Embracing uncertainty: Foundations of a learning system for food systems transformation

Kai Mausch[1], Andy Hall[2], Caroline Hambloch[3,4], Costanza Conti[5], Michael Hauser[6,7], Salina Abraham[8], Philippa Hammond[9], Enayat A. Moallemi[10]

[1] The Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF), Nairobi, Kenya and Bonn, Germany, ORCID: 0000-0002-2962-7646. K.Mausch@cifor-icraf.org

[2] The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia. ORCID: 0000-0002-8580-6569

[3] The Humboldt University of Berlin, Berlin, Germany. ORCID: 0000-0003-2450-1742

[4] University of Bonn, Department of Southeast Asian Studies, Bonn, Germany.

[5] Stockholm Resilience Centre, Stockholm, Sweden. ORCID: 0000-0002-6138-1543

[6] University of Natural Resources and Life Sciences, Gregor Mendel Strasse 33, A-1180, Vienna, Austria.

[7] The Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF), Nairobi, Kenya. ORCID: 0000-0003-3816-9218

[8] The Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF), Nairobi, Kenya.

[9] The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia. ORCID: 0000-0001-8238-9790

[10] The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Canberra, Australia. ORCID: 0000-0001-8346-4043

Abstract

Despite a broad consensus on the necessity of fundamental change, endeavors to transform food systems appear to have reached an impasse. Greater engagement with the uncertainty of food systems could open up new ways of triggering transformation directed towards achieving more sustainable and inclusive outcomes. As a way of reorienting current food system change efforts to better embrace uncertainty, we propose a framework for a transformative learning system that serves two aims. First, the framework highlights the importance of locally led action, experimentation, and learning, providing a way of focusing on the core capacities and skills needed to act in the face of uncertainty. Second, it outlines the different types of learning functions that need to operate at different scales of food systems to trigger disruptive, coordinated, and more democratic change processes. The operationalization of this framework necessitates shifts in roles and ways of working across the landscape of food system interventions. The discussion will address the who and how of this potential change, as well as its subsequent impact on the operational modalities of individuals, the process of change itself, and the structures and institutions involved in the process. We argue that embracing uncertainty and the focus on learning has the potential to facilitate a more agile and locally relevant change process. This would allow actors to learn

44 from decentrally pursued food systems reforms, leading to the emergence of diverse
45 pathways that complement on-going efforts and potentially   accelerate transformation
46 efforts.

47 **Keywords**: Complex systems; Sustainability; Equity; Localization; Tropentag 2023

1. Introduction

There is a growing recognition of the need for transformations in global food systems (Fanzo et al., 2020; IPES-Food and ETC Group, 2021). Currently, these systems are failing to achieve the desired societal outcomes (Ruggeri Laderchi et al., 2024; Rockström et al., 2023) and are causing significant negative impacts on people, climate, and the environment (Béné, 2022; Fanzo et al., 2021; Thornton, 2023). The lack of capacity to respond effectively to uncertainties, such as disruptions and unexpected external challenges, further exacerbates these effects. While the challenges faced by food systems manifest differently across different regions, the challenges are universal and the urgency to address them is growing (Webb et al., 2020). Despite the global consensus on the need for change, recent years have seen insufficient progress in overhauling food systems, resulting in slowed progress or even backsliding in meeting food and nutrition security goals or tackling environmental externalities (FAO et al., 2023). This situation prompts a critical question: why has there been so little progress despite widespread agreement on the need for transformation?

The theories of systems transformation have been critiqued for several reasons. First, these theories have been criticized for their inability to provide adequate guidance on the implementation of food systems transformation, as well as for their lack of consensus on the types of pathways to catalyze such transformation (Hubeau et al., 2017; Leach et al., 2020; Feola, 2015; Scoones et al., 2020). Second, the intricate connections and feedback loops between local action and broader national, regional, and global settings are often overlooked (Douthwaite and Hoffecker, 2017; Mayne et al., 2017, Woltering and Boa-Alvardo, 2024, Mausch et al. 2020; Conti et al. 2024; Hebnick et al. 2021; Fanzo et al. 2024). This detaches local action from the global transformation agenda, from which they could otherwise contribute valuable insights. A major challenge is the overwhelming scale of the task implied by transformation (Stirling, 2014), which can make practical action seem daunting at the local level. As a result, local initiatives may prioritize smaller, more manageable, and isolatable problems within their sphere of control. Similarly promising efforts at the local level can often appear insignificant and invisible in the broader context of food systems, which are inherently susceptible to systemic dynamics arising from uncertainty, prevailing patterns of power, and the dynamics of incumbency (Conti et al., 2021; Thompson and Scoones, 2009). Yet, wicked problems, such as those confronting food systems, that require transformative change, do not lend themselves to linear and technologically focused problem-solving methods (Newman and Head, 2017; Wanzenböck et al., 2020).

