Transformations to sustainability: combining structural, systemic and enabling approaches

Ian Scoones[1], Andrew Stirling[2], Dinesh Abrol[3], Joanes Atela[4], Lakshmi Charli-Joseph[5], Hallie Eakin[6], Adrian Ely[2], Per Olsson[7], Laura Pereira[8], Ritu Priya[3], Patrick van Zwanenberg[9] and Lichao Yang[10]

The imperatives of environmental sustainability, poverty alleviation and social justice (partially codified in the Sustainable Development Goals or SDGs) call for ambitious societal transformations. As such, few aspects of actionable knowledge for sustainability are more crucial than those concerning the processes of transformation. This article offers a brief overview of different conceptualisations of transformation, and outlines a set of practical principles for effective research and action towards sustainability. We review three approaches to transformations, labelled: 'structural', 'systemic' and 'enabling'. We show how different ways of understanding what we mean by transformations can affect what actions follow. But these approaches are not mutually exclusive. We use an international set of examples on low carbon economy transformations, seed systems, wetland conservation and peri-urban development to show how they can be complementary and reinforcing. We describe three cross-cutting practical considerations that must be taken seriously for effective transformations to sustainability: diverse knowledges, plural pathways and the essentially political nature of transformation. Realizing the ambitions of the SDGs, we conclude, requires being clear about what we mean by transformation, and recognizing these basic methodological principles for action.

Addresses
[1] STEPS Centre, Institute of Development Studies, University of Sussex, Falmer, Brighton BN1 9RE, UK
[2] STEPS Centre, Science Policy Research Unit, University of Sussex, Falmer, Brighton, BN1 9SL, UK
[3] Transdisciplinary Research Cluster on Sustainability Studies, Jawaharlal Nehru University, New Mehrauli Road, New Delhi 110067, India
[4] African Centre for Technology Studies, ICIPE Duduville Campus, Kasaran, P.O. Box 45917 – 00100, Nairobi, Kenya
[5] Laboratorio Nacional de Ciencias de la Sostenibilidad [LANCIS], Instituto de Ecología [IE], Universidad Nacional Autónoma de México [UNAM], Mexico City, 04500, Mexico
[6] School of Sustainability, Arizona State University, PO Box 875502, Tempe, AZ 85287-5502, USA
[7] Stockholm Resilience Centre, Stockholm University, Kräftriket 2B, SE-10691, Sweden
[8] Centre for Complex Systems in Transition, University of Stellenbosch, 19 Jonkershoek Rd, Stellenbosch, South Africa
[9] Centro de Investigaciones para la Transformación [CENIT], Universidad Nacional de San Martín [UNSAM], Av. Pres. Roque Sáenz Peña 832, CP1035, Ciudad Autonóma de Buenos Aires, Argentina
[10] School of Social Development and Public Policy, Beijing Normal University, 19 Xinjiekou Wai Street, Haidian District, Beijing 100875, China

Corresponding author: Stirling, Andrew (a.c.stirling@sussex.ac.uk)

Introduction: what is transformation?

Through the Sustainable Development Goals, or SDGs, the international community adopted an ambitious agenda to address the interlinked challenges of environmental sustainability (previously defined, for example, with reference to the 'planetary boundaries' [1,2]), eliminating poverty alongside fulfilling other social and economic needs [3], and promoting equity [4•]. In response, a wide literature reflects a large movement calling for transformations to sustainability. While a ubiquitous term, it is often not clear what should be transformed, by and for whom, and through what processes. As Feola argues, "high conceptual elasticity and lack of empirical grounding of the concept of transformation generate the risk of voiding the term of meaning" [5]. Others point to the risks inherent to the 'diminution or mainstreaming' [6], or the 'contortion or manipulation' of notions of transformation [7] in ways which act against genuine, radical change. In response, as argued elsewhere ([8••] chapter 1), including in this journal [9], we see a crucial need to consider reflexively how knowledge about transformation can inform efforts towards intentional change in line with social-environmental challenges and the SDGs. In order to do this, we first probe what is meant by 'transformation'.

According to Patterson, the term generally implies "fundamental changes in structural, functional, relational,

and cognitive aspects of socio-technical-ecological systems that lead to new patterns of interactions and outcomes" ([10], drawing on [11,12,5]). Other work on transformation emphasizes how system boundaries are defined, what functions and structure are recognized as determining of system states, and what dynamics are considered essential for a system's persistence [13,14]. The processes that generate transformations are also subject of debate [15]. For some, transformation arises endogenously from incremental, carefully planned interventions made by (often policy) actors [16], whilst for others, transformation is an emergent property of large-scale political-economic forces and social mobilization [17]. In other cases, transformation is not human-generated, but triggered by exogenous biophysical forces such as climate change, which, while they may be anthropogenic in nature, are outside the control of any actor or group [18].

Among those perspectives focusing specifically on the possible roles of social agency in the driving of transformation, three broadly distinguishable emphases emerge. Reflecting a critical stance concerning the current economic interests and practices producing unsustainable outcomes, some authors point to a need for fundamental structural changes to production and consumption [19–21]. Others advocate acceleration of more incremental approaches for managing social, technological and ecological transitions, driven by combinations of technological innovations and progressive policy [22,23]. Still others argue that change must emerge from below through networks of civic movements and grassroots activity that together, in often unruly ways, construct wider change [17]. How do we make sense of these different ways of understanding and enacting transformation?

This paper focuses particularly on human drivers of transformations — but recognises after Patterson (above) that these can be viewed equally as structural, functional, relational, or cognitive in nature. We argue that to achieve the humanitarian, ecological and technological visions encapsulated in the SDGs, transformation will be required at multiple scales and organizational levels, and with deliberate normative steering.

We suggest that contemporary debates about transformations to sustainability should draw on deep, contrasting political traditions, which reflect distinct but overlapping understandings of social processes that generate transformative change [8••,24•]. In the following sections we do this, drawing on these literatures to propose three distinct but complementary approaches to understanding and advancing transformations: 1) 'structural approaches', referring to fundamental changes in the way production and consumption is governed, organized and practiced by societies; 2) 'systemic approaches', referring to intentional change targeted at the interdependencies of specific

institutions, technologies and constellations of actors in order to steer complex systems towards normative goals; and 3) 'enabling approaches' focused on fostering the human agency, values and capacities necessary to manage uncertainty, act collectively, identify and enact pathways to desired futures.

Structural approaches

Structural approaches focus on changes in perceived underlying foundations of politics, economy and society, and the need for a complete overhaul of the ideological underpinnings of social systems writ large. Exponents include classical political economists like Marx, who argued that revolutionary change was possible at historical moments when relations of labour and capital do not match existing capabilities, techniques and technologies [25]. Drawing on Marx, Lenin focused on the class tensions wrought by processes of social differentiation in society [26], while Gramsci envisaged changes overturning generally accepted social values and understandings resulting in revolutionary transformation [27,28].

