frontiers in Climate

PERSPECTIVE
published: 08 December 2021
doi: 10.3389/fclim.2021.751691

Reflections on Enhancing the Impact of Climate Risk Management Through Transformative Adaptation

Jon Hellin[1]*, *Eleanor Fisher*[2] *and Ana María Loboguerrero*[3,4]

[1] Sustainable Impact Platform, International Rice Resaerch Institute (IRRI), Los Baños, Philippines, [2] Head of Research, The Nordic Africa Institute, Uppsala, Sweden, [3] CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Palmira, Colombia, [4] Bioversity International, Rome, Italy

Climate risk management is part of the response to the threat of climate change. Much effort has focused on the promotion on climate-resilient agriculture. There continues to be undue focus on technology solutions *per se* and not enough attention on the coupling of technologies and socio-economics and how they become embedded in ecological systems underpinning smallholder agriculture. In this perspective, we argue that an intertwined social–ecological–technological systems approach to climate risk management is needed to ensure that climate-resilient agriculture contributes more to the realization of goals of the Paris Agreement and the UN Framework Convention on Climate Change. Furthermore, in line with broader policy thinking on the need for transformative change toward sustainably living on the planet and "leaving no one behind," a greater focus on transformative adaptation is required. Transformative adaptation tackles the root causes of vulnerability including unevenly distributed power relations, and extant networks of control and influence. There are, however, relatively few examples of moving from the theory of transformative adaptation to practice. Three recent practical examples of transdisciplinary approaches, that we have direct experience of as researchers, provide lessons for initial ways forward as part of climate risk management initiatives. Examples from Vietnam, East and Southern Africa, and Guatemala illustrate the importance of inter- and transdisciplinary responses whereby the inequalities underlying unequal power structures may be addressed, enabling farmers to pursue climate risk management pathways that contribute to climate resilience and human development, as epitomized by the Sustainable Development Goals.

Keywords: socio-ecological resilience, transdisciplinary action research, social equity, agriculture, livelihood trajectories

OPEN ACCESS

Edited by:
Delia Catacutan,
World Agroforestry Centre, Indonesia

Reviewed by:
Munesh Kumar,
Hemwati Nandan Bahuguna Garhwal University, India
Rodel Lasco,
Oscar M. Lopez Center, Philippines
Celia A. Harvey,
Monteverde Institute, Costa Rica

***Correspondence:**
Jon Hellin
j.hellin@irri.org

Specialty section:
This article was submitted to Climate Risk Management, a section of the journal Frontiers in Climate

Received: *01 August 2021*
Accepted: *11 November 2021*
Published: *08 December 2021*

Citation:
Hellin J, Fisher E and Loboguerrero AM (2021) Reflections on Enhancing the Impact of Climate Risk Management Through Transformative Adaptation. Front. Clim. 3:751691. doi: 10.3389/fclim.2021.751691

INTRODUCTION

Droughts, erratic rainfall, floods, and high temperatures threaten the agricultural-based livelihoods of millions of smallholder farmers (FAO, 2019). Smallholders farmers' relatively limited adaptive capacity and their location in marginal areas makes them very vulnerable to climate change (Mirza, 2003; FAO, 2020). Land degradation contributes to smallholder farmer vulnerability. As the IPCC Special Report "Climate change and Land" states with a high degree of confidence, climate change exacerbates land degradation, and people living in already degraded or desertified areas are negatively affected by climate change (IPCC, 2019, p. 5). Responses include efforts to mitigate

climate risks and enhance farmers' resilience against climate extremes and variability (Lipper et al., 2014; Aggarwal et al., 2018). Significant effort has focused on climate risk management, including the promotion of climate-resilient agriculture, with efforts directed at particularly vulnerable people and areas (Omerkhil et al., 2020; Sekhri et al., 2020).

In the effort to extend opportunities to build climate resilience to more farmers, attention has been devoted to the need for effective scaling of initiatives, and there is a rich literature mapping this scaling of climate-resilient agriculture (e.g., Whitfield et al., 2015; Aggarwal et al., 2018; Shilomboleni and De Plaen, 2019; Woltering et al., 2019). What is clear from these and other studies is that scaling of climate-resilient agriculture depends on a combination of technologies and practices, of infrastructure development, and of an enabling institutional and organizational environment (Glover et al., 2019). Governments have a key role to play in providing an enabling environment (e.g., Jha et al., 2017).

Great score is given by the international community to quantitative targets achieved by climate-resilient agriculture, e.g., the number of farmers who have adopted, and the land area under, certain practices, and technologies (Hellin and Lopez-Ridaura, 2016; Woltering et al., 2019). For example, Acevedo et al. (2020) conducted a scoping review of small-scale farmers' adoption of climate-resilient crops in low- and middle-income countries, while Cavanagh et al. (2017) looked at the rates of farmer adoption of "climate-smart" agriculture in Kenya. In these and in other studies, adoption rates vary hugely and can often drop precipitously when donor support finishes (Hellin and Schrader, 2003).

