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Complexity ethics and UNFCCC practices for 1.5°C climate change

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Abstract

Introducing a 'complexity ethics' frame would help society mitigate or adapt to climate warming within or exceeding the Paris Agreement 1.5°C aim. A complexity ethics frame underlines existing facilitative multi-stakeholder methodologies used at subnational scales to build adaptive capacity and may be scaled-up in a transformed UNFCCC. Adopting such approaches at the international political level would permit non-state, non-Party stakeholders to more efficiently integrate their tremendous capacity for climate action into the global climate action process, leading to more substantial climate mitigation and adaptation for and over 1.5°C warming. In turn, this would help satisfy critiques regarding the democratic legitimacy of polycentric moves to include non-state actors at this level, incorporate other global initiatives and problems like the SDGs and biodiversity loss, and meet high-level calls for more co-operative responses.

INTRODUCTION

Anthropogenic greenhouse gas accumulation has moved the earth into a climate regime thought to be unseen in 60 million years [1], that left unchecked could produce climate regimes unknown in at least the past 420 million years and likely to be cataclysmal for the current assemblage of life on Earth [2*]. Thus, the politically negotiated but scientifically informed Paris Agreement aims to limit global average temperature increase to (preferably) under 1.5°C but (certainly) under 2.0°C warming above pre-industrial times to avoid the dangerous impacts of climate change [3]. Projections point toward a global average temperature rise of 2.7 to 5.2°C above pre-industrial norms by 2100 [2,3]. Furthermore, the 1.5°C mark may be passed as soon as 2026 [3] even without the shortfall in agreed Nationally Determined Contributions (NDC) for emissions reduction [4–7]. Poorly mitigated climate change may also exceed temperature-related human habitability or survivability in some Earth regions [8–11*]. Nor do climate change estimates directly factor other anthropogenic perils from mass extinction-level biodiversity loss, population and food security, and technological change [12-14,15*–17]. However, despite such ominous analyses, little action has been taken at the global political level to adapt to the stark possibility of a climate over 1.5 or 2.0°C [18]. The international community might, therefore, be said to be gambling on the success of Paris Agreement with no alternative 'plan B' for high-end warming. However, at more local scales, substantive action has been taken through participatory adaptive capacity and resilience building to respond to a range of climate scenarios [19**,20**]. An urgent need thus exists to push new ideas, even if incomplete, that could prepare humanity for a range of long-term climate futures.

In this spirit, this paper argues that this last-minute high-stakes wager on the social-ecological future of humanity by governing institutions through the United Nations Framework Convention on Climate Change (UNFCCC) process reflects a classical and erroneous assumption that reality comprises linear cause and effect relationships, and that politics-as-usual can control it. Operationalising a complexity ethics in the UNFCCC's structures and procedures to adopt facilitative decision-making methods and processes used in adaptive capacity building in sub-global contexts is proposed as a remedy. This would better mobilise state and non-state stakeholders for more effective climate action. It would also do much to resolve the ontological mismatch between complexity science and climate governance by reflecting in institutional procedures the general scientific position that reality is a complex, adaptive, dynamic system defined by non-linear interactions between elements. Doing so may institutionalise a practical ethics for global transformation in amenable to both meeting and exceeding 1.5°C climate change, which has yet to be fully addressed in the transformations literature [21**].

SIMPLE AND COMPLEX ONTOLOGIES AND ETHICS

Ontology refers to the objects or things that comprise a given understanding of reality and the nature of the relationships between those things [22,23]. Complexity science has grown in range and scope since the 1940s [24,25] and broadly holds that reality is a complex, dynamic, non-linear set of interactions between the elements of reality, humans and nonhumans, or the things that comprise them, and emergent in form and function. These complex interactions cannot be fully understood or predicted, remaining pregnant with potential and uncertainty. In the ecological sciences, research efforts have focused on complexity dynamics in ecosystems that began the 1970s [26]. They include the now common-place social-ecological systems approach that underpins much research on resilience and adaptation to climate change [19,23,25,27,28]. The social sciences also contain numerous articulations of society's intricacies, framed for example as, 'complex adaptive system' [29]; assemblages [30,31]; actor-networks and modes of existence [32,33]; posthumanism [34]; and via Indigenous knowledge systems [35]. Political ecology [36–38] includes polycentric governance of the environmental commons [39,40] and process-oriented approaches also appear in the humanities [41,42]. Emerging research is drawing on quantum theory to explain or explore social phenomena [43–45]. Indeed, the body of climate science that produces the evidence and projections of anthropogenic warming is an epistemological articulation of a basic complex, dynamic systems ontology.

