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Perspective

Embedding justice in the 1.5°C transition: A transdisciplinary research agenda

Jennifer Cronin[1,*], Nick Hughes[1,*], Julia Tomei[1], Lilia Caiado Couto[1], Muez Ali[2], Vivien Kizilcec[3], Ayo Adewole[2], Iwona Bisaga[3,4], Oliver Broad[1], Priti Parikh[3], Elusiyan Eludoyin[2], Leonhard Hofbauer[2], Pedro Gerber Machado[5], Isabela Butnar[1], Gabrial Anandarajah[2], Jeremy Webb[6], Xavier Lemaire[2], Jim Watson[1]

[1] UCL Institute for Sustainable Resources, University College London, Upper Woburn Place, London WC1H 0NN, UK
[2] UCL Energy Institute, University College London, Upper Woburn Place, London WC1H 0NN, UK
[3] Engineering for International Development Centre, UCL Civil, Environmental and Geomatic Engineering Department, University College London, Chadwick Building, London, WC1E 6BT, UK
[4] Geography and Environment, Loughborough University, Loughborough, LE11 3TU, UK
[5] Instituto de Energia e Ambiente, Universidade de São Paulo, Av. Prof. Luciano Gualberto, 1289, São Paulo - SP, 05508-010, Brazil
[6] UCL Department of Science, Technology, Engineering & Public Policy, University College London, Shropshire House, 11-20 Caper Street, London WC1E 6JA, UK

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ABSTRACT

Limiting global temperature rise to 1.5°C requires transformations in every aspect of our societies and economies. In contrast to 2°C pathways, the 1.5°C target requires even deeper and faster cuts in emissions. While this will bring enormous collective benefits, mitigation action also risks significant disruptions and losses to some groups. In this Perspective, we set out the justice implications of 1.5°C-consistent modelled pathways, focusing on fossil fuel extraction, critical resources, economic impacts and human needs. This leads to the identification of three cross-cutting characteristics of just transitions to 1.5°C-consistent pathways: the inherently politicised nature of transitions; the need to integrate multiple perspectives; and the challenges they present to values and assumptions. We propose a research agenda which recommends ways in which research must be interdisciplinary, integrative of diverse actors and perspectives, and able to robustly test and explore radical ideas if researchers are to rise to the challenge of delivering just transitions to 1.5°C.

Introduction

In order to limit the global temperature increase to "well below 2°C", global CO_2 emissions must be "net zero" by 2050 [1]. This rapid decarbonisation must be achieved while countries strive for a fast recovery from the COVID-19 pandemic and to deliver the Sustainable Development Goals (SDGs) by 2030. Failure to address climate change will make most of the SDGs harder to achieve [2]. Thus, strong action on climate change is of fundamental importance for the sustainable development agenda and redressing global injustices.

However, some actions to address climate change also risk exacerbating injustices themselves and therefore also pose risks to sustainable development [2]. These are associated with the right to develop, resource sovereignty, food security and livelihoods [3]. Overlooking these risks could create resistance to climate action. In contrast, employing justice as an orienting principle could increase the political feasibility and public acceptance of low-carbon transitions [4]. Just as addressing climate change is a prerequisite for redressing global injustice, delivering climate action in an equitable and just way is a prerequisite for the success of the transition.

Concepts of justice are much discussed and interrogated in academic literature and mean different things to different people in practice. In this paper, we emphasise that both distributional and procedural justice are crucial for a successful 1.5°C transition. By this we mean there must be an equitable distribution of the benefits and burdens of the transition, which could be based on principles such as equality, equity or need, and also the use of fair and inclusive processes.

Global attention is now increasingly focussed on the target to limit the global temperature rise to 1.5°C. Achieving this goal would have benefits for justice through reduced climate impacts compared to 2°C. However, the urgency and stringency of this more ambitious target could create even greater strains to principles of justice than previously foreseen. The justice implications of rapid climate mitigation have been widely discussed (e.g.[5]), however the increased urgency and all-

* Corresponding authors.
E-mail addresses: jennifer.cronin.15@ucl.ac.uk (J. Cronin), nicholas.hughes@ucl.ac.uk (N. Hughes).

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encompassing nature of the 1.5°C transition requires a fresh and comprehensive examination of the risks, and a proposal for how research can now best contribute.

