subject-independent perspective; *pragmatists'* research wants to increase climate resilience through usable climate information; *argumentivists* strive for assessing the justification of climate scientific findings, as well as adaptation decision-making that is based on these findings; *interpretivists* seek to empirically redescribe how the use of climate science for adaptation is shaped by, and shapes, various other social processes and political actors; and *critical* scholars work toward revealing how pervasive powerful interests and marginalizing discourses shape adaptation projects negatively. By comparing these five orders' respective scientific, environmental and social aims and concerns, this article pinpoints to how epistemological, ontological and methodological priorities not only drive scientific controversies on issues such as what "high-quality knowledge" is, but also how interdependent orders' methodological choices are with their epistemological and ontological positions. However, this analysis also reveals that while some scholars implicitly stick to their order, others are comfortable to collaborate across such borders. Overall, the diverging aims, priorities, and methods are unlikely to be ever fully reconciled. A better understanding of why academics from different orders differ in the approaches they take and the issues they care about will likely lead to a larger appreciation of the differences of other orders' research and broaden our understanding of key dynamics in studying "good" climate adaptation and "high-quality" climate knowledge.

Keywords: research paradigms, diversity of social science and the humanities, social-scientific perspectives on climate science and adaptation, scientific controversies, use of climate science for climate adaptation, climate knowledge

INTRODUCTION: A DIVERSITY OF RESEARCH STYLES AMONG SOCIAL SCIENTISTS AND HUMANITIES SCHOLARS

While most social scientists and scholars from the humanities are keen to emphasize that their research benefits people and the environment, some can also be harsh toward and intolerant of research undertaken by researchers with other styles. As such, descriptions of "tribalist tendencies amongst academics, such that researchers must cluster into schools of thought and create possibly fake factional conflicts amongst themselves" recur (Dunleavy, 2003, p. 15). This article explores five distinct research styles with which social scientists and humanities scholars frequently describe, analyse and critique social phenomena around the use of climate science in climate adaptation. By comparing the distinct aims, interests, concerns, and methodology of each *order of social science and the humanities*, I show how these five *orders* differ in what they judge "high-quality" knowledge and "good" adaptation to be. Such an understanding is important in several ways, including an appreciation of the diversity of perspectives research by social scientists and humanities scholars are able to offer for climate science and adaptation; noticing what blind spots and preoccupations different orders have; being able to more critically reflect by what academic calls-to-action are triggered; what insights and conclusions different orders are likely to offer; being a workable framework through which to group academic literature in one's reference management; as well as giving an oversight as to what issues are currently debated across a range of social-scientific strands.

Appreciating social-scientific frictions and understanding confluence in what "high-quality" knowledge and "good" adaptation is carries also important practical, social and political implications: while climatic changes dramatically alter livelihoods and lived experiences around the world, the prominence of science in shaping and underpinning policies makes both agreements and antagonisms among social scientists relevant to a range of issues, practices, and actors beyond academia. If indeed "today 'science' is the theology of the 'developed world' and technology serves as its religion," as Roy (1993, p. 247) writes, then the intensity and fervor with which some social scientists and humanities scholars exhibit their trade in (dis)respect to each other is similar to the frictions between religious *orders*. While some scholars see the frictions between these *orders of social science and the humanities* as worsening environmental controversies (e.g., Sarewitz, 2004), others worry more generally that a unified approach to science may produce too many societal controversies [Jasanoff, in Horgan (2019)] or is harmful to science itself (Feyerabend, 1993[1975]). Thus, with adapting to climate change and using climate science becoming increasingly relevant, understanding how contested key dimensions around living with climate change are from a social research perspective can assist decision-makers and citizens alike to act in a circumspect and aware manner.

This article is influenced by similar comparative research coining terms such as "thought styles" (Fleck, 1979[1935]), "paradigms" (Kuhn, 1996[1962]) or Foucault's "episteme" (cf. Gutting and Oksala, 2019). More recent research has focused on the ways social scientists and humanities scholars not only fertilize each other's research, but also on "paradigmatic controversies." Guba and Lincoln (2005), for instance, conclude that frictions and differences between scholars emerge from different ontological, epistemological, and methodological preferences. While some such assumptions are irreconcilable—or "incommensurable" (Kuhn, 1996[1962])—with each other, paradigms can also fertilize each other's research. In similar fashion, the scholar of qualitative research methodologies Freeman (2016) introduces five distinct "modes of thinking" social scientists and humanities scholars employ in order to produce their findings. She further emphasizes the importance of the researchers' own personal commitments in mediating which mode of thinking a researcher is drawn to. Freeman (2016), however, also makes explicit that many social scientists employ more than one mode in a research project. For instance, "categorical thinking"—the creation of criteria to identify and describe phenomena—is present in almost every piece of research. But while some stick to that mode, others venture into other modes including "dialectical" or "diagrammatical" thinking (cf. **Table 1**). All these works thus pinpoint to the observation that a rich yet frictional diversity of scholarship exists, each one offering different perspectives on climate science and climate adaptation.

In the domain of climate science and climate adaptation, frictions among social scientists recur around the role of climate science for decision-making, the aims and processes of "good" climate adaptation projects, and what criteria climate knowledge ought to have in order to be "high-quality." For instance, the knowledge dimensions of "credibility, saliency, and legitimacy" put forward by Cash et al. (2003) as well as the distinction by Lemos and Morehouse (2005) between the "usefulness" and "usability" of climate knowledge have had a lasting effect on the way climate knowledge for adaptation is envisaged. However, this contrasts with other calls for taking more socially situated perspectives of climate change, emphasizing the role of institutions, and actors rather than that of knowledge (Hulme, 2011; Castree et al., 2014). Disturbed about inequalities and power reproduced through science-informed policies, critical scholars call for more inclusive knowledge production reflecting local people's experience more (Forsyth, 2003; Agrawal, 2010) as well as a different understanding and depiction of people inhabiting this earth (Chakrabarty, 2009; Latour, 2017).

This study thus takes this Special Issue as an opportunity to illustrate and produce appreciation on the diversity of perspectives five *orders of social science and the humanities* have adopted and offered in their research on what I elsewhere dubbed "adapting climate science": the production, customization, use and appropriation of climate science for climate adaptation (Skelton, 2020a). Section Methodology describes the multi-stage process of collecting, selecting, and comparing peer-reviewed research articles, taking their shared and different motivations and problem definitions as a basis for clustering the articles

TABLE 1 | Characteristics of and positions taken by different *orders of social science and humanities*.