These kinds of structural analyses highlight how key moments, or conjunctures, are important in generating transformations, as the relationships between economies and societies shift, generating crises and tensions (as illustrated by Polanyi's seminal analysis [14]), or alternatively pointing towards new inspirations and movements for change [29]. Such movements emerging across civil society — for example, focusing on alternative economic models including zero growth [30,31] or de-growth [32,33], race, class or gender rights [34,35] — may also, some argue, come together to create a new politics for transformative structural change [36,37].

Structural approaches offer powerful historical analyses of transformations relating to markets, commodity forms or class relations occurring through radical, sometimes revolutionary, shifts in power and control at key moments. Yet many of these studies are rather generic and sweeping. Some emphasize material forces and downplay human agency and will, while others imply mechanical causal processes. Many of them are limited in their appreciation of environmental thresholds as they often focus on past transformations, rather than future-oriented efforts. The importance of localized activity, cultural practices or incremental policy action is frequently side-lined by a focus on deeper structural dynamics, driven by historical processes and shifting interests [38].

Systemic approaches

Systemic approaches, by contrast, follow the resurgence of growth in systems thinking in the 1980s [39,40] to identify particular features of systems (such as system elements, drivers, levels) as targets for focused change, typically modulated by policy, while recognizing the significant uncertainty, propensity for non-linear response

and inherent complexity of system interactions. On the one hand, perspectives from social-ecological systems thinking (developed from ecology [41]), highlight the interplay of innovation, learning, and adaptability in creating system properties such as resilience [42], acknowledging the potential for dynamic change across scales [43]. Over the past few decades, social-ecological systems approaches have taken many forms, and have increasingly paid attention to power, politics, institutions, social dimensions and local contexts [44,45]. Many sophisticated case studies have followed, with major implications for understanding system sustainability and transformative change [46]. These follow broadly similar patterns, in which multiple biophysical and social features are defined for a notionally bounded social-ecological system, with strategic interventions then designed to improve system resilience: the ability to return to a new state following various kinds of perturbation [47].

On the other hand, socio-technical systems approaches focus on different system components such as technology, infrastructure, financial rules, industry and distribution networks markets and user practices, regulations and policies [48]. Traditionally, these emphasise more controlled 'transitions', involving interlinked processes at levels of the 'niche' (localised settings where novelties emerge), the 'regime' (the rules and institutions ordering wider practice) and 'the landscape' (the deeper patterns shaping social and technological change) [49]. In this perspective 'niche' innovations are able to reform wider 'regimes' and so generate socio-technical transitions [50]. Knowledge about system properties is seen to offer chances for transitions to be managed in ways directed by policy [51]. Examples include transformations of transport systems, renewable energy innovations and agricultural practices. Over time, this approach has been extended to focus more on the social and political dimensions of change [52,53], as well as tackling how change is resisted. Explorations of 'niches' as sites for innovation have also been extended beyond technology to social and cultural innovations, variously addressing the roles of socio-political diversity [54•] and traditional ecological knowledge [31], and how these combine in movements [55,52,56•]. But a focus on particular system categories — like 'actors' and 'levels' — is retained, as is a commitment to policy change through incentives, investments and policy initiatives, usually led by the state, but often in alliance with others, across the private sector and civic groups [57,58].

Regardless of the degree of control over change processes and system outcomes, these system-focused approaches emphasize the need for knowledge on system dynamics: the interdependency of social, ecological, institutional and technological elements that together mark thresholds in system states. In focusing on the system as a whole,

system approaches have tended to diminish the role of individual agency, downplay the complexity of politics, power and asymmetries in human-environment dynamics [59,44]. Originating in the experience of social-technological change in the Global North or through the analysis of relatively bounded systems of natural resource management, these approaches have often implicitly presumed the embrace of Western ideals of deliberative democracy, pre-existing capacities for collective action, and general support for change that will result in enhanced equity, environmental integrity and improved public welfare [61]. Needless to say, it is not clear how well these assumptions hold even in places of established democratic institutions, and they may not hold true in many other parts of the world where progress in the SDGs is desperately needed [62,63].

Enabling approaches

Enabling approaches draw on both these traditions to highlight the agency and uncertainties inherent in choosing aims and directions for transformative change [64]. Enabling approaches focus less on specific desired configurations of the system state than structural approaches, and less on the management of system dynamics than system approaches. Instead, these approaches emphasize creating the social attributes — capacities — that empower individuals and communities to take action on their own behalf. By 'agency', we refer to the deliberate exercise of individual or collective will [65,66], with enabling approaches focusing especially on the most excluded interests. For example, many forms of low carbon transitions have been proposed, each presupposing different values, interests and actions. How can a policy-maker decide, in merely technical ways, which policy is most appropriate? What groups and individuals are able to mobilize the capacities to participate, make their interests heard and organize to implement change? How can conditions be created that support the formation of alliances and social networks through which the burden and benefits of transformational processes can be negotiated? Resilience raises similar queries, with system change following shocks and stress affecting different people in different ways, and marginalized groups typically the most vulnerable [13].

Enabling approaches take a more optimistic and directly activist stance than some structural or systems approaches, focusing on processes and capacities rather than just outcomes [67••]. Beyond major, historically-driven structural reconfigurations or system changes, opportunities for transformation are seen in terms of individually smaller actions that collectively, over time, shift system states in ways which may be unexpected but which reflect the values and visions of mobilized agents [17]. Placing less emphasis on grand theoretical frameworks or pre-decided categories of phenomena, enabling approaches focus on the values,

agency, relations and processes that underlie both structures and systems [68].

Multiple forms of power are exercised, with power emerging both in structural forces and in collective action [69]. Focusing on the scope for political mobilization and cultural change, an enabling approach takes a hopeful, caring, emancipatory stance on transformation; one that de-emphasizes controlling, violent or fearful futures [70•]. Enabling change will inevitably take different forms in different settings, and requires a wider, unruly and often adversarial politics of citizen mobilization at its heart [71–74]; in ways that it might be hoped are more protected from manipulation or management by privileged interests.

A number of perspectives are central to an enabling approach [75•,76•,77]. Network understandings may help address more messy power dynamics than are envisaged in structural or systemic approaches, linking emerging new actors, structures and processes that challenge incumbent positions and cultivate new pathways to sustainability [62,63,78•]. A focus on practice and agency affords more scope for action by citizens, enabling more emancipatory change, whatever the direction [79]. The politics of knowledge is also stressed, including how future transformations are imagined [75•,80•]. Enabling approaches may be critiqued for a bias towards privileging local perspectives in an inherently globalized world [81,82], or a lack of sufficient attention to how 'enabled' communities can induce needed structural changes to escape traps of poverty or oppression [83,84].

