



OPINION PIECE

Human and societal transformations are critical for food system responses to the climate crisis

**Andrew Juan Challinor^{1,*}, Jon Hellin², Vanessa Meadu³, Charles Spillane⁴,
Peter C. McKeown⁴, Stephen Whitfield¹, Steve Taylor⁵, Carmody T. Grey⁶,
Marieke Veeger⁷, Lucas Rutting⁸**

¹School of Earth and Environment, University of Leeds, Woodhouse Lane, Leeds LS2 9JT, UK

²International Rice Research Institute, Pili Drive, Los Baños, Laguna 4031, Philippines

³University of Edinburgh, Old College, South Bridge, Edinburgh EH8 9YL, UK

⁴University of Galway, University Road, Galway H91 TK33, Ireland

⁵Leeds Beckett University, City Campus, Leeds LS1 3HE, UK

⁶University of Durham, The Palatine Centre, University, Stockton Rd, Durham DH1 3LE, UK

⁷Alliance Bioversity-CIAT, Via di San Domenico 1, 00153 Rome, Italy

⁸Utrecht University, Heidelberglaan 8, 3584 CS Utrecht, Netherlands

ABSTRACT: Faced with the growing climate crisis, there are calls for transformative adaptation, a climate response that addresses the root causes of vulnerability and requires radical change in food systems. Transformation of food systems is hence essential to deal with the ongoing climate crisis and to fulfil wider sustainability and development challenges from local to global scales. Transformed food systems must minimise vulnerability to shocks while delivering environmental, social and economic benefits. This need can only be met by embracing food system transformation as a process of social and individual change that contributes to transformative adaptation. The scale of this societal and environmental challenge demands an equally grand vision — one that integrates climate, sustainability and systems thinking with human psychology, beliefs and values, and shared understandings. Such a vision, with community and individual transformation at its core, has the potential to deliver multiple benefits to society through transformative food system change, livelihood resilience and climate change adaptation and mitigation. Fostering conditions that support both individual transformation and the development of collective understanding therefore needs to be a core part of any strategies to transform food systems. In this opinion piece, we provide a framework to guide this transformative drive towards societal climate resilience.

KEY WORDS: Climate change · Food security · Transformation · Society · Food systems

1. INTRODUCTION

Climate change threatens food security with dire warnings of increased poverty and malnutrition. The agricultural sector is not only a significant source of greenhouse gas emissions but it is also adversely impacted by climate change, especially droughts, floods and increasing temperatures. Climate risk manage-

ment is part of the response to the threat of climate change. In particular, there is an urgent need for food system transformation that minimises vulnerability to climate shocks while delivering environmental, social, political and economic benefits (Whitfield et al. 2021, Zurek et al. 2022). Further, risks to food availability and access, conflict, migration, public health and security can interact and cascade across communities,

*Corresponding author: a.j.challinor@leeds.ac.uk

[§]Article was changed to Open Access, and the copyright notice updated after publication.
This corrected version: November 19, 2025

sectors and borders, effectively acting as a risk multiplier (Challinor & Benton 2021), especially for the most vulnerable.

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report, in recognition of the severity of the climate crisis, calls for a paradigm shift in the climate response from an incremental to a transformative one (IPCC 2022). The report also identifies the danger of the climate response inadvertently increasing the vulnerability of more marginalized groups. There have subsequently been calls for transformative adaptation, a climate response that addresses the root causes of vulnerability and requires radical change in food systems, including power dynamics between different value chain actors (Hellin et al. 2022).

The COVID-19 pandemic and the food system reverberations of the invasion of Ukraine revealed the low levels of resilience of global food systems to unexpected shocks, with the poorest and most vulnerable most negatively affected (Carducci et al. 2021, Alexander et al. 2023, Lin et al. 2023). COVID-19 brought transformational societal shifts to the forefront of global discourse and rapidly unlocked unprecedented financial support for social system transformation (Barrett et al. 2021) for a limited duration. Food system transformation, as part of the climate response, must be longer-lasting (including inter-generational dimensions), while enshrining environmental sustainability and ensuring that nobody is 'left behind'. A radical new agenda is required, one that embraces a rights-based approach to planetary boundaries (Ensor & Hoddy 2021) under the umbrella of climate justice (Newell 2022).

Agricultural research plays a major role in this transformation, but it requires researchers to work in different ways with much greater emphasis on inter- and transdisciplinary research and by embracing food system transformation as a process of change at societal and individual levels (Pender 2023). However, transformative change for individuals, communities and societies is inherently risky. Social equity issues arise in terms of who bears the burden of transformative change and how transformation towards more environmentally and socially sustainable food systems can be charted in ways that minimise maladaptation (Blythe et al. 2018, Eriksen et al. 2021, Tribaldos & Kortetmäki 2022).