Issue	Descriptivist order	Pragmatist order	Argumentivist order	Interpretivist order	Critical order
Inquiry aim*	Undistorted descriptions and explanation through the use and creation of criteria and categories. Propositional knowledge intrinsically valuable	Production of issue-driven, actionable knowledge fostering environmental resilience	Establish validity of scientific knowledge and decision support tools adequately incorporating uncertainties	Challenging orthodox descriptions through reconceptualizing phenomena as products of interacting forces	Social emancipation and transformation through revealing how societal injustices are stabilized
Inquirer posture*	Scientist as distanced honest broker informing decision makers	Transformative researcher as strategic facilitator of environmental action	Meticulous analyser of scientific knowledge and decision-making	Wary yet intrigued commentator of social behavior and aspirations	Transformative intellectual as an advocate for social emancipation
Notion of "high-quality" climate knowledge	Empirical, explanatory knowledge (statistically) characterizing study subject with other categories; assuming stable categories	Instrumental knowledge able to foster adaptation action; often actively co-produced between scientists and practitioners	Produced by appropriate scientific methods and/or logical arguments. Explicit treatment of knowledge's uncertainties	Co-constitutive knowledge critically aware of how particular practices and imaginations are products of a particular constellation of human, non-human, institutional, material and conceptual entities	Revelational, emancipatory knowledge revealing pervasiveness of powerful and marginalizing cultural practices through discourses
Notion of "good" adaptation	Harmoniously understood by actors. Enacted and legislated similarly across countries. Anticipatory policies and action consulting latest scientific and experts, yet decided by politicians. Includes environmental, social and legislative changes	Anticipatory, effective and widely implemented action upon environment. Risk management with anthropocentric and technocratic tendencies; primacy of co-produced (geophysical) climate science	Decision-making appropriately dealing with climate science's uncertainties; with proper demarcation of roles of scientists and decision-makers	Adaptation action mindful of entities shaping—and thus limiting—human abilities in consciously managing its environment. Wary of human fallacies of control and unintended consequences; critical of technocratic adaptation options	Transformative and emancipatory; challenging orthodox ways of policy-making; local and inclusive process; primacy on people's livelihoods and experiences
Ontology*	Post-positivist: reality imperfectly apprehensible; relatively stable categories and classifications also within the social domain to describe phenomena of interest		Notions of "reality" debated, with post-positivists and anti-realists of various hues	Constructivist: realities and meaning co-constructed through a variety of human and non-human factors	Historical-realist: shaped by political, economic, ethnic, and gender values
Values in research*	Values deemed insignificant for research findings	Explicit in pro-environmental values, yet rarely critically debated	Debated; with efforts to differentiate them	Formative to study aim and focus	Formative to study aim and focus
Epistemology*	Objectivist: findings probably true and empirically accessible		Degrees of "objectivity" debated	Subjectivist: findings are collectively yet implicitly mediated, in particular through science, politics, and technology	Subjectivist: findings are collectively mediated. Emancipatory values guide validity of results
Methodology*	Empirical, predominantly quantitative research favoring statistical analysis. Deductive reasoning; with falsification of hypotheses	Conceptual work focusing on aspirational and/or problematizing issues—yet not necessarily empirical. Can draw on both quantitative and qualitative data; with participatory workshops	Logical argumentative analysis; with deductive reasoning. Mostly conceptual, some empirical studies	Empirical, comparative and mostly qualitative research including ethnographic accounts and interviews. Inductive reasoning	Empirical, mostly qualitative research. Strong *a priori* theoretical foundations and deductive reasoning

(Continued)

TABLE 1 | Continued

Issue	Descriptivist order	Pragmatist order	Argumentivist order	Interpretivist order	Critical order
Dominant "mode of thinking" (cf. Freeman, 2016)	Categorical thinking: "to create criteria from which to identify and organize data units" in order "to determine what something is in relation to the conceptual scheme that gives it meaning"		(no equivalent)	Diagrammatical thinking: "to engineer new articulations of the effects of turbulent encounters between diverse human and non-human practices" by "unhing[ing] established forms of thinking"	Dialectical thinking: "to put into action a theory of change and rectify oppressive structures and practices" by "uncover[ing] inherent tensions that are assumed to exist in humans and societies"
Controversies and critiques (from)	• Not issue-driven enough (pragmatist) • Overconfident with findings' validity (argumentivist) • Technocratic tendencies; assumes stable categories (interpretivist, critical) • Maintains social injustices (critical)	• Too normative (descriptivist) • Overconfident with findings' validity (argumentivist) • Technocratic tendencies (interpretivist) • Increases social injustices (critical)	• Not enough focus on environmental action (pragmatist) • Maintains science's hegemony; constrains research (interpretivist, critical)	• Activist tendencies (descriptivist, argumentivist) • Too conceptual (pragmatist) • Speculative on cause and effect (argumentivist)	• Activist tendencies (descriptivist, argumentivist) • Not enough emphasis on environment (pragmatist) • Speculative on cause and effect (argumentivist)
Confluence & learnings (from)	• Stronger epistemological argument (argumentivist)	• Attention to social injustices (critical) • Problem descriptions (descriptivist)	• External empirical validity (descriptivist) • Attention to role of values in science (interpretivist, critical)	• Discourses stabilizing social behavior (critical) • Descriptions (descriptivist)	• Values stabilizing social behavior and science (interpretivist) • Descriptions (descriptivist) • Uncertainty of science (argumentivist)
Preferred journals	Global Environ Change; Climatic Change; Clim Policy; P Natl Acad Sci USA (PNAS); Reg Environ Change; Phil Trans R Soc A	Climate Services; Climate Risk Management; Nat Clim Change; Weather Clim Soc; WIREs Clim Change; Mitig Adapt Strat Gl; PNAS; Environ Res Lett	WIREs Clim Change; Philos Sci; Philosophy Compass; Synthese; B Am Geogr Soc (BAMS); Perspect Sci; P Natl Acad Sci USA (PNAS)	Nat Clim Change; Environ Sci Policy; Climatic Change; WIREs Clim Change; Climate Services; Futures; Reg Environ Change; Sci Technol Hum Val	Geography Compass; Dev Change; Minerva; Prog Hum Geog; R Institute Brit Geogr; Gend Dev; Clim Dev; Geoforum; WIREs Clim Change

*denotes issues along which also Guba and Lincoln (2005, p.194–196) analyzed their paradigmatic controversies. Guba and Lincoln (2005) do not have an equivalent to the pragmatist and argumentivist orders in their paradigms. These two orders thus extend their typology.

into *orders of social science and the humanities*. Importantly, academics' motivations and concerns influence not only the choice of data, methods and topics, but at a deeper level the different ontological, epistemological, and methodological commitments made by the researchers. The sections on the *descriptivist, pragmatist, argumentivist, interpretivist, and critical order* then describe the respective research topics, foci, problem framings, and proposed solutions so similar within each order, but so different between them. In section Discussion I then discuss how these distinct positions and aspirations influence different notions of "high-quality" climate knowledge and "good" adaptation. I conclude that a more thorough understanding of the differences allows not only a more conscious way of doing research, it could also allow to appreciate how other perspectives offer complimentary insights into the social dynamics climate change produces.

METHODOLOGY

In order to obtain an in-depth understanding of and appreciation for the diversity of thought being produced by social scientists and humanities scholars on *adapting climate science*, this review employs a number of strategies to navigate the overwhelming amount of peer-reviewed articles available while aiming to meaningfully characterize the literature along similarities in philosophical positions. Peer-reviewed articles and book chapters have been one of the most important products scientists produce, and so their comparison allows meaningful insights into how and why a diversity of styles of thinking exist. While other scientific practices—such as attending conferences and talks, participating in seminars and reading clubs, and having conversations in all these venues—also substantiated or provided impetus for refinement of the typology, the final step of the review only considers peer-reviewed articles and book chapters. Overall, I undertook three distinct phases to meaningfully compare similarities and differences between particular ways of describing and researching social phenomena around adapting climate science.

