Available online at www.sciencedirect.com

ScienceDirect

Current Opinion in Environmental Sustainability

Integrating institutional approaches and decision science to address climate change: a multi-level collective action research agenda

Abigail M York[1], Caitlin Drummond Otten[1,2], Shauna BurnSilver[1], Steven L Neuberg[3] and John M Anderies[1,4]

Climate change is a problem that requires a multi-scale response from the individual to the global. Each level and type of entity has some capacity to influence climate change action and policy, but as a multi-level collective action problem, it is not surprising that there is underprovision of climate change action; this challenge highlights the need to better understand decision-making processes. We propose an integrated research frontier that examines inter-level feedback processes, the role of individuals and organizations in promoting trust within and across levels, the importance of establishing and communicating norms, and inclusion of worldviews to situate decision makers within narratives of climate change. The failure to mitigate and adapt to climate change is a social science problem, perhaps the biggest social problem our society faces. To solve it requires that we advance a new frontier on decision making across a complex set of multi-level collective action relationships.

Addresses
[1] School of Human Evolution and Social Change, Arizona State University, P.O. Box 872402, Tempe, AZ 85287-2402, United States

[2] Erb Institute, Ross School of Business, University of Michigan 700 East University, Kresge Hall, 3rd Floor West, Suite 3510, Ann Arbor, MI 48109, United States
[3] Department of Psychology, Arizona State University, P.O. Box 871104, Tempe, AZ 85287-1104, United States
[4] School of Sustainability, Arizona State University, P.O. Box 875502, Tempe, AZ 85287-5502, United States

Corresponding author: York, Abigail M (abigail.york@asu.edu)

Current Opinion in Environmental Sustainability 2021, **51/52**:xx–yy

This review comes from a themed issue on **Climate decision-making**

Edited by **Diana Reckien**, **Cathy Vaughan** and **Rachael Shwom**

Received: 17 July 2020; Accepted: 03 June 2021

https://doi.org/10.1016/j.cosust.2021.06.001

Social and decision sciences largely were absent in early efforts to develop an understanding of the Earth's changing climate [1]. Much of the discourse amongst scientists and policymakers has focused on a technocratic understanding of the climate system, with the belief that the simple delivery of good science to the public would suffice to enable good policymaking. Although this naive worldview is still found in some circles [2,3•], it has become clear that the social and behavioral sciences are fundamental both to understanding climate change and to conceptualizing ways to mitigate it [4].

Climate change inaction has led to inequity with important power dimensions [5] with disparate impacts such as flooding risks [6], water scarcity [7•], temperature-related mortality [8], and sea level rise [9]. Nor are the costs associated with climate action and policy solutions borne equally [10•]. Further, climate change is a problem that requires a multi-scale response from the individual to the global. A successful research approach will be one that identifies issues at many scales, explores feedbacks within and between levels, and advances an integrated multi-level approach.

Building upon a foundation of economics and political science, scholars of institutions examine the conditions and decisions associated with effective collective action [11], yet this research has not fully incorporated insights from behavioral economics and psychology [12]. Much of the research on such choice architecture is based on Thaler and Sunstein's idea of 'nudging' [13], where restructuring choices push people toward socially desirable behavior.

While work on 'nudging' has largely focused on consumer choices, there is growing interest in employing more diverse behavioral approaches to study multi-level collective action problems such as climate change [14,15] and expanding beyond the western oriented consumption choices dominant in the economics literature [16]. We argue that we must integrate institutional approaches to collective action with the decision sciences to motivate climate action from the individual to the Earth system. We explore literature on collective action problems within and across levels of organization and spatial scales. We then propose the decision sciences as a lens through which to examine multi-level climate-related decision-making and articulate a framework with a set of integrative concepts. We conclude by outlining a research agenda that integrates decision sciences with climate

change governance to better understand and address perhaps the most pressing multi-level collective action problem of our time.

Climate change — a multi-level collective action problem

Climate-related decisions such as greenhouse gas emissions and deforestation alter the regulators of our climate system: atmosphere, land, ice and oceans [17]. Making this an extremely difficult problem is that the collective action challenge exists at multiple levels; climate-related decisions are made at household and firm levels, as well as by local to global government entities. There is debate over the efficacy of individual action [18], and needed structural changes in the food [19•] and energy systems [20•], but it is clear that action must occur at multiple levels, including so-called bottom-up and top-down action [21].