However, the prevailing, or *classical*, ontology governing the much of 20th century and present-day politics, including UNFCCC climate negotiations, rests on the assumption that reality is constituted by linear relationships between material objects that are predictable in relationship, hierarchically arranged, and discretely observable and measurable [44,46]. This classical understanding of reality grew out of 18th and 19th century Western intellectual thought (e.g. Hobbes, Smith, Marx, and others) [44], and provides the philosophical roots of current political ideas and institutions, and their decision-making rules and processes. These institutions include forms of government understood through normative frames such as left and right, liberal or conservative, representative or authoritarian, etc. [38]. Institutions built on classical ideas may be understood as dualistic [47] or "simple systems" [40] and are the common denominator of virtually all guises of contemporary national or global politics. This arrangement presumes a governing authority can control reality or events through normative (and often ideological

channels) of silo'd policy-making, treaties, laws, markets, goal-setting and the other forms of top-down, reductionist direction-finding, problem-solving, or resource distribution strategies that define relationships, or social contracts, between the public, private, non-government, and government spheres [38,48,49].

The processes and stakeholders used to negotiate the Paris Agreement 1.5°C aim - states themselves through the UNFCCC - are methodological manifestations of this linear ontological reasoning [21], which works as follows:

> *A global climate agreement, founded on science, and negotiated by representatives acting for self-interested states, will mobilise society's actors to meet quantified mitigation targets to keep warming below a 1.5 – 2.0°C increase.*

Drawing on social complexity theorist Luhmann [51][1], Valentinov [52**] in a discussion of complexity ethics, describes this logic as the "goal-rationality" of "a system-complexity reduction strategy of settling upon a course of action…and picking out its desired effects." As such, it is indicative of a linear, reductionist ontological position at odds with the complexity-based understanding of reality. However, a complex system by its nature is irreducible and such reductionism excludes the prospect that the goal may be unachievable within the constraints of the system, requiring open-ended knowledge production and mobilisation methods that incorporate diverse actors and uncertainty [21,57].

COMPLEXITY ETHICS FOR A COMPLEX REALITY

Society's ethics, or system of moral communication, refers to the values and norms that govern communication in society and are created to solve the problems of the time through the dominant lenses and values of the time [58]. Changes in ethics, values and norms at a societal level happen slowly, either organically through reflection and change or necessity [55]. For example, when powerful state-interests combined with weapons of mass destruction made war a catastrophic danger, a venue of state dialogue – the United Nations - was created to avoid it [59]. The nuclear change in worldview that made direct great-power military conflict unpalatable to the world community was a marked shift from the societal and elite values that had led to war until 1945. Other examples of shifts in moral communication include the advent of inclusive LGTBQ marriage laws and, the end of apartheid and other forms of institutionalised discrimination as social perspectives and new knowledge transformed people's attitudes and institutions.

In the classical understanding of reality, moral communication is framed by ideas of "responsibility, respect, or contempt" mediated by "economy, law, and politics" held by self-interested actors (e.g. individuals, groups, businesses or states) [33,52]. This system of moral

[1] Luhmann's approach to complexity emphasises that social subsystems each perform their own differentiated and stratified roles, via communicative modes that drive the operation of the overall system [51]. While Luhmann features in Valentinov's complexity ethics [52], critics argue that his functionalist approach lacks a reconciliation of emergence and structure/agency/environment interactions [53,54]. The argument for polycentricism and facilitative methods in this paper is a deviation from Luhmann as it addresses social(-ecological) complexity through collective reflexivity and learning (e.g. [53,55,56]), opening a door to further theoretical development of complexity ethics.

communication reflects the classical, individualistic 'goal-rationalising' reductionist ontology described earlier, and is therefore potentially ontologically incompatible with complexity-based ontology and complexity-rooted problems like climate change [25,52]. This form of 'methodologically nationalist' [60] moral communication is used by states through the UNFCCC COP (Conference of the Parties) process to address climate change. It appears in the state-vs-state positioning and operational concepts such as Common but Differentiated Responsibility and Respective Capabilities (CBDR-RC) central to COP negotiations and the Paris Agreement. CBDR-RC distinguishes countries as more less more responsible for, able, and obligated to address climate change based on historical and contemporary development patterns and related national capacities, and greenhouse gas emissions levels [61*,62]. Here, poorer countries can maintain development pathways aimed at poverty and inequality reduction, while avoiding the constraints of more radical obligations to mitigate climate change [62]. Thus, the moral communication of the Paris Agreement, achieved by rigorous deliberative negotiation, values both the rights of states to develop and their relative capabilities to limit climate change to 1.5 or 2.0°C. However, given NDC shortfalls, it is far from clear whether this is an effective strategy to rapidly mitigate warming, which is directly dependent on rapid decarbonisation and contentiously on social equity and development [63]. Responsibility for mitigation under CBDR-RC is relegated to states to pursue through NDCs which, as mentioned, so far appear unlikely to meet Paris objectives.