First, during the exploratory phase in early 2017, I sketched 1 year's worth of reading literature on the production, customization, use, and appropriation of climate science for climate adaptation into an initial typology of the diversity of perspectives, priorities and concerns present in academic debates. Motivation for this exercise was to onboard my interdisciplinary Ph.D., committee, which included a climate physicist. Presenting this initial typology at my institute, I also received valuable feedback and supplementary reading—including Guba and Lincoln's (2005) *Paradigmatic Controversies, Contradictions, and Emerging Confluences*. They contrast four "inquiry paradigms"—Positivism, Post-positivism, Critical Theory et al., and Constructivism—by their differing metaphysics or basic beliefs. While Positivism was dropped out of this article's orders due to a lack of such inquiries on *adapting climate science*, the other three are mirrored in the *descriptivist, critical,* and *interpretivist* order respectively. Two other clusters of literature—*pragmatist* and *argumentivist*—did not have an

equivalent, yet clearly extended the inquiry paradigms of Guba and Lincoln (2005). Based on this supplementary reading, I double-checked to which order I assigned already read articles in my reference manager.

The second phase, taking place from mid-2017 to mid-2019, was divided into three distinct actions. First, I continued reading and summarizing literature on the production and use of climate information for climate adaptation, as well as assigning each article an order in my reference manager. Second, to better understand how, and more importantly why, such a diversity of thinking exists among social scientists and humanities scholars more generally, through self-study of such scholarship as well as taking part in a number of seminars and reading groups dedicated to illuminating multiple orders of social science and the humanities. One key text in these endeavors was Freeman's (2016) *Modes of Thinking for Qualitative Data Analysis*, contrasting "categorical," "narrative," "dialectical," "poetical," and "diagrammatical" modes of thinking. Two such ways of thinking—narrative and poetical—were not encountered in my literature review. However, her descriptions of "categorical" mirror in many ways the scholarship produced by *descriptivists*, "dialectical" that by the *critical* order, and "diagrammatical" that by *interpretivists*. And third, attending talks, conferences, and workshops of social scientists and humanities scholars from different orders, as well as presenting myself and receiving their feedback, also provided valuable input either substantiating my understanding of how and why social scientific thought is so diverse, or by inviting me to revisit and refine the typology. For example, the modes of thinking described by Freeman (2016) emphasized that on the topic of *adapting climate science* two additional modes—with the pragmatists being very dominant and the *argumentivists* less so—can be differentiated. At the end of the second phase, I thus had a refined understanding of how and why different orders exist, as well as a reference manager indexing several hundred articles and book chapters on adapting climate science.

The third phase of this review, from mid-2019 to mid-2020, was dedicated to analytically comparing the scholarship collected in the reference manager, carrying out a multi-step approach. First, as the collected literature was scarcer for the *argumentivist* and *critical* order, I undertook a dedicated and targeted review effort to close this gap, so that similar amount of research informed the subsequent analysis[1]. That is, the refined typology of phase 2 highlighted where I had ample of scholarship to draw upon for this analytical comparison, and where additional efforts were required to balance the amount of material used. Second, as my background research into why contrasting schools of thought are so prevalent among social science and the humanities pinpoint toward the importance of the ontological, epistemological and methodological positions, I drew in particular on Guba and Lincoln (2005) for comparing the key diverging issues between these five orders. These include, inter alia, inquiry aim, inquirer posture, or ontology (see issues denoted with * in **Table 1** for full set). These dimensions also

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[1]Despite the dedicated effort to source articles by the *critical* order, this order had fewer articles on offer. This seems thus to be a characteristic of this order.

helped to characterize the similarities within and between the two orders missing in both Guba and Lincoln (2005) and Freeman (2016), namely *pragmatists* and *argumentivists*. Additionally, I compared different notions of what "high-quality" knowledge and "good" adaptation is, what critiques are brought forward by other orders, and what confluences orders have. Third, based on my typology of phase 2 and the compared characteristics, I double-checked whether my previous assignment of an article to an order is still warranted. Fourth, within each order, I grouped the articles by similar topics, before noting and then summarizing the shared and key characteristics found in **Table 1**.

Overall, this review aimed to condense the sheer amount of scholarship on adapting climate science not by selecting articles based on keywords, but by a multi-phase process. An initial identification of the five orders took place relatively early, but was then challenged not only through consecutive reviewing of additional articles, but also through scholarship dedicated to similar questions of diversity and frictions in social research more generally. In the final analytical phase, a number of processes were taken to ensure the review's methodological integrity, including the search for additional literature to substantiate the description of two orders, double-checking prior grouping of articles to an order, and drawing on key distinctions with literature dedicated to the subject of "modes of thinking" (Freeman, 2016) and "paradigmatic controversies" (Guba and Lincoln, 2005), in order to best guarantee within-order homogeneity and between-order distinctiveness.

THE DESCRIPTIVIST ORDER: MIRRORING CLIMATE SCIENCE AND CLIMATE ADAPTATION

Descriptivist scholars show a particular desire to mirror how climate science is produced and used, and which adaptation processes have been adopted. This order is composed of political scientists, psychologists, economists as well as environmental social scientists who share a similar understanding of social science and its aims: providing undistorted descriptions and explanations. Three features recur frequently (see **Table 1**): *Methodologically*, an empiricism predominantly carried out by using (and assuming) stable categories with shared meanings to describe study subjects, relying mostly on the use of quantitative data such as surveys, or the creation of quantitative metrics from qualitative source material such as government reports for statistical purposes. *Ontologically*, a belief that the phenomena of interest are imperfectly apprehensible and measurable through pre-existing categories and stable classifications, such as age, wealth, geography or gender. And *epistemologically*, that unless falsified, descriptivist research produces findings probably true and empirically accessible. The following paragraphs give a flavor what phenomena social scientists in the descriptivist camp have explored.

The production and origin of climate science is one prominent descriptivist account. Such largely quantitative studies use bibliometric methods to assess the growth of climate science,

its expansion into other disciplines, or the producers' geography (e.g., Pasgaard and Strange, 2013). All find that a minority of countries—richer and with higher carbon emissions—produce the bulk of climate research. More qualitative accounts of how climate projections informing about future climatic changes were jointly produced with a number of actors (e.g., Jacobs and Buizer, 2016), how such projections are made available across the globe (Hewitson et al., 2017), or how the boundary organization UK Climate Impacts Programme UKCIP aimed to mainstream climate adaptation (Hedger et al., 2006).

Descriptivist research also illustrates climate adaptation policies, climate service practice and their use of climate science is. This includes mapping of stakeholders working on climate adaptation and services (e.g., Lorenz et al., 2019), the positive effect designated climate adaptation officers have on governmental policy (Stiller and Meijerink, 2016) or case studies on what role institutions and "boundary organizations" play (e.g., Ekstrom and Moser, 2013). Lorenz et al. (2017) analyzed how differently German and British local authorities used climate information in decision making, relating differences back to contrasting regulatory and fiscal governance systems. Similarly, Porter et al. (2014) describe what adaptation action UK households have taken, adding descriptions of less institutionalized and expert-driven adaptation processes.

Descriptivist attention is also focused on the differences of governmental adaptation policies. Comparing different national adaptation strategies in Europe, Albrecht and Arts (2005) found a convergence to a similar understanding of adaptation policy across countries. Similarly, Biesbroek et al. (2010) compare European countries' national adaptation plans across six dimensions, including how adaptation is both implemented and linked up with other policy domains. Still, climate adaptation is understood differently across sectors (Widmer, 2018). Also the uncertainty so prominent in climate scientific discussions is often simplified in such governmental documents (Füssel and Hildén, 2014).