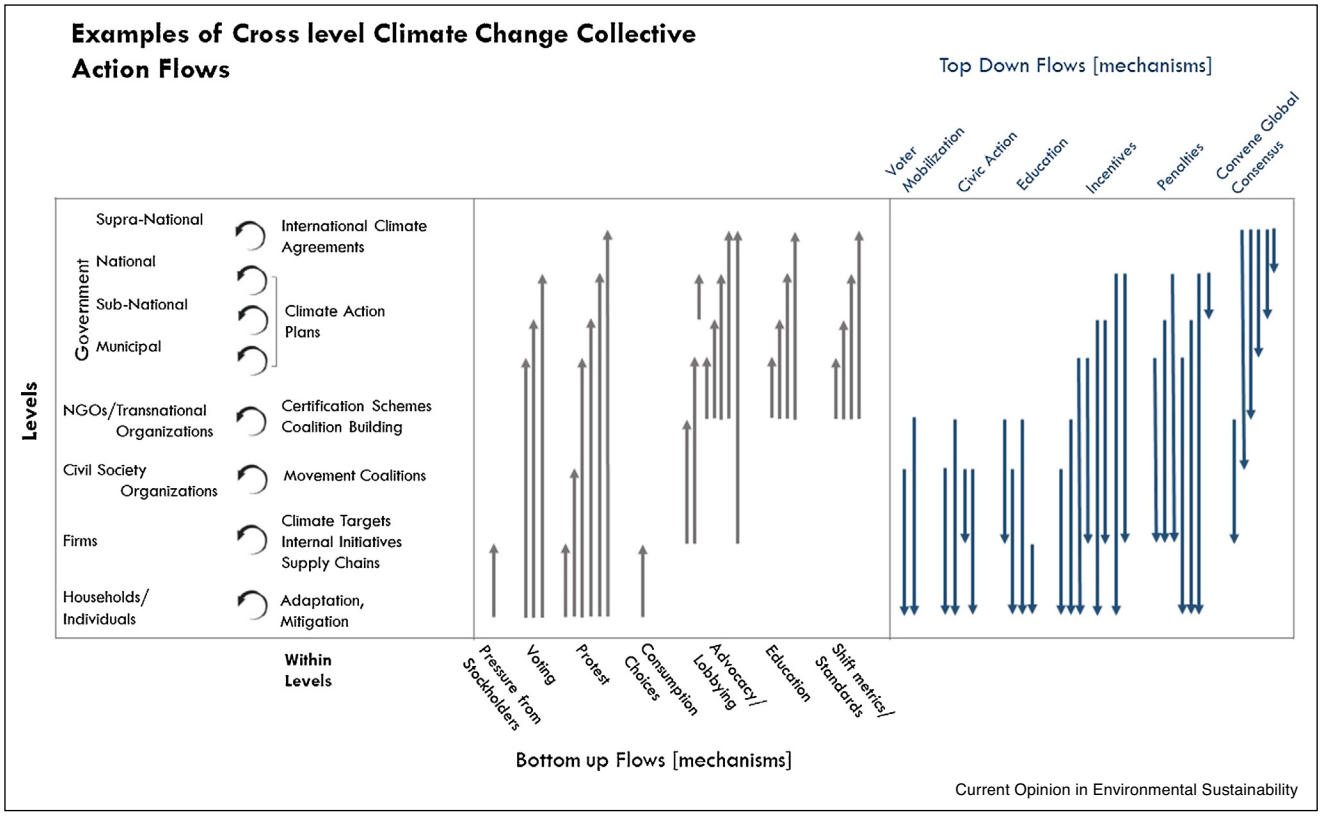
Levels of collective action

Household actions, via consumer choices about housing, food, transportation, and travel, have tremendous impact on climate change [22] and research reveals that differences in people's perceived exposure to the impact of climate change, and its associated costs and benefits, partially explain their beliefs and decisions to adopt pro-climate behaviors [23]. Educating people about the impacts of climate change may influence behavior, but this relationship is moderated by existing beliefs and social interactions [24•].

Firms may also adopt pro-climate policies, with most research focusing on the costs and benefits of these choices [25]. Corporate actions may be fueled by a desire to improve their image, sometimes derisively known as 'greenwashing' [26]. Choices may also be driven internally by desire to increase status in industry networks, acquire certifications [27], or reflect pressures from stockholders or owners. Climate change focused non-governmental organizations (NGOs) and civil society organizations may act to decrease climate change impacts, such as those affecting public health outcomes [28].

Government entities, ranging from local municipalities to nation-states or supra-national entities, make policy decisions affecting climate. Local government adoption of climate action plans may also be driven by political entrepreneurs or attempts to achieve status in transnational networks; importantly, the adoption of policies does not always lead to change in practice (i.e. building

Figure 1



Multi-level Earth System Governance-flows and feedbacks.

codes or land use planning), which often is driven by congruence with local concerns [29]. National climate policy adoption is influenced by political conditions, high-income status, and vulnerability to climate change, as well as whether countries are member states of the European Union [30•]. Political context also influences the selection of policy instruments [31•].

Because climate change is a global problem, significant attention in public discourse and the research literature has focused on international agreements. The Paris Agreement represented an important step toward effective climate change mitigation and adaptation at the global scale. The agreement was riddled with issues that reduced efficacy, such as perceived inadequacy of national climate pledges [32] thwarted by participation, compliance, and targets that are not sufficiently ambitious [33•].

Connecting the levels

It is clear that action at single levels has the potential to affect action at other levels. Some exemplar cross-level actions, here conceptualized as flows are highlighted in Figure 1. Individuals can potentially motivate action by firms through consumption choices, or as stockholders through support for pro-climate management choices [34]. Further, they can exert influence on policymaking via voting, advocacy, and protest. Such action may be motivated by a sense of collective disadvantage and a belief in collective efficacy [35], or, more simply, psychologically salient social norms [36]. That said, even climate change 'believers' engage in only limited political action [37]. Moreover, even when they do, such action at the individual level may backfire. For example, climate-focused voting [38] may further strengthen climate (dis)belief, thereby generating greater division amongst the population. Thus, although action at the individual level has the potential to shape action at other levels, these effects are not always straightforward.