Complementary lenses

Structural, systemic and enabling approaches are not mutually exclusive: they offer complementary analytical lenses on transformative change, as well as complementary approaches to understanding and trying to bring about real-world change (Table 1). There is no necessary sequence or logic to conditions that favour structural, systemic or enabling transformation. While in some cases, change can be triggered by larger-scale ideological shifts and movements of capital, leading in turn to enhanced opportunity and agency for previously marginalized actors, in other cases, change may be more dispersed and grassroots in nature, cascading up from local innovations that disrupt system dynamics to create structural change. Nevertheless, we would argue that for socially just and equitable transformations (in line with the ambitions of the SDGs) to occur, necessary structural and systemic changes will demand enabling and emancipatory change as well. Two illustrations show how transformations may emerge in different ways.

First, there are *transformations to low carbon energy systems* that are essential for tackling climate change. These are recognized across many governments, businesses and civil society organizations across the world. With such transformations central to a number of SDGs, most recognize that climate change requires deep structural shifts away from fossil fuels [85]. A structural approach argues for the reconfiguring of global markets and infrastructures, radically shifting forms of production and consumption [86]. Requiring support for alternatives, this fundamentally challenges incumbent interests and implies asymmetrical costs for transitioning populations. Across Europe,

Table 1

Complementary lenses

Approach	Definition/emphasis	Pros	Cons	Example
Structural	Fundamental changes in the way production and consumption is governed, organized and practiced by societies	Highlights the prevalent economic and political processes and associated interests that serve to perpetuate current conditions	Lack of emphasis on environmental triggers and processes, individual agency and the possibilities of incremental change; historical studies may downplay the role of complexity and serendipity	Emergent discourses on decarbonization or zero- or degrowth economic structures Mass social mobilization around climate change and economic inequity
Systemic	Intentional change targeted at the interdependencies of specific institutions, technologies and constellations of actors in order to steer complex systems towards normative goals	Highlights interdependencies, connectivity across scale and geography, and the potential for non-linear shifts in system dynamics across scales. Emphasizes the role of ecological dynamics in social change and vice versa.	Critiqued for de-emphasis of individual agency, power and politics and/or overly managerial approach, glossing over differences in capacities, governance structure and politics	Low carbon energy transitions, focusing on technology-centred developments, modulated by incentives and disincentives enacted in policy mixes
Enabling	Fostering the human agency, values and capacities necessary to manage uncertainty, act collectively, identify and enact pathways to desired futures	Recognizes potential of human agents for collective action; explicitly addresses asymmetries in power and circumstances of social injustice	May neglect significant structural, political obstacles to social transformation; burdens those with greatest vulnerability with task of transformation	Community led environmental action; hacker/maker spaces for grassroots innovation; commoning approaches to sustainable local economies

structural transformations have emerged through radical shifts in economic conditions, such as dramatic reductions in costs of renewable energy, shifting options in the energy sector. Change may also result from new political and institutional commitments — with structural shifts away from conventional energy infrastructures, as currently pursued in Germany [87].

A socio-technical systems approach, by contrast, examines how an incumbent fossil fuel 'regime' can be transformed through substitution by new low carbon innovations emerging in 'niches' (like wind and solar power), and how these can be nurtured and protected [88]. This approach, now evident in many European countries, advocates incremental responses to adapt to changes in an existing energy regime, including shifts in production patterns, consumption behaviour and motivating expectations that allow new, more resilient systems to develop [89]. Recent work in Kenya has investigated the potential for systemic change associated with the pay-as-you go solar photovoltaic niche and examined its transformative potential in terms of *inter alia* the national context for innovation and technology uptake [90].

An enabling approach to low carbon transformation, by contrast, focuses on supporting novel pathways for more emergent social, political and cultural changes, often involving the mobilization of grassroots movements and alliances driven by a new ethics of sustainability [91]. Examples can be found in many contributions made by civil society in areas like community-owned wind power, socially-useful production or ecological agricultural practices [92••]. Here, directions of transformation are deliberated upon more politically, articulating diverse definitions of sustainability and wider social priorities [93,94•].

More control-oriented approaches, aiming at structural and systemic changes, may not engage in this broad politics of deliberation [70•]. 'Eco-modernist' visions, for example, highlight rapid technological 'solutions' for climate change, including focusing on nuclear or geo-engineering technologies [95,96••]. But this technical, control-focus can neglect wider implications around uncertainty, justice or cultural fit. By contrast, an enabling approach highlights complementarities between social and environmental aims, with an openness to contestation, dissent and deliberation. This helps to shape actively sustainability transformations that advance social justice as well as ecological integrity.

A second example highlights the importance of *open source approaches to sustainable food and farming systems*. Transformations in food and farming systems away from input-intensive polluting industrial farming towards more diverse sustainable systems are immensely challenging. This is especially so in settings like

Argentina where monolithic systems of intensive commodity crop and animal production are expanding rapidly, destroying existing agricultural system diversity. A pre-condition for agricultural transformation is to protect what remains of agricultural diversity and expand it further, to retain a range of alternative working practices that experiment with less input-intensive and more socially inclusive and productive agricultural systems. Here enabling approaches, such as shifts towards open source legal rules for seed innovation, or co-operative business models and fair-trade certifications, provide ways to preserve and foster agricultural diversity. This is because they help open up space for emergent opportunities, enabling new actors to engage and novel practices to develop.

For example, institutional innovations like open source seed licenses can help to reconfigure the wider political economic structures of food and farming that drive unsustainability. Such licenses are more accessible to economically marginal interests and avoid the exclusions of patent-based rules for governing seed innovation [97••]. In Argentina, such new institutional arrangements have helped form bridges between those concerned with adverse effects of strict intellectual property regimes on domestic industries and technological capabilities and those committed to changing seed systems in favour of more marginalized producers [98]. In turn, through involving new people, ideas and practices, such change builds awareness of the constraints and opportunities imposed by wider political-economic structures, and enables a novel politics of transformation around seed production and associated farming systems.

Structural, systemic and enabling approaches are thus complementary. Instrumental systemic change in policies and institutions can be enabling of social movements and novel alliances seeking to address sustainability challenges in diverse ways, and at the same time, to lay the ground for a reconfiguration of broader structures.