At the same time, however, the Paris Agreement and UNFCCC are beginning to emphasise a more polycentric approach to climate governance [64] that aims to better incorporate the actions and capacities of non-state actors in global climate action [65*]. Local governments, businesses, financial institutions, charities, youth, Indigenous and grassroots groups, and private citizens engaging in climate action already act as part of the system and thus have an interest in mobilising their tremendous potential to address global warming [66–68]. The visible results from fossil fuel divestment initiatives and local governments, for example, demonstrate impactful, system-level, non-state international cooperation toward decarbonisation [69,70]. Yet, despite proactive formal efforts to include non-state stakeholders, their participation remains relegated to the classically structured "technical process of the UNFCCC" [65], under the authority of official state Parties. The facilitated Talanoa dialogue for introduced by the COP 23 Fijian presidency for 2018, is a step away from this classical approach, but remains a limited progress assessment toward Paris Agreement decarbonisation via NDCs, outside UNFCCC decision-making [71]. Thus, despite changes to incorporate non-state efforts in the UNFCCC, calls continue to be made for the more robust inclusion of non-state forces [72,73] in effective and democratically legitimate ways [65,74**].

Taking into account this state of affairs, complexity ethics, ontologically congruent with complexity science, repositions moral communication away from classical ideas of actor responsibility to the system-level, recognising the inherent dynamic relationality and uncertainty within complex systems [52,75]. Responsibility in complexity ethics cannot be reduced to individual or self-interested agents, as all individual agents are parts of the system, therefore co-dependent, as non-linearity and uncertainty means that disturbances or actor behaviour has the potential to impact any other actor in anticipated and unforeseen ways [52,75]. In this sense, system-level forms of moral communication are in-line with individual self-interest as there is both collective and individual benefit for maintaining system functions (i.e. it understands the ethics as an all-for-one-one-for-all "win-win" game) for different actors or entities [52]. As such, complexity ethics may provide a philosophical basis for more effectively mobilising the diversity of local and global actors for action on 1.5°C climate change.

HARNESSING DIVERSE LOCAL AND GLOBAL ACTORS

Complexity ethics' recognition of the system-level allows consideration and engagement with system actors other than states in climate action where these actors to take responsibility for each other as well themselves, mindful of the co-dependencies that a systems perspective reveals. The driving motivation behind these kinds of efforts is the need for a collective response to an unprecedented global problem irrespective of whether national governments consider meaningful climate action within state interests (with resulting shortfalls of NDCs) [76]. A complexity-based approach to 1.5°C climate change at the UNFCCC would expand current efforts (e.g. Talanoa), to incorporate non-state actors in the UNFCCC process toward a technical transformation that concentrates much less on the classical dualism of differentiated responsibility and takes advantage of the state of knowledge in collective multi-stakeholder action processes for climate adaptation.

The annual COP meetings use a highly structured procedural decision-making model. The UNFCCC document FCCC/CP/1996/2 contains the 59 rules detailing the linear, procedural vote-based method by which the international community reaches agreement on climate matters [77]. While it is consensus-based, consensus here refers to classical decision-making positions for COP deliberation adopted by national elites (via appointed negotiators), who may be from representative or autocratic states [78]. A weakness of this system is that it allows the self-interest of powerful governments or national elites to trump those of others, creating a 'tragedy of the commons' for the climate challenge [79]. A further weakness, yet potential opportunity, especially for the principle of complexity ethics, is that while this system incorporates non-state and sub-state actors, guidance for climate action (e.g. the 1.5°C, IPCC Assessment Reports) *still* flows hierarchically from state governments and international agreements to other non- or substate actors, to mixed effect [21,70,74]. Nonetheless, this movement toward polycentric climate governance [64] may reflect climate change as a stimulus for "new understandings of the nation and the state, and international and inter-urban cooperation" [60].

This set-up presents the odd situation of two slightly overlapping spheres of climate action, state-level and non-state, that are only indirectly reconciled in global climate decision-making [65,73]. However, it is only the state sphere that has the added dimension of directly including climate science through the IPCC report process and the significant capacity for coercive legal and practical direction and action that states embody [80]. For example, Second World War cooperation between states and the direct enlistment of non-state industry and society towards the war effort might be read as an effective rapid mobilisation of directed polycentric efforts toward a global crisis. Present efforts at integrating these the state and non-state forces toward climate action are unlike this wartime norm and remain fragmented and indirect as the UNFCCC recognises non-state actors through various fora outside formal action and commitment [71,73].

