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PERSPECTIVE

Transformative adaptation and implications for transdisciplinary climate change research

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Abstract

The severity of the climate challenge requires a change in the climate response, from an incremental to a more far-reaching and radical transformative one. There is also a need to avoid maladaptation whereby responses to climate risk inadvertently reinforce vulnerability, exposure and risk for some sections of society. Innovative technological interventions are critical but enabling social, institutional and governance factors are the actual drivers of the transformative process. Bringing about this transformation requires inter- and transdisciplinary approaches, and the embracing of social equity. In this *Perspective,* we unpack what this means for agricultural research and, based on our collective experience, we map out a research agenda that weaves different research components into a holistic and transformative one. We do not offer best practice, but rather reflections on how agricultural research can more readily contribute to transformative adaptation, along with the personal and practical challenges of designing and implementing such an agenda.

1. Introduction

The working group (WG) II contribution to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report assesses the impact of climate change; it makes grim and sobering reading (IPCC 2022). The IPCC report has a focus on climate justice and 'transformational adaptation', and a call for a change in the climate response from incremental to more far-reaching transformative change. The IPCC report also warns of the danger of maladaptive responses to climate risk that reinforce vulnerability, exposure and risk.

There is a plurality of definitions of the term systems transformation and its derivatives (Scoones *et al* 2020). Few *et al* (2017) propose the term 'transformative adaptation' to define actions that address the root causes of vulnerability. We subscribe to this thinking along with the necessary changes in the fundamental attributes of food systems in the face of climate change. Changes are required to ensure that transformation contributes to the outcomes of the UN Food Systems Summit and, ultimately, the sustainable development goals.

Systems transformation is a process of societal and environmental change where different actors work in concert to change collectively a system towards greater sustainability. This level of transformation is needed to meet global climate goals. Agricultural research-for-development has long contributed to climate risk

management. Much effort to date has focused climate change adaptation and mitigation and the promotion of climate-resilient agriculture (Hansen *et al* 2019). Where emphasis on transformation is different to established approaches to climate risk management is around the critical need to shift from incremental adaptation to adaptation underpinned by systems transformation at different scales, as required for human wellbeing and ecosystem health, described by IPCC WG II as climate resilient development (IPCC 2022).

Transformative adaptation is a challenge for researchers, development practitioners and policy-makers because it requires inter- and transdisciplinary approaches where innovative technological interventions are critical but where the enabling social, institutional and governance environment drives the transformative process. Here, non-research partners engaged in policy and practice play a vital role in building the flexible, multi-sectoral and long-term planning approaches needed for successful adaptation. Clearly, within these transdisciplinary processes, political choices have to be made and negotiated, and trade-offs recognized (Scoones *et al* 2020). The potential for uncertainty and unexpected outcomes emerges, as highlighted by emerging social science on transformation in the Global South (Fisher *et al* 2022). Despite the increasing literature on the importance of transformative adaptation, there are few examples of moving from theory to practice, especially in terms of new ways of doing research (Kehrer *et al* 2020).

In this *Perspective*, we outline some of the challenges and ways forward to enhance the transformative impact of climate change research. We represent a diverse group of agricultural researchers. Many of us have been active over the last decade in the Consultative Group on International Agricultural Research (CGIAR) Research Program on Climate Change, Agriculture and Food Security (CCAFS). CCAFS has marshalled the science and expertise of CGIAR (a global research partnership for a food secure future) and its partners to catalyse positive change for climate-smart agriculture. Nowak *et al* (2021) highlight the distinctive approach to science promoted by CCAFS, which focuses primarily on systems thinking, including participatory, user-oriented science, rather than on more traditional, linear, technology-led approaches. Transformative adaptation resonates with our reflections from our research evidence over the last 10–15 years. It would be presumptuous to claim that we offer best practice for future transformative research; rather we outline learning that seeks to chart a course through the challenging and unpredictable terrain that faces any researcher as s/he embarks on climate change research projects with the aspiration to contribute to something as fundamental (and urgent) as systems transformation.

2. Inter- and transdisciplinary collaboration

Effective climate responses via transformative adaptation increasingly require inter- and transdisciplinary approaches with the concomitant need to recognize the challenges of working across different knowledge domains and disciplines (Rigg and Mason 2018, Leal Filho *et al* 2021); not least that '*transdisciplinary collaborations inevitably bring together partners who hold different levels of power, as perceived by themselves and others, in a variety of domains*' (Cundill *et al* 2019b). Transformative adaptation, hence, refers as much to the ways that diverse stakeholders (including agricultural researchers) need to address the power imbalances inherent in collaboration, as it does to the far-reaching impact of increasing the climate resilience of vulnerable populations while avoiding maladaptation (Atteridge and Remling 2018).