Principles for pursuing complementarities in transformative change

These examples highlight how efforts to advance transformations to sustainability may draw on complementary approaches. Nevertheless, achieving such complementarity implies open, plural and democratic politics, with central roles not just for policy, but also for mobilization, critique and political challenge [92••]. Such aspirational conditions are clearly not equally available across the globe, and, given the diversity of contexts in which transformation is urgently needed, processes of change are likely to be contested, in some cases, violently. How, then, can the science and policy communities vested in the realization of the SDGs respond practically and ethically? What specific approaches can help facilitate transformative change? What principles can best help realize the complementarities? We suggest three.

The first is '*taking diverse knowledges seriously*'. Different perspectives compete in processes of transformation, rooted in different worldviews, positions and knowledges. It is crucial for scientists and practitioners to appreciate this diversity — and not homogenize it into a singular view of progress driven by circumscribed, expert sustainability science [99••]. This is not just about respecting 'indigenous' or 'lay' knowledges, but exploring how new hybrid knowledge systems — combining diverse sources of knowledge — can emerge through productive interactions in which research priorities, problem definitions and options are negotiated [100,101].

This is the essence of transdisciplinarity, where multiple forms of expertise co-construct new knowledges that are both broader in what they consider and more open in their implications for change [102]. Such processes of co-construction are intensely political, as new ways of thinking about problems and solutions are created, together with new ways of tackling problems and acting on the world [103]. This is more than 'getting people around a table' and engineering consensus in managerial forms of participation. Required instead are more equal processes of collaboration and exchange, exploring diverse visions from different standpoints [104]. The process through which such collaboration and exchange is realized will necessarily differ, and needs to be acutely sensitive to the political opportunities and costs, social-cultural context and the current state of a particular system [105]. For scientists and practitioners, enabling approaches often require a transformation in roles, embracing positions that emphasize facilitation, 'brokering', convening and steering rather than solely knowledge production or policy implementation [106].

For example, 'transformation labs' have been used in a number of recent initiatives as spaces for dialogue around transformation [67••,97••,107••,108]. These processes help mobilize people and action around a problem, giving opportunities for learning and reflexivity in exploring divergent values and interests [109••,110]. What constitutes the structure and process for a transformation lab in the United Kingdom, however, will be quite different to what such a process looks like in China [106,111], given existing political circumstances and governance structures that place different costs on the recognition of plural knowledges. In addressing the sustainability challenges of the Xochimilco wetland in Mexico City, for instance, a culture of exchange was created that enabled participants to re-frame basic challenges. Through participatory activities, the transformation lab embraced an enabling approach, building space for participants to step back from the contentious land use and water quality issues that divided the community, to focus on the values and meanings they collectively wanted to conserve [107••]. Rather than an exhausting task of fighting forces that the participants felt were beyond participants' control, the problem was recast as one of maintaining the identity and meanings they attached to the 'Xochimilco wetland'. By focusing on capacities and agency, both of individual people and different social groups, the process illuminated where power is held and how it can be mobilized to achieve more just and sustainable development pathways [112].

Beyond appreciation of diverse knowledges, there is a need to '*take plural pathways seriously*'. Different ideas and values of sustainability imply multiple — very material — institutional and infrastructural transformations. No matter how specific the context, there is never only one relevant, viable path. The many indicators and targets of the SDGs usefully delimit a target space — but how to realize the plurality of ways to get there? This will require demanding new forms of deliberation amongst contending actors. Especially crucial is engagement not just with diverse ideas, but also with the contrasting norms, interests and practices of different actors. In areas like agricultural strategies, energy policy or public health, approaches like multi-criteria mapping and participatory scenario workshops can help collaborative efforts to navigate the implications of different pathways and the contrasting ways to develop any one [113].

For example, progress in addressing the sustainability challenges of the Xochimilco wetland has been stymied by disagreement over the best strategies to pursue. Those who consider themselves native to the communities that have practised agriculture within this wetland argue that the persistent degradation and urbanization of this environment, the decline of traditional farming techniques, and the commodification of the ecosystem suit the interests of the urban elite. They are suspicious of formal development plans and interventions by the city, and advocate local sovereignty and control in the face of external power: in other words, a structural transformation. Alternatively, some focus on technological interventions, arguing that transformation is needed in the ways people live within the system, rather than with the system itself. Thus, they demand institutional and policy support for eco-friendly sanitation technologies and rainwater harvesting, as mechanisms through which the human relationship to the ecosystem can be fundamentally changed. The transformation lab created a space to confront and discuss assumptions about which pathway — of many possibilities — will be most successful for whom, and why.

Our third principle, '*taking politics seriously*', builds directly on the previous two. It reminds us that — however well assisted by technical expertise — engaging with a diversity of contexts or a plurality of perspectives is always deeply political. Negotiations among contending knowledges and divergent interests across multiple actors inevitably involves politics: confronting disparate views, interests and forms of incumbent power [114•]. Wider political institutions, economic systems and technical infrastructures

inevitably shape what happens and what might be possible. But taking an enabling approach means a focus on agency and the capacities of actors to open up opportunities, often in surprising alliances.

Both in the Xochimilco wetland and in the city of Gurgaon in India, different perspectives on sustainability again play a key role. In the case of Gurgaon, participatory practices around the Gurgaon Water Forum have been able to make a significant impact on the imaginations, values and interests of public administrators, resident welfare associations and citizen groups working to transform urban planning and governance [115••]. In the Xochimilco wetland, local farmers see degradation of the wetland ecosystem as a result of decline in traditional systems of land use and commodification of the area by urban elites. For them, transformation is about resistance in the face of the power of development plans and elite control. However, an expected change in political leadership and new opportunities presented by Mexico City's embrace of planning for resilience are now providing new platforms for action. The case underscores not only the interlinked nature of sustainability goals, but also that the pathways to these goals will require negotiation, contestation and alliance-building. Taking diverse knowledges — including values and moral positions — seriously helps reframe dominant policy narratives in formal political arenas. This broadens out what is taken into account and opens up possibilities for change: challenging discursive closures that exclude alternative pathways.

Likewise in peri-urban Delhi, India, alliances of citizen environmentalists are addressing toxic pollution using a range of strategies from legal activism to citizen science monitoring [57]. Strategic alignments between activist interventions and some within the state or business are challenging established pathways and opening up opportunities for change [59]. A focus on social innovation helps move the emphasis away from technological fixes or instrumental policy intervention and towards the realizing of entirely new possibilities. This requires thinking deliberately about where the chinks lie in the armour of power — and what the opportunities might be for tactical alliances. It means looking for political openings: in who has the capacity to act and what mobilizations are required to challenge incumbent interests and constraining structures. Alongside more conventional 'academic rigour', then, taking politics seriously also emphasises 'political rigour' — where diverse people and knowledges challenge prevailing power in collective political interventions. Many examples can be found in environmental justice struggles around the world; for instance in the hundreds of cases documented in the global '*EJ-Atlas*' or Latin American '*Grupo Confluencias*' initiatives [60]. Political rigour of course entails significant risks and costs, and such risks can be debilitating for transformative action. Nevertheless, attention to how

and when such mobilization is occurring and what such movements imply for the meaning, process and direction of transformative change is fundamental to achieving the aspirations articulated in the SDGs.