Firms also have the capacity to shape action at other levels. They exert pressure on government entities—perhaps most notably in the case of transnational firms that influence policy throughout the world [39•]—but also affect the choices that individuals make (e.g. through advertising), often increasing consumption and emissions [40]. Insurance industries, in particular, respond both to individual decisions and government interventions (e.g. declarations of emergency), influencing climate change consumption and adaptation decisions for individuals and organizations [41]. Both firms and nongovernmental organizations use sophisticated public relations strategies to influence public opinion and policymaking [42]. Civil society organizations may focus on education or grassroots mobilization efforts, while elite NGOs may focus more narrowly on policy influence instead of climate justice [43]. NGOs are also involved in developing and maintaining certification schemes for firms [44]. Influential shadow networks often provide the 'back room' dealings whereby policymaking processes occur, and these spaces or forums may be created by or filled with individuals employed by NGOs (e.g. shadow networks have been documented in water policymaking; [45]). Other transnational NGO networks, such as ICLEI — Local Governments for Sustainability [46], facilitate information transfer and shift the standards and metrics through which pro-climate action is judged.

Decisions at all levels of government are influenced by citizens and firms through voting, advocacy and protest, although these processes are shaped by the form of governments (e.g. whether it is a democracy) [47]. Governments influence individuals [18], firms [48•], and nongovernmental organizations [49•] through penalties and incentives. Local and subnational governments are incentivized, or constrained, by (in)action at the national level [50], such as in American states where pro-climate policy adoption in Democratic-leaning states increased after Trump's election [51•]. Transnational municipal networks facilitate adaptation policy adoption in particular [52]. There is interplay between domestic politics and the international stage [53], which is often overlooked by focusing on policy dynamics within single levels. The emergence of transnational regime complexes further shifts the focus of governance from multi-lateral agreements between nation-states, such as the United Nations Framework Convention on Climate Change (UNFCCC), to networked governance structures that include an intergovernmental sphere, as well as action by nonstate and subnational actors [54]. Negotiations surrounding the UNFCCC led to issue-level organizational fields that influenced firm choices [55].

The need for a multi-scale approach

In Figure 1, we present some exemplar decisions and flows. Some flows, such as stockholder pressure, link two levels, whereas others, such as protest, cascade through the system from the individual to global. Supra-national government organizations flow through the system affecting firm standards and governments at all levels, whereas upward flows such as civic action and voting are constrained by government characteristics (e.g. the democratic status of nation-states) or policies (e.g. whether protest or other forms of civic action are allowed). Nation-states, subnational, and local governments also incentivize and constrain actions of individuals and organizations.

Although each level and type of entity has some capacity to influence climate change action and policy the coordination challenge has yet to be addressed. As a multi-level collective action problem, it is not surprising that there is underprovision of climate change action (at all levels) and in aggregate at the global scale; this challenge highlights

the need to better understand decision-making processes if we are going to attempt to solve it. Critically no single scale is appropriate for all actions, for example, adaptation to flooding or urban heat may be best solved at a regional or local level, but coordination across levels is essential due to cascading effects across levels [56]. Earth system governance is an approach recognizing the multiple levels of decision-making, scales of challenges, and diverse sectors [56–58], yet this literature has not been integrated with decision sciences.

Decision sciences

The decision sciences approach provides a common framework for conceptualizing climate-related decision-making on each of the levels (discussed below), and for helping understand inter-level dynamics (discussed in the next section). The decision sciences encompass three interrelated perspectives on decision-making: normative analyses examine the choices that informed, rational decision-makers would make, descriptive analyses examine actual decision-making, and prescriptive interventions seek to bridge the gap between ideal and actual decision-making by drawing on behavioral principles governing how people form judgments and make decisions [59,60,63]. Decision sciences characterizes choices by what options are available, and what valued outcomes and uncertainties are associated with those options. The decision science framework has been used to inform responses to climate change at many levels, including the adoption of residential smart grid technologies [61], household energy usage [62] and preparing for sea-level rise [63].

Under conditions of complexity and uncertainty, which characterize most climate change-relevant decisions, limits to human information processing and attention make fully informed choice impossible [64]. Formal normative analysis, in collaboration with climate experts, is needed to identify what scientific information is most relevant to a decision-maker or decision-makers, and social science is needed to characterize the decision in the form of a set of options, and their associated outcomes and uncertainties [63,60].

Descriptive analyses examine actual decision-making, drawing on qualitative and quantitative analyses of decision-makers' knowledge, beliefs, and behaviors [65]. Decisions may differ from ideal decisions when decision-makers have incomplete knowledge of the problem: for example, decision-makers may have incomplete or incorrect mental models of the complex and unfamiliar processes that characterize climate change [66,67]. General behavioral principles shaping how individuals and groups typically form judgments and decisions can also form a wedge between actual and ideal decision-making. For example, the behavioral principle that immediate outcomes are generally valued more than future outcomes poses a challenge for addressing climate change, which often necessitates the undesirable tradeoff of immediate costs in exchange for future benefits.