In this paper, we argue that to effect the needed change in our food systems, actors involved in transformation should adopt a more adaptive approach that embraces uncertainty in how change is governed and supported from the global to the local level. To help achieve this, we propose a framework for a transformative learning system as a way of re-orienting development practice toward a more locally centered and experimental modality where local learning is explicitly connected into broader learning and adaptation processes. The rationale for proposing such a framework and approach is rooted in a renewed interest in development thinking on uncertainty and system complexity. We outline the conceptual foundations and the debates about how this may substantially reframe current development efforts to affect the food systems change that is needed. For example, Scoones (2024, p. 6) argues that "taking uncertainty seriously means rethinking our world quite fundamentally – from top to bottom, from politics and policy to individual practice".

More specifically, we argue that a more pragmatic approach to navigating uncertainty is to embrace 'muddling through'[1] as opposed to the prevailing assumption that we can engineer pathways to a better future. This shift in focus entails that localized action assumes a central role in efforts for food systems transformation (Sengers et al. 2019), while ensuring that changes at the higher levels of the food system are effectively implemented. A focus on localized action has the potential to provide valuable insights that may have been previously overlooked (Moallemi et al. 2019; Moallemi et al. 2020) or intentionally sidelined due to vested interests or power asymmetries. The transformative learning system framework that we propose offers a way of conceptualizing how different capacities for learning and adaptation can be utilized and developed in an integrated way. We suggest that the intersection of locally-led action and a learning system has the potential to trigger broader scale system transformation. This intersection is where new insights, forms of knowledge, and system dynamics will emerge.

This paper has two main goals: first, to highlight the need for a shift in thinking and practice to embrace uncertainty in food systems; and second, to propose a framework for a new transformative learning system to support this shift. It has been recognised that change is unpredictable and that interactions across scales enable or inhibit change which thereby requires flexible thinking and methods from systems science (Thompson and Scoones, 2009). The proposed framework builds on existing concepts and tools but does not aim to provide a detailed guide or exhaustively explore the full range of tools and learning functions, as these must be adapted to specific contexts and addressed on a case-by-case basis. Instead, the emphasis is placed on the manner in which diverse actors within food systems - such as development agencies, local communities, or individuals - can engage and enhance each other's actions to drive more effective transformation. We acknowledge that supporting people and organizations to 'muddle through' by strengthening learning and evaluation capacities is in itself not a new idea. This approach is fundamental to the established field of complex systems practice (e.g. Wanzenböck et al., 2020; EEA, 2024; Hertz et al., 2021; Singh et al. 2023; Moallemi et al. 2024; Patton, 2023; Ofir and Rugg, 2021). Furthermore, we acknowledge that strengthening learning and evaluation capabilities in isolation is insufficient to transform food systems. Instead, the objective of this paper is to highlight an alternative and complementary approach that actors ranging from the local to system scale can adopt to meaningfully engage in the food systems transformation agenda.

To provide the conceptual underpinning of the proposed transformative learning system framework, we begin by giving an overview of foundational concepts addressing uncertainty and complexity and how they relate to food systems transformation. Our discussion outlines the implications of a more uncertainty-aware approach and how roles within the transformation process will need to change, as well as where entry points for this shift are already emerging. Taking current development practice as a starting point, we focus on four enabling entry points to support the approach: (i) A shift in mindsets; (ii) New project designs and theories of change; (iii) Evaluation methods; and (iv) Funding options for supporting new roles and learning functions. We conclude with a reflection on how the proposed

---

[1] The term 'muddling through' draws from Lindblom (1959) and Hirschman and Lindblom (1971), who understand muddling through as incremental learning from changes in uncertain environments. Here, we think about muddling through as responding to and adapting to uncertainties in the implementation of interventions.

134 transformative learning system relates to the broader changes that are necessary to support
135 food systems transformation.

2. Uncertainty, complexity and transformative change

2.1 Renewed interest in uncertainty and complexity

138 The topic of uncertainty is receiving renewed attention in research tackling, among other
139 problems, global food systems challenges (e.g. Scoones and Stirling, 2020; DeMartino et al.,
140 2024; Scoones, 2024). Unlike risk, where different known outcomes have known probabilities
141 of occurrence, uncertainty could manifest in different ways, falling sometimes under the
142 categories of Knightian, deep, or severe uncertainty which cannot be characterised
143 probabilistically and may not be assigned a likelihood of occurrence (Knight, 1921; Lempert et
144 al. 2003; Ben-Haim, 2006). In systems science, uncertainty is an inherent property of a
145 complex system (see for example Checkland, 1999; Checkland and Poulter, 2010). In this
146 context, complexity refers to systems that consist of an ensemble of numerous elements that
147 interact in a disordered manner, making it difficult to determine and predict cause-and-effect
148 relationships. Emergent properties are a result of the totality of the interactions of
149 components parts. Scoones (2024) argues that examples such as climate change, the Covid-
150 19 pandemic and the global financial crisis as well as a range of persistent development
151 challenges, including sustainability and equity challenges of current food systems, display the
152 property of deep uncertainty and are rarely amenable to simple solutions.