Transformative food system change is driven by multiple agents, who operate at different levels and dimensions of societal and economic systems. Critically, transformation is a socio-political choice (Pender 2023). While technological innovations are fundamen-

tal to the process (Barrett et al. 2020), the social and institutional environments ultimately enable and drive transformation (Hellin et al. 2022). There is a need to couple technologies and innovations with broader societal, institutional and governance change (International Science Council 2023). Government and governance are responsible for profound economic, political and social changes, but as O'Brien (2018) noted, these structural changes are themselves underpinned by shifts in the mental models (i.e. the values and assumptions) of the individuals that comprise those structures. Hence, social transformation consists of practical, political and personal transformation.

A transformative response to the climate crisis is, hence, both a huge challenge and opportunity for agricultural researchers. There is no denying that the challenge can at times be overwhelming. In a Comment piece titled 'Scientists have emotional responses to climate change too', Schipper et al. (2024, p. 1011) recognized that 'trying to resolve problems with serious consequences over which you have inadequate control is the literal definition of distress—and not surprisingly, many climate scientists are reporting feelings of distress and anxiety'. We very much relate to this reality.

In this Opinion piece, we propose a framework (Fig. 1) that highlights the importance of internal and external dimensions of both individual and collective change for food system transformation. We do not provide a blueprint on how the framework could be operationalized (that would be well beyond the scope of this Opinion piece and our expertise). Rather, we provide the framework to illustrate the type of human and societal transformations that underpin urgently needed food system responses to the climate crisis. We see the framework as a contribution (however small) to the fusion of science and humanism which is so urgently needed to 'provide not only solace and inspiration, but also maps and narratives toward a better future for nature and people' (Jackson 2019, p. 1076). A framework that, in the words of Wilson et al. (2020, p. 200), can help 'our understanding of behaviours that lead to greater societal resilience in the long-term'.

2. ROLE OF HUMAN AND SOCIETAL TRANSFORMATION IN RESPONDING TO THE CLIMATE CRISIS

Most analyses to date have focused primarily on external aspects of transformation, whether in the systems themselves (e.g. Hall & Dijkman 2019), regulatory instruments (government policies, laws) or the behav-