Taken together, formal and descriptive analyses suggest prescriptive interventions to improve decisions. Interventions providing needed information to decision-makers can improve climate-relevant decisions in situations where decision-makers' knowledge is incomplete or inaccurate; for example, the usage of in-home energy displays can help motivated consumers reduce energy usage [68]. However, factors unrelated to climate science itself, such as prior beliefs and values that may be encoded in worldviews, can also influence climate-related decision-making, by shaping how people value the outcomes associated with choice options, and how they understand and apply information. For example, through a process known as motivated reasoning, desired outcomes influence how people process information [69]: people require more evidence to come to an undesired conclusion [70] and evaluate evidence more positively when it supports their beliefs [71].

The goal of prescriptive interventions is to aid climate decision-makers at all levels to understand the outcomes and uncertainties associated with their options in a way that enables them to make decisions consistent with their values [63]. Decision-makers with a shared understanding of the facts might value outcomes differently, leading to different decisions. Efforts to understand and improve climate-related decision-making within and across levels might ask how best to communicate and coordinate the information and values informing decisions.

Integrating decision science with earth system governance

Mitigating and adapting to climate change is a multi-level collective action problem requiring coordinated action within and across levels [Figure 1]. Integrating decision science approaches with Earth system governance and climate governance research advances a richer understanding of climate-related decision-making by providing a framework that can capture how decision-making differs at different levels of climate governance. Moreover, while the existing work on climate change governance and decision sciences approaches have typically focused on decision-making within individual, organization, or specific government levels, the multi-level nature of climate change necessitates an understanding of *inter-level* dynamics and how they might impede or facilitate climate action.

In this section, we extend the Earth System Governance integrative framework to articulate a research agenda examining inter-level dynamics. Below, we detail integrative concepts, typically applied at the individual level but critically relevant at higher levels. The integrative

concepts we highlight, while not exhaustive, suggest promising directions for future research.

Feedback and trust

The spatially distributed, temporally distant, and uncertain nature of climate change limits the extent to which decision-makers are able to receive feedback on the outcomes of their climate-related decisions. Feedback enables decision-makers to assess the impacts of their actions and whether those impacts are aligned with their values or goals, and is needed to develop the domain expertise that promotes good decision-making [72]. Viewing climate change as a multi-level collective action problem suggests the critical importance of both unidirectional flows [Figure 1] and feedback loops within and across levels that convey information about decisions, their outcomes, and the values informing them. For example, efforts by activists, NGOs, and academics to track opaque corporate supply chains and link them to environmental and social outcomes can promote sustainability in corporate and consumer decision-making [73]. Further, public integration into institutional decision-making, as has been used in energy policy [74], provides a mechanism to integrate public values into institutional decisions and facilitate dialogue and transparency regarding how values can and should inform institutional decision-making on climate. Such inter-level dialogues may also help to establish trust between involved parties by enabling them to demonstrate their expertise and trustworthiness [75]. Future work might ask how intra-inter-level feedback loops could be best designed to effect informed decision-making, trust, and collective climate action.

Norms

Behavioral experiments have shown that communicating norms of what other decision-makers do (descriptive norms) and think people should do (injunctive norms) can change behavior [76,77]. Organizations and policymakers can promote sustainable behavior by communicating norms: for example, providing individuals with social norm information comparing their energy consumption to that of others can reduce energy usage [78]. Organizations like the United Nations can set norms for valued outcomes in climate action through global agendas like the Sustainable Development Goals. Further, understanding the norms that govern behavior at different levels can alter behavior: communicating scientific norms on climate change can depolarize politically polarized attitudes [79•] and promote belief in climate change [80]. Future work studying the intra-inter-level dynamics of norms could provide insights into how policymakers and organizations can facilitate the establishment of norms [81], how norms may differ across and within levels of climate governance, and how shared understanding of and coordination of norms might depolarize organizations and facilitate collective climate action.

Worldviews and narratives

Cultural communities' ontological and epistemological orientations reflect their values and beliefs and influence how they see and engage with the world [82]. Similarly, narratives, which serve to structure observed events into causal sequences, can communicate complex scientific processes and connect them to decision-makers' everyday realities [83]. Constructing compelling climate change narratives may facilitate communication of complex dynamics that link climate action across levels, encouraging collective climate action. For example, exposure to climate disaster narratives in film may increase public concern about climate [84]. However, there are potential tradeoffs associated with any streamlined pro-climate or anti-climate change narrative, as the discontinuities, power relationships and inequities embedded in them [85] can obscure foundational relationships and dynamics [86]. Worldviews and narratives represent largely unexplored factors that cut across levels by placing decision-makers' values and actions into the broader storylines of climate change, their beginnings and ends.

Research agenda

In this paper, we develop an Earth system governance research approach integrating the institutional literature, which provides a rich, but understudied understanding of the multi-level characteristics of collective action, with the decision science literature, which provides a common conceptual framework for understanding behavior change within levels as well as how interactions across levels might facilitate change. In order to both understand and motivate change for Earth system problems, such as a climate change, we must examine multiple levels and integrate decision sciences. Our proposed framework and the associated integrated research frontier suggest several promising directions for future research promoting multi-level collective action by studying inter-level dynamics, including inter-level feedback processes, their role in promoting trust, establishing and communicating norms, and how worldview and narratives situate decision makers within narratives of climate change. Many more directions exist.