This Perspective is the result of a collaborative effort by members of the UCL-based Energy and Development Group, which contains members from diverse academic disciplines and backgrounds. In order to elucidate the justice implications of climate mitigation consistent with 1.5°C, the group held a workshop to map the justice issues associated with the scenarios produced by the global models, then proceeded with several stages of discussion, drafting and reflection. From this work, four themes emerged as having particularly strong implications for justice: the more rapid reduction of fossil fuel production; the more rapid increase of other resource extraction; the risk of a rapid transition simply replicating the current uneven distributions of economic wealth; and the fact that the urgency could be seen to justify a top-down technocratic approach which could overlook basic human needs.

Here we describe the particular challenges to justice that could be associated with the global effort aiming for 1.5°C and examine implications for research. We argue that research concerned with enabling a just transition must be transdisciplinary, by which we mean interdisciplinary and integrative, and able to engage rigorously with radical ideas. Based on these principles, we suggest a set of specific items for a 1.5°C research agenda, upon which we hope others will build and expand. We propose this research agenda for the broad academic community, including those who have not yet extensively engaged with the politics of just transitions, as well as by those that commission, fund, engage with or consume research.

What 1.5°C means: urgency in the face of persistent and numerous inequalities

Integrated assessment models (IAMs) provide quantified insights into the transformations of technologies, behaviours and resource-use that would be consistent with limiting the global temperature rise. Compared with modelled 2°C-consistent pathways, 1.5°C pathways require earlier emissions reductions across all sectors, faster roll-out of low carbon energy, a greater role for energy demand-reduction and a greater role for negative emissions technologies, including land-based CO_2 removal [1]. Whereas in 2°C pathways, there is some leeway for low and middle-income countries (LMICs) to continue for longer with a fossil fuel-led development model before decarbonising, 1.5°C pathways 'require fast action across all countries at all levels of development' [6].

But this call for fast action 'across all countries' is taking place in a highly uneven ethical context. Some countries have benefited substantially from the exploitation of fossil fuels, while others have little historic responsibility for emissions. Many of those with least historic responsibility are experiencing the worst climate impacts and still have substantial development needs. The land-based carbon sinks and natural resources that are critical to the transition are unevenly distributed between regions and communities. The potential social and economic benefits and burdens of low carbon transitions are likely to fall unevenly.

In the following sections we discuss four areas in which 1.5°C-consistent modelled pathways have particularly significant implications for justice, and in which careful negotiation, cooperation and understanding between various actors are required.

Fossil fuel extraction

While the availability of carbon capture and storage and the potential role of natural gas as a bridging technology remain uncertain, the stringent carbon budget for the 1.5°C target clearly requires a rapid reduction in the production and use of fossil fuels [1].

Countries might choose to avoid producing fossil fuels for several reasons. For example, fossil fuel-led development has been associated with structural inequalities, corruption and unequal distribution of revenues among populations [7–9], meaning that resource extraction is often not translated into improved wellbeing for the majority. In financial terms, as the cost of low carbon technologies fall, they are becoming increasingly good investments compared to fossil fuel portfolios [10]. Efforts such as divestment campaigns, the fossil fuel non-proliferation treaty [11], and the Lofoten Declaration aim to build further consensus on leaving fossil fuels in the ground.

However, many developing countries are dependent on fossil fuel production for state revenue and foreign exchange earnings. For example, approximately 30% of the Malaysian government's revenue is petroleum-related [12] and Mozambique expects to gain seven times the country's GDP over 25 years from newly discovered natural gas reserves [13]. Such earnings may be particularly vital as countries seek to recover from the economic impacts of the COVID-19 pandemic. There are therefore tensions between the need for rapid fossil fuel decline, and the economic strategies of some fossil fuel producing states.

Centring justice in the debate around the remaining carbon budget, it has been proposed that the rights to exploit the remaining fossil fuels could be allocated based on relative circumstances of the producing countries – for example, their need for development [14,15]. However, if the world as a whole is successful in reducing demand for fossil fuels in line with 1.5°C consistent pathways, a country investing in fossil fuel infrastructure would be selling into a rapidly declining market, creating a risk of stranded assets [15].

Direct compensation for foregone revenues from avoided fossil fuel development could be a way of addressing development needs and incentivising alternative development paths. However, attempts at mobilising international finance in this way have so far met with limited success, an example being the Yasuní-ITT Initiative in Ecuador [16]. Furthermore, in addition to the techno-economic challenges of assessing forgone profits, establishing a right to claim reimbursement for not undertaking activities that are lucrative in the short-term, but damaging in the longer term or in other geographies, could set an undesirable precedent. Global commitments that imply restrictions of fossil fuels will at some point run into conflict with the principle of national sovereignty, which includes the right to develop, and to economic freedom without interference [17].