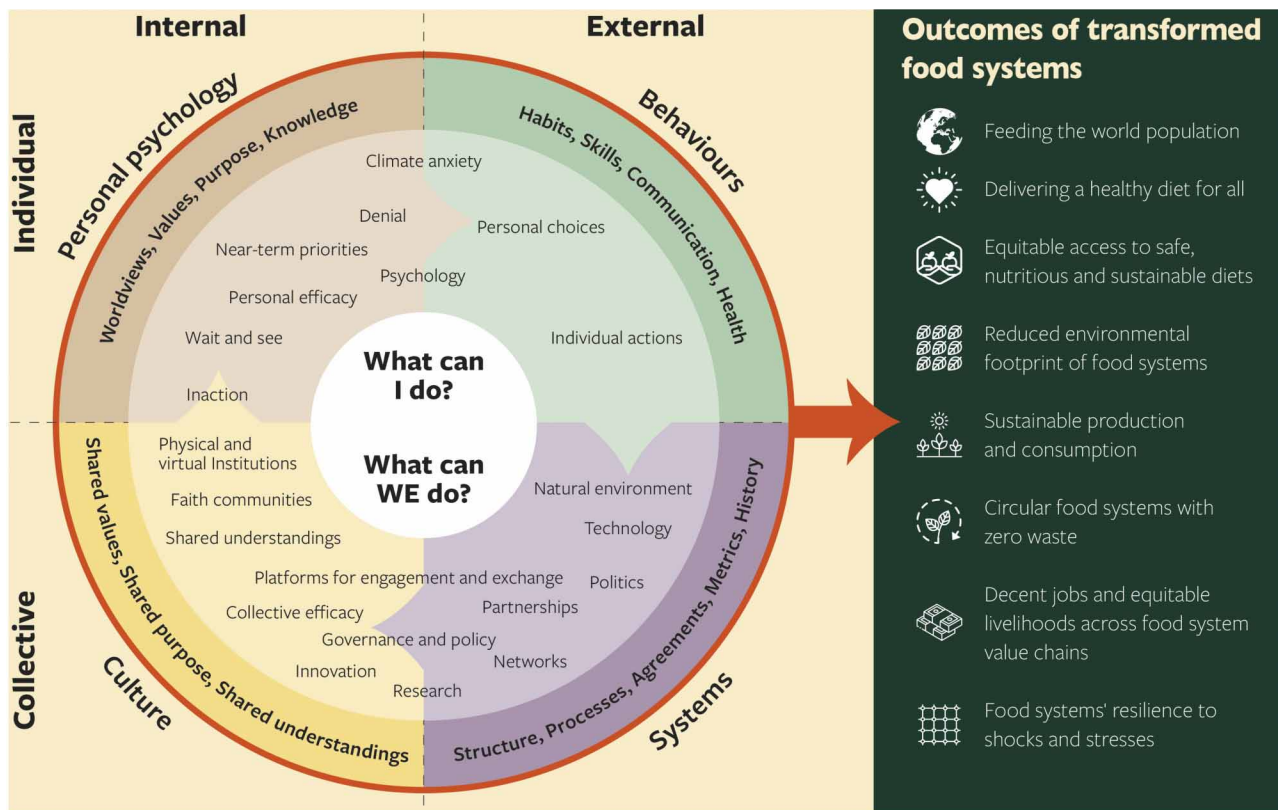


Fig. 1. Food systems transformation framework that highlights the importance of internal and external dimensions of both individual and collective change. Figure adapted from Wilber (2001). Outcomes of transformed food systems are derived from the 2021 World Food Systems Summit Action Tracks (<https://www.un.org/en/food-systems-summit/action-tracks>) and from Béné et al. (2019)

journal patterns of individuals (e.g. Karanja et al. 2022). Our focus here is instead on the internal aspects of transformation—both the personal psychology and the cultures that can result in agency as a transformative force. The organisations and institutions that comprise and drive food systems all arise from collective culture which is itself affected by individual agency. We use the term 'internally driven transformation' to emphasise this ever-present role of individuals and society in fostering change (Clare et al. 2017).

Those who exercise their agency may act, at different times, as consumers, or as actors within value chains, as well as members of research, regulators and advisory entities, governments and multilateral organisations. The importance of individual agency applies therefore to all such groups. Organisations and institutions interact in multiple ways to produce food system outcomes (Fig. 1, green column) through presenting options, choice-editing, enabling actions, rewarding progress or penalising unwilling actors, where outcomes can cascade across other systems, sectors, geographies and communities.

3. HUMAN TRANSFORMATION: INDIVIDUALS AND BEHAVIOURAL CHANGE

The behaviour of individuals is shaped by their personal and collective values and worldviews (Pender 2023). Human behaviour is also shaped and influenced by innovations and policies, and is aggregated through a range of different institutions in society, including households, communities, workplaces and civil society (Granderson 2014). Transformative change in food systems can occur when sufficient numbers of individuals feel empowered or are required to take actions that collectively drive structural and systemic shifts. If such changes at the collective level in turn generate further individual transformation, positive feedback loops of transformational change can arise.

Understanding pathways of system change requires disaggregation of the various overlapping roles that individuals play within systems, structures and society, e.g. as consumers, farmers, processors, retailers, regulators, family and other social roles, as well as their roles in advocacy or civil society groups. Being