Above all, the frontier we present here must not only examine decision-making levels in isolation. A focus on multi-level coordinated governance is necessary. The substantial body of literature on the connections between each level can and should be enhanced with decision science insights, such as dynamics linking individual voters to elected officials or the nation-state to international agreements. However, understanding the larger system that encompasses dynamics across multiple levels remains a major gap of this research. Networked governance approaches, thresholds of behaviors that lead to systemic changes, as well as nested social-ecological systems research provide lenses for examining these complex systems, as well as examining the roles of

shadow networks in influencing climate change action. The failure to mitigate and adapt to climate change is a social science problem, perhaps the biggest social problem our society faces. To solve it requires that we advance a new frontier on decision making across a complex set of multi-level collective action relationships.

Conflict of interest statement

Nothing declared.

Acknowledgement

This material is based upon work supported by the National Science Foundation under grant number NNA-1928235.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest

1. Reid WV, Bréchignac C, Tseh Lee Y: **Earth system research priorities**. *Science (80-)* 2009, **325**.

2. Yearley S: **Sociology and climate change after Kyoto**. *Curr Sociol* 2009, **57**:389-405.

3. • Grundmann R, Rödder S: **Sociological perspectives on earth system modeling**. *J Adv Model Earth Syst* 2019, **11**:3878-3892
The authors argue that sociological perspectives are largely absent from climate policy debates where social science discourse focuses primarily on individual behaviors and education campaigns. Nor are efforts such as IPCC reflexive integrating roles of corporate actors and pressure groups, knowledge politics, and a multiple-worlds model of the society whereby actors respond to different information and drivers.

4. Fischhoff B: **Making behavioral science integral to climate science and action**. *Behav Public Policy* 2020:1-15 http://dx.doi.org/10.1017/bpp.2020.38.

5. Marino E, Ribot J: **Special issue introduction: adding insult to injury: climate change and the inequities of climate intervention**. *Glob Environ Change* 2012, **22**:323-328.

6. Arnell NW, Gosling SN: **The impacts of climate change on river flood risk at the global scale**. *Clim Change* 2016, **134**:387-401.

7. • Koutroulis AG, Papadimitriou LV, Grillakis MG, Tsanis IK, Warren R, Betts RA: **Global water availability under high-end climate change: a vulnerability based assessment**. *Glob Planet Change* 2019, **175**:52-63
The authors present global freshwater vulnerability framework to assess exposure to decreased freshwater availability with different socio-economic developments, described as adaptation, and warming levels. Greater adaptation investments will be required for warming of 4°C versus 1.5°C or 2°C, although adaptation efficacy is dependent on a number of uncertainties including interactions with other sectors.

8. Gasparrini A, Guo Y, Sera F, Vicedo-Cabrera AM, Huber V, Tong S, de Sousa Zanotti Stagliorio Coelho M, Nascimento Saldiva PH, Lavigne E, Matus Correa P *et al.*: **Projections of temperature-related excess mortality under climate change scenarios**. *Lancet Planet Health* 2017, **1**:e360-e367.

9. Chen X, Feng Y, Huang NE: **Global sea level trend during 1993-2012**. *Glob Planet Change* 2014, **112**:26-32.

10. • Kuosmanen T, Zhou X, Dai S: **How much climate policy has cost for OECD countries?** *World Dev* 2020, **125**:104681
In this study, the authors calculate the greenhouse gas abatement costs for 28 OECD countries from 1990–2015, finding that EU countries bear higher costs, but costs are substantially lower than the 1990s cost predictions. There is a large variation in marginal abatement costs across countries, indicating policy inefficiency. Authors argue that given the relatively low abatement costs, policymakers should adopt more ambitious climate mitigation strategies.

11. Olson M: *The Logic of Collective Action*. 1965.

12. Downs JS, Loewenstein G, Wisdom J: **Strategies for promoting healthier food choices**. *Am Econ Rev* 2009, **99**:159-164.

13. Thaler R, Sunstein C: *Nudge: Improving Decisions about Health, Wealth, and Happiness*. 2008.

14. Arvai J, Gregory R: **Beyond choice architecture: a building code for structuring climate risk management decisions**. *Behav Public Policy* 2020:1-20 http://dx.doi.org/10.1017/bpp.2020.37.

15. Ostrom E: **Polycentric systems for coping with collective action and global environmental change**. *Glob Environ Change* 2010, **20**:550-557.

16. Agrawal A, Lemos MC, Orlove B, Ribot J: **Cool heads for a hot world - social sciences under a changing sky**. *Glob Environ Change* 2012, **22**:329-331.

17. Gettelman A, Rood RB: *Components of the Climate System*. Berlin, Heidelberg: Springer; 2016, 13-22.

18. Stern PC, Wolske KS: **Limiting climate change: what's most worth doing?** *Environ Res Lett* 2017, **12**:091001.

19. • Springmann M, Clark M, Mason-D'Croz D, Wiebe K, Bodirsky BL, Lassaletta L, de Vries W, Vermeulen SJ, Herrero M, Carlson KM *et al.*: **Options for keeping the food system within environmental limits**. *Nature* 2018, **562**:519-525
Using a planetary boundary framework, the authors develop a global food system model with country-level data and show that environmental effects of the food system will increase by 50–90% from 2010–2050 with current trends in the absence of technological change or mitigation measures. Adoption of these changes, such as reduction of food waste, increasing crop yields, nutrient and water management strategies, and changing dietary demands, may provide a pathway to stay within planetary boundaries.