Evaluating adaptation efforts across countries has also gained scholarly attention. Methodological discussions concern how to meaningfully compare the diversity of adaptation practices across countries (Dupuis and Biesbroek, 2013), including what indicators are useful to assess the effectiveness of particular adaptation options (Arnott et al., 2016). Others have developed indicators to track countries' adaptation progress, using the availability of climate science or the existence of national adaptation plans as proxies (Ford et al., 2013). This methodology has then been applied to describe climate adaptation progress globally (Berrang-Ford et al., 2014), and, controversially, labeling countries explicitly into adaptation "leaders" and "laggards" (Lesnikowski et al., 2015).

Psychologists, among others, have assessed both the public's ability to comprehend climate information, their attitudes toward climate adaptation and their knowledge on climate change. The comprehension of texts, tables or figures depicting the uncertainty attached to climate information has been a common

study theme, in order to empirically find which are the most influential (e.g., Taylor et al., 2015; McMahon et al., 2016). This also includes analyzing how readable scientific reports are, such as the IPCC's summary for policymakers (Barkemeyer et al., 2015). More recently a strong proponent of the *pragmatist* co-production paradigm ran two *descriptivist* decision-lab studies to assess different modes of user interaction (in-person, live webinar, and a self-guided recorded webinar), finding little effect on users' understanding, as well as perceptions of credibility and fit, of climate information (Lemos et al., 2019). This suggests that scaling up of user interactions by less resource demanding means is possible in many situations.

Other psychologists have undertaken empirical studies on how UK residents understand climate change impacts and climate adaptation (Harcourt et al., 2019), as well as conducting a meta-analysis to understand what motivates people to adapt (van Valkengoed and Steg, 2019). In particular, norms, negative emotions, and the perceived efficacy of climate adaptation outcomes were found to be key indicators. However, numerous such studies suggest that many people do not distinguish between climate adaptation and mitigation (e.g., Harcourt et al., 2019).

Descriptivists thus understand "high-quality" climate knowledge to be empirical and explanatory, often using statistical analysis to characterize their study subject through other categories (**Table 1**). An implicit assumption is that knowledge derived in one origin is also valid in others. This is also mirrored in notions of "good" adaptation as being harmoniously understood by different sets of actors, as well as similarly enacted and legislated in different countries. While adaptation policy-making is squarely seen as politicians' task, consulting the latest research findings and experts is a key feature in "good" adaptation.

THE PRAGMATIST ORDER: MAKING CLIMATE SCIENCE *FOR* AND *WITH* SOCIETY

Characteristically, *pragmatist* academics produce research aimed at increasing the social, ecological and technological resilience toward climatic impacts by improving adaptation decision-making through the production of more usable climate science. Initiated in the 1990s by calls for more issue-driven rather than curiosity-driven science (e.g., Funtowicz and Ravetz, 1993), *pragmatists* advocate science–stakeholder collaborations to produce relevant and usable knowledge as a required first step in triggering climate action. **Table 1** shows that *pragmatist* research shares many methodological, ontological and epistemological positions with *descriptivists*. For instance, although *pragmatists* are focused on participatory research, their articles still predominantly write from a more subject-independent perspective. But, importantly, pragmatists see their research output as contributions to a larger transformation, and see themselves as strategic facilitators of environmental action, often taking vocalizing their positions in calls-to-action.

Echoing throughout the pragmatist literature is the proclamation that climate science has to play a dominant role in how societies address climate change. Such scholarship is often quite upfront about this, even stating these ambitions in the title, such as to "Using climate predictions to better serve society's needs" (Hewitt et al., 2013, p. 105) or "Science for successful climate adaptation" (Preston et al., 2013). In line with such assertions, a whole research field has formed based on *pragmatist* motivations. For instance, "climate services" have been prominently pushed by the World Meteorological Organization WMO, national meteorological agencies as well as the European Commission (cf. Vaughan and Dessai, 2014). Dominated by goals of increasing resilience, pragmatist research puts climate science in the service of climate adaptation.

A range of barriers to using climate science for adaptation decision-making have been identified. Moser and Ekstrom (2010), for instance, developed a diagnosis framework to find, and possibly solve, barriers to adaptation planning. Assuming an "idealized, rational" decision-making process—labels that they themselves use—the authors propose a process asking two questions: What could act as a barrier? And how do the actors contribute to this barrier? This diagnosis then allows them to find "points of intervention" fostering climate action (Moser and Ekstrom, 2010, p. 22,026). Similarly, Ernst et al. (2019) identify three clusters of constraints—production, dissemination, and stakeholder engagement—in producing climate services. Ironically, two of these clusters were already strategically employed to promote and facilitate adaptation decision-making in Sweden, yet failed to adequately produce the intended results. Similar challenges with producing usable and thus "high-quality" knowledge are reported from a US-based regional climate service center (Briley et al., 2015). Cvitanovic et al. (2015), meanwhile, turn the perspective around, looking at the barriers scientists perceive in stakeholder engagement. Overall, the aim of identifying—and thus overcoming—barriers in the use of climate science for adaptation is a recurring *pragmatist* research theme.

Climate services also profited from research emphasizing that the existing climate and social science is hardly used. Calls for the reconciliation of the "demand and supply" of climate information (e.g., McNie, 2007), the closure of the "science–action gap" (Moser and Dilling, 2011) or the "usability gap" (Lemos et al., 2012) all tried to foster broad awareness and public action on climate change. Or, as Swart et al. (2014, p. 1) put it: "while an abundance of adaptation strategies, plans, and programmes have been developed, progress in turning these into action has been slow. The development of a sound knowledge basis to support adaptation globally is suggested to accelerate progress, but has lagged behind." The normative assumptions and policy preferences of many pragmatist research papers crystallize in aims such as: fostering climate action on the basis and primacy of science.

To produce the required "sound knowledge base" (Swart et al., 2014), "usable science" (Lemos et al., 2012) and "actionable knowledge" (Kirchhoff et al., 2013) to accelerate climate adaptation efforts around the globe, various academics have argued for engaging stakeholders in research projects.

This process was labeled "co-production of knowledge"[2] (e.g., Lemos et al., 2012), "co-creation" (e.g., Mauser et al., 2013), "co-design" (e.g., Moser, 2016a), or "co-development" (e.g., Leitch et al., 2019), while in Continental Europe it continued to be recognized under the independently established research paradigm of "transdisciplinarity" (e.g., Pohl, 2008). By doing so, the pragmatists' perceived need to advance global action on climate change with their research has joined earlier calls for a new type of science (Funtowicz and Ravetz, 1993). Interestingly, also stakeholders have become more vocal in calling for science–practice partnerships (e.g., Beier et al., 2017).

Another way of ensuring climate knowledge's relevance for a range of stakeholders has been taken by research on "user needs," offering a way to produce usable knowledge without costly face-to-face interaction. Some such use(r) requirement studies are noteworthy for their specificity, for instance for Australian vineyards (Dunn et al., 2015). Others have mapped sectoral information requirements, such as water (e.g., Mehta et al., 2013), policy-makers' climate information preferences (Hanger et al., 2013) or information needs for community-level adaptation (Srinivasan et al., 2011). The findings of such studies can illuminate what specific information—for instance, drought indicators—is desired by users, or through which channels it can be accessed. Such studies are thus another pragmatist example of producing "high-quality," "usable" climate knowledge for "good" adaptation.