an effective agent of change may have many dimensions, including internal psychology (Fig. 1, upper left) from which the desire to express agency and drive behavioural change (upper right) may emerge. The key question here, as shown in Fig. 1, is 'What can I do, either individually and/or as part of wider networks and organisations?'

Individual and group transformation is a highly effective, and usually entirely overlooked, way of increasing the agency of individuals in effecting change (Pender 2023). Research on individuals who undergo positive personal transformation following periods of intense psychological turmoil highlights a shift towards greater and more cooperative agency. Such individuals tend to transcend notions of group identity (such as attachment to a particular religious, political or ethnic affiliation) in favour of wider-ranging and more open perspectives. There is an expansion of conceptual awareness, with a transcendence of a self-centred perspective and a greater concern for other people's problems and for social and global issues (Taylor 2012, 2021).

Individual transformation does not need to await the occurrence of intense turmoil. Ken Wilber (whose 'Four quadrants' model provides a basis for Fig. 1) viewed personal development partly as a progression from an 'egocentric' to a 'sociocentric' and then a 'worldcentric' worldview (Wilber 1995). At the egocentric level, the individual is entirely preoccupied with self-needs, whereas at the sociocentric level, they prioritise the needs of their group or community beyond self-needs. At the worldcentric level, the individual identifies with humanity as a whole, beyond any notions of nationality, ethnicity, religion or gender. Similarly, Maslow (1970) saw this wide-ranging identification as one of the characteristics of the highly developed individuals he termed 'self-actualisers.'

Viewed in this way, individual transformation becomes an essential element of sustained social change such as transformative climate change adaptation, particularly any shifts towards a more global perspective, involving global citizenship with greater consideration of justice and fairness. While not discounting the possible value of 'enlightened self-interest' in certain circumstances, social and political change cannot be sustainable without a corresponding psychological shift in individuals. Although such a shift often occurs accidentally, it can be consciously cultivated. Various practices and lifestyles are traditionally strongly associated with spiritual growth, such as meditation, altruism, empathy, voluntary simplicity and contact with nature. A person may also follow a more systematic path of self-development such as the Buddhist 8-fold

path, the 8-limbed path of Yoga, or the practices of contemplative or mystical Christianity.