Scholz and Steiner (2015a) and Scholz (2020) point out that it is not just climate change adaptation that calls for inter-and transdisciplinary work; such an approach is relevant for complex issues that science alone cannot address such as the transition of energy systems and mitigating tensions between different religions. In these cases, science is but one stakeholder in transdisciplinary partnerships that require collaboration across disciplines and the incorporation of '*the great abundance of creative and innovative capabilities in society itself in the coping with these challenges*' (Scholz and Steiner 2015a, p 528). A common challenge in such partnerships is one of power imbalances whereby stakeholders do not operate on an equal footing. This can manifest itself in scientists seeing themselves as omnipotent and best positioned to make decisions (Scholz and Steiner 2015b), or even donors seeking to sway unduly the research process.

Successful transdisciplinary processes are often based on trust and confidence among the different stakeholders with this often achieved through informal processes (Scholz and Steiner 2015b). Building genuine partnerships often requires moving beyond short-term projects to long-term platforms that allow for transdisciplinary system science (Grove and Pickett 2019). In the case of climate change, a particular problem in achieving transformative adaptation is the tendency to operate within short-term projects that can undermine parties' effort to working together over time to identify longer-term transdisciplinary solutions.

Furthermore, in the context of a climate response, transdisciplinary networks of researchers and practitioners can further blur the lines between research and development (Cundill *et al* 2019a). There is a danger of mission drift in terms of researchers straying too much into development work for which they have neither the skills nor long-term presence on the ground (Hellin *et al* 2020). Of equal concern is the growing

trend for researchers and research organizations being evaluated as though they are development organizations, this has often led to researchers over-promising on the impact of research outputs and disappointment when these impacts are not realized (Leeuwis *et al* 2017). The danger can be mitigated by plausible theories of change that capture the complexity of societal transformations (Schneider *et al* 2019), and that detail the roles, legitimacy and *modus operandi* of different actors along the impact pathway (Thornton *et al* 2017, Hellin *et al* 2020).

3. Maladaptation and the need for social equity

Transformative adaptation's focus on action to address the root causes of vulnerability shines the spotlight on the need to ensure climate adaptation is just and equitable. It also highlights the dangers of maladaptation, when adaptation strategies go wrong due to an intervention—unintentionally—exposing people to greater climate risk and new hazards (Magnan *et al* 2016, Dilling *et al* 2019). As Araos *et al* (2021) note, '*without intentional and consistent attention to ensure equity in planning and implementation of adaptation for marginalized groups, climate change will likely exacerbate and reproduce existing inequities and vulnerabilities in society*'.

Addressing equity encompasses a broad agenda on climate justice, including attention to the historically rooted inequalities that determine extant discrimination, disempowerment and vulnerability in terms of gender, ethnicity, youth etc (Orlove *et al* 2020, Whitfield *et al* 2021). Ideally, this can feed into planning approaches that are inclusive, with emphasis on cross-sectoral working and governance arrangements, although the challenges of shifting established power relations and inequalities cannot be underestimated.

In light of the IPCC's focus on justice as a means to understand the successes and failures of adaptation, we see social equity as a cross-cutting theme that is intrinsic to all aspects of the climate response with a goal of achieving greater justice through transformation. After all, transformative adaptation tackles the root causes of vulnerability, including unevenly distributed power relations, and existing networks of control and influence (Schipper *et al* 2021), hence, in the absence of social equity, any change will, by definition, likely be less than transformative. To systematically address these issues, we advocate a social equity framework to guide climate change research that builds on Leach *et al* (2018) and Fisher *et al* (2019). This can facilitate understanding of the scope to generate equitable and sustainable transformative change.