These numbers fail to capture the complexity of technological change and the social, economic, and cultural drivers of this change (Glover et al., 2019). This is a serious oversight given how people's access to and up-take of climate risk management interventions is shaped by societal dynamics, including existing inequalities, which encompass those related to the uneven distribution of climate risk. In effect, climate risk management initiatives tend to focus on technology solutions *per se* and not enough attention is directed at the coupling of technologies and socio-economics and how they become embedded in ecological systems underpinning smallholder agriculture. In this respect there is cross-learning for agricultural research from analysis of urban systems, as McPhearson et al. (2021) argue, the climate challenge is so profound that a true systems approach is needed, one that builds on the interplay between social–ecological (S-E), social–technological (S-T), and ecological–technological (E-T) systems. The authors refer to this as an intertwined social–ecological–technological systems (SET) approach.

A premise for McPhearson et al.'s argument is that deliberative transformation for sustainability needs to build just, equitable, and resilient futures. In this respect, application of a SET approach can show how risk management interventions may reinforce existing inequalities and indeed create new ones, raising the moral spectacle of impoverished people in the Global South carrying further burdens generated by initiatives to address climate impacts, while contributing little to the causes of climate change. In this line, climate risk management sheds light on relations of power and brings to the fore issues around social equity, which can be envisaged as encompassing fairness in how society treats people and the social determinants of inequality (Fisher et al., 2019). It includes the myriad of ways that inequalities can be overcome and, in the context of climate risk management, it focuses on the transformative dynamics of efforts that aim to address both climate risk and social justice (Fisher et al., 2019).

In keeping with broader policy thinking on the need for transformative change toward sustainably living on the planet, generating transformative pathways that "leave no one behind" (UN General Assembly, 2015; Rockström et al., 2021), studies have placed increasing emphasis on the need to move from either mitigation or incremental adaptation to transformative adaptation (Schipper et al., 2020; Eriksen et al., 2021). Here we follow Kates et al. (2012) by distinguishing between incremental "*extensions of actions and behaviors that already reduce the losses or enhance the benefits of natural variations in climate or extreme events*" to transformative adaptations "*at a much larger scale or intensity, those that are truly new to a particular region or resource system, and those that transform places and shift locations*" (Kates et al., 2012). Furthermore, we follow the distinction that Few et al. (2017) make between *transformative adaptation* (tackling root causes of vulnerability) and *transformational adaptation* (tackling the immediate causes of vulnerability). We see the former as a more radical and necessary approach in order to reduce the root causes of vulnerability, enhance resilience, and ultimately, increase the impact of climate risk management.

As research underlines, these processes of transformative adaptation are inherently political (O'Brien, 2013; Eriksen et al., 2021). They challenge the power relations that generate and perpetuate the vulnerability of marginal smallholder famers in their exposure to climate risk and in the distribution of positive impact of climate risk management interventions (Schipper et al., 2020). In addition, and importantly, these studies also underline how issues of power provoked by the need for transformative adaptation bring to the fore the significance of plurality in the knowledges needed to inform the development of transformative pathways. In this context, we can remind ourselves of long-existing "*farmer first*" debates (Chambers et al., 1989; Scoones and Thompson, 1994), in which the knowledge and understanding of farmers should be taken into account in ways that are empowering and transformative when problems are identified, agricultural policy formulated, and projects implemented.

Eriksen et al. (2021) review the outcomes of several agricultural climate change adaptation initiatives. Critically, they seek to unpack the reasons for maladaptive outcomes, whereby interventions may (inadvertently) create, redistribute, and/or reinforce new sources of vulnerability. They highlight a combination of weak understanding of vulnerability contexts, inequitable stakeholder engagement in initiatives, retrofitting adaptation onto existing initiatives, and a lack of attention to detail in terms of the definition of success of climate change adaptation. One point they emphasize is that learning processes within organizations and with marginalized populations need to be brought to the fore within adaptation objectives. In a

similar line, Leach et al. (2012) point to the need for new kinds of training, capacity building, and recognition in building sustainability innovations that bridge different scales between the local and global.

Shifting emphasis to transformative adaptation can help to capture the potential of climate risk management to contribute to a broader range of impacts, many encapsulated by the Sustainable Development Goals (SDGs). We argue that to enhance the impact of climate risk management in smallholder agriculture, researchers, development practitioners, and policy-makers need to embrace a more radical climate change agenda that explicitly recognizes that climate adaptation requires transformative adaptation. If the root causes of vulnerability are not addressed, fewer farmers will benefit from climate risk management efforts. This Perspective, hence, complements other papers in this special issue on *Climate Risk Management in Smallholder Agriculture* by stressing the importance of transformative adaptation in smallholder agriculture to ensure that adaptation efforts have greater positive impact on farmers' resilience and well-being.

RESILIENCE, TRANSDISCIPLINARY APPROACHES, AND EQUITY – A TRANSFORMATIVE AGENDA

Ideally, climate-resilient agriculture leads to higher resilience and fewer risks to food security (Lipper et al., 2014; Kumar et al., 2020). It is worth unpacking the term "resilience" because this is at the heart of the outcomes that are being sought. The term classically refers to the ability of a social-ecological system to reorganize and undergo change in the face of disturbances while essentially remaining broadly similar (Walker et al., 2004). Pushing beyond this steady state orientation, thinking on social-ecological systems has embraced how resilience at different scales encompasses both adaptation within current development trajectories, and the crossing of thresholds into new trajectories when old systems become untenable (Folke et al., 2010; Jackson et al., 2010).