Emancipatory transformations to sustainability

Achieving the SDGs by 2030 will require massive transformations in economies, societies and politics. If such transformations are to be not only ecologically beneficial, but emancipatory for the most marginalised people, then approaches are required that are at once structural, systemic and enabling. Structural or systemic approaches may underpin analysis and offer strategic responses, whether through informing social movements or guiding policy interventions that aim to elevate small-scale niche experiments beyond the local. Complementary enabling approaches may also draw upon these analyses whilst focusing on fostering agency, values and capacities for emancipatory change. This requires embedding the three principles proposed here: taking seriously diverse knowledges, plural pathways and the inherently political nature of transformations. This paper offers some pointers for thinking more deeply about these challenges — and for translating results into action-oriented practice, as illustrated by the examples discussed. Combining recognition for deep structural realities as well as vibrant social possibilities, these three principles help open up space for new social and technical innovations, as well as deliberation, contestation and democratic debate. These qualities are each individually essential — as well as collectively necessary — for achieving both the SDGs and the wider ambitions of sustainability.

Conflict of interest statement
Nothing declared.

Acknowledgements

References and recommended reading
Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. Steffen W *et al.*: **Planetary boundaries: guiding human development on a changing planet**. *Science (80-)* 2015, **347**.

2. Rockström J *et al.*: **A safe operating space for humanity**. *Nature* 2009, **461**:472-475.

3. Raworth K: *A Safe and Just Space for Humanity: Can We Live Within the Doughnut?* . Available (November 2019) at: Oxford: Oxfam; 2012 https://www-cdn.oxfam.org/s3fs-public/file_attachments/ dp-a-safe-and-just-space-for-humanity-130212-en_5.pdf.

4. Leach M *et al.*: **Equity and sustainability in the anthropocene: a**
•   **social–ecological systems perspective on their intertwined**
    futures. *Glob Sustain* 2018, **1**
This important review by some of the leading authorities in the field,
summarizes the state of knowledge concerning the interlinked challenges
of equity and sustainability. Emphasizing that they cannot be addressed
separately, it outlines emerging new thinking which recognizes the multi-
ple perspectives and dimensions involved.

5. Feola G: **Societal transformation in response to global**
    environmental change: a review of emerging concepts. *Ambio*
    2014, **44**:376-390.

6. Pelling M: **Transformation: a renewed window on development**
    responsibility for risk management. *J Extreme Events* 2014, **1** p.
    1402003.

7. Blythe J *et al.*: **The dark side of transformation: latent risks in**
    contemporary sustainability discourse. *Antipode* 2018,
    50:1206-1223.

8. Scoones I, Newell P, Leach M: *The Politics of Green*
•• *Transformations*. London: Earthscan Routledge; 2015
Resulting from a series of conferences and workshops held by the Global
Consortium for Social Technological and Environmental Pathways to
Sustainability (STEPS), this state-of-the-art edited volume contains a
series of chapters summarizing key divergent perspectives on transfor-
mations to sustainability.

9. W.-P. G, Arnott J, Mach K: **Transforming science-society**
    engagement and generating actionable knowledge for
    environmental sustainability under global change. *Curr Opin*
    Environ Sustain 2020.

10. Patterson J, Schulz K, Vervoort J, Van Der Hel S, Sethi M,
    Barau A: **Exploring the governance and politics of**
    transformations towards sustainability. *Environ Innov Soc*
    Transitions 2017, **24**:1-16.

11. Hackmann AL, St. Clair H: **Transformative cornerstones of**
    social science research for global change. *Int Soc Sci Counc*
    Paris 2013, **4**:117-152.

12. O'Brien K: **Global environmental change III: closing the gap**
    between knowledge and action. *Prog Hum Geogr* 2012,
    37:587-596.

13. Leach M, Scoones I, Stirling A: *Dynamic Sustainabilities:*
    Technology, Environment, Social Justice. London: Earthscan;
    2010.

14. Stirling A: **Pluralising progress: from integrative transitions to**
    transformative diversity. *Environ Innov Soc Transitions* 2011,
    1:82-88.

15. Smith A, Stirling A, Berkhout F: **The governance of sustainable**
    socio-technical transitions. *Res Policy* 2005, **34**:1491-1510.

16. Schot J, Steinmueller WE: **New directions for innovation**
    studies: missions and transformation. *Res Poliicy* 2018,
    47:1583-1584.

17. Stirling A: **Emancipating transformations: from controlling 'the**
    transition' to culturing plural radical progress. *The Politics of*
    Green Transformations. London: Routledge; 2015, 54-67.

18. Kates RW, Travis WR, Wilbanks TJ: **Transformational adaptation**
    when incremental adaptations to climate change are
    insufficient. *Proc Natl Acad Sci U S A* 2012, **109**:7156-7161.

19. Newell P: **The politics of green transformations in capitalism**. In
    The Politics of Green Transformation. Edited by Scoones I, Leach
    M, Newel P. London: Earthscan; 2015.

20. Foster JB, Clark B, York R: *The Ecological Rift: Capitalism's War on*
    the Earth. New York: Monthly Review Press; 2010.

21. D'Alisa G, Demaria F, Kallis G (Eds): *Degrowth: a Vocabulary for a*
    New Era. London: Routledge; 2015.

22. O'Brien K, O'Brien K: **Global environmental change II: from**
    adaptation to deliberate transformation. *Prog Hum Geogr* 2012,
    36:667-676.

23. Grin J, Rotmans J, Schot J, Geels F, Loorbach D: *Transitions to*
    Sustainable Development: New Directions in the Study of Long
    Term Transformative Change. London: Routledge; 2010.

24. Scoones I: **The politics of sustainability and development**. *Annu*
•   *Rev Environ Resour* 2016:1-27
In a field increasingly subject to pressures for professionalization and
instrumentalization, this paper offers an up-to-date state-of-the art review
of the hitherto often unduly neglected political aspects of relations
between sustainability and development. Examining political dimensions
both of patterns of resource use and of scarcity, it discusses technology-
led, market-led, state-led, and citizen-led processes of change.