The framework (figure 1) encompasses: (a) recognitional equity (how acknowledgement and respect is given to identity, values, social norms, and rights); (b) procedural equity (how decisions are made, and the degree to which different groups of people can influence these decisions or have their knowledge and perspectives represented or incorporated, through the roles of institutions, governance and participation); (c) distributional equity (how costs and benefits, and resources are distributed between people and groups) and, (d) intergenerational equity (how justice and injustice are perpetuated or changed through generations). By addressing 'equity of what' and 'equity between whom', the framework includes gender but treats it as part of a broader contextual framing that recognizes differential exposure to vulnerability and to how people's lived experience reflects multiple identities (Leach *et al* 2018). By implication this contributes to an understanding of how intersecting inequalities may be reproduced and perpetuated, enduring, deepening or becoming resolved in the context of efforts to address the impacts of climate risk.

By paying systematic attention to social equity and by being alert to the danger of maladaptation within transformative adaptation, ideas of justice can become grounded within practice, rather than treating ideas of justice as a normative abstraction (Ulriksen and Plagerson 2022). Anchoring attention to equity within the practice of adaptation helps provide a means to tease out tensions between competing claims and equity issues at different sites and scales in the food system, with the ambition of generating just solutions to food system transformation.

4. Research for system transformation: moving beyond technological innovations

Transformative adaptation requires multi-actor, multi-sectoral, inclusive planning and flexible pathways that encourage timely actions and ensure benefits in multiple sectors and systems. Such an approach provides a solution space for adapting to long-term climate change (IPCC 2022). While technological innovations are critical, enabling social, institutional and governance factors are the actual drivers of the transformative process. In this context, an intertwined social-ecological-technological systems approach holds potential for positive contribution to advancing a transdisciplinary climate change research agenda with a focus on governance, decision-making, partnerships and social networks (Cosens *et al* 2021, McPhearson *et al* 2021). This can enable researchers and food system practitioners to transform food systems by integrating social equity, environmental protection, and technology while building resilience to climate change. The following research components weaved into a holistic transformative agenda that foregrounds social equity and

Figure 1. Social equity framework to guide climate change research and generate equitable and sustainable transformative change. Building on Leach *et al* (2018) and Fisher *et al* (2019).

capacity development, illustrate one such pathway: reducing risk in food systems; mitigating conflict; informing policy using co-developed scenarios; enabling inclusive governance and institutions; and finally enhancing adaptation through climate finance.

4.1. Reduce risk in food systems

Food systems in many parts of the world are evolving in ways that are not compatible with climate resilience or adaptation, for example longer supply chains, food traveling greater distances, loss and waste, and increased refrigeration needs, etc. At the production level, smallholder rain-fed agriculture is particularly susceptible to climatic-induced risk in production and post-harvest value chains due to the variability in biophysical conditions and their temporal and spatial distribution (Isbell *et al* 2015, Harris *et al* 2022). The

nature of this risk is imperfectly understood; agriculture is seen as a 'risky business', and one that gets riskier in the face of climate change. Skinner *et al* (2014) argue that it is difficult to manage risk and uncertainties if they are not identified and/or understood. Typologies of uncertainty and risk can enhance this identification and understanding.

A first in reducing risk in rain-fed agriculture is knowing how the climate is likely to change, and how these changes may affect ecosystems and agricultural production systems (Yu *et al* 2020). Fostering transformative adaptation then depends on identifying who is at risk, where they are located, in what ways they are vulnerable, and what are the most appropriate social–ecological–technological innovations to foster climate resilient agriculture. Digital tools play an increasingly important role in supporting transformative adaptation. Examples include the development of climate-risk profiling systems and production system typologies to identify differential vulnerability in different farming contexts (You *et al* 2009), and the provision of climate information services (Jones *et al* 2015) that, in turn, can enable climate-informed investment planning geared towards the needs of different types of farmers.

4.2. Strengthen climate security

Climate change acts as a 'threat multiplier', exacerbating existing risks such as agricultural losses, food insecurity or inequalities. This increases the risk, duration and intensity of political insecurity and conflict. In fragile contexts, additional deprivations generated by the inability of the poorest households to cope with climate change, can significantly increase competition over natural resources and exacerbate grievances, tensions, and conflicts, which can further reduce climate resilience capacities as part of a growing vicious circle. The subsequent adverse impacts on peace and security (Koubi 2019) have generated growing interest in the 'climate security nexus', one that is characterized by non-linear and emergent processes because climate impacts are the product of processes occurring across different temporal and spatial scales, with global-level climatic trends for instance interacting with a particular set of localized conditions and characteristics. This subsequently requires context-specific responses.