Drawing on much descriptivist scholarship analyzing climate science communication and comprehension, various pragmatist studies have highlighted how to improve the consideration of climate science in climate adaptation. For instance, conveying climate science through stories is one such recommendation, such as the "tales of future weather" (Hazeleger et al., 2015) and "narratives" (Dessai et al., 2018). In reviewing climate change communication from 2010 onwards, Moser (2016b) emphasizes that opportunities for communicating the impacts of climate change, also within politicized contexts, arise increasingly not only from IPCC's Assessment Reports and UNFCCC COPs, but also from extreme weather events, statements by business associations or religious leaders, and political events such as elections and even pandemics.

Pragmatist scholarship emphasizes issue-driven, instrumental, and scientific knowledge as particularly able to effectively foster climate action (**Table 1**). And such knowledge is more likely to be used by society when scientists engage in more direct interaction with stakeholders and practitioners. As such, "high-quality" knowledge is often equalized to being "actionable" or "usable." Further, pragmatists widely understand "good" adaptation as a process underpinned by geophysical climate science, allowing the anticipatory management of climate risks.

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[2]The term "co-production" enjoys two different meanings (Bremer and Meisch, 2017). On the one hand, pragmatists understand it as *doing* co-production with stakeholders, whereas the interpretivists take to the *studying* co-production in its initial sense as coined by Elinor Ostrom in the 1970s, i.e., examining the ways science and society influence each other's practices and phenomena.

THE ARGUMENTIVIST ORDER: ANALYZING KNOWLEDGE, DEMARCATING SCIENCE

Academics following the *argumentivist* order usually use a purely conceptual approach to both meticulously analyse what climate knowledge claims can be validly derived from certain research activities, as well as to propose ways in which decision-makers can successfully navigate and incorporate not only climate science's uncertainties, but also their own values and risk preferences in climate adaptation projects. Composed mainly of analytic philosophers of science (to use a pleonasm), argumentivists' work can trace back its origins also to the writings of Popper, Hempel or Lakatos. *Methodologically* they are unified by their commitment to work predominantly conceptually in order to logically and argumentatively dissect, reconstruct and critique arguments. In line with such an emphasis, argumentivists take—and critique—a variety of ontological and epistemological positions. Such internal debates should be understood as an exemplary case of the unifying theme of this order, namely meticulous focus on arguments. Overall, *argumentivist* philosophers of climate science engage with philosophical and conceptual issues that arise in the practices of climate science.

Various analytic philosophers discuss the adequacy of climate simulations for making reliable predictions and for understanding aspects of the climate system (e.g., Smith, 2002; Parker, 2014). A climate scientist by training, Held (2005) worries that the attempts to create realistic models makes them so complex that it is impossible to trace why they behave the way they do. Thus, the complexity of climate models—made possible by ever increasing computer power—might make it difficult to actually assess whether model results are reliable. Further, with data and observations becoming more abundantly available, machine learning and big data applications provide new opportunities for climate scientists to research and understand climate change. However, Knüsel et al. (2019) argue that in big data-only approaches, the data alone is insufficient to warrant an assumption of constancy (ceteris paribus). Theory-based knowledge is thus still relevant to climate predictions produced by machine learning algorithms. Overall, analytic philosophers carefully analyse to what extent such modeling approaches are able to provide high-quality knowledge.

With climate scientists increasingly using multiple climate models to assess some of the inherent uncertainties attached to climate change, and the prominence climate models have in informing adaptation decisions, *argumentivists* have been actively engaged in discussions on combining models in ensembles. For instance, Parker (2010) has characterized the different types of "model ensembles" which exist. As such, perturbed-physics ensembles, multi-model ensembles, and initial condition ensembles help analyzing different sources of uncertainty. Baumberger et al. (2017) argumentatively follows up the implications of how to appropriately select and weight climate models. More recently, with datasets playing an important role in calibrating and validating climate

models, Zumwald et al. (2020) propose to extend the use of ensembles to multiple datasets in order to better assess climate science's uncertainties.

However, how to obtain and interpret quantified uncertainty estimates from climate model ensembles has been a source of friction between climate scientists and argumentivists. For instance, some analytic philosophers strongly objected to how the climate scientists producing the British climate projections UKCP09 (Murphy et al., 2010) communicated their findings as probabilities. The criticism of British climate scientists' "myopia" (Frigg et al., 2013) was caused by disagreements on how to interpret the "probabilities" derived from climate simulations. The British climate scientists assumed that these probabilities are a good way of expressing their actual uncertainty. But Frigg et al. (2013) caution against interpreting the British climate projections UKCP09 as being able to be reliable expressions of uncertainty of future climates up to the end of the twenty-first century. Therefore, this argumentivist analysis has implications for how adaptation projects ought to take up and integrate climate science, in particular for high-risk events.

With "unknown unknowns" (Parker and Risbey, 2015) making it impossible to know the full event space and the corresponding probabilities with certainty, decision principles and tools have been proposed which consider these constraints. Betz (2010, 2016) argues decision-makers need to focus more on their risk preferences when judging "worst-case" and "best-case" scenarios of climate change, rather than its probabilities Similarly, thoughtfully integrating uncertainty explicitly in policy deliberations, both Bradley and Steele (2015) and Hirsch Hadorn et al. (2015) discuss decision strategies to analytically decide whether to accept, revise, or postpone adaptation and mitigation decisions. Roussos et al. (2020) consider three dimensions for more confident decisions using model ensembles: the models' output as probabilities; an expert judgement of confidence in these probabilities; as well as an actor's stakes and cautiousness. These three dimensions allow to characterize and deal with different sources of uncertainty. As such, argumentivists have offered ways in which climate science could be more appropriately taken up in current adaptation decision-making, to ensure "good" adaptation by "high-quality" knowledge.

Argumentivists also contributed to the pragmatist discussions of how to co-produce actionable knowledge. Thompson et al. (2016) argue that climate services too often treat climate models' unmodified output as real-world probability distributions. To avoid the pitfalls associated with such unwarranted confidence in climate models while taking climate science seriously in climate adaptation, they propose that structured expert elicitation processes would allow a range of experts to systematically discuss climate science with other available knowledge in order to produce more scientifically justified as well as decision-relevant climate services. In a similar vein, Parker and Lusk (2019) enrich the pragmatist studies of including user values in the co-production of climate knowledge by highlighting that the types of errors which users want to avoid—risk of overestimating or underestimating particular climatic changes—is of importance when producing actionable knowledge. Parker and Lusk (2019) enrich co-production discussions by emphasizing that users can

also guide scientists' methodological choices: knowing whether under- or overestimation is of greater consequence to users can favor one approach over another.

Argumentivists are thus bound together by their commitment to "high-quality" knowledge being produced by appropriate methods or flawlessly argued, always explicitly dealing with science's uncertainties (**Table 1**). This is mirrored in their understanding of "good" adaptation as adequately acknowledging yet still incorporating these uncertainties meaningfully. Often, argumentivists take care in demarcating where the expertise of scientists end and the role of politicians start.

THE INTERPRETIVIST ORDER: RE-CONCEPTUALIZING CO-CONSTITUTIVE INFLUENCES

Interpretivist scholarship aims to unhinge established forms of thinking and descriptions, by redescribing collective behaviors and discourses as products of complex encounters between cultural norms, collective aspirations, socio-political pressures and technological innovations. Composed of scholars of Science and Technology Studies, empirical human geographers, and qualitative interdisciplinary researchers, *interpretivist* scholarship shares the following three features (see **Table 1**). *Methodologically*, interpretivists favor an empirical and mostly qualitative perspective, drawing for instance on ethnographic accounts and semi-structured interviews. Often comparative in nature, much scholarship uses inductive reasoning to bring often unnoticed yet stable patterns into focus. *Ontologically*, interpretivists see social practices, meaning, and realities as being the product of multiple influences—beliefs, imaginations, technologies, knowledge, politics. And *epistemologically*, a subjectivist view of findings being collectively mediated by reciprocal interactions of society, science, politics and technology dominates. With such a background, interpretivist research has emphasized how various practices around "high-quality" climate science and "good" climate adaptation are socially negotiated and stabilized, and so subject to human fascinations, manipulations and fallacies.