Enabling a rapid transition away from fossil fuels while respecting the right to develop requires an understanding of foregone economic opportunities in specific local contexts. In view of development needs, low carbon development pathways must also help provide the balance of foreign exchange, domestic revenue and employment generation that are among the attractions of fossil fuel industries [18].

Critical resources

1.5°C-consistent pathways imply dramatic increases in demand for land and certain minerals. The geographic distribution of these critical resources and the urgency with which 1.5°C demands their scale-up creates new, or exacerbated, governance challenges.

Land is likely to come under strongly increasing pressure. The protection of standing forests is critical for carbon sequestration, and the many other ecosystem services and wellbeing benefits they provide. However, the land implications of the bioenergy used in 1.5°C-consistent scenarios are potentially huge – estimated as up to 700Mha by 2050 [1], which is equivalent to approximately 45% of current global cropland. Substantial areas of land are also needed for reforestation and afforestation to achieve further land-based carbon dioxide removal. Large-scale deployment of wind, solar and hydropower will also have significant impacts on land use and water.

Modelled 1.5°C-consistent pathways also imply a large increase in demand for the minerals required for technologies such as solar PV panels, wind turbines and batteries, which are key to the low carbon transition [19]. The extraction of minerals such as cobalt, copper and lithium has significant and sometimes irrevocable impacts on the land from which they are mined, and in some regions extraction has been linked to violence, conflict and human rights abuses [20]. These re-

sources are unevenly distributed geographically, with large portions of the world's reserves in LMICs [21], subject to global demands. Their extraction and use could therefore give rise to significant inequalities and governance challenges, as international financial flows and global agreements overlap with claims to resources at national or local level. Driven by perceived land availability, the lower price of land, and higher carbon sequestration rates in tropical forests [22], transnational offsetting schemes will likely encourage funding of afforestation or other land-based mitigation projects by higher income countries in lower income countries. Such schemes risk driving large-scale land acquisitions, which overlook local rights and needs, bringing negative local economic, social and environmental impacts and a failure to recognise procedural justice or deliver sustainable development [23,24]. The involvement of international actors in land acquisitions could present a new form of 'carbon colonialism' [25]. Strong institutional commitment and engagement of local communities are important prerequisites for mitigating such risks [26].

As demand for critical resources rapidly intensifies, it is vital that both distributive and procedural justice are embedded in the governance of access to these resources and the land that hosts them. Through deep interconnections with land, resources are subject to differing claims of ownership and rights to use, exploit or protect. Such claims can be made by actors at various levels, from local communities, indigenous tribes, regions, nation states or the global community. Each group may be operating under different value systems and conceptions of rights to own or use land and resources, with outcomes affected by the distribution and exercise of power. This makes managing these critical resources in a just 1.5°C-consistent transition a complex challenge in which multiple types of sovereignty intersect and the claims of actors at a variety of levels must be negotiated.

The distribution of economic gains and losses

The rapid pace of technological roll-out required for 1.5°C consistent pathways will create economic opportunities for some but losses for others.

Most obviously, potential 'losers' from the transition are workers employed in fossil fuel industries which must be radically down-scaled, creating substantial risks of stranded assets, workers and communities [27,28]. Job losses will be compensated to some extent by growth in renewables and low carbon industries [29], and there is evidence that renewable power plants can have higher employment factors than fossil-based ones [30]. However, the new green jobs may not be in the same location as those lost from carbon-intensive industries. Such spatial disparities may be addressed by strategic action with national policies. For example, locating a new battery factory in a coal-mining region [31] or undertaking retraining or compensation for laid-off workers [27].

Existing international disparities in capacity and knowledge could result in the global distribution of the economic costs and benefits of decarbonisation maintaining current regional inequalities. For example, PV manufacturing in India faces strong competition from China due to the lower manufacturing costs and is further hindered by low import tariffs [32]. A solar industry may have more potential to develop in South-East Asia than in Sub-Saharan Africa because of regional differences in existing infrastructure, capacity for innovation and technological development, human capital and financial resources [33,34]. If such differences persist, many countries are likely to continue to adopt new technologies developed elsewhere, rather than capturing the benefits from developing their own domestic industries.