ADAPTIVELY TRANSFORMING UNFCCC PROCESSES FOR COMPLEXITY GOVERNANCE

As others have discussed, matching governance regimes to complexity-rooted problems or reality is difficult and may necessitate a view that government is an enabling or facilitative

body, rather than a controlling authority [25,38]. For the UNFCCC, the move to incorporate non-state actors is a noted shift from regulation to facilitation [65], but there are still calls for better approaches to climate decision and action with these actors [72,73]. A possible solution pathway is to structurally transform the UNFCCC into a facilitative "transformative boundary organisation" to harness knowledge, action, and stakeholder networks for action [21]. This approach would draw on the extensive science and practice of group decision and negotiation [81,82] and participatory adaptive capacity building and mainstreaming for climate change [83–88] to directly capture both complexity and non-state actors. These methods take different forms (e.g. facilitated stakeholder workshops, scenario planning, conflict resolution methods, online venues) and are wide-spread in the action research and practice communities [20,84,87,89,90]. These methods are congruent with complexity ethics in that they ontologically, epistemologically, and methodologically embrace social-ecological complexity, climate science and uncertainty, and social learning through stakeholder participation and learning processes [20]. Rooted in a complexity ontology (e.g. social-ecological systems thinking) they are the state-of-the-art for future-oriented decision-making for multiple stakeholders in environmental adaptation and management contexts [83–87]. Crucially, when applied to sustainability problems, the stakeholder cooperation inherent in these methods embraces emergence and nonlinear group dynamics to avoid the traps of classical or dualistic approaches and produce novel solutions, viewpoints, and opportunities through social learning that may reduce the danger of maladaptation [20,21,47,91–93]. However, while these methods prominently feature in climate change adaptive capacity building, their application occurs sectorally or locally outside of the classically-oriented state arena of the UNFCCC [20,84,87,89]. The cases described in this issue [19]** provide examples of the benefits of stakeholder-based participatory approaches to 1.5°C climate change in different contexts. As such, these methods offer a credible alternative to the classical UNFCCC decision-making process of climate change emissions reduction goals, self-interest dominated decision processes, and win-lose approaches.

By combining systems-level focus of complexity ethics and with the empirically well-established methodological knowledge of facilitated multi-stakeholder processes, an ontologically coherent vision emerges of a transformed global institutional process for climate action toward mitigation for both the 1.5°C aim and adaptation to high-end climate change. This moves away from the goal-oriented constraint of the 1.5 – 2.0°C aims, which leaves no contingency for missing this urgent objective[2]. Instead, crucially, scaling up facilitative adaptive capacity building methods to the global institutional level creates a process-oriented multi-stakeholder/sector global mechanism that: (1) accommodates much greater potential for action by, (2) directly incorporating the widest array of stakeholders who can then, (3) explore actions under the diverse range of climate scenarios. This is critically important as high-end climate change raises serious survivability and habitability questions for humanity that may existentially challenge the states whose governments are the dominant actors in global action to climate change [8–11]. Such a move would help breaking-down or bypass the (possibly obstructive) historical, geographical and political divisions, and knowledge barriers that define the current UNFCCC process.

Embracing participatory adaptive capacity building at the UNFCCC level may also meet calls for more effective collective action across state and non-state actors [65,74] in a way that

[2] Minimally, even an argument for goal-setting as an innovation toward sustainability (via the Sustainable Development Goals) also suggests it requires or ought to produce more flexible forms of governance [94].

accommodates scenarios for both meeting or exceeding 1.5°C warming 1.5°C, help to satisfy questions of democratic legitimacy [74], and compensate for state governments of reduced capability [61]. Moreover, it could offset the prospect of nationalist withdrawal from the Paris Agreement and other forms of global fragmentation [76,95], by introducing multiple channels of communication and action between a broader diversity of highly capable actors and their ideas. For example, the capacities of Elon Musk's organisations to supply energy needs at very large regional scales (South Australia, Puerto Rico) might overcome shortfalls in government in climate disadvantaged states.

However, applying a facilitative adaptive polycentric approach at the UNFCCC political level would likely require some experimentation in methods for that scale. Thi Hong Phuong et al. [20], in a systematic review of social learning and adaptive capacity scholarship may provide some ready insight into how to do this. They identify strengths and weakness between approaches toward social learning and adaptive capacity that are either hybrid or stress social learning or adaptive capacity. Focusing on applications to communities in high, and low/middle-income country blocs (i.e. COP members), Thi Hong Phuong et al. find hybrid approaches are particularly suited to creating,

> "'generative plurality': people with different backgrounds from different levels come together in a friendly environment where they respect each other and can reach a consensus with confidence about the co-created solutions for carrying out adaptation activities."[20]

Such a methodological guide applied at the UNFCCC/COP level (given structural inequalities between states) would build on the spirit of the Talanoa dialogue [71] to bring to action high-level calls for a "new culture of global cooperation, substantiated by mutual respect and support, to make the transformation towards sustainability a reality" involving state and non-state actors to meet Paris Agreement goals [96].