In Fig. 1, the internal quadrant of personal psychology can be seen as a key driver of external change. In particular, the aspects of worldview and values are highly significant. Critical global issues such as equitable sustainable food systems and just climate change transitions (the change advocated by IPCC 2022) can only be adequately dealt with from this wider conceptual perspective: any attempt to deal with them from a social system perspective alone will emphasise and exacerbate conflicting competitive agendas, which run the risk of exacerbating the very problems they intend to address.

In terms of values, personal development or transformation involves a movement towards increased empathy and altruism, hence shifting towards a more connective orientation in which an individual is no longer enclosed within their own psychological space, with a sense of duality between them and the world (including other beings). The 'transformed' individual feels a more empathic connection with other people and with other living beings and the natural world itself (Taylor 2012, 2021). Individuals are more likely to act if they believe that their action will bring about positive change (Wilson et al. 2020).

With this heightened sense of socio-ecological connection comes a sense of responsibility. The individual feels an impulse to respect and support others, and the natural world itself, because they feel that their identity is shared, that they are part of a wider network of being. Indeed, it could be argued that it is a lack of empathic connection that has led to our present environmental crises, with a lack of responsibility to the natural world. Whilst this attitude is far from universal, it is prevalent enough to be the underlying major driver of anthropogenic environmental change.

Personal transformation ('What can I do?') is complemented by an additional perspective in Fig. 1: 'What can we do?'. Here, it is communities that are the engine of change, since it is within communities that the necessary deep reorientation of systems and practices, now clearly identified as *our* systems and practices, can begin (Pisor et al. 2022). It is here that questions can be asked, and meaning found, about the goal and direction of food systems. The notions of individual and personal transformation necessarily imply 'transformation towards what?' just as the notion of sustainability immediately raises the question: 'What do we want to sustain, and how?'

Large-scale societal change, which is driven by a positive collective vision, is more likely to be effective in the long term, because change is motivated and un-

derpinned by a shift to a transformed mode of thinking and feeling about one's place in the world as a whole. Collective understanding is therefore a key part of the human transformation that is needed for transformative adaptation. Transformative change is underpinned by both individual and shared understandings and assumptions about the world, which in turn influence perceptions and interpretations of food systems.

Collective understandings also define what is individually and collectively imaginable, desirable, and viable, based on different understandings of causality, perceptions of agency, and assumptions about leadership. Thus, when considering the role of individuals and communities as subjects of change, the related issues of equity and justice emerge starkly, particularly regarding concepts of climate justice and just transition pathways (Rockström et al. 2021, Whitfield et al. 2021, Newell 2022). Individual transformation towards pro-environmental values and behaviours is likely to occur most reliably when practised and habituated in community. Communities and collective action is therefore a key instrument in creating large-scale social change.

4. SOCIETAL TRANSFORMATION THROUGH COLLECTIVE UNDERSTANDING

There are multiple pathways and feedbacks between collective understandings and the individuals that together form the collective (i.e. between the top and bottom halves of Fig. 1). Social and societal norms play a key role in generating the behaviours and beliefs of individuals (Gifford & Nilsson 2014). Motivation for personal change is, to a significant degree, socially generated. We consistently underestimate how much others influence our choices and behaviours (Wilson & Dunn 2004). Social affiliation has a demonstrated effect on environmental behaviours (Hoffarth & Hodson 2016).

Collective understandings can be facilitated through dialogues that respect communities' rights and autonomy, and forge common interests regarding transformation, rather than dialogues that simply communicate or entrench the positions of different (often opposing) groups (Pender 2023). Indeed, enabling multiple perspectives may prove more useful to accelerate food systems transformation than operating within silos or traditional dividing lines. This calls for inter- and trans-disciplinary responses as part of the climate response (Cundill et al. 2019), including polycentric governance processes (Ostrom 2010). For example, delineating left versus right politics can tend to produce opposing drivers that hinder rather than serve transformation.

The transformative visions with the greatest potential may be those where there is a broad range of views that allow for the identification of common interests and alterations to structures that stymie collective agency—from the multinational corporations that are driving change in food systems through to food sovereignty movements and broader animal welfare perspectives. This kind of pluralism and diversity of values and perspectives can be argued to be central to the progress of knowledge about the world (Longino 1990).