153 Scoones and Stirling (2020) have noted that the recognition of the significance of uncertainty
154 is not a novel concept. Since the 1960s, development economists have advocated for
155 embracing uncertainty and, more broadly, system complexity (Hirschman and Lindblom, 1971;
156 DeMartino et al., 2024). However, DeMartino et al. (2024) argue that ideas around uncertainty
157 have been marginalized in development economics. Consequently, they advocate for
158 revitalizing heterodox approaches that explicitly account for uncertainty. This paper builds
159 from DeMartino et al. (2024) to argue that, like many societal challenges, the transformation
160 of food systems needs to be understood as a complex systems problem and embrace
161 uncertainty.

162 Uncertainty in food systems means that the future evolution, including the nature of shocks,
163 drivers, and outcomes, is unknown or unknowable. In an increasingly turbulent global context,
164 it is argued that we should replace the current control oriented, risk-based calculative
165 approach, where we assume we know about and can manage the future, with a more flexible,
166 practices-based approach that is responsive to uncertain conditions (Scoones, 2024; Stirling,
167 2010). Scoones (2024) goes on to propose that if uncertainty is to be navigated effectively,
168 new approaches are needed that are more open, inclusive and collective, some reclaimed and
169 adopted from previous times and different cultures. This echoes earlier calls to give greater
170 attention to complexity and uncertainty in international development practice, prompted by
171 a growing recognition that development projects are always embedded in and influenced by
172 the unpredictable dynamics of the broader systems in which they are embedded (Ramalingan
173 et al., 2008; Jones et al., 2015; Conti, et al., 2024).

2.2 Food Systems transformation as an arena of uncertainty and complexity

Calls to recognize and engage with uncertainty and complexity in global development are mirrored in current discourse on food systems transformation (Foran et al., 2014; Kampelmann et al., 2018; Conti et al., 2024; Moallemi et al. 2024). A complex systems approach enables an understanding of the interconnected web of actors, drivers, and interactions at different physical and temporal scales in the production, processing, distribution, consumption, and disposal of foods, generating non-linear and uncertain (and hence unpredictable) pathways of food systems transformations (IPES-Food, 2015). Such an approach requires an awareness that solving systemic problems, such as food insecurity, cannot be achieved by simply analyzing the component parts of the systems (Hambloch et al., 2023). Nonlinear cause-effects are inherent properties of the system itself (Conti et al., 2021; Hambloch et al., 2023).

When attempting to improve food systems outcomes, the complexity and uncertainty of food systems can manifest in various and often contradictory ways. Clear interactions exist between different global targets, such as the SDGs, including synergies, trade-offs, and feedback loops (Herrero et al., 2021). For example, achieving success in one area, such as increasing food availability through improved farm productivity, may unintentionally result in the exclusion of smallholder producers due to falling food prices, incomes, and profitability (Mausch et al., 2020). Similarly, relying solely on smallholder farmers to address food production and income shortfalls is unlikely to be effective unless systemic issues are also addressed (Gassner et al., 2019). Many people in the global south, particularly those in fragile environments, frequently confront uncertainties as a fundamental aspect of their daily lives, and have strategies to address those uncertainties (see e.g. DeMartino, 2024). For example, pastoralists in Kenya adopt diverse practices in response to droughts, including sharing livestock, dividing herds, and negotiating land access (Mohamed and Scoones, 2023). Uncertainty is thus part of daily lives and factoring in uncertainty is core part of these farmers' decision-making process (Bacon et al., 2017; Molla et al., 2020).

The complexity and uncertainty of food systems are often exacerbated by power dynamics and the political influence of dominant actors. Clapp (2021) and Bene (2022) argue that political economy factors may well derail the great food systems transformation agenda. Power and politics are key sources of inertia and path dependency in food systems development and a key lock-in preventing the transformation of these systems to more environmentally sustainable and inclusive pathways (Conti et al., 2021). This can lead to unintended consequences, such as perpetuating poverty and malnutrition, despite well-intentioned development efforts (Leach et al., 2020, Bene, 2022; Even et al., 2024). For instance, efforts to enhance diets and address nutritional security may face obstacles due to the interests and incentives of influential actors in food value chains who are seeking new sources of revenue rather than nutritional outcomes (Hambloch et al., 2023; Ansari et al., 2018). In addition, it is important to note that powerful actors and their interests can greatly influence the way problems and solutions are presented. Furthermore, local priorities may not always align with international priorities and more negotiation room need to be incorporated. Harris (2023) illustrates this in relation to the nutrition agenda in Zambia, outlining how the political economy plays out in this debate. In situations where the outcomes and pathways for transforming food systems are highly uncertain, incumbent power and

219 politics may restrict the range of possible pathways and in doing so reduce the preparedness
220 for shocks (Stirling, 2008; Scoones and Stirling, 2020; Scoones, 2024).