Interpretivist scholars have had continuing interest in the way socio-cultural factors shape climate scientists' work. Shackley (2001) and contributions edited by Heymann et al. (2017) empirically compare the "epistemic lifestyles" or "cultures of prediction" of climate modeling centers as a sociological phenomenon. This includes, for instance, the mutually beneficial interplay between modelers and experimentalists through parametrisations (a method for replacing sub-scale atmospheric processes in climate models with empirical observations), thus also socially—and not only epistemically—legitimizing climate models as an accepted research mode (Shackley et al., 1998; Sundberg, 2007). Further, Mahony and Hulme (2012) describe how the UK regional climate model PRECIS was motivated by the wish to make the climate center's science globally available while simultaneously collecting the knowledge of the regional expert stakeholders to reduce obvious model errors. Further,

climate scientists often imagine users of climate information to be either similarly numerate as themselves (Porter and Dessai, 2017) or through other simplified categorisations, such as being an academic, practitioner or by sector (Skelton et al., 2019a). Both studies show how powerful imaginations—yet empirically inadequate descriptions—legitimize and guide much development of climate services.

How science and politics mutually influence each other is another intriguing research topic for interpretivist researchers—confusingly also known as the *study* of "co-production" rather than pragmatists' *doing* co-production with stakeholders (cf. Bremer and Meisch, 2017). With the concept of "civic epistemologies," Jasanoff (2005) emphasizes that democracies have distinct preferences as to which kind of science and expertise is seen as legitimate for policy-making. For instance, Skelton et al. (2017) found patterns of judging "good" climate science and "good" stakeholder participation in climate projections matching the political cultures of the UK, Switzerland and the Netherlands, respectively. Another such comparative study is the evidence-based research on the politics of climate adaptation in the UK and Australia (Tangney, 2017). Other interpretivist studies focus on single countries, such as how Germany established political consensus on climate change (Beck, 2012), or the goals of the UK Met Office as a world-leading climate science center also being fuelled by political ambitions to support the UK's climate negotiation position (Mahony and Hulme, 2016).

Another interpretivist research strand investigates how the relationship between climate science and climate action is framed and politically embedded. For instance, Gillard (2016) highlights the significant rhetorical shift between two consecutive British governments, from one dedicated to being a "climate leader" in both adaptation and mitigation to one skeptical of the state's role in orchestrating policy targets. Similarly, Tangney (2017) critically examines how ideas and fascinations with evidence-based approaches in decision-making politicizes climate science, in particular by asking science to be the *only* source of answers on the normative policy dimensions. On a global level, the lack of democratic legitimacy of supranational knowledge bodies such as the IPCC have led Bäckstrand (2003) to call for a wider stakeholder interaction in the synthesis of climate science for decisions. Overall, there is thus widespread interpretivist interest in how changes in how environmental governance is perceived shift policy responses.

Interpretivists have also noted how the use of climate science is part of a wider societal concern with anticipating the future. Enserink et al. (2013) show that decision-makers and scientists understand "scenarios" differently, so much so that what was meant to clarify led to confusion. Social and emotional factors also play a role in interpreting climate simulations, including a certain "seductive power" in acknowledging the model's uncertainty (Lahsen, 2005). Further, Groves (2017) examines how "anticipation" and the fascination of desired futures shapes climate politics today. Similarly, Skelton (2020b) analyses why building technicians and greenspace managers appropriated knowledge on urban heatwaves so more successfully than spatial planners and health specialists. He argues that the more "cognitive links" sectors share with climate science

concepts (e.g., indoor climate, bioclimates) and the more authority and control experts have over climate adaptation options, the more climate knowledge fits "comfortable" with a sector's priorities. This interpretivist strand of research thus highlights how prospective knowledge on future climate change has already significantly altered our perceptions and thoughts today.

Further, cautioning against dominant *pragmatist* fascinations is a common interpretivist practice—even a *raison d'être* for some (cf. Horgan, 2019). Many scholars critique the dominance of the "interaction imperative" embedded in climate services, either because it is too consensual (Klenk and Meehan, 2015); because joint co-design of knowledge does not necessarily lead to trust (Lahsen, 2007); because too often stakeholder engagements are just "lip service" (Klenk et al., 2015); or because participation often perpetuates rather than challenges existing power dynamics (Chilvers and Kearnes, 2016; Turnhout et al., 2020). Others critique the "managerial" intentions prominent in adaptation discourses prominent in both socio-technical as well as socio-ecological paradigms (Gillard et al., 2016). Further, interpretivist scholars see the shift of climate services from the public to the private domain critically (Keele, 2019), and have scrutinized the way the World Bank has produced and circulates "best practices" for adaptation (Webber, 2015). In general, being wary of other social science orders' efforts, the study of discourses and the collective fabrication of desired futures by science–society interactions (so-called "sociotechnical imaginaries," cf. Jasanoff and Kim, 2015) is a distinguishing feature of interpretivist scholarship.

Thus, *interpretivists'* understand "high-quality" climate knowledge to consider the interrelated factors stabilizing human practices and sense-making in a particular way (**Table 1**). Such an understanding of "high-quality" knowledge then translates into "good" adaptation action as being mindful of the profound influences individuals, institutions, ideas, practices, materials, and non-humans have on human action. Interpretivists are thus wary of technocratic fallacies of control possibly producing severe unintended consequences.

THE CRITICAL ORDER: REVEALING INJUSTICES REPRODUCED BY SCIENCE

Working toward increased social emancipation, the *critical* order aims to reveal how actors and institutional practices stabilize a particular understanding and framing of climate change—the so-called discourse—and so maintain and reproduce social injustices and privileges enjoyed only by few. Critical scholars aim to unveil how culturally ingrained depictions privileging benevolent scientific, political or economic leaders in their ability to effectively manage environmental pollution, or inversely, shifting the understanding of what the problem is and who needs to act onto less responsible and affluent actors. Although comparatively few *critical* studies on climate have been published, key similarities between

postcolonial, feminist and political ecological scholarship are, *methodologically* often apply prior theories and concepts to climate science and climate adaptation. *Ontologically*, critical scholarship is shaped by political, economic, ethnic and gender values, while *epistemologically*, critical thought is subjectivist, where findings are collectively mediated and thus changeable.

Post-colonial studies take a close and critical look at how ideas and discourses on climate adaptation have neo-colonial underpinnings of Western superiority and a disregard of nations' policy-making sovereignty. Bankoff (2001), for example, points out that discourses of vulnerability updates, and so maintains, older conceptions of Africa, Asia, and South America being dangerous and/or requiring "Western" support. Between the Seventeenth and early Twentieth century, such places were framed as disease-stricken lands in need of Western medicine, before being portrayed as impoverished and in need of Western investment and aid after World War II. The current discourse, as Bankoff (2001) argues, is one in which these countries are vulnerable to natural hazards, with science seen as its remedy. As such, his study demonstrates how persistent such marginalizing framings are. Further critique has been directed at *pragmatist* discourses romanticizing so-called indigenous knowledge, not only by seeing it as being of distinctly different quality than scientific knowledge, but by subjugating such knowledge to the pragmatists' aims rather than respecting those of its original holders (Agrawal, 2010; Klenk et al., 2017). Such studies thus emphasize how other *orders'* judgements of "high-quality" knowledge and "good" adaptation can be problematic.