It is the crossing of thresholds that is so important in the context of climate resilience and smallholder agriculture, where there needs to be a stronger emphasis on human development. Barrett and Constas (2014) capture the fundamental differences between ecological and development resilience. The authors write that in the case of the former, the emphasis is on "*persistence and recovery in the face of change and unpredictability,*" while the latter "*concerns individual agents with basic rights as well as aspirations for improved living conditions, that necessitates differentiation from and adaptation of preexisting, systems-oriented uses of the resilience concept in fields like ecology.*" In this respect, when it comes to climate risk management, social resilience requires not only a reduction in farmers' vulnerability but also an improvement in their well-being. This is the essence of transformative adaptation.

Social-ecological resilience, hence, encompasses both "persistence and recovery" and also the transformation (progression) of farm households from one asset threshold to another, sometimes including the pursuance of non-agricultural livelihood pathways (Hellin and Fisher, 2018). It is only by this livelihood transformation that climate-resilient agriculture will contribute meaningfully to realization of the SDGs. This represents a radical departure because responses to climate change have tended to focus on mitigation and adaptation rather than "*problems of unevenly distributed power relations, networks of control and influence, and rampant injustices of the 'system'*" (O'Brien, 2013).

Climate risk management often requires an in-depth understanding and appreciation of farmers' realities and the required changes to empower farmers to realize more fulfilling and prosperous livelihood opportunities (O'Brien, 2010, 2012; Castree, 2015). Furthermore, climate change poses such a challenge that inter- and transdisciplinary responses are required, ones that encourage and facilitate practitioners, researchers and policy-makers to work together to tackle complex problems (Cundill et al., 2019b). Interdisciplinary approaches involve integrating knowledge and methods from different disciplines, while transdisciplinary ones integrate research with policy-makers, private sector, development practitioners etc. Such transdisciplinary networks deliberately blur the lines between "research" and "development," where the key is to increase farmers' adaptive capacity and empower them to pursue climate risk management pathways in line with their realities and aspirations (Cundill et al., 2019a).

Climate-resilient agriculture *per se* is not always the best type of development intervention; alternatives may be more appropriate (Hellin and Fisher, 2018; Hansen et al., 2019). These alternatives may involve facilitating farmers exit from agriculture, at least where it is based on smallholder farming in contexts of diminishing returns on production. This may involve a move to urban-based livelihoods or to alternative options in rural contexts. Of course, this is most viable in contexts where there is a dynamic urban or rural economy, translating into the potential for a range of livelihood options. In such contexts, farmers themselves explore alternatives to farming, for instance through investment in income generation or through mobility and migration.

In rural locations where there are diminishing returns from agriculture and where employment and income generating prospects are negligible or non-existent, with high poverty levels, social protection maybe essential. Social protection includes social assistance (e.g., in-kind transfers, and cash), social insurance, and labor market programs such as unemployment benefits (Hansen et al., 2019). Fisher et al. (2017) show that well-targeted social protection interventions in Africa can have a positive impact on farmers' livelihood strategies and lead to an improvement in agricultural productivity. Social protection can have a mitigating impact on the negative impact of weather shocks, and by implication have the potential to be a valuable *ex ante* strategy to help the poor adapt to climate variability. To realize positive impact, studies emphasize the need to incorporate attention to climate risk within the design of social protection programs, and have forward-looking strategies for long-term adaptation (Tenzing, 2019; Loboguerrero et al., 2020).

Climate risk management interventions do not inherently include a focus on social equity in terms of how outcomes are

distributed and who is best positioned to benefit (Collins, 2018; Eriksen et al., 2021). Those who seek to increase the impact of climate risk management would benefit from understanding how smallholder farmers' ability to take advantage of interventions is determined by existing power imbalances and socio-economic inequalities (Hansen et al., 2019; Hellin and Fisher, 2019).

TRANSLATING A TRANSFORMATIVE AGENDA INTO PRACTICE

Translating resilience, transdisciplinary approaches, and equity into practical climate risk management interventions is challenging, not least because there are relatively few examples of moving from the theory of transformative adaptation to practice (Kehrer et al., 2020). Nevertheless, in the context of the need for farming populations to build resilience to climate change, this is a challenge that must be grappled with, building learning on what suite of policies and practical actions work and what are unsuccessful. Three recent practical examples of transdisciplinary approaches, that we have direct experience of as researchers, provide lessons for initial ways forward.

Over-Coming the Paralysis of Uncertainty: Sea Level Rise and Mega-Deltas in Asia

Asia is host to many river deltas that support large populations dependent on rice-based systems. Sea level rise, caused by climate change, threatens farmers' livelihoods in coastal areas (Kontgis et al., 2019; Lenton et al., 2019). A rise in sea level can lead to salinization, flooding and erosion (Minderhoud et al., 2017, 2019; Kulp and Strauss, 2019). Smajgl et al. (2015) identify the Mekong Delta in Vietnam, Ayeyarwady Delta in Myanmar, and the Ganges-Brahmaputra-Meghna Delta in India and Bangladesh as particularly vulnerable to sea level rise.