While global supply chains can reduce costs, more localised supply chains could have greater in-country benefits, as the COVID-19 pandemic has highlighted, with some renewable energy projects stalled due to supply chain disruptions [35]. Ensuring that the economic benefits of 1.5°C-consistent transitions are shared equitably will require well-functioning institutions, supportive financial instruments and policy, and regulatory reform at multiple scales [36,37]. For example, falling costs of power sector renewables and the risk of locking in to fossil fuel infrastructure are challenging the assumption that decarbonisation is an economic burden [35,36]. Nonetheless, in LMICs high cost of capital can restrict the potential to benefit fully from these cost reductions, especially for small scale actors.

Justice and ethics have relevance for technology transfer. Advancing technology development in LMICs requires policies for the transfer of both hardware and knowledge. This means access to intellectual property rights and manufacturing plants, transfer of knowledge, skills and expertise in a sustained process of capacity development so that recipient countries and companies are able to maintain, improve and innovate independently [38].

Focusing climate-compatible development on human needs

There are currently huge inequalities in how human needs are met across the world [39,40]. Although there are clear synergies between addressing climate change and meeting human needs as envisaged by the SDGs [2], the fast decision-making that is now required to put the world on a 1.5°C-consistent pathway risks exacerbating existing inequalities and overlooking the needs of marginalised communities.

Human needs encompass access to materials and services, such as food and clean water, energy access, secure livelihoods, mobility, healthcare and education. Needs can be absolute, i.e. essential to survival, or socially constructed, and are geographically diverse. They are an ever-shifting target as once basic needs are met, the goal then becomes to meet higher-order needs [41].

The rapid phase-out of fossil fuels could create direct challenges to meeting human needs. For example, low carbon options for transport are limited in many LMICs, and may be less affordable. Several programmes recommend LPG for cooking due to its health benefits for domestic users, despite its carbon emissions [42]. While quickly phasing out fossil fuels is consistent with climate targets, substantial material support is needed (regarding technology development and transfer, as well as finance) to ensure that human needs and key development objectives can be met without fossil fuels.

Energy efficiency measures can offer synergies with tackling energy poverty. Centring the issue of energy poverty could foster greater political and public buy-in for energy efficiency measures. Policy choices to promote and subsidise fast decarbonisation must consider fairness and affordability for different groups. Choosing to meet costs of energy decarbonisation through fuel subsidy reform, local or national level taxes, or as part of household bills would each have different distributional impacts [43].

The likelihood of IAMs solving for 1.5°C is significantly increased under low energy demand scenarios [1]. This raises the questions of whether the high consumption lifestyles of the richest can be maintained in a just 1.5°C future [44], and of the relationships between economic growth, wellbeing and environmental impact [45,46]. Some argue that even if lower consumption or degrowth are needed, calling for either is so unpalatable to key groups that it in fact makes climate mitigation harder to achieve. Approaches such as Raworth's doughnut economics [47] may provide frameworks for envisaging how to meet human needs, while staying within the bounds of environmental sustainability.

Clearly, for household-level low carbon solutions to be successful, the technologies and required behaviour changes must be convenient and compatible with cultural values. It is therefore critical that all voices are included in decision-making. Supporting just 1.5°C transitions means recognising the diverse and dynamic nature of human needs, setting them centre stage, and operationalising existing frameworks to turn them into meaningful tools for practitioners and policymakers on the ground.

Implications for research

Previous sections have set out the key justice implications of transitions to 1.5˚C. Drawing on this, we identify three important characteristics of a research agenda for a just 1.5˚C-consistent transition. We argue that this transition involves complex political and ethical issues, a wide range of actors with different perspectives, and challenges to values and assumptions. Accordingly, a research agenda for embedding justice in the 1.5˚C transition should be interdisciplinary and integrative (i.e. transdisciplinary) and able to engage rigorously with radical ideas. This framework is complementary to that which emerged from Winskel et al.'s [48] discussion of whole systems energy research. Here, we explore how this framework arises from the justice implications of 1.5˚C transitions and make initial suggestions for the research agenda that could be built within it.

A complex and politicised context calls for interdisciplinary research

The 1.5˚C-consistent pathways described by IAMs have major political, ethical and cultural implications. The rapid phase-out of fossil fuels is intertwined with politics and power, just as their historic development was [49,50]. Increasing competition for land and the scaled-up extraction of other critical resources also present challenges for multi-level governance and sovereignty. The distribution of the economic costs and benefits of the transition are politicised within the contexts of trade, competitiveness, and intellectual property. All of this is taking place in the context of highly uneven human needs, historic responsibility for climate change, and capacity to adapt.