Collective understanding can also be embodied by faith communities. Around 84% of the world's population belong to a faith community, and this number is growing (Sherwood 2018). These communities are often heirs to traditions of practice that foster personal transformation towards a wider sense of solidarity with others and with the natural world. Altruism is an explicit value of every world faith. Indeed, extending a sense of kinship beyond biological relation, generating empathy and fellow-feeling with those more distant from oneself, is thought to be a significant evolutionary role of religion (MacIntyre 2004). Faith communities thus represent an under-utilised resource in fostering the transformation of individuals at a large scale, and so creating transformative social and environmental change (Müller 2021).

Despite the key role of collective understanding and agency, they remain a necessary but not sufficient element of internally driven food system transformation. For change to occur at a societal level, actors need to form new and potentially unconventional partnerships to allow for the scaling of new knowledge and innovations. Truly transformative processes therefore require reform of both governance and power relations, by forging new coalitions and partnerships that espouse both sustainability and equity and which work towards societal change. Public investments and policies are an important stimulus for many necessary changes. These include de-risking transformative climate adaptation pathways via incentives, infrastructure and support. Governments are innovation partners, along with investors (donors, private sector and philanthropy) and both public and private agricultural research organisations (Hall & Dijkman 2019).

5. ACHIEVING FOOD SYSTEMS TRANSFORMATION AND TRANSFORMATIVE ADAPTATION

We have proposed the need to incorporate individual agency and self-actualisation into food systems transformation, as a counterpoint to the more common

focus on institutional and policy change. What evidence is there that such an approach can work? Certainly, the process of developing collective understandings, as outlined above, has the potential to generate bottom-up change (Mehta et al. 2021). For example, new conversations and partnerships at the local level can affect change in food systems (e.g. Freedman & Bess 2011); local-level food system change can occur in response to geopolitical events and global food regime changes (e.g. Mukahhal et al. 2022); and collectively envisaged food system scenarios can lead to effective policy formation in the context of a climate response (Chaudhury et al. 2013, Vermeulen et al. 2013, Vervoort et al. 2014, Palazzo et al. 2017, Wiebe et al. 2018, Veeger et al. 2019, Rutting et al. 2021).

Do the pathways that we outline here have the potential to scale sufficiently to engender system-wide transformation of food systems as a response to the climate crisis? There are definite examples at the national level from outside of food systems. In the Netherlands, people working for various government agencies and universities recently became organised to pressure their pension fund—the biggest in the country—to divest from fossil fuels (Rutting et al. 2021). Another example of internally driven change comes from Honduras, in the wake of the destruction caused by Hurricane Mitch in 1998 (McSweeney & Coomes 2011). Household-level innovations in land management spurred by the natural disaster spread from household to household, eventually resulting in a shift to a system built on more than just land distribution and protected forest areas that proved much more resilient when a similar flooding occurred a decade later (McSweeney & Coomes 2011, Westley et al. 2011).

There are also a number of examples of specific food system transformations that resulted from internally driven change, as documented by Pereira et al. (2023). In Costa Rica, more ambitious mitigation goals were included in the Intended Nationally Determined Contribution (INDC) due an inclusive process where transformation was envisioned. The INDC team engaged with researchers, asking them to set up a participatory process for exploring futures that ultimately helped them demonstrate public aspiration towards an ambitious goal. A somewhat similar example is presented in the same reference for Ghana, where national science-policy dialogues resulted in policy, strategy and programme advancement. Pereira et al. (2023) also provided an analysis of both barriers to change and means of overcoming those barriers.

Despite the examples provided here, the ability of internally driven change to foster national-to-global

food systems transformations is far from guaranteed. Fostering and maintaining local-level initiatives that can scale up to the national level has significant challenges. For example, whilst food hubs have seen growth in recent years, and can contribute to food system resilience, support beyond current levels is needed to ensure longevity (Neuman & Sharpe 2023). However, there is at least some cause for optimism. First, there is evidence that societal tipping points can, during peak mobilisation events at least, occur when just 3.5% of a national population is actively engaged in protest to effect change (Christensen et al. 2013, Chenoweth 2020). Platforms for engagement and exchange could be used to scale up individual and community action. Indeed, the internet and social media systems are increasingly used as a resource for the forming of shared understanding and actions (Earl & Kimport 2013, Foodtank 2022). If the associated challenges of misinformation, echo-chambers and filter bubbles that arise from power and agenda processes can be addressed (Rhodes 2022), then these platforms offer significant potential for a transformative approach to the climate crisis.

A second cause for optimism is that the cultural shifts can result from positive feedback across scales (and thus across the quadrants of Fig. 1). For example, modelling results suggest that dietary shifts away from meat result from interactions between social norms and self-efficacy, findings which 'stress the importance of value-driven actions motivated either by intrinsic identity or by group dynamics' (Eker et al. 2019, p. 725). A similar result can be seen in the field of environmental psychology, with collective efficacy shown to increase pro-environmental intentions through increasing self-efficacy (Jugert et al. 2016). Self-efficacy can also be increased by addressing underlying anxieties, as has been argued for the case of climate by Mortreux et al. (2023).