The impact of sea level rise varies according to local geography, state of preparedness, distribution of population in the deltas, and farmers' resource endowments. In some worse-case scenarios the impacts of sea level rise may be such that agricultural-based livelihoods are no longer feasible; the result may be large-scale migration (Wrathall et al., 2019). A challenge for those working on responses to climate change is the high degree of uncertainty when it comes to climate change predictions. Decision-makers tend to avoid taking action when they are faced with uncertainties (Meah, 2019). For example scenarios based on a 0.5, 0.75, or 1 m rise in sea level by 2050, have very different implications when it comes to land-use planning. The uncertainty over what the situation will be in 30 years' time, can stymie concrete action against the adverse impacts of sea level rise in the region (Yen et al., 2019).

Ways forward to reduce the "paralysis" arising from uncertainty involve genuine partnerships with key stakeholders such as government agencies, civil society organizations, etc. so that decision-makers better understand the rationale behind uncertainty. Participatory approaches to mapping climate risks and detailing climate interventions, along with strengthening governments' meteorological and planning capacity, can overcome some of the uncertainty-induced policy paralysis. Such approaches require investment of time and energy from project design to implementation (Faure et al., 2018). In Vietnam, partnerships between climate scientists and the government means that the latter better understands risk maps and cropping patterns and, as a result, this has helped it craft context-specific transformative adaptive programs at sub-national levels (Yen et al., 2019).

Transdisciplinary Partnerships: Index Insurance and Climate Finance

Farmer adoption of climate-resilient agriculture is stymied by risk and farmers' risk aversion (Carter et al., 2016). There is much interest in the potential that index insurance schemes can enhance farmers' climate risk management (Miranda and Farrin, 2012; Jensen et al., 2017). Much effort on the promotion of index insurance has been directed at East and Southern Africa (Fisher et al., 2019).

The drawback of conventional indemnity insurance is that it relies on direct measurement of the loss or damage that farmers have suffered. This can be expensive, especially when farmers are distributed over a large geographical area. Index insurance overcomes this obstacle as it pays for a loss based on a pre-determined index. The most common indices are rainfall and average area crop yield (Binswanger-Mkhize, 2012). One of the advantages of index insurance is that specific risks can be transferred to agricultural insurance markets. Farmers can be incentivized to make investments in climate-resilient agriculture when their risk burden is reduced (Bobojonov et al., 2013; Greatrex et al., 2015). Furthermore, farmers are better able to access credit when they are covered by index insurance as lenders are more encouraged to make loans.

In the last 10 years, donors, governments and the private sector have entered into insurance markets (Murphy, 2014). These markets bring together very diverse actors from reinsurance companies to input suppliers to farmers. They are an example of how climate finance can lubricate the types of transdisciplinary partnerships that are critical to enhancing the impact of climate risk management in smallholder agriculture. The time and effort required to establish these transdisciplinary partnerships, however, should not be underestimated. Successful examples of index insurance are often the result of prolonged efforts to bring disparate actors together, to build trust amongst them and to understand their motivations (Fisher et al., 2019).

Climate-Agriculture-Peace Nexus

There is also growing interest in the climate-agriculture-peace nexus (Eriksen et al., 2021; Lovbrand and Mobjork, 2021; van Leeuwen et al., 2021). The conventional discourse focuses on the impact of climate change on renewable natural resources (Klomp and Bulte, 2013; Raleigh et al., 2014). Climate change can undermine livelihood security by reducing farmers' access to and use of threatened natural resources (Barnett and Adger, 2007). Climate change is exacerbating disputes over natural resources, e.g., grazing land (Thebaud and Batterbury, 2001), water resources (Geheb and Suhardiman, 2019), etc. These disputes can be sources of conflict even though this may be non-violent in nature.

While the relationship between climate-induced depletion of natural resources and conflict is a concern, there is also evidence that resource competition can stimulate collective action, greater social-ecological resilience, and strengthened local climate change adaptation capacities (Ratner et al., 2013). This contributes to the recognized importance of localized, community-led endeavors to adapt to climate change (Thornton et al., 2009). Guatemala is an example of a "hotspot" for climate change that is also plagued by rural poverty and food insecurity, and yet simultaneously where efforts to enhance the climate-agriculture-peace nexus have had some success.

Present-day socio-political tensions in Guatemala have been exacerbated by an almost four-decade civil war that ended in the mid-1990s. Inequalities and social tension continue with indigenous groups at a particular disadvantage (Wayland and Kuniholm, 2016; Lopez-Ridaura et al., 2019). The legacy of the civil war has left people in many rural communities "*deeply suspicious of one another and profoundly divided over the concept of 'organization'*" (McAllister, 2009, p 650). Such suspicions and mistrust make the task of collective action and improved natural resource management that much more difficult but not impossible (Kline et al., 2020).

Progress depends on long-term commitments by numerous stakeholders that include non-governmental organizations, researchers, and government officials, the type of partnership that can only be established and sustained by long-term support and commitment. Hellin et al. (2018) document locally-specific collective action approaches in Guatemala that have reduced social tensions and enhanced climate change adaptation. In many of these cases, the focus has been on watershed management, i.e., nature-based solutions to provide ecosystem services such as enhanced availability and quality of water, along with incorporation of indigenous knowledge. Das et al. (2021) point out the benefits of this type of approach because indigenous ecological belief systems are often closely linked with ecosystem conservation.