221 The implications for transformation and development practice that seek to contribute to this,
222 are that the approaches to and destinations of change pathways "remain deeply uncertain"
223 (Scoones and Stirling, 2020). Yet, uncertainty is not (only) something to fear; it can be a source
224 of opportunities (Scoones, 2024). When false narratives on control of complex problems are
225 overcome, new opportunities to collectively imagine different futures can emerge. These
226 opportunities emerge from a more diverse array of knowledge sources and have the potential
227 to catalyze innovation, disrupt established pathways, and foster unconventional partnerships
228 (Scoones, 2024). However, the current trend of expanding the range of indicators used in
229 development practice is counter to this thinking, and suggests an attempt to convert
230 uncertainties into quantifiable risks, disregarding the actual experiences of uncertainty and
231 the current mechanisms that deal with its consequences (Scoones, 1994; DeMartino et al.,
232 2024). For instance, early warning systems for famines in the drylands of Eastern Africa are
233 intrinsically fraught with uncertainties related to weather forecasting and conflicts, which
234 increases the likelihood of underestimating the impacts on food insecurity (Krishnamurthy et
235 al., 2020).

236 Since the emerging effects of system uncertainties are experienced in highly context specific
237 ways, food systems transformation will necessarily need to be a locally rooted process (Sayer
238 et al., 2008). This will require local communities acquiring tacit knowledge which in itself is a
239 type of knowledge that is not gained in a plannable approach but reveals itself through
240 practice and the acquisition is therefore itself deeply uncertain in nature (Scoones, 2024). For
241 some time, it has been argued that dealing with uncertainty requires experimentation,
242 learning and adaptation in a particular setting to create new capacity and knowledge to act
243 (Watts et al. 2005; Ramalingan et al. 2008; Bossyns and Verle, 2016; Cronkleton et al. 2022,
244 Oliver et al., 2021). This requires a fundamentally different approach where locally-centered
245 action and learning take center stage and where supporting the capacity to act locally
246 cognisant of broader system dynamics is a core strategy

3. A locally centered, coordinated learning system for transformation

3.1 Learning centered on locally led action

249 In this paper, we argue for a learning focused approach that embraces uncertainties in food
250 systems transformation (similar to Oliver et al., 2021; EEA, 2024). To operationalize this novel
251 approach to development practice and policy, it is imperative to (re)assemble new and
252 existing tools, frameworks, and practices around this new task. To guide investment and
253 intervention here we suggest a framework that builds on ideas of Oliver et al. (2021) as a way
254 of engaging with the need to facilitate local actions and learning, and connect action and
255 learning across scales within systems during the transformation process. We believe that the
256 intersection of locally-led action and a learning system has the power to trigger broader scale
257 system transformation that complement and accelerate on-going change processes.

258 The purpose of the framework is twofold. Firstly, it conceptualizes the organization of an
259 integrated set of learning functions that are centred on locally-led action. At the same time it
260 recognises that learning and adaptation also need to take place at higher systems scales to
261 truly engage with the uncertainties of the food systems transformation process. Secondly, and

perhaps more importantly, it serves as a framework for guiding investment in food systems transformation toward the capabilities, institutional arrangements and sources of change needed to enable these learning functions (see Oliver et al., 2021; EEA, 2024). Accordingly, this framework is principally oriented towards rethinking development practice by practitioners and funders in the Global North. Nevertheless, it is also relevant for development actors in the Global South. We refer to this as a transformative learning system because it is transformative in two senses. Firstly, it supports local action and learning to disrupt and direct efforts in the wider food systems to support local experimentation while it also helps to scale promising transformation practices and processes where desirable outcomes are negotiated between bottom up and top down processes. In this way, the learning dynamic between local and system scales is enabled through virtuous learning cycles while remaining embedded in wider system level changes. Secondly, it is transformative in the sense that it disrupts and transforms the way individuals and communities engage with uncertainty by providing a different way to imagine and organize the learning arrangement required in specific local circumstances.

3.2 Capacities and functions of the learning system

The proposed framework builds on the recognition that additional capacities and skills will be critical for change in complex systems and in the food systems transformation process specifically (Oliver et al., 2021; EEA, 2024). Before describing the key learning functions in the proposed framework it is useful to describe the broad types of capacity that these learning functions will need to support. Below we describe three critical capabilities for food systems transformation based on an elaboration of the work of Oliver et al. (2021) and EEA (2024).