The framework presented here offers a lens through which to consider the complexity and challenge of transformation to sustainability: transforming food systems as part of a radical response to the climate crisis. It does so by looking at who can, who will and who should act as an agent of change, and how change can be fostered. The adoption of this framework would allow us to better perceive and understand the roles played by different agents of change across system nodes, grasp the systemic consequences and identify the blockages or enablers that can emerge in pathways of transformation to sustainable and equitable climate futures. There are many pathways for change; internally driven change can not only occur through the routes we have focused on here, but also through en-

gendering large-scale structural change. We believe that the framework contributes to the emerging literature on how to foster societal transformation in different contexts (Fisher et al. 2022) and especially the growing number of bottom-up examples of transformative climate change adaptation. Mehta et al. (2021) referred to these examples as 'socio-ecological bright spots' or 'patches of transformation' that can inspire 'transformative societal changes that can be scaled up and out' (p. 112).

Acknowledgements. We are very grateful to 2 anonymous reviewers for their invaluable comments and suggestions on an earlier version of this paper. This work was underpinned throughout with core research funding from the University of Leeds (to A.J.C.) with subsequent support from the CGIAR research project on Climate Resilience (ClimBeR) and the CGIAR Climate Action Science Program. We thank all funders who supported this research through their contributions to the CGIAR Trust Fund (www.cgiar.org/funders/).

LITERATURE CITED

- ✦ Alexander P, Arneth A, Henry R, Maire J, Rabin S, Rounsevell MDA (2023) High energy and fertilizer prices are more damaging than food export curtailment from Ukraine and Russia for food prices, health and the environment. *Nat Food* 4:84–95
- ✦ Barrett CB, Benton TG, Cooper KA, Fanzo J and others (2020) Bundling innovations to transform agri-food systems. *Nat Sustain* 3:974–976
- ✦ Barrett CB, Fanzo J, Herrero M, Mason-D'Croz D and others (2021) COVID-19 pandemic lessons for agri-food systems innovation. *Environ Res Lett* 16:101001
- ✦ Béné C, Prager SD, Achicanoy HAE, Toro PA, Lamotte L, Bonilla C, Mapes BR (2019) Global map and indicators of food system sustainability. *Sci Data* 6:279
- ✦ Blythe J, Silver J, Evans L, Armitage D and others (2018) The dark side of transformation: latent risks in contemporary sustainability discourse. *Antipode* 50:1206–1223
- ✦ Carducci B, Keats EC, Ruel M, Haddad L, Osendarp SJM, Bhutta ZA (2021) Food systems, diets and nutrition in the wake of COVID-19. *Nat Food* 2:68–70
- ✦ Challinor A, Benton TG (2021) International dimensions. In: Betts RA, Howard AB, Pearson KV (eds) *The Third UK Climate Change Risk Assessment Technical Report*. Prepared for the Climate Change Committee, London. <https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Chapter-7-FINAL.pdf>
- ✦ Chaudhury M, Vervoort J, Kristjanson P, Ericksen P, Ainslie A (2013) Participatory scenarios as a tool to link science and policy on food security under climate change in East Africa. *Reg Environ Change* 13:389–398
- ✦ Chenoweth E (2020) Questions, answers, and some cautionary updates regarding the 3.5% rule. Carr-Ryan Center for Human Rights Policy, Harvard Kennedy School, Cambridge, MA. https://www.hks.harvard.edu/sites/default/files/2024-05/Erica%20Chenoweth_2020-005.pdf
- Christensen C, Raynor ME, McDonald R (2013) Disruptive innovation. *Harvard Business Review*, Brighton, MA
- ✦ Clare A, Graber R, Jones L, Conway D (2017) Subjective measures of climate resilience: What is the added value for policy and programming? *Glob Environ Change* 46:17–22
- ✦ Cundill G, Currie-Alder B, Leone M (2019) The future is collaborative. *Nat Clim Change* 9:343–345
- Earl J, Kimport K (2013) *Digitally enabled social change: activism in the internet age*. MIT Press, Cambridge, MA
- ✦ Eker S, Reese G, Obersteiner M (2019) Modelling the drivers of a widespread shift to sustainable diets. *Nat Sustain* 2:725–735
- ✦ Ensor J, Hoddy E (2021) Securing the social foundation: a rights-based approach to planetary boundaries. *Earth Syst Gov* 7:100086
- ✦ Eriksen S, Schipper ELF, Scoville-Simonds M, Vincent K and others (2021) Adaptation interventions and their effect on vulnerability in developing countries: help, hindrance or irrelevance? *World Dev* 141:105383
- ✦ Fisher E, Brondizio E, Boyd E (2022) Critical social science perspectives on transformations to sustainability. *Curr Opin Environ Sustain* 55:101160
- ✦ Foodtank (2022) 21 Organizations transforming Australia's food system. <https://foodtank.com/news/2019/01/21-organizations-transforming-australias-food-system/> (accessed October 2022)
- ✦ Gifford R, Nilsson A (2014) Personal and social factors that influence pro-environmental concern and behaviour: a review. *Int J Psychol* 49:141–157
- ✦ Granderson AA (2014) Making sense of climate change risks and responses at the community level: a cultural-political lens. *Clim Risk Manage* 3:55–64
- ✦ Hall A, Dijkman J (2019) Public agricultural research in an era of transformation: the challenge of agri-food system innovation. CGIAR Independent Science and Partnership Council (ISPC) Secretariat and Commonwealth Scientific and Industrial Research Organisation (CSIRO), Rome and Canberra. <https://cas.cgiar.org/isdc/publications/public-agricultural-research-era-transformation-challenge-agri-food-system>
- ✦ Hellin J, Amarnath G, Challinor A and others (2022) Transformative adaptation and implications for transdisciplinary climate change research. *Environ Res Clim* 1:023001
- ✦ Hoffarth MR, Hodson G (2016) Green on the outside, red on the inside: perceived environmentalist threat as a factor explaining political polarization of climate change. *J Environ Psychol* 45(Suppl C):40–49
- ✦ International Science Council (2023) Flipping the science model: a roadmap to science missions for sustainability. <https://council.science/wp-content/uploads/2023/08/Flipping-the-Science-Model-1.pdf>
- ✦ IPCC (2022) Climate change 2022: impacts, adaptation, and vulnerability. In: Pörtner H-O, Roberts DC, Tignor M, Poloczanska ES and others (eds) *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge
- ✦ Jackson ST (2019) Humboldt for the Anthropocene. *Science* 365:1074–1076
- ✦ Jugert P, Greenaway KH, Barth M, Büchner R, Eisentraut S, Fritsche I (2016) Collective efficacy increases pro-environmental intentions through increasing self-efficacy. *J Environ Psychol* 48:12–23
- ✦ Karanja A, Ickowitz B, Stadlmayr S, McMullin S (2022) Understanding drivers of food choice in low- and middle-income countries: a systematic mapping study. *Glob Food Secur* 32:100615