DISCUSSION AND CONCLUSIONS

In this Perspective, we have sought to reflect on the need for transformative adaptation in smallholder agriculture given how limited existing knowledge is on how deliberative transformation can occur in practice in ways that are equitable and build resilience for farmers negatively impacted by climate change. This has led us to use three examples from our research experience, to identify different climate risk management pathways in diverse socio-ecological contexts, paying attention to transdisciplinarity, and stakeholder partnerships. An example from mega-deltas in Asia illustrates the melding of partnerships needed to reduce the paralysis of uncertainty and enhance the climate resilience of rice-based farming systems in the context of sea level rise. The example of index insurance in East and Southern Africa shows the importance of adopting a cross-sectoral approach to risk management strategies and the importance of climate finance and the role of the private sector. Finally, a Guatemala example shows how conflict over access to threatened natural resources can be mitigated by collective action leading to greater social-ecological resilience.

We have highlighted how that the threat of climate change is so great and the required response so profound, that incremental adaptation and mitigation are not enough; effective climate risk management will increasingly require transformative adaptation, incorporating social, economic, cultural, and political change. All three examples underline the value of adopting a social equity lens in recognition of the differential impact of climate risk management pathways due to extant and long-established social norms. Enhancing farmers' climate change adaptive capacity often means challenging entrenched power dynamics. This is by no means easy, it requires action by change-makers willing to challenge the status quo, the will to change on the part of people themselves, and the identification of windows of opportunity where issues can be addressed in ways that reduce rather than magnify existing tensions and conflicts.

It is only *via* more radical transformative processes that the inequalities underlying unequal power structures may be addressed, enabling farmers to pursue climate risk management pathways that contribute to climate resilience and broader development, as epitomized by the SDGs. Transformative adaptation refers as much to the potentially far-reaching impact of climate risk management, as it does to the often new ways that diverse stakeholders (including agricultural researchers) need to embrace the implications of transformative change for their work, and recognize that by so doing they are challenging social norms and questioning the continuation of unevenly distributed power relations.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

JH, EF, and AML: conceptualization and writing. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

CCAFS is carried out with support from the CGIAR Trust Fund and through bilateral funding agreements. For details please visit https://ccafs.cgiar.org/donors.

REFERENCES

Acevedo, M., Pixley, K., Zinyengere, N., Meng, S., Tufan, H., Cichy, K., et al. (2020). A scoping review of adoption of climate-resilient crops by small-scale producers in low- and middle-income countries. *Nature Plants* 6, 1231–1241. doi: 10.1038/s41477-020-00783-z

Aggarwal, P., Jarvis, A., Campbell, B., Zougmoré, R., Khatri-chhetri, A., Vermeulen, S., et al. (2018). The climate-smart village approach: framework of an integrative strategy. *Ecol. Society* 23:15. doi: 10.5751/ES-09844-230114

Barnett, J., and Adger, W. N. (2007). Climate change, human security and violent conflict. *Polit. Geogr.* 26, 639–655. doi: 10.1016/j.polgeo.2007.03.003

Barrett, C. B., and Constas, M. A. (2014). Toward a theory of resilience for international development applications. *Proc. Natl. Acad. Sci. U.S.A.* 111, 14625–14630. doi: 10.1073/pnas.1320880111

Binswanger-Mkhize, H. (2012). Is there too much hype about index-based agricultural insurance? *J. Dev. Stud.* 48, 187–200. doi: 10.1080/00220388.2011.625411

Bobojonov, I., Aw-Hassan, A., and Sommer, R. (2013). Index-based insurance for climate risk management and rural development in Syria. *Clim. Dev.* 6, 166–178. doi: 10.1080/17565529.2013.844676

Carter, M. R., Cheng, L., and Sarris, A. (2016). Where and how index insurance can boost the adoption of improved agricultural technologies. *J. Dev. Econ.* 118, 59–71. doi: 10.1016/j.jdeveco.2015.08.008

Castree, N. (2015). Geography and global change science: relationships necessary, absent, and possible. *Geogr. Res.* 53, 1–15. doi: 10.1111/1745-5871.12100

Cavanagh, C. J., Chemarum, A. K., Vedeld, P. O., and Petursson, J. G. (2017). Old wine, new bottles? Investigating the differential adoption of 'climate-smart' agricultural practices in western Kenya. *J. Rural Stud.* 56, 114–123. doi: 10.1016/j.jrurstud.2017.09.010

Chambers, R., Pacey, A., and Thrupp, L. (eds.). (1989). *Farmer First: Farmer Innovation and Agricultural Research*. London: Intermediate Technology Publications. doi: 10.3362/9781780440149

Collins, A. (2018). Saying all the right things? Gendered discourse in climate-smart agriculture. *J. Peasant Stud.* 45, 175–191.

Cundill, G., Currie-Alder, B., and Leone, M. (2019a). The future is collaborative. *Nat. Clim. Change*. 9, 343–345. doi: 10.1038/s41558-019-0447-3

Cundill, G., Harvey, B., Tebboth, M., Cochrane, L., Currie-Alder, B., Vincent, K., et al. (2019b). Large-scale transdisciplinary collaboration for adaptation research: challenges and insights. *Glob. Challenges*. 3:1700132. doi: 10.1002/gch2.201700132

Das, M., Das, A., Seikh, S., and Pandey, R. (2021). Nexus between indigenous ecological knowledge and ecosystem services: a socio-ecological analysis for sustainable ecosystem management. *Environ Sci Pollut Res.* doi: 10.1007/s11356-021-15605-8. [Epub ahead of print].