How these relationships manifest themselves in any given context is unpredictable and requires adaptive approaches to policy and humanitarian, development, and peacebuilding programming (De Coning 2018). Climate research has much to contribute, for example, through efforts underway by CGIAR to develop a Climate Security Observatory. The Observatory will be an online decision-support tool that allows access to a range of global climate and security analyses for use in stakeholders' decision-making processes. It, hence, will contribute to conflict prevention and supporting regional, national, and local early warning systems; improving the targeting of interventions during conflict events; and ensuring climate security-sensitive recovery and development trajectories in post-conflict settings.

4.3. Co-develop policy pathways

Integrated Assessment Models are a tool to assess how the human and natural worlds interact to alter climate and society. Developing policy pathways from these models has helped explore energy and food outcomes (Müller and Robertson 2014), although the complexity of food systems processes means those that can be quantified may be subject to significant uncertainty propagation (Webber *et al* 2014). Integrated Assessment Frameworks (IAFs) provide an alternative way to combine systems thinking with crop-climate and emissions modelling to develop transformative co-produced policy pathways to climate resilient futures (Jennings *et al* 2022). IAFs combine model projections with expert judgment from across the natural and social sciences, using a formal system for summarizing model output. For each component of the integrated modelling, modelling experts summarize results using concise statements, which are calibrated to assess confidence using IPCC methods (Mastrandrea *et al* 2011). Confidence is expressed in terms of both robustness (internal consistency across the model ensemble used) and the level of agreement with existing literature.

Early, sustained and representative stakeholder engagement is critical to IAFs. Co-development of policy pathways can begin with a scenario exercise to identify stakeholder concerns and policy aspirations (e.g. climate risk, greater access to agricultural markets) and frame the modelling directly on the specifics of the scenarios deemed plausible (desirable or otherwise) by the stakeholders (O'Neill *et al* 2020). Later engagement can focus on developing the implications of the modelling, in order to describe and quantify the scenarios. Contrasting these possible futures enables robust conclusions to be made regarding the impact of environmental and policy change, despite the large irreducible uncertainties involved.

4.4. Foster multi-scale governance

By determining when, how, and who is able to adapt to climate risks, governance is critical to large-scale societal transformation (Pickering *et al* 2022). The recent IPCC report stresses that adaptation requires strong multi-scale governance systems at local, national, regional and global levels (IPCC 2022). Governance

actors need to work together across arenas of engagement in inclusive and synchronous ways (Garmestani and Benson 2013), which requires moving beyond a 'silo' approach to governance. Multi-scale or polycentric governance approaches allow for the co-design, and co-implementation of social–ecological–technological innovations by different actors. When these polycentric governance processes build from the bottom up, opportunities emerge for self-organization and learning across systems, but independent decision making for adaptation planning and implementation at multiple levels. Fasting *et al* (2021) use the example of the Association of Southeast Asian Nations Climate Resilience Network as a polycentric governance system that allows for autonomous units to self-organize and simultaneously to enhance climate resilience at different scales. Such an approach lends itself to being replicated in different contexts (Dorsch and Flachsland 2017).

4.5. Increase climate finance

Considerable investment is necessary for enabling transformative adaptation but there is a major gap in the funds required. Investment is needed to implement transformative adaptation, but transformative adaptation needs to be designed to attract investment and be economically-sustainable in the long term. If done well, there is a potentially four-fold return on investment (IPCC 2022); however, there are barriers to unlocking this finance. These include perceived lack of profitable investments and low commercial readiness of climate adaptation and resilient solutions. Incentives or tangible returns are needed for private finance to support adaptation. Market business models or policy interventions can attract this finance, for example blended finance mechanisms where the public funds absorb the first losses on investments, protecting the private and improving the risk-return profile for the investment.

There is an opportunity for research and development to address this challenge through transformative adaptation investment planning that aligns investment opportunities with national priorities and investment feasibility. Investment planning facilitates the emergence of a pipeline of investment opportunities geared to transformative adaptation and based on scientifically rigorous risk assessments. It is important to include farmers themselves and micro, small and medium sized enterprises (MSMEs) who are often have the greatest need for access to finance, but are often seen by financiers to be highly risky for finance and investment. More broadly, financialization through investment in the agriculture sector can also bring potential adverse effects, as the sector is prone to volatility and needs mechanisms to protect from these risks. This can be addressed through de-risking mechanisms, such as insurance either through commercial providers or government programs. A risk contingent credit product is one innovative approach, which bundles credit with insurance in one product (Ndegwa *et al* 2022).