- Lin F, Li X, Jia N, Feng F and others (2023) The impact of Russia-Ukraine conflict on global food security. *Glob Food Secur* 36:100661
- Longino H (1990) Science as social knowledge: values and objectivity in scientific inquiry. Princeton University Press, Princeton, NJ
- MacIntyre F (2004) Was religion a kinship surrogate? *J Am Acad Relig* 72:653–694
- Maslow A (1970) Motivation and personality, 2nd edn. Harper and Row, New York, NY
- McSweeney K, Coomes OT (2011) Climate-related disaster opens a window of opportunity for rural poor in northeastern Honduras. *Proc Natl Acad Sci USA* 108:5203–5208
- Mehta L, Srivastava S, Movik S, Adam HN and others (2021) Transformation as praxis: responding to climate change uncertainties in marginal environments in South Asia. *Curr Opin Environ Sustain* 49:110–117
- Mortreux C, Barnett J, Jarillo S, Greenaway KH (2023) Reducing personal climate anxiety is key to adaptation. *Nat Clim Change* 13:590
- Mukahhal W, Abebe GK, Bahn RA, Martiniello G (2022) Historical construction of local food system transformations in Lebanon: implications for the local food system. *Front Sustain Food Syst* 6:870412
- Müller T (2021) People of faith are allies to stall climate change. *Nature* 592:9
- Neumann N, Sharpe R (2023) Sustainable food hubs and food system resilience: plugging gaps or forging the way ahead? Food Research Collaboration (FRC) Discussion Paper. FRC, Centre for Food Policy, City, University of London. <https://foodresearch.org.uk/publications/sustainable-food-hubs-and-food-system-resilience-plugging-gaps-or-forging-the-way-ahead/>
- Newell P (2022) Climate justice. *J Peasant Stud* 49:915–923
- O'Brien K (2018) Is the 1.5°C target possible? Exploring the three spheres of transformation. *Curr Opin Environ Sustain* 31:153–160
- Ostrom E (2010) Polycentric systems for coping with collective action and global environmental change. *Glob Environ Change* 20:550–557
- Palazzo A, Vervoort JM, Mason-D'Croz D, Rutting L and others (2017) Linking regional stakeholder scenarios and shared socioeconomic pathways: quantified West African food and climate futures in a global context. *Glob Environ Change* 45:227–242
- Pender A (2023) From partial to integrated perspectives: how understanding worldviews can expand our capacity for transformative climate governance. *Earth Syst Gov* 16:100174
- Pereira L, Vrettos C, Cramer L, Drimie S and others (2023) Policies and design processes to enable transformation. In: Campbell B, Thornton P, Loboguerrero AM, Dinesh D, Nowak A (eds) Transforming food systems under climate change through innovation. Cambridge University Press, Cambridge, p 119–129
- Pisor AC, Basurto X, Douglass KG, Mach KJ and others (2022) Effective climate change adaptation means supporting community autonomy. *Nat Clim Change* 12:213–215
- Rhodes SC (2022) Filter bubbles, echo chambers, and fake news: how social media conditions individuals to be less critical of political misinformation. *Polit Commun* 39:1–22
- Rockström J, Gupta J, Qin D, Pedde S, Broadgate W, Warszawski L (2021) Stockholm to Stockholm: achieving a safe Earth requires goals that incorporate a just approach. *One Earth* 4:1209–1211
- Rutting L, Vervoort JM, Mees H, Driessen PPJ (2021) Participatory scenario planning and framing of social-ecological systems: an analysis of policy formulation processes in Rwanda and Tanzania. *Ecol Soc* 26:20
- Schipper ELF, Maharaj SS, Pecl GT (2024) Scientists have emotional responses to climate change too. *Nat Clim Change* 14:1010–1012
- Sherwood H (2018) Religion: Why faith is becoming more and more popular. *The Guardian*, 27 August 2018. <https://www.theguardian.com/news/2018/aug/27/religion-why-is-faith-growing-and-what-happens-next>
- Taylor S (2012) Transformation through suffering: a study of individuals who have experienced positive psychological transformation following periods of intense turmoil and trauma. *J Humanist Psychol* 52:30–52
- Taylor S (2021) Transformation through loss and grief: a study of personal transformation following bereavement. *Humanist Psychol* 49:381–399
- Tribaldos T, Kortetmäki T (2022) Just transition principles and criteria for food systems and beyond. *Environ Innov Soc Transit* 43:244–256
- Veeger M, Mason-D'Croz D, Dunston S, Vervoort J, Palazzo A (2019) Crash-testing policies; how scenarios can support climate change policy formulation: a methodological guide with case studies from Latin America. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). <https://cgispace.cgiar.org/server/api/core/bitstreams/a71df517-aec8-4b29-9032-4c55de04c538/content>
- Vermeulen SJ, Challinor AJ, Thornton PK, Campbell BM and others (2013) Addressing uncertainty in adaptation planning for agriculture. *Proc Natl Acad Sci USA* 110:8357–8362
- Vervoort JM, Thornton PK, Kristjanson P, Förch W and others (2014) Challenges to scenario-guided adaptive action on food security under climate change. *Glob Environ Change* 28:383–394
- Westley F, Olsson P, Folke C, Homer-Dixon T and others (2011) Tipping toward sustainability: emerging pathways of transformation. *Ambio* 40:762–780
- Whitfield S, Apgar M, Chabvuta C, Challinor A and others (2021) A framework for examining justice in food system transformations research. *Nat Food* 2:383–385
- Wiebe K, Zurek M, Lord S, Brzezina N and others (2018) Scenario development and foresight analysis: exploring options to inform choices. *Annu Rev Environ Resour* 43:545–570
- Wilber K (1995) Sex, ecology, spirituality: the spirit of evolution. Shambhala Publications, Boston, MA
- Wilber K (2001) A theory of everything — an integral vision for business, politics, science, and spirituality. Shambhala Publications, Boston, MA
- Wilson RS, Herziger A, Hamilton M, Brooks JS (2020) From incremental to transformative adaptation in individual responses to climate-exacerbated hazards. *Nat Clim Change* 10:200–208
- Wilson TD, Dunn EW (2004) Self-knowledge: its limits, value, and potential for improvement. *Annu Rev Psychol* 55:493–518
- Zurek M, Ingram J, Sanderson Bellamy A, Goold C and others (2022) Food system resilience: concepts, issues, and challenges. *Annu Rev Environ Resour* 47:511–534

Editorial responsibility: Mikhail Semenov,
Harpenden, UK

Reviewed by: N. Senapati and 1 anonymous referee

Submitted: March 27, 2025; Accepted: September 8, 2025

Proofs received from author(s): October 2, 2025

This article is Open Access under the Creative Commons by Attribution (CC-BY) 4.0 License, <https://creativecommons.org/licenses/by/4.0/deed.en>. Use, distribution and reproduction are unrestricted provided the authors and original publication are credited, and indicate if changes were made