Capacity for *local action within systems*. The food systems transformation agenda suggests that communities at local scales will need to navigate the uncertainties in both their responses to a changing global context and in their attempts to identify new pathways to sustainable and inclusive futures. In order to achieve this, individuals, projects, and organizations involved in the transformation process will need the capacity to make sense of and refine their own experimentation and adaptations through learning, evaluation, planning, and replanning processes. Consequently, the need to support people, communities, organizations in navigating these uncertainties and leading local initiatives to address and learn from emergent issues becomes paramount. These groups are not only confronted with the uncertainties surrounding a changing global context, but also uniquely positioned to drive change within the transformation process, experiment with new approaches, and assess their effectivenessThe necessity of providing support lies not merely in the provision of resources, but in the facilitation of learning processes that enable strategic and tactical adaptation, thus ensuring the effective navigation of emerging uncertainties.

Capacity for *coordinated action and collaborative sensemaking across actions*. A focus on systems transformation that emerges from local disruption and inspiration gives rise to a need for a greater degree of coordination across local initiatives. This involves synergizing efforts, avoiding duplication, and building coalitions of interest. It also entails supporting broader learning efforts to strengthen the collective 'muddling through' processes that uncertainty demands. In order to facilitate this form of collaboration across local efforts, there is a need for the incorporation of localized reflections in order to gain sight of negative consequences and trade-offs that may be affecting people in other geographies. The strengthening of the learning and evaluation capabilities of people and organizations will contribute to better

coordination across geographies. However, this process also requires a broader range of methods in order to consider other forms of knowledge and insights, allowing tacit knowledge to emerge.

Capacity for *distributed governance and trust*. New governance arrangements are necessary for the integration of local knowledge and learnings across scales, ultimately leading to larger systems transformation. These governance arrangements must be based on full local leadership and agency, facilitating engagement in transformation within the lived realities of people while being embedded across scales. Specifically, governance arrangements that form the basis for legitimacy and resulting forms of leadership are required to set a broader and more democratic global agenda. In essence, local ownership of transformation involves not only the ownership of local agendas, actions, and outcomes, but also the assurance of a role in influencing national and global agendas that, by their very nature, establish the framework conditions for local action through regulatory frameworks, incentives, and market mechanisms. The glue that holds these arrangements together is the establishment of trust, which is founded on the transparency of the arrangements to collect information on transformation outcomes and lessons rooted in the values of people and organizations.

In order to transform food systems, it is essential that these capacities be purposefully directed. This will enable individuals within the system and the system itself to learn about systems transformation during the change process. The combination of these capacities (see above) and learning functions (see below) will serve as the foundation for the proposed locally centered and coordinated transformative learning system. Figure 1 summarizes how these learning functions and capacities work together to enable transformation.
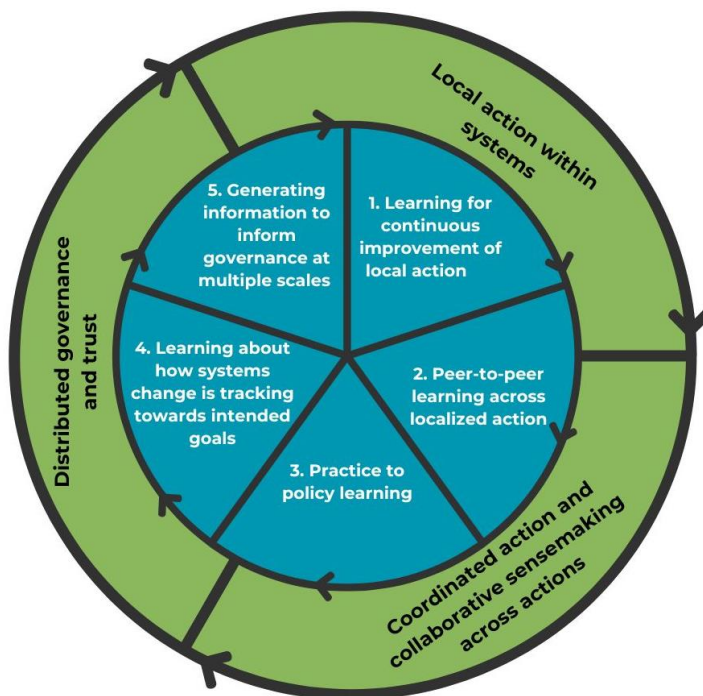
Figure 1: Proposed capacities (in green) and functions (in blue) needed to embrace uncertainty within a transformative learning system.

We propose five key learning functions within the proposed framework to harness the capacities to embrace uncertainty for transformative change:

1. **Learning for continuous improvement of local action:** This learning function focuses on framing problems on a local level and strengthening the learning and evaluation capacity of individuals and organizations to understand and manage their own transformation journey within the system. It provides the means to experiment with action and impact logics against aspirations to change parts of food systems performance, and to develop lessons about what works and where broader system blockages or lock-ins occur.