20. • Bistline JE, Hodson E, Rossmann CG, Creason J, Murray B, Barron AR: **Electric sector policy, technological change, and U. S. emissions reductions goals: results from the EMF 32 model intercomparison project**. *Energy Econ* 2018, **73**:307-325
The authors evaluate 16 different models across six policies on electric sector investments and emissions. The results indicate that climate policy has the potential to drive transformation in the sector.

21. Mangalagiu D, Bisaro A, Hinkel J, Tàbaral JD: **Transformative narratives for climate action**. *Clim Change* 2020, **160**:495-506 http://dx.doi.org/10.1007/s10584-020-02761-y.

22. Wynes S, Nicholas KA: **The climate mitigation gap: education and government recommendations miss the most effective individual actions - IOPscience**. *Environ Res Lett* 2017, **12**:074024.

23. Mase AS, Gramig BM, Prokopy LS: **Climate change beliefs, risk perceptions, and adaptation behavior among Midwestern U.S. crop farmers**. *Clim Risk Manag* 2017, **15**:8-17.

24. • Valdez RX, Peterson MN, Stevenson KT: **How communication with teachers, family and friends contributes to predicting climate change behaviour among adolescents**. *Environ Conserv* 2018, **45**:183-191
The authors evaluated the predictive ability of climate change communication with teachers, friends, and family, concern, knowledge, on climate change behaviors using a random sample of 1371 middle-school students in North Carolina, USA. Concern and communication with friends and family were the strongest predictors, as were urban high socio-economic status schools.

25. Linnenluecke MK, Griffiths A, Winn MI: **Firm and industry adaptation to climate change: a review of climate adaptation studies in the business and management field**. *Wiley Interdiscip Rev Clim Change* 2013, **4**:397-416.

26. Bowen F, Aragon-Correa JA: **Greenwashing in corporate environmentalism research and practice**. *Organ Environ* 2014, **27**:107-112.

27. Melo I, Turnhout E, Arts B: **Integrating multiple benefits in market-based climate mitigation schemes: The case of the Climate, Community and Biodiversity certification scheme**. *Environ Sci Policy* 2014, **35**:49-56.

28. Frumkin H, Hess J, Luber G, Malilay J, McGeehin M: **Climate change: the public health response**. *Am J Public Health* 2008, **98**:435-445.

29. Ryan D: **From commitment to action: a literature review on climate policy implementation at city level**. *Clim Change* 2015, **131**:519-529.

30. • Schmidt NM, Fleig A: **Global patterns of national climate policies: analyzing 171 country portfolios on climate policy integration**. *Environ Sci Policy* 2018, **84**:177-185
Using the *Climate Change Laws of the World* database, the authors evaluate factors influencing national climate policy adoption from 1990–2016 for 171 countries. They find that European Union countries, those with higher GDP, and higher vulnerability adopt more comprehensive policies, while energy and administrative arrangement domains are the most common policies adopted.

31. • Stead D: **Policy preferences and the diversity of instrument choice for mitigating climate change impacts in the transport sector**. *J Environ Plan Manag* 2018, **61**:2445-2467
In this article, the author examines the role that national policy preference plays in climate change policy adoption in the transport sector in four European countries: France, Germany, Sweden, and the United Kingdom, as well as how underlying cultural, social, and economic factors explain the persistence of policy instruments adopted not related to national political power changes. There is heterogeneity in national policies adopted, which is not related to the statist tendencies of the country; generally, there is the persistence of policy instrument mix uncoupled from political changes.

32. Piggot G, Erickson P, van Asselt H, Lazarus M: **Swimming upstream: addressing fossil fuel supply under the UNFCCC**. *Clim Policy* 2018, **18**:1189-1202.

33. • Dimitrov R, Hovi J, Sprinz DF, Saelen H, Underdal A: **Institutional and environmental effectiveness: will the Paris Agreement work?** *Wiley Interdiscip Rev Clim Change* 2019, **10**:e583
Using a literature review, the authors evaluate the deep commitments, broad participation, and compliance rates of the 2015 Paris Agreement finding that there is broad participation, but commitments must be ratcheted up, which will be associated with pressure from non-state actors, while compliance requires leadership changes from major emitters, such as USA and China, and greater transparency.

34. Yadav P, Han S, Kim H: **Manager's Dilemma: stockholders' and consumers' responses to corporate environmental efforts**. *Sustainability* 2017, **9**:1108.

35. Jost JT, Nosek BA, Gosling SD: **Ideology: its resurgence in social, personality, and political psychology**. *Perspect Psychol Sci* 2008, **3**:126-136.

36. Doherty D, Dowling CM, Gerber AS, Huber GA: **Are voting norms conditional? How electoral context and peer behavior shape the social returns to voting**. *J Polit* 2017, **79**:1095-1100.

37. Hornsey MJ, Harris EA, Bain PG, Fielding KS: **Meta-analyses of the determinants and outcomes of belief in climate change**. *Nat Clim Change* 2016, **6**:622-626.

38. McCrea R, Leviston Z, Walker IA: **Climate change skepticism and voting behavior**. *Environ Behav* 2016, **48**:1309-1334.