25. Marx K: *Capital: a Critique of Political Economy - Volume 1*.
    Harmondsworth: Penguin; 1976.

26. Lenin VI: *Revolution, Democracy, Socialism*. London: Pluto Press;
    2008.

27. Gramsci A: *Selections from the Prison Notebooks of Antonio*
    Gramsci. New York: International Publishers; 1971.

28. Davis M: *Old Gods, New Enigmas - Marx's Lost Theory*. London:
    Verso; 2018.

29. Mouffe C: *For a Left Populism*. London: Verso; 2018.

30. Jackson T: Prosperity without growth London. Available
    (November 2019) at: http://www.sd-commission.org.uk/data/files/
    publications/prosperity_without_growth_report.pdf.

31. Lara LG, Pereira LM, Ravera F, Jiménez-Aceituno A: **Flipping the**
    tortilla: social-ecological innovations and traditional
    ecological knowledge for more sustainable agri-food systems
    in spain. *Sustainability* 2009, **11**.

32. Martínez-alier J, Pascual U, Vivien F, Zaccai E: **Sustainable de-**
    growth: mapping the context, criticisms and future prospects
    of an emergent paradigm. *Ecol Econ* 2010, **69**:1741-1747.

33. Kallis G, Kerschner C, Martinez-Alier J: **The economics of**
    degrowth. *Ecol Econ* 2012, **84**:172-180.

34. Kaijser A, Kronsell A: **Climate change through the lens of**
    intersectionality. *Environ Polit* 2014, **23**:417-433.

35. Maina-okori NM, Koushik JR, Wilson A: **Reimagining**
    intersectionality in environmental and sustainability
    education: a critical literature review. *J Environ Educ* 2018,
    49:286-296.

36. Fraser N: **A triple movement?** *New Left Rev* 2013, **81**:119-132.

37. Wainwright H: *A New Politics From the Left*. Chichester: John
    Wiley & Sons; 2018.

38. Abrol D: **Conditions for the achievement of pharmaceutical**
    innovation for sustainable development: lessons from India.
    World Rev Sci Technol Sustain Dev 2006, **3**.

39. Meadows DH: **System dynamics meets the press**. *Syst Dyn Rev*
    1989, **5**:69-80.

40. Meadows DH, Meadows DL, Randers J: *Beyond the Limits: Global*
    Collapse or A Sustainable Future. London: Earthscan Publications
    Ltd; 1992. Earthscan.

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

42. Folke C, Carpenter SR, Walker B, Scheffer M, Chapin T,
    Rockström J: **Resilience thinking: integrating resilience,**
    adaptability and transformability. *Ecol Soc* 2010, **15**.

43. Berkes F, Colding J, Folke C (Eds): *Social-ecological Systems:*
    Building Resilience For Complexity and Change. Cambridge:
    Cambridge University Press; 2003.

44. Brown K: **Global Environmental Change I: A Social Turn For**
    Resilience? *Prog Hum Geogr* 2013, **38(1)**:107-117.

45. Westley F *et al.*: **Tipping toward sustainability: emerging**
    pathways of transformation. *Ambio* 2011, **40**:762-780.

46. Olsson P, Galaz V, Boonstra WJ: **Sustainability transformations:**
    a resilience perspective. *Ecol Soc* 2014, **19**.

47. Folke C: **Resilience: the emergence of a perspective for social–**
    ecological systems analyses. *Glob Environ Change* 2006,
    16:253-267.

48. Geels FW: **Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study**. *Res Policy* 2002, **31**:1257-1274.

49. Rip A, Kemp R: **Technological change**. In *Human Choice and climate change: an international assessment.* Edited by Rayner S, Malone EL. Columbus: Batelle Press; 1998:327-399.

50. Geels F: *Technological Transitions and System Innovations: a Co-evolutionary and Socio-technical Analysis*. Cheltenham, UK; Northampton, MA: Edward Elgar; 2005.

51. Loorbach D, Rotmans J: **The practice of transition management: examples and lessons from four distinct cases**. *Futures* 2010, **42**:237-246.

52. Kern F: **Energy transitions and deliberate transition management: implementing the green economy**. *Okol Wirtschaften* 2013, **3**:20-23.

53. Geels FW: **Regime resistance against low carbon transitions: introducing politics and power into the multi-level perspective**. *Theory Cult Soc* 2014, **31**:21-40.

54. Raven R, Ghosh B, Wieczorek A, Stirling A, Ghosh D, Jolly S,
• Karjangtimapron E, Prabudhanitisarn S, Roy J, Sangawongse S, Sengers F: **Unpacking sustainabilities in diverse transition contexts: solar photovoltaic and urban mobility experiments in India and Thailand**. *Sustain. Sci.* 2017, **12(4)**:579-596
Focusing on two key fields for sustainability transformations in two urban settings in the Global South, this paper explores a dimension that is unusual in the 'technological transitions' field, in that it systematically analyses a number of dimensions of diversity in the framing both of sustainability and transformation.

55. Seyfang G: **The new economics of sustainable consumption: seeds of change**. *Basingstoke*. Palgrave Macmillan; 2008.

56. Pansera M, Owen R: **Framing inclusive innovation within the
• discourse of development: insights from case studies in India**. *Res Policy* 2017, **47**:23-34
Exploring ideas and practices around 'inclusive innovation' in an important setting in the Global South, this provides a useful and authoritative overview of a concept that is becoming increasingly prominent in discussions of transformations to sustainability.

57. Abrol D: **Embedding technology in community-based production systems through people's technology initiatives: lessons from the Indian experience**. *Int J Technol Manag Sustain Dev* 2005, **4**:3-20.

58. Schmitz H: **Green transformation: is there a fast track?** In *The Politics of Green Transformations.* Edited by Scoones I, Leach M, Newell P. London: Routledge; 2015.

59. Meadowcroft J: **Engaging with the politics of sustainability transitions**. *Environ Innov Soc Transitions* 2011, **1**:70-75.

60. Temper L, Walter M, Rodriguez I, Kothari A, Turhan E: **A perspective on radical transformations to sustainability: resistances, movements and alternatives**. *Sustain Sci* 2018, **13**:747-764.

61. Shove E, Walker G: **CAUTION! Transitions ahead: politics, practice, and sustainable transition management**. *Environ Plan A* 2007, **39**:763-770.

62. Moore M-L, Olsson P, Nilsson W, Rose L, Westley FR: **Navigating emergence and system reflexivity as key transformative capacities: experiences from a Global Fellowship program**. *Ecol Soc* 2018, **23**.

63. Drimie S, Hamann R, Manderson AP, Mlondobozi N: **Creating transformative spaces for dialogue and action: reflecting on the experience of the Southern Africa Food Lab**. *Ecol Soc* 2018, **23**.

64. Brien KO: **Political agency: the key to tackling climate change**. *Science (80-)* 2015, **350**.

65. Sools A, Hein Mooren J: **Towards narrative futuring in psychology: becoming resilient by imagining the future**. *Grad J Soc Sci* 2012, **9**:203.