Eriksen, S., Schipper, E. L. F., Scoville-Simonds, M., Vincent, K., Adam, H. N., Brooks, N., et al. (2021). Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance? *World Dev.* 141:105383. doi: 10.1016/j.worlddev.2020.105383

FAO (2019). *Agriculture and Climate Change – Challenges and Opportunities at the Global and Local Level – Collaboration on Climate-Smart Agriculture*. Rome: Food and Agriculture Organization of the United Nations.

FAO (2020). *Agriculture and Climate Change – Law and Governance in Support of Climate Smart Agriculture and International Climate Change Goals*. Rome: Food and Agriculture Organization of the United Nations.

Faure, G., Barret, D., Blundo-Canto, G., Dabat, M., Devaux-Spatarakis, A., Le Guerroué, J. L., et al. (2018). How different agricultural research models contribute to impacts: Evidence from 13 case studies in developing countries. *Agricult. Syst.* 165, 128–136. doi: 10.1016/j.agsy.2018.06.002

Few, R., Morchain, D., Spear, D., Mensah, A., and Bendapudi, R. (2017). Transformation, adaptation and development: relating concepts to practice. *Palgr. Commun.* 3:92. doi: 10.1057/palcomms.2017.92

Fisher, E., Attah, R., Barca, V., O'Brien, C., Brook, S., Holland, J., et al. (2017). The livelihood impacts of cash transfers in Sub-Saharan Africa: beneficiary perspectives from six countries. *World Dev.* 99:20. doi: 10.1016/j.worlddev.2017.05.020

Fisher, E., Hellin, J., Greatrex, H., and Jensen, N. (2019). Index insurance and climate risk management: addressing social equity. *Dev. Policy Rev.* 37:12387. doi: 10.1111/dpr.12387

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., and Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecol. Soc.* 15:20. doi: 10.5751/ES-03610-150420

Geheb, K., and Suhardiman, D. (2019). The political ecology of hydropower in the Mekong River Basin. *Curr. Opin. Environ. Sustainabil.* 37, 8–13. doi: 10.1016/j.cosust.2019.02.001

Glover, D., Sumberg, J., Ton, G., Andersson, J., and Badstue, L. (2019). Rethinking technological change in smallholder agriculture. *Outlook Agric.* 48, 169–180. doi: 10.1177/0030727019864978

Greatrex, H., Hansen, J. W., Garvin, S., Diro, R., Blakeley, S., Le Guen, M., et al. (2015). *Scaling Up Index Insurance for Smallholder Farmers: Recent Evidence and Insights*. CCAFS Report No. 14 Copenhagen: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org

Hansen, J., Hellin, J., Rosenstock, T., Fisher, E., Cairns, J., Stirling, C., et al. (2019). Climate risk management and rural poverty reduction. *Agricult. Syst.* 172, 28–46. doi: 10.1016/j.agsy.2018.01.019

Hellin, J., and Fisher, E. (2018). Building pathways out of poverty through climate smart agriculture and effective targeting. *Dev. Pract.* 28, 974–979. doi: 10.1080/09614524.2018.1492516

Hellin, J., and Fisher, E. (2019). The Achilles heel of climate-smart agriculture. *Nat. Clim. Change* 9, 493–494. doi: 10.1038/s41558-019-0515-8

Hellin, J., and Lopez-Ridaura, S. (2016). Soil and water conservation on Central American hillsides: if more technologies is the answer, what is the question? *AIMS Agricult. Foodture Food* 1, 194–207. doi: 10.3934/agrfood.2016.2.194

Hellin, J., Ratner, B. D., Meinzen-Dick, R., and Lopez-Ridaura, S. (2018). Increasing social-ecological resilience within small-scale agriculture in conflict-affected Guatemala. *Ecol. Society* 23:5. doi: 10.5751/ES-10250-230305

Hellin, J., and Schrader, K. (2003). The case against direct incentives and the search for alternative approaches to better land management in Central America. *Agricult. Ecosyst. Environ.* 99, 61–81. doi: 10.1016/S0167-8809(03)00149-X

IPCC (2019). "Climate change and land: an IPCC special report," in *Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems,* eds J. M. P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick (IPCC).

Jackson, L., van Noordwijk, M., Bengtsson, J., Foster, W., Lipper, L., Pulleman, M., et al. (2010). Biodiversity and agricultural sustainagility: from assessment to adaptive management. *Current Opinion in Environmental Sustainability* 2:80–87. doi: 10.1016/j.cosust.2010.02.007

Jensen, N. D., Barrett, C. B., and Mude, A. G. (2017). Cash transfers and index insurance: A comparative impact analysis from northern Kenya. *J. Dev. Econ.* 129, 14–28. doi: 10.1016/j.jdeveco.2017.08.002

Jha, S. K., Mishra, S., Sinha, B., Alatalo, J. M., and Pandey, R. (2017). Rural development program in tribal region: a protocol for adaptation and addressing climate change vulnerability. *J. Rural Stud.* 51, 151–157. doi: 10.1016/j.jrurstud.2017.02.013

Kates, R. W., Travis, W. R., and Wilbanks, T. J. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *Proc. Natl. Acad. Sci. U.S.A.* 109, 7156–7161. doi: 10.1073/pnas.1115521109

Kehrer, D., Flossmann-Kraus, U., Alarcon, S. V. R., Albers, V., and Aschmann, G. (2020). *Transforming Our Work: Getting Ready for Transformational Projects*. Bonn; Eschborn: GIZ.