Thus, a complexity-based, participatory adaptive capacity oriented logic statement for a future UNFCCC climate agreement and action process might read as follows:

> *A global climate decision-making process directly incorporating state, substate, and non-state stakeholders, will co-create mitigative and adaptive responses to climate change under scientifically-informed scenarios of both meeting and exceeding 1.5°C warming in the near and long-term.*

Moreover, the open-ended nature of this approach also allows other issues, such as biodiversity loss and technological advances mentioned earlier, to factor into climate action. It at least seems possible to imagine an eclectic mix of scientists, civil servants, private and NGO sector actors, indigenous representatives, youth, and others gathered around real or figurative tables with flip-chart paper and markers sharing knowledge and insight to devise concrete actions around a range of climate mitigation and adaptation scenarios.

CONCLUSION

This paper has argued for a conceptual move from the classical ethical framework that guides the UNFCCC process toward a complexity ethics model that features a system-level focus on moral communication. Importantly, this would allow ethical considerations around climate

change to shift in step with an uncertain and changing complex ecological, social, and technological environment. Doing so brings the methods used for global climate action through the UNFCCC process into ontological alignment with the complexity-rooted understandings of reality now described across the sciences, humanities, and social sciences. To turn this conceptual frame to action, the use of facilitative methods and organisational procedures and structures for collective decision-making in a transformed UNFCCC process can more directly include non-state actors or stakeholders in impactful global climate action. This flexible approach, mindful of human needs and embracing participation, would help avoid the risk of ethical relativism and overcome power differentials. While it is beyond the scope of this paper to suggest the precise technical form of a transformed UNFCCC processes, the case for ontological congruence may provide a grounding for such measures. The stakeholder learning and action process (rather than goal) focus of facilitative methods, in turn, has the potential to increase the coordination of very rapid action for both 1.5°C and high-end scenarios. This is especially important as the adaptive capacity of some states may significantly or catastrophically weaken under +2.0°C climate scenarios, requiring a global 'plan B' for climate action.

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1. Zeebe RE, Ridgwell A, Zachos JC: **Anthropogenic carbon release rate unprecedented during the past 66 million years**. *Nat Geosci* 2016, **9**:325–329.

*2. Foster GL, Royer DL, Lunt DJ: **Future climate forcing potentially without precedent in the last 420 million years**. *Nat Commun* 2017, **8**:14845.
One of a number of studies appearing now that reinforce the significance of anthropogenic influences on the climate. Juxtaposed against bureaucratic processes like the, these kinds of studies reinforce the urgency of the challenge of effective action and the need to consider radical steps for effective societal responses.

3. United Nations: *Paris Agreement*. 2015.

4. United Nations: *The sustainable development goals report 2016*. United Nations; 2016.

5. UNEP: *The Emissions Gap Report 2016*. United Nations Environment Programme (UNEP); 2016.

6. Levin K, Fransen T: **INSIDER: Why Are INDC Studies Reaching Different Temperature Estimates? | World Resources Institute**. 2015,

7. UNFCCC: *Synthesis report on the aggregate effect of the intended nationally determined contributions*. Conference of the Parties 21; 2015.

8. Lelieveld J, Proestos Y, Hadjinicolaou P, Tanarhte M, Tyrlis E, Zittis G: **Strongly increasing heat extremes in the Middle East and North Africa (MENA) in the 21st century**. *Clim Change* 2016, **137**:245–260.

9. Pal JS, Eltahir EAB: **Future temperature in southwest Asia projected to exceed a threshold for human adaptability**. *Nat Clim Change* 2016, **6**:197–200.

10. Russo S, Sillmann J, Sterl A: **Humid heat waves at different warming levels**. *Sci Rep* 2017, **7**.

*11. Im E-S, Pal JS, Eltahir EAB: **Deadly heat waves projected in the densely populated agricultural regions of South Asia**. *Sci Adv* 2017, **3**.
One of a growing number of recent papers that raise the prospect of uninhabitable regions of the Earth given human physiology. The political implications of these kinds of findings have yet to be explored.

12. Jantz SM, Barker B, Brooks TM, Chini LP, Huang Q, Moore RM, Noel J, Hurtt GC: **Future habitat loss and extinctions driven by land-use change in biodiversity hotspots under four scenarios of climate-change mitigation: Future Habitat Loss and Extinctions**. *Conserv Biol* 2015, **29**:1122–1131.

13. Ceballos G, Ehrlich PR, Barnosky AD, García A, Pringle RM, Palmer TM: **Accelerated modern human–induced species losses: Entering the sixth mass extinction**. *Sci Adv* 2015, **1**.

14. Urban MC: **Accelerating extinction risk from climate change**. *Science* 2015, **348**:571.

*15. Ceballos G, Ehrlich PR, Dirzo R: **Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines**. *Proc Natl Acad Sci* 2017, **114**:E6089–E6096.
The most recent of two papers led by Ceballos that describe the scale, scope, and risk of biodiversity losses on Earth. This paper highlights the other massive environmental change occurring now that while related to climate change, largely results from human marine and land use.