2. **Peer-to-peer learning across localized action:** This learning function focuses on continuous, incremental, and adaptive peer-to-peer learning. It provides the means to generate lessons from transformation experiences in different contexts of uncertainty and across scales (people, organization, geographies).

3. **Practice-to-policy learning:** This learning function focuses on locally embedded practice-to-policy learning. It emphasizes the application of knowledge from local practices to the development of policy and decision-making processes within governments, development agencies, and funding entities. It facilitates the dissemination of insights and lessons learned, with the objective of informing and guiding further policy and institutional reforms to achieve food systems performance goals.

4. **Learning about how systems change is tracking towards intended goals:** This learning function focuses on the collaborative development of mechanisms for tracking progress and directionality across different contexts, leveraging multiple forms of data and means of collecting them to extend performance insights.

5. **Generating information to inform governance at multiple scales:** This learning function focuses on generating information on governance, outcomes, and impacts. It provides the means for the transparent dissemination of information to different stakeholders regarding the progress of ongoing transformation processes aimed at achieving food systems performance goals. This approach highlights trade-offs and perverse consequences, especially for marginalized groups. Furthermore, it provides politically influential metrics that have the capacity to catalyze sustained investment.

In order for learning to be meaningful and generate actionable insights, the development systems within which the transformation should occur will need to change. Individuals within this system must have agency in order to truly effect change. People have long been dealing with uncertainties at the local level and have deep insights into how they unfold. This fundamentally reframes the role of interventions to one of supporting autonomous experimentation. This approach involves a locally-led strategic experimentation process that aims to transform systems while acknowledging uncertainty and incorporating learning loops into action. At the same time, it is important to emphasize that these localized experiments must be interconnected and interact in a meaningful way. The insights gathered from these experiments enhance other local experiments and the envisioned change accelerates through to the wider food systems levels. It should be noted that we do not argue that other types of intervention are redundant. Far from it, we posit that locally initiated actions, when integrated with systemic interventions, can enhance their efficacy, rendering them more agile and purpose-driven in the face of uncertainty.

3.3 A coordinated system of locally led experimentation

New approaches and lines of support should be aligned with the diverse visions and needs of the people projects engage with when attempting to implement a system of people-focused, local innovation and leadership during food systems transformations (Mausch et al., 2021a). It is important to consider how current and future interventions could support multiple and diverse locally-led pathways (Mausch et al., 2021b). This shift in focus raises different questions that are at the heart of learning needs. The proposed process would facilitate the generating of insights and directions regarding the current pathways and their inherent diversity, with the participants' vision serving as the fundamental guiding principle. This approach would enable a transformative reshaping of operational modalities and the focus of support mechanisms, thereby democratizing the innovation process.

When local conditions are diverse and individual visions for the future are heterogeneous, a localized[2] and decolonized[3] approach to interventions becomes critically important. Embracing uncertainty essentially means that these approaches transcend their current perception as rights-based. Instead, they emerge as pivotal catalysts for transformation in uncertain environments. This paradigm shift challenges top-down approaches, solutions and pathways by emphasizing the agency of people within the process. It also challenges dominant solution-oriented development narratives that rarely reflect the lived reality of complexity and uncertainty of food systems (Sanga and Schülter, 2025). To promote diversity and alternative pathways, it is necessary to prioritize inclusivity, cultural sensitivity, strengthening capabilities enhancement, adaptivity, and evidence-based approaches (Stirling, 2009; Tschersich and Kok, 2022; Cuppen, 2012).

We argue that uncertainty and the resulting need to connect locally led processes of experimentation with a broader agenda of food systems transformation and the development system this is currently embedded in requires a fundamental shift in roles across people and structures within the system (see Figure 2). Ideas and actions will need to be shaped and led locally by those people and communities that are affected. Simultaneously, organizations implementing projects and broader structures and institutional arrangements (system) within the sector must directly support these local processes, as well as connect localized actions towards learning across time and scale across all dimensions.