Kline, K. L., Ramirez, L. F., Sum, C., Lopez-Ridaura, S., and Dale, V. H. (2020). Enhance indigenous agricultural systems to reduce migration. *Nature Sustainabil.* 3, 74–76. doi: 10.1038/s41893-020-0473-1

Klomp, J., and Bulte, E. (2013). Climate change, weather shocks, and violent conflict: A critical look at the evidence. *Agricult. Econ.* 44(SUPPL1), 63–78. doi: 10.1111/agec.12051

Kontgis, C., Schneider, A., Ozdogan, M., Kucharik, C., Tri, V. P. D., Duc, N. H., et al. (2019). Climate change impacts on rice productivity in the Mekong River Delta. *Appl. Geogr.* 102, 71–83. doi: 10.1016/j.apgeog.2018.12.004

Kulp, S. A., and Strauss, B. H. (2019). New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding. *Nat. Commun.* 10:4844. doi: 10.1038/s41467-019-12808-z

Kumar, S., Mishra, A. K., Pramanik, S., Mamidanna, S., and Whitbread, A. (2020). Climate risk, vulnerability and resilience: supporting livelihood of smallholders in semiarid India. *Land Use Policy* 97:104729. doi: 10.1016/j.landusepol.2020.104729

Leach, M., Rockström, J., Raskin, P., Scoones, I., Stirling, A. C., Smith, A., et al. (2012). Transforming innovation for sustainability. *Ecol. Society* 17:11. doi: 10.5751/ES-04933-170211

Lenton, T. M., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W., et al. (2019). Climate tipping points - too risky to bet against. *Nature* 575, 592–595. doi: 10.1038/d41586-019-03595-0

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., et al. (2014). Climate-smart agriculture for food security. *Nature Clim. Change* 4, 1068–1072. doi: 10.1038/nclimate2437

Loboguerrero, A. M., Thornton, P., Wadsworth, J., Campbell, B. M., Herrero, M., Mason-D'Croz, D., et al. (2020). Perspective article: actions to reconfigure food systems. *Glob. Food Secur.* 26:100432. doi: 10.1016/j.gfs.2020.100432

Lopez-Ridaura, S., Barba-Escoto, L., Reyna, C., Hellin, J., Gerard, B., and van Wijk, M. (2019). Food security and agriculture in the Western Highlands of Guatemala. *Food Security* 11, 817–833. doi: 10.1007/s12571-019-00940-z

Lovbrand, E., and Mobjork, M. (eds.). (2021). *Anthropocene (In)securities*. SIPRI Research Report No. 26. Solna: Oxford University Press.

McAllister, C. (2009). Seeing like an indigenous community: the World Bank's Agriculture for Development Report read from the perspective of postwar rural Guatemala. *J. Peasant Stud.* 36, 645–651. doi: 10.1080/03066150903143038

McPhearson, T., Raymond, C. M., Gulsrud, N., Albert, C., Coles, N., Fagerholm, N., et al. (2021). Radical changes are needed for transformations to a good Anthropocene. *NPJ Urban Sustainabil.* 1:5. doi: 10.1038/s42949-021-00017-x

Meah, N. (2019). Climate uncertainty and policy making—what do policy makers want to know? *Reg. Environ. Change* 19, 1611–1621. doi: 10.1007/s10113-019-01492-w

Minderhoud, P. S. J., Coumou, L., Erkens, G., Middelkoop, H., and Stouthamer, E. (2019). Mekong delta much lower than previously assumed in sea-level rise impact assessments. *Nat. Commun.* 10: 3847. doi: 10.1038/s41467-019-11602-1

Minderhoud, P. S. J., Erkens, G., Pham, V. H., Bui, V. T., Erban, L., Kooi, H., et al. (2017). Impacts of 25 years of groundwater extraction on subsidence in the Mekong delta, Vietnam. *Environ. Res. Lett.* 12:064006. doi: 10.1088/1748-9326/aa7146

Miranda, M. J., and Farrin, K. (2012). Index insurance for developing countries. *Appl. Econ. Persp. Policy* 34, 391–427. doi: 10.1093/aepp/pps031

Mirza, M. M. Q. (2003). Climate change and extreme weather events: can developing countries adapt? *Climate Policy* 3, 233–248. doi: 10.1016/S1469-3062(03)00052-4

Murphy, D. J. (2014). Booms and busts: asset dynamics, disaster, and the politics of wealth in rural Mongolia. *Econ. Anthropol.* 1, 104–123. doi: 10.1002/sea2.12007

O'Brien, K. (2010). Responding to environmental change: a new age for human geography? *Progr. Human Geogr.* 35, 542–549. doi: 10.1177/0309132510377573

O'Brien, K. (2012). From adaptation to deliberate transformation. *Progr. Human Geogr.* 36, 667–676. doi: 10.1177/0309132511425767

O'Brien, K. (2013). Global environmental change III: Closing the gap between knowledge and action. *Progr. Human Geogr.* 37, 587–596. doi: 10.1177/0309132512469589