16. Hall C, Dawson TP, Macdiarmid JI, Matthews RB, Smith P: **The impact of population growth and climate change on food security in Africa: looking ahead to 2050**. *Int J Agric Sustain* 2017, **15**:124–135.

17. Bostrom N: *Superintelligence: paths, dangers, strategies*. Oxford University Press; 2014.

18. Jordan A, Rayner T, Schroeder H, Adger N, Anderson K, Bows A, Quéré CL, Joshi M, Mander S, Vaughan N, et al.: **Going beyond two degrees? The risks and opportunities of alternative options**. *Clim Policy* 2013, **13**:751–769.

19. Fazey I, Carmen E, Chapin FSI, Ross H, Williams J, Lyon C, Connon IL, Searle BA, Knox K: **Community Resilience for a 1.5oC World. *Curr Opin Environ Sustain* In review.
This paper identifies a number key principles for community resilience. These principles are supported by several case studies of that use participatory methods, and support the main point of this paper regarding transforming the UNFCCC.

20. Thi Hong Phuong L, Biesbroek GR, Wals AEJ: **The interplay between social learning and adaptive capacity in climate change adaptation: A systematic review. *NJAS - Wagening J Life Sci* 2017, **82**:1–9.

This systematic review of the literature on adaptive capacity and social learning shows the relationship between and the effectiveness of these approaches in different contexts. A highly useful paper, it has implications for the kinds of methods used to build adaptive capacity, particularly at global scales.

21. Tàbara JD, St. Clair AL, Hermansen EAT: **Transforming communication and knowledge production processes to address high-end climate change. *Environ Sci Policy* 2017, **70**:31–37.
This paper addresses the social and political implications of high-end climate change. As the prospect of missing Paris Agreement goals grows, this body of research will become more important.

22. Hofweber T: **Logic and Ontology**. In *The Stanford Encyclopedia of Philosophy*. Edited by Zalta EN. 2014.

23. Welsh M: **Resilience and responsibility: governing uncertainty in a complex world**. *Geogr J* 2014, **180**:15–26.

24. Castellani B: **Map of the complexity sciences**. 2017,

25. Duit A, Galaz V, Eckerberg K, Ebbesson J: **Governance, complexity, and resilience**. *Gov Complex Resil* 2010, **20**:363–368.

26. Holling CS: **Resilience and stability of ecological systems**. *Annu Rev Ecol Syst* 1973, **4**:1–23.

27. Gunderson LH, Holling CS: *Panarchy: understanding transformations in human and natural systems*. Island Press; 2002.

28. Allen CR, Angeler DG, Garmestani AS, Gunderson LH, Holling CS: **Panarchy: Theory and Application**. *Ecosystems* 2014, **17**:578–589.

29. Buckley W, Schwendt D, Goldstein JA: **Society as a complex adaptive system.(Classic paper section)(Reprint)**. *Emergence Complex Organ* 2008, **10**:86(27).

30. De Landa M: *Assemblage theory*. Edinburgh University Press; 2016.

31. Bennett J: *Vibrant matter: a political ecology of things*. Duke University Press; 2010.

32. Latour B: *Reassembling the social : an introduction to actor-network-theory*. Oxford University Press; 2005.

33. Latour B: *An inquiry into modes of existence: an anthropology of the moderns*. Harvard University Press; 2013.

34. Braidotti R: **Posthuman, all too human: towards a new process ontology**. *Theory Cult Soc* 2006, **23**:197–208.

35. Johnson JT, Howitt R, Cajete G, Berkes F, Louis RP, Kliskey A: **Weaving Indigenous and sustainability sciences to diversify our methods**. *Sustain Sci* 2016, **11**:1–11.

36. Neumann R: *Making political ecology*. Hodder Arnold ;;Distributed in the United States of America by Oxford University Press; 2005.

37. Greenberg JB, Park TK: **Political ecology**. *J Polit Ecol* 1994, **1**:1–12.

38. Chandler D: *Resilience: the governance of complexity*. Routledge; 2014.

39. Ostrom E: *Governing the commons: the evolution of institutions for collective action*. Cambridge University Press; 1990.

40. Ostrom E: **Beyond markets and states: polycentric governance of complex economic systems**. *Am Econ Rev* 2010, **100**:641–672.

41. Whitehead AN: *Process and reality: an essay in cosmology*. Free Press; 1978.

42. Cobb JB: *Is it too late? a theology of ecology*. Environmental Ethics Books; 1995.

43. O'Brien KL: **Climate change and social transformations: is it time for a quantum leap?: Is it time for a quantum leap?** *Wiley Interdiscip Rev Clim Change* 2016, **7**:618–626.

44. Wendt A: *Quantum mind and social science: unifying physical and social ontology*. Cambridge University Press; 2015.

45. Barad KM: *Meeting the universe halfway: quantum physics and the entanglement of matter and meaning*. Duke University Press; 2007.