There will of course remain a crucial role for specialised single discipline research. However, improved interdisciplinary research, which draws on not only technology and economics, but also politics, ethics, psychology and other disciplines, is therefore essential to embedding justice in the 1.5˚C transition. This means researchers from different disciplines informing and challenging each other at multiple stages throughout the research process, beginning from the research design stage.

Interdisciplinary collaboration could usefully analyse the choice of modelling approaches and assumptions that have significant justice implications, for example whether to focus on cost-optimal pathways or to emphasise alternative ethical distributive principles [15], or the implications of discount rates on the balance between near-term and long-term carbon mitigation [51]. The implications of global modelled pathways on country-level development prospects, politics and governance could be analysed in collaboration with country-specific experts. Insights may be fed back into modelling iterations, thereby increasing the richness and policy-relevance of the output.

Beyond quantitative modelling, interdisciplinary approaches are needed to examine the remaining role for fossil fuels in development pathways, the importance of power dynamics and institutional capacities in negotiating fair deals for the use of sovereign resources, the institutional barriers preventing the roll out of renewables in some countries.

Greater consideration of the intersections and parallels between the 1.5˚C transition and historic resource extraction and forms of injustice or exploitation could contribute to forging transformative ethical frameworks that are needed for addressing broader intergenerational injustices. Furthermore, insights from behavioural science are needed regarding cognitive and social barriers to action, and concepts from social psychology, such as denial, disavowal and solution aversion may help to illuminate the many complex reasons why decision-makers at all levels fail to act on climate change, in order that they can be overcome.

Multiple perspectives demand integrative research

Nation states are key actors in climate negotiations. However, exploring the justice implications of 1.5˚C has also brought numerous non-state actors into focus [52]. These include small and large-scale private companies and entrepreneurs, NGOs, cities and regional governments, and land users including traditional or indigenous communities [53].

These non-state actors are relevant to climate negotiations because many of them affect national positions. They are also capable of taking action in their own right, as shown by numerous non-state actor coalitions which are progressing climate action and, in many cases, ahead of the positions of their respective national governments [54,55].

Whilst accounting for multiple actors and perspectives may add complexity to an already complex and urgent transition, it is an essential prerequisite for success. Climate change policies have often been designed by and for the privileged, excluding vulnerable and marginalised segments of society [56]. There is a risk of injustices to vulnerable groups if they are unable to influence the design of policies that affect them. In contrast, applying the principle of procedural justice with a focus on human needs could help ensure the success of ambitious emissions mitigation action.

Accordingly, research needs to be integrative of different voices and perspectives including those that are under-represented in academic work. Co-creation of research with policy makers increases its relevance to current policy concerns and its tractability within the policy process. But integrative research should also involve engaging in public forums beyond those typical of the academic discourse. This could include deliberative scenario development, Citizens' Assemblies [57] and other participatory approaches that help create legitimacy [58], and transform passive recipients of technology into active participants with vital knowledge and skills [59]. Such integrative forms of research may be further enhanced by proactive identification and engagement with less powerful voices, which are often overlooked in public discourse. Consideration of modes of communication and forms of inclusive language should be crucial considerations for integrative research.

Integrative academic research should aim to understand the perspectives and priorities of different actor groups, contextualised by an appreciation of whole system context, and of contrasting perspectives of other actors. This kind of critical engagement at multiple levels could help to identify synergies and strategies for removing obstacles to progress that the actors themselves may find hard to perceive.

Challenges to values and assumptions require research that is able to process radical thinking

Through engagement with multiple actors in integrative research, researchers will inevitably encounter multiple and contrasting value systems. By understanding the value systems that underlie various perspectives, researchers can make constructive contributions to political dialogue.

A part of this is understanding that value systems can be challenged, reformed or even overthrown. A 1.5˚C-consistent transition will involve transformation and challenge to values and basic assumptions about the world and how we engage with it. For example, 1.5˚C modelled scenarios are technically extremely challenging, but scenarios based on assumptions of low energy and resource demand have a greater chance of success, while high inequality is an impediment [1]. Radical lifestyle shifts to reduce the energy and resource demands of the affluent might enable human needs to be met more equitably across the world within the stringent 1.5˚C carbon budget. This means that engaging with and rigorously testing value systems radically different from those to which we are culturally habituated is no longer a fringe or niche activity, but must be central to how we address the 1.5˚C challenge. Relatedly, demands of activists for extremely rapid decarbonisation are radical but do have moral force.