Climate models have received critique for their embedded neocolonial assumptions underpinning their development and deployment. For instance, the UK established the Met Office Hadley Center also because of a political concern that without its own, national climate model, the UK would be unable to independently act in international climate negotiations, relying instead on knowledge produced in the US and continental Europe (Mahony and Hulme, 2016). Inversely, Anglosaxon climate scientists were at the forefront for producing one-size-fits-all tools for generating climate projections *for* poorer countries, further circulated through workshops held by UNFCCC while continuing to fund own climate scientists rather than adaptation elsewhere (Skelton et al., 2019b). Climate projections and their models thus carry colonial connotations of power and influence over sovereign, national adaptation policy-making (Mahony and Hulme, 2018). Similarly, Lahsen (2007) reminds that Brazilian policy-makers do not automatically trust climate science just because Brazilian scientists were involved. Rather, joint climate research projects are often eyed suspiciously for their goals favoring US over Brazilian interests. While not a *subaltern* view developing a narrative independent of more powerful actors common in postcolonial scholarship (e.g., Chakrabarty, 2012), Miguel (2017) shows that emerging economies such as Brazil have started to develop their own national climate models in an explicit effort to be more scientifically independent in their national climate policies. Overall, both explicit and implicit

postcolonial studies illuminate how neocolonial conceptions of "good" adaptation are manifested in climate models as favoring a distinct perspective on what "high-quality" scientific knowledge is.

How a discourse mirrors the interests and perspectives of more powerful actors is also revealed by feminist scholars. Seager (2009) traces how the 2°C target was first coined and subsequently internationally endorsed through a politics with "gendered political and ideological underpinnings," as climate risks below 2°C are acceptable and manageable only for temperate, mid-latitude and richer countries. "Many ecosystems and peoples will hit limits to adaptation long before 2°C, and some already have" (Seager, 2009, p. 15). Such a "mechanistic" and "masculinized" understanding of humans' ability to effectively manage their environment is, in many *critical* eyes, an unwarranted fallacy of control. By endorsing the 1.5°C target in 2015, however, in particular poorer nations successfully changed the climatic discourse in their favor, and the orthodox science–politics relationship topsy-turvy. Taken by surprise, climate science had to catch up—rather than inform—climate policy (cf. Livingston and Rummukainen, 2020).

Drawing on feminist geography and feminist political ecology, Sultana (2014) uses her own research in South Asia to show how divisions of labor, cultural norms of "proper" behavior for women, and unequal rights and decision-making power exacerbate women's vulnerabilities and workload when climate impacts hit. Specifically, even in crises certain "lines of work," such as fetching drinking water, remain almost exclusively the burden of women. "Notions of shame, honor, and dignity are strongly enforced by both men and women in maintaining social practices even during disasters," and with it the "[p]roper decorum and constructions of feminized subjectivities result in women being unwilling to associate with unknown men, be alone in public places, and be outside of familiar kinship structures" (Sultana, 2014, p. 376). The combination of women being less likely to seek refuge and male elders not always supporting women in sheltering tragically produces higher mortality rates for women during catastrophes. Consequently, Jost et al. (2016) find that due to such patriarchal factors the adaptive capacity of women is lower than that of men.

Taking an intersectional perspective—a notion that emphasizes that multiple sociocultural strands of influence (e.g., religion, ethnicity, ability) intersect and so produce a person's identities and cultural roles—Carr and Thompson (2014) argue that a binary lens of gender is a too simplistic category to base policies aiming to foster "good" adaptation. Similarly, Ravera et al. (2016) show that identities based on caste, wealth, age and gender produce different adaptation strategies in two Indian states. They show that "a priori assumptions on the basis of male/female dichotomy are unable to lead to a comprehensive understanding of farmers' choices, vulnerability, adaptation process, and barriers to adoption" (Ravera et al., 2016, p. S346). In other words, the intra-gender variability of experiences and adaptation practices is too large to be explained solely by a single binary,

revealing how intersectional thinking can better capture such multi-factorial differences.

Paying close attention to how powerful economic interests influence discourses so as to retain their privileges, Forsyth (2003) elaborates how a "critical political ecology" can help to understand and address the adverse effects "environmental orthodoxies"—widely held inaccurate and simplistic explanations of environmental problems—have when they underpin environmental policies. Motivated by how many policies worsen rather than improve local livelihoods in particular in poorer regions, Forsyth (2003) draws on recent *argumentivist* and *interpretivist* scholarship to trace back how actors and institutions stabilize "environmental orthodoxies" which inadequately underpin many policies and so reproduce local inequalities. Taylor (2014, p. 11) uses such a perspective to critique how simplified and biased the dominant conception—or "discursive apparatus"—of climate adaptation is, with "its grounding notion of climate as an external system that provides exogenous stimulus and shocks to which society must then adapt". Rather, "lived environments" such as rice paddies are "actively yet unequally" produced by interlinked and coupled human and meteorological forces. Such a binary nature–society perspective often successfully veils issues of power and ethics in policies. For instance, talking to Indian farmers about climate adaptation in the orthodox way blanks out that these farmers effectively have to respond to greenhouse gas emissions produced largely by wealthy actors elsewhere, often blaming instead local farming practices as inadequate.

Many critical scholars thus pay attention to how uncomfortable knowledge gets omitted and lost when people stabilize ideas. Chakrabarty (2009, p. 216, emphases in original) asks blatantly "[wh]y should one include the poor of the world—whose carbon foot print is small anyway—by use of such all-inclusive terms as *species* or *mankind* when the blame for the current crisis should be squarely laid at the door of the rich nations in the first place and of the richer classes in the poorer ones?" With such normative efforts of "denaturalising" discourses, critical political ecologists aim to bring into focus—and therefore attention—"the uneven distribution of gains and risks arising from deeply fused social and ecological processes" (Taylor, 2014, p. 16). Similarly, Turnhout et al. (2020) argue that "depoliticising" co-production projects on the actionability of climate knowledge can, when used in unreflective manner, reinforce elite perspectives. Critically reminding that dominant solutions might just be an easy way to shift responsibilities of blame and action elsewhere is thus a key characteristic of political ecologists and like-minded scholars.

Critical scholars understand "high-quality" knowledge as having high revelatory and emancipatory potential for social change (**Table 1**). Such knowledge is often geared around how powerful interests shift the discourse, responsibilities and action in their interests. "Good" adaptation action thus pays tribute to more local experiences and is more inclusive of marginalized sections of populations. Often, too, "high-quality" knowledge aims to promote a more situated understanding of people in their environments (e.g., Latour, 2017).