46. Chandler D: **Beyond neoliberalism: resilience, the new art of governing complexity**. *Resilience* 2014, **2**:47–63.

47. Tàbara JD, Pahl-Wostl C: **Sustainability learning in natural resource use and management**. *Ecol Soc* 2007, **12**:3.

48. O'Brien K, Hayward B, Berkes F: **Rethinking social contracts: Building resilience in a changing climate**. *Ecol Soc* 2009, **14**:12.

49. Adger WN, Quinn T, Lorenzoni I, Murphy C, Sweeney J: **Changing social contracts in climate-change adaptation**. *Nat Clim Change* 2013, **3**:330–333.

50. Luhmann N: *Zweckbegriff und Systemrationalität: über die Funktion von Zwecken in sozialen Systemen*. Suhrkamp; 1999.

51. Luhmann N: **Differentiation of society**. *Can J Sociol Can Sociol* 1977, **2**:29–53.

52. Valentinov V, Hielscher S, Pies I: **Emergence: A Systems Theory's Challenge to Ethics. *Syst Pract Action Res* 2016, **29**:597–610.
Together with [69], this paper is one of the few sources addressing the idea of ethics in complexity-approaches. As such, it addresses a key oversight given the widespread uptake of complexity science.

53. Hatt K: **Considering complexity: toward a strategy for non-linear analysis**. *Can J Sociol* 2009, **34**:313–348.

54. Elder-Vass D: **Luhmann and Emergentism: Competing Paradigms for Social Systems Theory?** *Philos Soc Sci* 2007, **37**:408–432.

55. Archer M: *Realist social theory: the morphogenetic approach*. Cambridge University Press; 1995.

56. Trosper RL: **Emergence unites ecology and society**. *Ecol Soc* 2005, **10**:14.

57. Nowotny H: *The cunning of uncertainty*. Polity; 2016.

58. Tronto JC: *Moral boundaries: a political argument for an ethic of care*. Routledge; 1993.

59. Dyer G: *War*. Vintage Canada; 2005.

60. Beck U: **Emancipatory catastrophism: What does it mean to climate change and risk society?** *Curr Sociol* 2014, **63**:75–88.

*61. Klinsky S, Waskow D, Northrop E, Bevins W: **Operationalizing equity and supporting ambition: identifying a more robust approach to 'respective capabilities.'** *Clim Dev* 2017, **9**:287–297.
This climate justice focused paper advocates a shift of from responsibility for climate change to the relative capabilities of states in human development, resilience, economics, governance, and technology and innovation. As such it reflects a creative alternative to some of the main sticking points for climate action between states.

62. Rajamani L: **Ambition and differentiation in the 2015 paris agreement: interpretative possibilities and underlying politics**. *Int Comp Law Q* 2016, **65**:493–514.

63. Klinsky S, Roberts T, Huq S, Okereke C, Newell P, Dauvergne P, O'Brien K, Schroeder H, Tschakert P, Clapp J, et al.: **Why equity is fundamental in climate change policy research**. *Glob Environ Change* 2016, doi:10.1016/j.gloenvcha.2016.08.002.

64. Jordan AJ, Huitema D, Hilden M, van Asselt H, Rayner TJ, Schoenefeld JJ, Tosun J, Forster J, Boasson EL: **Emergence of polycentric climate governance and its future prospects**. *Nat Clim Change* 2015, **5**:977–982.

*65. Hale T: **"All Hands on Deck": The Paris Agreement and Nonstate Climate Action**. *Glob Environ Polit* 2016, **16**:12–22.
This paper explores the inclusion non-state actors in the Paris Agreement. This paper highlights key questions this raises for the climate governance.

66. Chan S, Falkner R, Goldberg M, van Asselt H: **Effective and geographically balanced? An output-based assessment of non-state climate actions**. *Clim Policy* 2016, doi:10.1080/14693062.2016.1248343.

67. Hsu A, Moffat AS, Weinfurter AJ, Schwartz JD: **Towards a new climate diplomacy**. *Nat Clim Change* 2015, **5**:501–503.

68. Chan S, van Asselt H, Hale T, Abbott KW, Beisheim M, Hoffmann M, Guy B, Höhne N, Hsu A, Pattberg P, et al.: **Reinvigorating International Climate Policy: A**

Comprehensive Framework for Effective Nonstate Action. *Glob Policy* 2015, **6**:466–473.

69. C40 Climate Cities Leadership Group: **C40 Cities**. 2017, http://www.c40.org/cities.

70. Ayling J, Gunningham N: **Non-state governance and climate policy: the fossil fuel divestment movement**. *Clim Policy* 2017, **17**:131–149.

71. Conference of the Parties: **Proposal by the President Draft Decision 1/CP.23 Fiji Momentum for Implementation [FCCC/CP/2017/L.13]**. 2017,

72. Hulme M: **1.5°C and climate research after the Paris Agreement**. *Nat Clim Change* 2016, **6**:222–224.

73. Chan S, Brandi C, Bauer S: **Aligning transnational climate action with international climate governance: The road from paris**. *Rev Eur Comp Int Environ Law* 2016, **25**:238–247.