39. • Folke C, Österblom H, Jouffray JB, Lambin EF, Adger WN, Scheffer M, Crona BI, Nyström M, Levin SA, Carpenter SR *et al.*: **Transnational corporations and the challenge of biosphere stewardship**. *Nat Ecol Evol* 2019, **3**:1396-1403
The authors examine dominant transnational corporations' current impact on the biosphere and their potential impact to advance biosphere stewardship through alignment of vision, the inclusion of sustainability frameworks like the Sustainability Development Goals in corporate practice, affording licenses to operate to those advancing stewardship, that is, the United Kingdom's Modern Slavery Act that requiring disclosure corporate practices to reduce slavery and human trafficking, transforming the financial sector through changes in fiduciary duty or shared principles in order finance transformations, radical transparency to monitor progress in biosphere stewardship, and evidence-based knowledge to action.

40. Sanne C: **Willing consumers - or locked-in? Policies for a sustainable consumption**. *Ecol Econ* 2002, **42**:273-287.

41. Kunreuther H: *Insurance and Behavioral Economics Improving Decisions in the Most Misunderstood Industry*. 2013.

42. Greenberg J, Knight G, Westersund E: **Spinning climate change: corporate and NGO public relations strategies in Canada and the United States**. *Int Commun Gaz* 2011, **73**:65-82.

43. Schlosberg D, Collins LB: **From environmental to climate justice: climate change and the discourse of environmental justice**. *Wiley Interdiscip Rev Clim Change* 2014, **5**:359-374.

44. Hyatt D, Johnson J: **Expanding boundaries: nongovernmental organizations as supply chain members**. *Elem Sci Anthr* 2016, **4**:000093.

45. Sendzimir J, Magnuszewski P, Balogh P, Vári A: **Anticipatory modeling of biocomplexity in the Tisza River Basin: First steps to establish a participatory adaptive framework**. *Environ Model Softw* 2007, **22**:599-609.

46. Yi H, Krause RM, Feiock RC: **Back-pedaling or continuing quietly? Assessing the impact of ICLEI membership termination on cities' sustainability actions**. *Environ Polit* 2017, **26**:138-160.

47. Burnell P: **Democracy, democratization and climate change: complex relationships**. *Democratization* 2012, **19**:813-842.

48. • Zhou P, Wen W: **Carbon-constrained firm decisions: from business strategies to operations modeling**. *Eur J Oper Res* 2020, **281**:1-15
The authors define and categorize ten climate change business operations models from 116 journal articles. They find that policy-driven carbon constraints are the most dominant model, mainly as related to emissions trading and carbon taxes. There are several emerging trends, such as a shift to long-term solutions, such as networks, collaborative approaches, and mixed-product models.

49. • Berny N, Rootes C: **Environmental NGOs at a crossroads?** *Environ Polit* 2018, **27**:947-972
The authors explore the role of environmental NGOs (ENGOs) working within policy arenas and established institutions or seeking to advocate for change outside the mainstream through more radical movements arguing that there is a symbiotic but asymmetric relationship between these two paths. They examine how ENGOs have taken different strategies through the years with some, but not ENGOs, moving from direct action to institutional strategies and advocate for understanding the heterogeneity of strategies from the perspective of the actors, as well as the larger environmental movement.

50. Urwin K, Jordan A: **Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance**. *Glob Environ Change* 2008, **18**:180-191.

51. • Bromley-Trujillo R, Holman MR: **Climate change policymaking in the states: a view at 2020**. *Publius J Fed* 2020, **50**:446-472 http://dx.doi.org/10.1093/PUBLIUS/PJAA008
The authors develop a Poisson model to analyze state legislature bill introductions of climate change policy to examine how national politics affect state agenda-setting from 2011–2018. They found pro-climate bills are associated with professionalism, political culture, and region while during the Trump administration, they find that political ideology, as measured by state partisanship and chamber ideology, is also significant as there is a return to state domination in climate policymaking due to federal rollbacks and inaction.

52. Fünfgeld H: **Facilitating local climate change adaptation through transnational municipal networks**. *Curr Opin Environ Sustain* 2015, **12**:67-73.

53. Hale T, Roger C: **Orchestration and transnational climate governance**. *Rev Int Organ* 2014, **9**:59-82.

54. Widerberg O, Pattberg P: **Accountability challenges in the transnational regime complex for climate change**. *Rev Policy Res* 2017, **34**:68-87.

55. Levy DL, Kolk A: **Strategic responses to global climate change: conflicting pressures on multinationals in the oil industry**. *Bus Polit* 2002, **4**:275-300.

56. Burch S, Gupta A, Inoue CYA, Kalfagianni A, Persson Å, Gerlak AK, Ishii A, Patterson J, Pickering J, Scobie M *et al.*: **New directions in earth system governance research**. *Earth Syst Gov* 2019, **1**:100006.

57. Biermann F, Betsill MM, Gupta J, Kanie N, Lebel L, Liverman D, Schroeder H, Siebenhüner B, Zondervan R: **Earth system governance: a research framework**. *Int Environ Agreem Polit Law Econ* 2010, **10**:277-298.

58. Biermann F, Abbott K, Andresen S, Bäckstrand K, Bernstein S, Betsill MM, Bulkeley H, Cashore B, Clapp J, Folke C *et al.*: **Navigating the anthropocene: improving earth system governance**. *Science (80-)* 2012, **335**:1306-1307.