To understand the benefits and adverse effects of climate finance, monitoring of investment impact is important to document environmental, social, and governance impacts, but there is a dearth of good measurement metrics (Widyawati 2020). Financial institutions require capacity building to better assess risks and design risk management products for smallholder farmers and MSMEs. Innovative partnerships utilizing science-based research can resolve many of the barriers to finance reaching smallholder farmers and MSMEs.

4.6. Transform ways of working

A transformative climate response needs to address the dual challenges of sustainability and equity (Leach *et al* 2018). For climate change researchers meeting this challenge will require new ways of working. As Kehrer *et al* (2020, p 9) note '*we will need to transform our work before transforming our world*'. We embrace the need to 'do research differently' and that translating the aforementioned five research components into a transformative agenda, requires inter- and transdisciplinary approaches and the embracing of social equity. We do not profile an adaptation pathway *per se* but rather outline a transdisciplinary research approach that allows for transformative pathways to evolve with non-academic partners, including farmers. Such an approach provides a way of integrating the qualitative social sciences, economic research, participatory policy modelling, governance and participatory peace and conflict research.

The research process together with capacity development and social networking allows for a transdisciplinary process. This aims to produce greater equality from climate services, from policy measures that strengthen agricultural resilience—including where there is agriculture-related climate security risk—and from investments made through partnerships with a focus on vulnerable farmers and climate-affected communities. Cundill *et al* (2019a, p 344) note that '*the most effective researchers are likely to be those who embrace diversity in team composition and structure, and that look beyond their disciplines, their home institutions and their national borders to build their research networks*'. The personal and practical challenges of designing and implementing such an agenda should not be underestimated. Climate researchers, however, can gain more inspiration by knowing that in response to increasingly complex societal changes, inter- and transdisciplinary responses are a 'form of utilizing and generating scientific knowledge that has the potential to become a main pillar of the scientific structures and institutions of the twenty-first Century ' (Scholz and Steiner 2015b, p 667).

5. Conclusions

The severity of the climate crisis requires transformative adaptation, a process of societal, environmental, and economic change, in some cases radical change. Addressing transformation through research requires a new way of working in terms of inter-disciplinary teams engaged with multiple stakeholders in transdisciplinary networks that increasingly include scientists and others from the Global South. Furthermore, the goal of achieving greater justice through transformation means that social equity is intrinsic to any climate response. This implies foregrounding complex inequalities, ensuring the intervention itself does not contribute to maladaptation, and making political choices about the (re)distribution of benefits.

The challenge is a daunting one from the perspective of climate change research. It requires a transformation in the way that researchers 'do research', in terms of embedding their disciplinary expertise in an interdisciplinary team. It also means broadening their research focus from one on technological innovations *per se* to working with policy and practitioner partners embedded within institutions that may be far removed from the transformations one wants to engender. Fostering transformative adaptation may face strong opposition as is evident from efforts to introduce climate change policies during recent decades. Faced with such opposition, the most effective strategy may in the short-term be incremental changes that cumulatively add up to transformative change.

Using the example of one possible adaptation pathway integrating research, we outline an approach that seeks to chart a course through the challenging and unpredictable terrain that faces any researcher as s/he grapples with designing and implementing climate change research leading to systems transformation. In the research process, technological innovations are still critical but attention to equity, scaling and sustainability relies on an enabling social, institutional and governance environment. The identified adaptation pathway foregrounds social equity and includes reducing risk in food systems; mitigating conflict; informing policy through participatory scenarios; enabling multi-scale governance; and attracting much-need climate finance.

The focus on systems thinking and participatory, user-oriented science is critical but enormous challenges (and opportunities) remain. Establishing the required inter- and transdisciplinary teams and connecting research to practice takes time; often far longer than three- or even five-year funding cycles. Moving from research outputs to outcomes and impact is a precariously unpredictable and non-linear process that depends on decisions by multiple actors as impact pathways develop. Climate change researchers are key actors in transformative adaptation; their contribution will be much enhanced by innovative thinking, bold action, reflective learning and upfront investment in fostering inter- and transdisciplinary teams that include a strong voice from low- and middle-income countries where climate change impacts are the most intense. The formation of these teams almost inevitably exposes different levels of power among team members, requiring a greater emphasis on capacity building and empowerment to ensure genuine systematic co-production of knowledge.

Data availability statement

No new data were created or analysed in this study.

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