---

[2] Localization of development has recently regained significant traction and appears to be mainstream now among development agencies (Bilsky et al., 2021; North and Longhurst, 2013; Reddy, 2016). Localization of development refers to the shift towards increased access for local actors to funding streams, decision-making spaces, capacity development, local leadership, and policy influence (Robillard et al. 2021). Fundamentally, it recognizes that local actors are often better positioned to contextualize uncertainty and respond to it. Localization became formally part of mainstream humanitarian development after the 2016 World Humanitarian Summit. For the currently wide endorsement, see for example the widely signed and endorsed Charter for Change (Charter for Change, 2024)

[3] "Decolonizing development means disrupting the deeply rooted hierarchies, asymmetric power structures, the universalization of Western knowledge, the privileging of whiteness, and the taken-for-granted Othering of the majority world." (Sultana 2019, p. 34). This involves addressing power inequalities in development finance and implementation, respecting, and including diverse forms of knowledge, and promoting a diversity of transformation pathways in food systems (Nelson and Edwards, 2020). Despite also being a political project, decolonizing development implies the redefinition of goals where personal life goals become the focus and multiple pathways are therefore supported independently from outside agendas or priorities (Domptail et al., 2023; Herring et al., 2020).
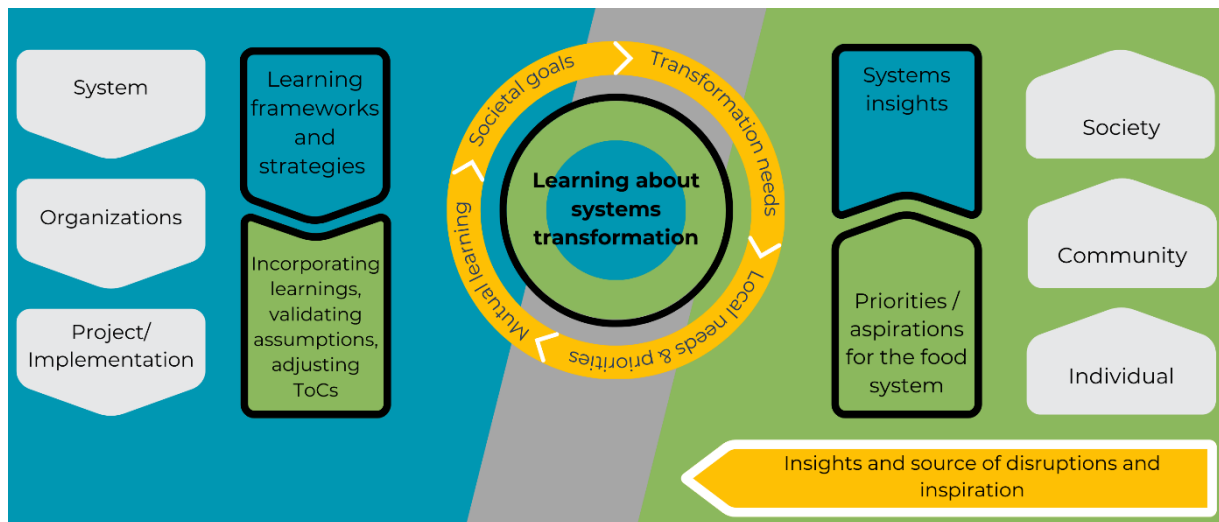
Figure 2: Shifting roles for connecting localized experimentation and action to system scale learning and transformational change.

This process would open additional and complementary pathways towards the needed food systems transformation. The emphasis should be on an expanded system to guide investments and actions that will facilitate local action learnings. During the transformation process, this system further connects these learnings across scales within the development system. This new system builds on autonomous action and learning will offer new approaches for transformation and has the ability to embrace uncertainty.

4. Steps towards putting a transformative learning system into practice

4.1 Entry points from current practice to trigger change

The arguments proposed by Scoones (2024) stress the importance of locally-led action as a strategy for addressing food systems transformation. This mirrors a growing trend in development thinking (Booth and Unsworth, 2014; OECD, 2024). Many international development agencies have instituted guidelines that stress the importance of local leadership (Charter for Change, 2024). This shift in focus signifies a reorientation of development practice and policy towards local leadership and action. It is also a strategy that has the potential to address the context specificity of uncertainty and leverage the accumulated knowledge and practices within these contexts. Consequently, this reorientation paves the way for the transformative learning system to be rolled out and for the emergence of the complementary pathways we believe can contribute to the realization of the necessary transformation.

Furthermore, many individual tools needed are already in use today in food or other related sectors (e.g. multi-stakeholder platforms, theories of change, MEL systems) and will remain relevant for the new learning system. These instruments must be deployed in different modes and for a set of adjusted goals. Table 1 summarizes the new roles emerging from the previous section and provides some examples of existing tools that can be deployed in different ways to address these new roles.