As researchers contemplate the need to engage seriously with radical ideas from all sections of society, it is worth reflecting that 'radical' is not a fixed concept. Radical transformations in technological systems have been known to occur with rapidity [60] and ideas such as gender and social equality, and environmental protection itself, once perceived as

radical, are now mainstream. Awareness of such historical context may help academic research to approach seemingly radical ideas with critical rigour, but also without value judgement or prejudice with regard to public acceptance or feasibility. Without compromising on principles of evidence and rigour, academic research can engage seriously with such proposals, including identifying major trade-offs, practical engineering or logistical challenges, as well as the actions and knowledge required to bring them about.

Interdisciplinary, integrative and radical

These three principles are independent but are far from being mutually exclusive. In addition to specialised single-discipline research, and dedicated integrative or interdisciplinary research, we argue that research that applies all three of the principles outlined will provide vital contributions to this urgent agenda.

The table illustrates how the three principles are relevant to three examples of research topics which arise from the themes presented in the paper. The examples aim to inspire application of the principles to many further topics.

Topic	Challenge	Interdisciplinary	Integrative	Radical
PV	PV is a crucial decarbonisation technology in 1.5C-consistent scenarios. This requires continued rapid roll-out.	Although costs have fallen, deployment still depends on access to finance, including for small-scale actors, supply chains and institutional frameworks, calling for multiple, complementary forms of analysis.	The multi-scale applicability of PV could see actors at numerous scales, including small-scale and local, being key to distributed roll out, and decentralised wealth creation; need for coordination and integration with national-scale grid expansion plans and financing.	There is a huge potential for distributed wealth creation, but also a possibility for wealth to be concentrated with large scale technology developers. Ethical technology transfer could be a radical redistributive solution.
Electric Vehicles (EVs)	The transport sector must be zero carbon by 2050 and EVs appear to be critical to this. But EVs are currently more expensive than Internal Combustion Engines, and there are considerable inequalities in access to transport, and exposure to its negative impacts.	Drawing on analysis of health impacts to assess global air pollution inequalities, to reconsider the justice of cost optimal technology diffusion scenarios. Investigation of socioeconomic impacts of extraction of minerals in specific countries with e.g. lithium reserves.	Inclusion of the perspectives of those most affected by vehicle pollution, i.e. those living and working in pollution hotspots. Inclusion of multiple perspectives of those with interest in or connection to land and resources affected by mineral mining.	Exploring alternatives to purely market-led technological diffusion, in which affluent consumers are first adopters – instead, ethical technology transfer focussing on those most exposed to transport's negative externalities. Challenging the need for technological substitution, instead considering radical demand reduction, including through urban re-design and lifestyle change.
Bioenergy	A large uptake of bioenergy crops is indicated in modelled 1.5°C pathways. Potential expansion of international biomass trade and assumed reliance on marginal land poses risks of land acquisitions as well as to livelihoods and land rights.	Insights from multi-scale techno-economic and social modelling should be integrated, along with social research to: i) check the compatibility of land use projections; ii) examine local impacts on agriculture and land access; and iii) explore how national policy and international actors can align to protect rights.	Voices of farmers and indigenous people must be included to assess and ensure social sustainability, and support equitable land governance.	Acknowledge the multiple interests/claims on resources. Consider how forms of polycentric governance can improve fair distribution / representation, and facilitate high levels of bioenergy scale-up while ensuring environmental sustainability, human rights, and multiple types of land sovereignty are respected.

Conclusions

Limiting the global temperature rise to 1.5°C is essential for justice, and the equitable meeting of human needs. However, some actions required to bring about a 1.5-consistent pathway entail their own risks to justice, which, if not addressed, could exacerbate existing problems and impede chances of meeting the SDGs. In turn, this is likely to reduce support for climate action and threaten the achievability of the 1.5°C target. Distributive justice demands a fair sharing out of both the burdens and benefits of the transition; procedural justice demands that the concerns of all affected people are heard and considered. Both these forms of justice are crucial to achieving both 1.5°C and the SDGs.

This Perspective has explored some of the major implications of 1.5°C-consistent pathways for justice, with respect to the stranding or development of resources, the distribution of costs and benefits, and the equitable meeting of human needs. Based on these, it has described how achieving a just 1.5°C transition requires attending to a complex and politicised context with multiple actors and involves challenges to values and assumptions. Accordingly, we argue that for a just 1.5°C transition, research that is interdisciplinary, integrative, and able to engage seriously with radical ideas is urgently required. We call for this research agenda to be considered by those who commission, fund, engage with or consume academic research, as well as by researchers themselves. The challenge of a just 1.5°C transition demands that we all enlarge and enrich our understanding of the nature and potential of academic research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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