74. Bäckstrand K, Kuyper JW: **The democratic legitimacy of orchestration: the UNFCCC, non-state actors, and transnational climate governance. *Environ Polit* 2017, **26**:764–788.
This paper is an key early attempt to critically analyse the means by which the UNFCCC's more polycentric approach to climate governance currently functions. It assesses the democratic legitimacy of the UNFCCC's 'orchestration' of its non-state initiatives, the high-level Lima-Paris Action Agenda (LPAA) and bottom-up oriented Non-state Actor Zone for Climate Action (NAZCA), using the criteria of participation, deliberation, accountability, and transparency. LPAA is found to suffer an accountabiity deficit, and NAZCA to be poorly democratic on all fronts.

75. Woermann M: *On the (im)possibility of business ethics: critical complexity, deconstruction, and implications for understanding the ethics of business*. Springer; 2013.

76. Kemp L: **US-proofing the Paris Climate Agreement**. *Clim Policy* 2017, **17**:86–101.

77. UNFCCC: **Draft rules of procedure of the conference of the parties and its subsidiary bodies [FCCC/CP/1996/2]**. 1996.

78. Fishkin JS: *When the people speak: deliberative democracy and public consultation*. Oxford University Press; 2009.

79. Hardin G: **The tragedy of the commons**. *Science* 1968, **162**:1243–1248.

80. IPCC: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]*. IPCC; 2014.

81. Bajwa D, Koeszegi ST, Vetschera R (Eds): *Group Decision and Negotiation. Theory, Empirical Evidence, and Application*. Springer International Publishing; 2017.

82. Gerrits L, Marks P: *Understanding collective decision making: a fitness landscape model approach*. Elgar; 2017.

83. Rawluk A, Godber A: **Widening the scope of scenario planning in small communities: A case study use of an altnernative method**. *Ecol Soc* 2011, **16**:11.

84. Tschakert P, Dietrich K, Tamminga K, Prins E, Shaffer J, Liwenga E, Asiedu A: **Learning and envisioning under climatic uncertainty: an African experience**. *Environ Plan A* 2014, **46**:1049–1067.

85. Papamichail KN, Alves G, French S, Yang JB, Snowdon R: **Facilitation practices in decision workshops**. *J Oper Res Soc* 2007, **58**:614–632.

86. Yearworth M, White L: **Demystifying facilitation: A new approach to investigating the role of facilitation in group decision support processes**. In *Group Decision and Negotiation. Theory, Empirical Evidence, and Application: 16th International Conference, GDN 2016, Bellingham, WA, USA, June 20-24, 2016, Revised Selected Papers*. Edited by Bajwa D, Koeszegi ST, Vetschera R. Springer International Publishing; 2017:69–86.

87. Raymond CM, Cleary J: **A tool and process that facilitate community capacity building and social learning for natural resource management**. *Ecol Soc* 2013, **18**.

88. Runhaar H, Wilk B, Persson Å, Uittenbroek C, Wamsler C: **Mainstreaming climate adaptation: taking stock about "what works" from empirical research worldwide**. *Reg Environ Change* 2017, doi:10.1007/s10113-017-1259-5.

89. Kok K, van Vliet M, Bärlund I, Dubel A, Sendzimir J: **Combining participative backcasting and exploratory scenario development: Experiences from the SCENES project**. *Backcasting Sustain* 2011, **78**:835–851.

90. Chambers R: *Participatory workshops: a sourcebook of 21 sets of ideas and activities*. Earthscan Publications; 2002.

91. Petersen I, Kruss G, Gastrow M, Nalivata PC: **Innovation Capacity-Building and Inclusive Development in Informal Settings: A Comparative Analysis of two Interactive Learning Spaces in South Africa and Malawi**. *J Int Dev* 2016, doi:10.1002/jid.3232.

92. Brown K, Naylor L, Quinn T: **Making Space for Proactive Adaptation of Rapidly Changing Coasts: A Windows of Opportunity Approach**. *Sustainability* 2017, **9**:1408.

93. Ziervogel G, Cowen A, Ziniades J: **Moving from adaptive to transformative capacity: Building foundations for inclusive, thriving, and regenerative urban settlements**. *Sustainability* 2016, **8**:955.

94. Biermann F, Kanie N, Kim RE: **Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals**. *Curr Opin Environ Sustain* 2017, **26–27**:26–31.

95. Hale T, Held D (Eds): *Beyond gridlock*. Polity Press; 2017.

96. German Development Institute, International Institute for Applied Systems Analysis, COP 23: **Crossroads Conference Bonn 2017 (DIE / IIASA)**. *Crossroadsbonn.org* 2017.