DISCUSSION: UNDERSTANDING WHY DIFFERENT NOTIONS OF "HIGH-QUALITY" KNOWLEDGE AND "GOOD" ADAPTATION EXIST AMONG THE FIVE *ORDERS OF SOCIAL SCIENCE AND THE HUMANITIES*

This article has compared five distinct ways social scientists and humanities scholars study climate adaptation and climate science, illustrating both different academic perspectives as well as the diversity of social, cultural, and political facets in "adapting climate science" (cf. Skelton, 2020a). However, novice scholars are unlikely to be the only ones potentially baffled how to adequately make sense of and order this diversity. This study shows that grouping by topic, even method, is not always meaningful to understand how, and more importantly why, social science research is driven by different motivations, critiques different elements, and takes different ontological and epistemological positions. The five *orders* portrayed here—*descriptivist*, *pragmatist*, *argumentivist*, *interpretivist*, and *critical*—aim to produce an understanding of the wealth of social scientific thinking, as well as their respective areas of frictions and confluence. In particular, it extends earlier classifications of "paradigmatic controversies" (Guba and Lincoln, 2005) and "modes of thinking" (Freeman, 2016) by showcasing two additional orders common to the study of adapting climate science specifically, and arguably social environmental science more generally: *pragmatists* and *argumentivists*. **Table 1** summarizes the above sections, enabling straightforward comparison of the orders' different aims, concerns, positions as well as different notions of what "high-quality" climate knowledge and "good" adaptation is.

My analysis revealed that what is understood as "high-quality" climate knowledge is different between, yet similar within, *orders* (**Table 1**). Influenced largely by orders' inquiry aim and posture, *pragmatists* favor instrumental, issue-driven, usable knowledge which is able to foster climate action, while *descriptivists*' notion is less activist and more curiosity-driven, aiming to mirror social phenomena. *Argumentivist*, *interpretivist* and *critical* scholarship, however, is united by a more wary stance toward knowledge in general. There the similarities end though, with *argumentivists* in strong favor of explicit treatment of knowledge's uncertainties. For *interpretivists* meanwhile "high-quality" knowledge re-describes—re-orders, so to speak—our stable social practices, often revealing a mismatch between how people express something and how an anthropologist would describe this behavior. To end, for *critical* scholars "high-quality" climate knowledge is emancipatory by being concerned about how dominant discourses mask political, economic and cultural ways injustices, veiling responsibilities and shifting the action imperative to other peoples.

Consequently, the five orders also contrast as to what "good" adaptation is. While for instance *critical* scholars are concerned with emancipatory adaptation which fosters equality and is more

inclusive of people's lived experiences, for many *interpretivists* "good" adaptation is more democratic and less technocratic, with a more succinct acknowledgment of how science helps stabilizing a particular way of "good" adaptation over others, but itself being embedded with value assumptions. Similarly, *argumentivists* emphasize that climate science's uncertainties ought to be appropriately integrated in order to ensure "good" adaptation—often also by emphasizing where and how decision-makers' own value and risk preferences should be center stage. *Pragmatists* have a broader take on "good" adaptation, as one which actually takes place and is grounded in mostly geophysical climate science. *Descriptivists* are less upfront about what criteria are required for "good" adaptation, apart from that measures and policies need to be in place, and effectively reduce geophysical climate risks.

Thus, this research emphasizes that numerous distinct notions of "high-quality" climate knowledge and "good" adaptation exist among social scientists and humanities scholars. Uniting and differentiating features of these five *orders* are diverging aims and concerns—categorical description, knowledge for climate action, knowledge quality check, redescriptions of established patterns, and exposing of power. Interestingly, these aims are mirrored—likely even required to be precipitated—in deeper ontological and epistemological positions. **Table 1** emphasizes that orders favoring social change prefer perspectives which describe their phenomena as something inter-subjectively constructed and delicately maintained collective process— and thus changeable through the subjects' values and norms. Correspondingly, orders more interested to meaningfully describe and/or analyse phenomena require categories to be more stable and less constructed. Similarly, in studying phenomena around "adapting climate science," the five orders also employ methods particularly able to actively produce the insights supporting the order's aim or sharing its concern. In previous scholarship on "research paradigms" (Guba and Lincoln, 2005) or "modes of thinking" (Freeman, 2016), the intricate links as how methodological, ontological, and epistemological positions and research aims largely require and complement each other gets less attention. As this article argues, however, internally consistent links within an order are dominant. This is likely not random. My own experience using data collected in a *descriptivist* and *pragmatist* fashion yet wanting to write in an *interpretivist* or *critical* style was frequently challenging: Too often the qualitative source material was missing which would allow the production of such insights.

Further, these differences have been the source for some misunderstandings and friction between orders (cf. Guba and Lincoln, 2005; Freeman, 2016). **Table 1** gives examples for what a particular order is critiqued and criticized, and by whom. Fault lines appear most often when two orders' key aims not consider each other adequately at best, or remain largely incommensurable at worst. For instance, *argumentivists* frequently take issue with other order's epistemic overconfidence; while *critical* scholars often object to other orders' flippancy as to how scientific knowledge can exacerbate livelihoods and reproduce injustice by legitimizing

technocratic rather than democratic governance. However, from my reading, such critiques often reverberate mostly within one's own order, strengthening one's own argument and clarifying one's position—rather than engaging in a constructive way. Still, critique is likely unavoidable, as some differences are not easily resolved. Even if unaware, readers will take cues from the way the text is written, how results are collected and described, and how authors positions themselves within the literature (Dunleavy, 2003). Thus, working toward an order's aims is still mostly taking place within orders, with specializing journals and conferences assisting such specialization.

While some differences in aims and opinions are unlikely to be fully resolved, careful readers will have noted that some social scientists and humanities scholars are associated with more than one *order*, in particular when co-authoring articles. However, more common than such inter-*order* collaborations are cross-fertilizations and learnings between distinct orders. For instance, through a Special Issue, Arnott et al. (2020) collect a variety of perspectives to illuminate a nascent "science of actionable knowledge." Such confluence is particularly visible for the pairs descriptivist–pragmatist and interpretivist–critical, bound by a ontology of how stable or constructed categories are. For the latter pair, this includes for instance attention to ideas' and discourses' "performativity": the effect that language not only describes, but also orders, structures and encodes a particular way of thinking and therefore acting. In practice, such (diagrammatical) thinking "brings to the analytic task a way of reading, or a form of intervening, into this moving matter [of reality]" (Freeman, 2016, p. 105). But characterizing the five *orders* also reveals that learning takes place across this dichotomy. For example, taking input from *critical* scholarship, *pragmatists* increasingly recognize issues of social justice as important in fostering adaptation action (see **Table 1**). Similarly, *argumentivists*' focus on uncertainties in science has helped *critical* scholars to reveal that powerful actors promote, consciously or not, their interests through describing science as being more certain than epistemically warranted.

This classification of social-scientific orders may help to understand where such frustration arise, and while scholars do not need to share another order's opinion, understanding one's own, and other academics' behavior could produce more tolerant reviews and possibly fruitful collaborations. Castree et al. (2014) have argued for the importance of a more socially situated view of climate change. Such a focus would allow to extend the knowledge of human impacts on the environment with a more profound awareness of how these environmental changes produce new—as well as reinforce old—assumptions and conceptions for people's lives and well-being. While both Castree et al. (2014) and Hulme (2011) lament the marginalization, even absence, of the social sciences and the humanities in many scientific climate change discussions, this review also highlights that not all *orders* are similarly interested in collaborating with biophysical climate scientists or assisting climate policies and governance in achieving climate resilience. While some dear-held aims might be at odds with such a collaborative

approach, a more profound understanding of the diversity and wealth of social-scientific perspectives can crystallize the manifold social, political, and cultural dimensions climatic change has.

AUTHOR CONTRIBUTIONS

MS was responsible for all parts of the research, including developing the research question, reviewing the literature, as well as writing and revising the manuscript throughout the peer-review process.

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