66. Bandura A: **Toward a psychology of human agency**. *Perspect Psychol Sci* 2006, **1**:164-180.

67. Pereira LM, Karpouzoglou T, Frantzeskaki N, Olsson P: **Designing
•• transformative spaces for sustainability in social-ecological systems**. *Ecol Soc* 2018, **23**
Providing an overview of an important state-of-the art special issue, this article summarises current experience in the building of transformative spaces, which is all the more valuable for redressing the neglect elsewhere of attention to initiatives undertaken in the Global South.

68. Hulme M: *Why We Disagree About Climate Change*. Cambridge: Cambridge Univ Press; 2009.

69. Stirling A: **Transforming power: social science and the politics of energy choices**. *Energy Res Soc Sci* 2014, **1**:83-95.

70. Stirling A: **Engineering and sustainability: control and care in
• unfoldings of modernity**. In *Routledge Companion to Philosophy of Engineering*, , vol. 06. Edited by Michelfelder DP, Doorn N. London: Routledge; 2019
Addressing a key distinguishing feature of 'enabling' approaches to transformation, this paper explores the contrast between 'caring' and 'controlling' approaches to sustainability– and examines the ways in which the latter understanding is constantly pressurised in the colonialities of contemporary globalising modernity.

71. Mouffe C: *The Return of the Political*. London: Verso; 1993.

72. Fraser N: **Can society be commodities all the way down? Polanyian reflections on capitalist crisis**. *FMSH* 2012. 18 August 2012.

73. Hall AJ, Yoganand B, Sulaiman RV, C.N.G (Eds): *Post-harvest Innovations in Innovation: Reflections on Partnership and Learning*. Patancheru: Crop Post-Harvest Programme, South Asia; 2003.

74. Abrol D: **Pro-poor innovation-making, knowledge production and technology implementation for rural areas: lessons from the Indian experience**. In *Innovation in India: Melting Economic Growth with Inclusive Development.* Edited by Ramani S. Cambridge: Cambridge Univ Press; 2014.

75. Pereira LM, Hichert T, Hamann M, Preiser R, Biggs R: **Using
• futures methods to create transformative spaces: visions of a good Anthropocene in southern Africa**. *Ecol Soc* 2018, **23**
Organised around the key concept of the Anthropocene, which features strongly in much discussion of sustainability transformations, this paper provides a useful contemporary analysis from a Global Southern perspective of the value of futures methods in addressing challenges of complexity, diversity, and uncertainty.

76. Galafassi D *et al.*: **Stories in social-ecological knowledge
• cocreation**. *Ecol Soc* 2018, **23**
Drawing on contemporary experience with knowledge co-creation processes for sustainability transformations in in Kenya and Mozambique, this paper usefully analyzes the role of techniques for fostering "shared conceptual repertoires" in order to facilitate communicative spaces.

77. Dyer M: **Transforming communicative spaces: the rhythm of gender in meetings in rural Solomon Islands**. *Ecol Soc* 2018, **23**.

78. Marshall F, Dolley J, Priya R: **Transdisciplinary research as
• transformative space making for sustainability: enhancing propoor transformative agency in periurban contexts**. *Ecol Soc* 2018, **23**
Drawing on research undertaken around Delhi, this paper analyses the role of transdisciplinary development research (TDR) in building sustainability transformations. Extending attention beyond this, the authors explore a novel idea of 'transformative space making' (TSM) as a means to cocreate solution-oriented knowledge focusing especially on contending power relations.

79. Arora S: *Defying Control: Aspects of Caring Engagement Between Divergent Knowledge Practices*. Brighton: STEPS Centre; 2017.

80. Hebinck A, Vervoort JM, Hebinck P, Rutting L, Galli F: **Imagining
• transformative futures: participatory foresight for food systems change**. *Ecol Soc* 2018, **23**
Drawing on research in southern Africa, this paper focuses on the potential roles that might be played by the deliberate envisioning of positive futures is a first step in creating a shared understanding and commitment towards radical transformations toward sustainability.

81. Born B, Purcell M: **Avoiding the local trap: scale and food systems in planning research**. *J Plan Educ Res* 2006, **26**:195-207.

82. Brown JC, Purcell M: **There's nothing inherent about scale: political ecology, the local trap, and the politics of**

development in the Brazilian Amazon. *Geoforum* 2005, **36**:607-624.

83. Eakin H: **The 'turn to capacity' in vulnerability research**. In *Applied Studies in Climate Adaptation*. Edited by Palutikof D, Boulter JP, Barnett S, Rissik J. Chichester: John Wiley; 2015.

84. Jasanoff S: **Just transitions: a humble approach to global energy futures**. *Energy Res Soc Sci* 2018, **35**:11-14.

85. Mitchell T: *Carbon Democracy: Political Power in the Age of Oil*. London: Verso; 2011.

86. Bulkeley H *et al.*: **Governing climate change transnationally: assessing the evidence from a database of sixty initiatives**. *Environ Plan C Polit Sp* 2014, **30**:591-612.

87. Kuzemko C, Mitchell C, Lockwood M, Hoggett R: **Policies, politics and demand side innovations: the untold story of Germany's energy transition**. *Energy Res Soc Sci* 2017, **28**:58-67.

88. Smith A, Raven R: **What is protective space? Reconsidering niches in transitions to sustainability**. *Res Policy* 2012, **41**:1025-1036.

89. Folke C, Hahn T, Olsson P, Norberg J: **Adaptive governance of social-ecological systems**. *Annu Rev Environ Resour* 2005, **30**:441-473.

90. Ockwell D *et al.*: **Can pay-as-you-go, digitally enabled business models support sustainability transformations in developing countries? Outstanding questions and a theoretical basis for future research**. *Sustainability* 2019, **11**:1-21.

91. Smith A, Fressoli M, Abrol D, Around E, Ely A: *Grassroots Innovation Movements*. London: Routledge Earthscan; 2016.

92. Smith A, Stirling A: **Innovation, sustainability and democracy:**
•• **an analysis of grassroots contributions**. *J Self-Governance Manag Econ* 2018, **6**:64-97
The role of democratic struggle and grassroots mobilization is a crucial but arguably underemphasized theme in much high-level policy discussion of sustainability transformations– especially in relation to science, technology and innovation. This paper provides a useful general overview of key current themes in this field.

93. STEPS Centre: *Innovation, Sustainability, Development: A New Manifesto*. . Available (November 2019) at: Brighton: STEPS Centre; 2010 In: *https://steps-centre.org/publication/innovation-sustainability-development-a-new-manifesto/*.