Omerkhil, N., Kumar, P., Mallick, M., Meru, L. B., Chand, T., Rawat, P. S., et al. (2020). Micro-level adaptation strategies by smallholders to adapt climate change in the least developed countries (LDCs): Insights from Afghanistan. *Ecol. Indic.* 118:106781. doi: 10.1016/j.ecolind.2020.106781

Raleigh, C., Linke, A., and O'Loughlin, J. (2014). Extreme temperatures and violence. *Nat. Clim. Change* 4, 76–77. doi: 10.1038/nclimate2101

Ratner, B. D., Meinzen-Dick, R., May, C., and Haglund, E. (2013). Resource conflict, collective action, and resilience: An analytical framework. *Int. J. the Commons* 7, 183–208. doi: 10.18352/ijc.276

Rockström, J., Gupta, J., Qin, D., Pedde, S., Broadgate, W., and Warszawski, L. (2021). Stockholm to Stockholm: achieving a safe Earth requires goals that incorporate a just approach. *One Earth* 4, 1209–1211. doi: 10.1016/j.oneear.2021.08.012

Schipper, E. L. F., Eriksen, S. E., Fernandez Carril, L. R., Glavovic, B. C., and Shawoo, Z. (2020). Turbulent transformation: abrupt societal disruption and climate resilient development. *Clim. Dev.* 13, 1–8. doi: 10.1080/17565529.2020.1799738

Scoones, I., and Thompson, J. (eds.). (1994). *Beyond Farmer First: Rural People's Knowledge, Agricultural Research and Extension Practice*. London: Intermediate Technology Publications. doi: 10.3362/9781780442372

Sekhri, S., Kumar, P., Fürst, C., and Pandey, R. (2020). Mountain specific multi-hazard risk management framework (MSMRMF): Assessment and mitigation of multi-hazard and climate change risk in the Indian Himalayan Region. *Ecol. Indicators* 118:106700. doi: 10.1016/j.ecolind.2020.106700

Shilomboleni, H., and De Plaen, R. (2019). Scaling up research-for-development innovations in food and agricultural systems. *Dev. Pract.* 29, 723–734. doi: 10.1080/09614524.2019.1590531

Smajgl, A., Toan, T. Q., Nhan, D. K., Ward, J., Trung, N. H., Tri, L. Q., et al. (2015). Responding to rising sea levels in the Mekong Delta. *Nat. Clim. Change* 5, 167–174. doi: 10.1038/nclimate2469

Tenzing, J. D. (2019). Integrating social protection and climate change adaptation : a review. *Wiley Interdisc. Rev.* 11:e626. doi: 10.1002/wcc.626

Thebaud, B., and Batterbury, S. (2001). Sahel pastoralists: opportunism, struggle, conflict and negotiation. A case study from eastern Niger. *Glob. Environ. Change* 11, 69–78. doi: 10.1016/S0959-3780(00)00046-7

Thornton, P. K., Jones, P. G., Alagarswamy, G., and Andresen, J. (2009). Spatial variation of crop yield response to climate change in East Africa. *Glob. Environ. Change* 19, 54–65. doi: 10.1016/j.gloenvcha.2008.08.005

UN General Assembly (2015). *Resolution Adopted by the General Assembly on 25 September 2015*. Available online at: https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf

van Leeuwen, M., Ansoms, A., Mushagalusa Mudinga, E., Nyenyezi Bisoka, A., Niyonkuru, R. C., Shaw, J., et al. (2021). Promoting land tenure security for sustainable peace — lessons on the politics of transformation. *Curr. Opin. Environ. Sustainabil.* 49, 57–65. doi: 10.1016/j.cosust.2021.02.012

Walker, B., Holling, C. S., Carpenter, S., and Kiznig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecol. Soc.* 9:5. doi: 10.5751/ES-00650-090205

Wayland, J., and Kuniholm, M. (2016). Legacies of conflict and natural resource resistance in Guatemala. *Extractive Ind. Soc.* 3, 395–403. doi: 10.1016/j.exis.2016.03.001

Whitfield, S., Dougill, A. J., Dyer, J. C., Kalaba, F. K., Leventon, J., and Stringer, L. C. (2015). Critical reflection on knowledge and narratives of conservation agriculture. *Geoforum* 60, 133–142. doi: 10.1016/j.geoforum.2015.01.016

Woltering, L., Fehlenberg, K., Gerard, B., Ubels, J., and Cooley, L. (2019). Scaling – from "reaching many" to sustainable systems change at scale: a critical shift in mindset. *Agricult. Syst.* 176:102652. doi: 10.1016/j.agsy.2019.102652

Wrathall, D. J., Mueller, V., Clark, P. U., Bell, A., Oppenheimer, M., Hauer, M., et al. (2019). sea-level change and human migration. *Nat. Clim. Change* 9, 898–901. doi: 10.1038/s41558-019-0640-4

Yen, B. T., Son, N. H., Tung, L. T., Amjath-Babu, T. S., and Sebastian, L. (2019). Development of a participatory approach for mapping climate risks and adaptive interventions (CS-MAP) in Vietnam's Mekong River Delta. *Clim. Risk Manag.* 24, 59–70. doi: 10.1016/j.crm.2019.04.004

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.