59. Fischhoff B, Broomell SB: **Judgment and decision making**. *Annu Rev Psychol* 2020, **71**:331-355.

60. Fischhoff B: **The sciences of science communication**. *Proc Natl Acad Sci U S A* 2013, **110**:14033-14039.

61. Krishnamurti T, Schwartz D, Davis A, Fischhoff B, de Bruin WB, Lave L, Wang J: **Preparing for smart grid technologies: a behavioral decision research approach to understanding consumer expectations about smart meters**. *Energy Policy* 2012, **41**:790-797.

62. Krishnamurti T, Davis AL, Wong-Parodi G, Wang J, Canfield C: **Creating an in-home display: experimental evidence and guidelines for design**. *Appl Energy* 2013, **108**:448-458.

63. Wong-Parodi G, Krishnamurti T, Davis A, Schwartz D, Fischhoff B: **A decision science approach for integrating social science in climate and energy solutions**. *Nat Clim Change* 2016, **6**:563-569.

64. Simon HA: **Theories of bounded rationality**. *Decision and Organization*. 1972:161-176.

65. Bruine De Bruin W, Bostrom A: **Assessing what to address in science communication**. *Proc Natl Acad Sci U S A* 2013, **110**:14062-14068.

66. Bostrom A, Morgan MG, Fischhoff B, Read D: **What do people know about global climate change? 1. Mental models**. *Risk Anal* 1994, **14**:959-970.

67. Sterman JD, Sweeney LB: **Understanding public complacency about climate change: adults' mental models of climate change violate conservation of matter**. *Clim Change* 2007, **80**:213-238.

68. Davis AL, Krishnamurti T, Fischhoff B, Bruine de Bruin W: **Setting a standard for electricity pilot studies**. *Energy Policy* 2013, **62**:401-409.

69. Kunda Z: **The case for motivated reasoning**. *Psychol Bull* 1990, **108**:480-498.

70. Ditto PH, Lopez DF: **Motivated skepticism: use of differential decision criteria for preferred and nonpreferred conclusions**. *J Pers Soc Psychol* 1992, **63**:568-584.

71. Lord CG, Ross L, Lepper MR: **Biased assimilation and attitude polarization: the effects of prior theories on subsequently considered evidence**. *J Pers Soc Psychol* 1979, **37**:2098-2109.

72. Kahneman D, Klein G: **Conditions for intuitive expertise: a failure to disagree**. *Am Psychol* 2009, **64**:515-526.

73. Goldstein B, Newell JP: **Why academics should study the supply chains of individual corporations**. *J Ind Ecol* 2019, **23**:1316-1327.

74. Pidgeon N, Demski C, Butler C, Parkhill K, Spence A: **Creating a national citizen engagement process for energy policy**. *Proc Natl Acad Sci U S A* 2014, **111**:13606-13613.

75. Fiske ST, Dupree C: **Gaining trust as well as respect in communicating to motivated audiences about science topics**. *Proc Natl Acad Sci U S A* 2014, **111**:13593-13597.

76. Cialdini RB, Reno RR, Kallgren CA: **A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places**. *J Pers Soc Psychol* 1990, **58**:1015-1026.

77. Allcott H: **Social norms and energy conservation**. *J Public Econ* 2011, **95**:1082-1095.

78. Wong-Parodi G, Krishnamurti T, Gluck J, Agarwal Y: **Encouraging energy conservation at work: a field study testing social norm feedback and awareness of monitoring**. *Energy Policy* 2019, **130**:197-205.

79. • Van Der Linden S, Leiserowitz A, Maibach E: **Scientific agreement can neutralize politicization of facts**. *Nat Hum Behav* 2018, **2**:2-3

In this study, the authors explore whether communicating scientific information increases polarization, especially amongst highly educated individuals, using a large nationally representative survey experiment (N = 6301). They find evidence of motivated cognition with a correlation of conservative ideology and high education, resulting in lower acceptance of scientific consensus. Exposure to a scientific consensus norm reduced differences between liberals and conservatives and eliminated the interaction between education and conservative ideology.

80. Van Linden SLD, Leiserowitz AA, Feinberg GD, Maibach EW: **The scientific consensus on climate change as a gateway belief: Experimental evidence**. *PLoS One* 2015, **10**:2-9.

81. Nyborg K, Anderies JM, Dannenberg A, Lindahl T, Schill C, Schlüter M, Adger WN, Arrow KJ, Barrett S, Carpenter S *et al.*: **Social norms as solutions**. *Science (80-)* 2016, **354**.

82. Medin DL, Bang M: **The cultural side of science communication**. *Proc Natl Acad Sci U S A* 2014, **111**:13621-13626.

83. Downs JS: **Prescriptive scientific narratives for communicating usable science**. *Proc Natl Acad Sci U S A* 2014, **111**:13627-13633.

84. Lowe T, Brown K, Dessai S, De França Doria M, Haynes K, Vincent K: **Does tomorrow ever come? Disaster narrative and public perceptions of climate change**. *Public Underst Sci* 2006, **15**:435-457.

85. Sapiains R, Ibarra C, Jiménez G, O'Ryan R, Blanco G, Moraga P, Rojas M: **Exploring the contours of climate governance: an interdisciplinary systematic literature review from a southern perspective**. *Environ Policy Gov* 2021, **31**:46-59.

86. Cronon W: **A place for stories: nature, history, and narrative**. *J Am Hist* 1992, **78**:1347.