94. Abrol D: **Technological alternatives for Indian futures**. In
• *Alternative Futures: India Unshackled*. Edited by Kothari A, Joy KJ. Delhi: Authors Upfront; 2017
In a courageous and farsighted volume by a diverse array of leading scholars on issues on sustainability transformation, this chapter focuses in particular on what key lessons from past radical critique of technology have to offer for contemporary debates about the potential role for technological alternatives.

95. Asafu-Adjaye J *et al.*: *An Ecomodernist Manifesto*. . Available (November 2019) at: Washington: Breathrough Institute; 2015 In: *http://www.ecomodernism.org/*.

96. Preiser R, Pereira LM, (Oonsie) Biggs R: **Navigating alternative**
•• **framings of human-environment interactions: variations on the theme of 'Finding Nemo,'**. *Anthropocene* 2017, **20**:83-87
This group of leading activist-scholars, working on sustainability transformations in Africa, usefully explore the practical implications of four contending framings of human-environment interactions: the eco- modernist perspective, the planetary stewardship paradigm; the pathways to sustainability approach; and the critical post-humanist paradigm. They conclude by developing a novel synthetic approach based on 'the Anthropocene as responsibility'.

97. Van Zwanenberg P, Cremaschi A, Obaya M, Marin A,
•• Lowenstein V: **Seeking unconventional alliances and bridging innovations in spaces for transformative change: the seed sector and agricultural sustainability**. *Ecol Soc* 2018, **23**
This paper draws on experience in developing an important contemporary sustainability transformations intervention initiated in Argentina, concerning a radical new open source seed licensing system. Exploring the implications well beyond the particular initial setting, this work offers a compelling model for other kinds and applications of activist scholarship in this field.

98. Marin A, Stubrin L, van Zwanenberg P, Van Zwanenberg P: *Developing Capabilities in the Seed Industry: Which Direction to Follow?* Brighton: Science Policy Research Unit; 2014. Available (November 2019) at: *http://sro.sussex.ac.uk/id/eprint/49232/*.

99. Wright EO, Folbre N, Andersson J, Hearn J, Himmelweit S,
•• Stirling A: **Chapter 21. The multiple directions of social progress: ways forward**. *International Panel on Social Progress: Rethinking Society for the 21st Century*. Cambridge: Cambridge University Press; 2018
Convened as a global initiative to address crucial challenges in progressive visions of sustainability transformations, the International Panel on Social Progress provides a comprehensive state-of-the-art review of many key dimensions of associated political struggle.

100. Vogel C, Moser SC, Kasperson RE, Dabelko GD: **Linking vulnerability, adaptation, and resilience science to practice: pathways, players, and partnerships**. *Glob Environ Change* 2007, **17**:349-364.

101. Tengö M, Brondizio ES, Elmqvist T, Malmer P, Spierenburg M: **Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach**. *Ambio* 2014, **43**:579-591.

102. Marshall F: **Recognising sustainability frontiers in the peri-urban**. *South Asian Water Stud* 2016, **5**:98-102.

103. Jasanoff S (Ed): *States of Knowledge: the Co-production of Science and Social Order*. London: Routledge; 2004.

104. Pereira L, Karpouzoglou T, Doshi S, Frantzeskaki N: **Organising a safe space for navigating social-ecological transformations to sustainability**. *Int J Environ Res Public Health* 2015, **12**:6027-6044.

105. Pereira L, Frantzeskaki N, Hebinck A, Charli L, Scott J, Dyer M: **Transformative spaces in the making : key lessons from nine cases in the Global South**. *Sustain Sci* 2019:1-18.

106. Wittmayer JM, Scha N: **Action, research and participation: roles of researchers in sustainability transitions**. *Sustain Sci* 2014, **9**:483-496.

107. Charli-Joseph L, Siqueiros-Garcia JM, Eakin H, Manuel-
•• Navarrete D, Shelton R: **Promoting agency for social-ecological transformation: a transformation-lab in the Xochimilco social-ecological system**. *Ecol Soc* 2018, **23**
This team of activist-researchers working in Mexico City describe an important initiative in the peri-urban Xochimilco wetland, in which an innovative 'T-lab' experiment explored a compelling hybrid participatory-analytic approach towards the building of genuinely bottom-up transformative spaces– aiming to create conditions for 'endogenous transformations'.

108. Pereira L, Drimie S, Zgambo O, Biggs RO: *Planning for change: Transformation Labs for an alternative food system in the Western Cape*. . Stellenbosch, South Africa 2018.

109. Ely A, Marin A: **Learning about 'Engaged Excellence' across a**
•• **transformative knowledge network**. *IDS Bull* 2016, **47**
Coordinating a successful sustainability transformations collaborative research initiative across four continents, the authors reflect on key general lessons arising across the diverse approaches and settings. A number of practical conclusions arise for the conduct of a 'pathways approach' to 'engaged excellence'.

110. Sharpe B, Hodgson A, Leicester G, Lyon A, Fazey I: **Three horizons: a pathways practice for transformation**. *Ecol Soc* 2016, **21**:47.

111. Yang A, Jiang L, Ely C: **A study of 'Green Unemployed Groups' from a resilience perspective**. *Guizhou Soc Sci* 2018, **347**:135-142.

112. Eakin H, Shelton R, Siqueiros-Garcia JM, Charli-Joseph L, Manuel-Navarrete D: **Loss and social-ecological transformation: Pathways of change in Xochimilco, Mexico**. *Ecol Soc* 2020, **24(3)**:1-15.

113. Eames M, Mcdowall W: **Sustainability, foresight and contested futures: exploring visions and pathways in the transition to a hydrogen economy**. *Technol Anal Strateg Manag* 2010, **22**:671-692.

114. Stirling A: **How deep is incumbency? A 'configuring fields'**
• **approach to redistributing and reorienting power in socio-material change**. *Energy Res Soc Sci* 2019, **58**:101239

This paper explores the extent to which the global patterns of incumbency implicated in sustainabilty challenges can exercise conditioning effects even on the content of research concerning possibilities for progressive social transformations. Diagnosing resulting tendencies to adopt' eagle-eye' views of change processes, it proposes an alternative' worm-eye' view that better recognizes (and so may help enable) a stronger role for democratic struggle.

115. Abrol D: **Intervening for the sustainable transformation of**
●● **urban environment and water management in Gurgaon: learning from the creation of a multistakeholder platform in India**. *Front Environ Health Rev* 2020. Forthcoming
This paper recounts experience of a key case mentioned in the present article, arising from many years of activist research in the northern Indian city of Gurgaon. The Gurgaon Water Forum offers a model for engaging the imaginations, values and interests of public administrators, resident welfare associations and citizen groups in transformative urban planning.