435 *Table 1: Practical steps towards the transformative learning system: changing roles and corresponding tools for people and system.*

	People		System	
Function	**New role**	**Existing tools**	**New role**	**Existing tools**
Learning for continuous improvement of local action	Primary source of knowledge, problem framing, solution identification, project leadership	Design-thinking toolbox (Korner 2021), Community engagement workshops, leadership training	Capacity development for systemic thinking, accepting higher risk for innovation	Experimental approaches (Sengers et al. 2019), grant schemes, challenge programs, system dynamics modelling (Moallemi et al. 2021)
Learning across localized action	Facilitate emancipatory learning, challenge status quo	Peer-to-peer support networks, communities of practice (Strasser et al. 2022)	Utilize existing capabilities, learning-oriented approach, sustainable financing	Complex Theories of Change (Marciniak et al. 2024), experimental systemic interventions, adaptive project management
Practice to policy learning	Generate and disseminate disruptive lessons and information	Stock-taking exercises	Bridge practical experiences and policy-making	Communities of practice, donor coordination, policy think tanks, research networks, Theory based evaluation (Rogers, 2007)
Learning about how systems change is tracking towards intended goals:	Provide localized insights, manage trade-offs	Mapping exercises, local case studies Modeling/ integrated assessment (Moallemi et al. 2024a)	Reflexive approach, focus on process and complexity, develop complex metrics	Analysis and learning facilitation capabilities Lazurko et al. 2025), new process indicators, data collection protocols for national statistics and citizen science (Fritz et al. 2019), Modeling/ integrated assessment
Generating information to inform governance at multiple scales	Integrate diverse knowledge sources	Collaborative research platforms (Norström et al. 2020), knowledge sharing forums	Ensure adherence to principles in outcome assessments	Principle-based assessment guidelines, systemic evaluation frameworks

436

13

437 In practice, however, there is currently a lack of integration among tools. The transformative
438 learning system suggested here argues for a more deliberate approach which explicitly
439 incorporates uncertainty and embeds relevant tools. This implies short-term adjustments
440 with longer-term changes in sight to be the starting point for connecting and implementing
441 the learning elements across locations and levels.

4.2 Shifting mindsets

443 The foundation of the new learning system is a shift in mindsets and ways of thinking.
444 According to Centola et al. (2018), a relatively small minority of about 25% of a group can
445 effectively catalyze a shift in social conventions, thereby reaching a tipping point. This can be
446 initiated by posing different questions, adding new dimensions to the discussion, and
447 implementing novel practices. Subsequently, building strategic alliances within and across all
448 levels can start momentum. Similarly, at the organizational level, food systems actors should
449 form strategic alliances with groups that are challenging current system practices, such as
450 social movements, labor unions, and farmers' organizations, to enable transformative change
451 from the grassroots level, rather than trying to engineer it from the top-down (Behar, 2022).
452 This is where mutual learning occurs, and local and global agendas intersect to facilitate
453 transformative change.

454 For example, the Stakeholder Approach to Risk-informed and Evidence-based Decision-
455 making (SHARED) process (see Neely et al., 2021) brings multiple forms of evidence and
456 diverse voices into development planning and design. The application of this process already
457 led to the intentional integration of learning loops (act - reflect - replan) into the Turkana
458 (Kenya) county development plan (Neely et al. 2021). Within a process such as the one in
459 Turkana, the JUSTRA matrix can support reflection on power imbalances and help to identify
460 approaches to overcome these (Conti et al., 2025).

461 The beginning of the change process is simple, yet challenging. Adopting a learning
462 perspective and reflecting on current projects from the vantage point of systems
463 transformation is crucial. This involves adopting an adaptive and reflexive approach that
464 allows for a different set of questions to be asked. Adding new and different types of metrics
465 into monitoring indicators that prioritize the process of change, meticulously examining the
466 assumptions underlying theories of change, or engaging in alternative dialogues with people
467 engaged in or affected by the project. Embracing the uncertainty that is already part of daily
468 operations and using it as a catalyst for reflection can offer new perspectives and insights.
469 These initial steps can be incorporated into existing project approaches with minimal or no
470 additional cost, while generating valuable insights that are instrumental in facilitating systems
471 transformation processes.

4.3 New project designs and Theories of Change

473 However, the project environment itself requires a different setup. Beyond the shift in
474 mindsets and the corresponding incorporation of new perspectives, adjustments within the
475 current project environment are needed to effect a change of the sector. For the learning
476 system to start functioning, the focus must be on the new sources of disruption to the current
477 system and new avenues for generating insights into the system responses. This will require
478 new types of project governance, as well as engagement processes that will take different
479 forms. Most radically, it would take the opposite form of today's standard operations and start

480 from the local population that engages an agency to support their muddling process, rather
481 than agencies implementing solutions in a location (Sanga and Schülter, 2025).

482 This new arrangement will result in a shift of the roles that project participants and local
483 organizations play in the process. Projects will be designed and led locally and institutions will
484 assume a supporting role providing feedback into the process and offering learning
485 frameworks and strategies. The tools currently in use are already able to accommodate these
486 changes and remain relevant, although they will need to be deployed in different and more
487 integrated ways and forms. One example is Theories of Change (ToCs). In practice, these would
488 be slightly more complex with locally led projects and corresponding ToCs being embedded in
489 a higher-level learning structure that is able to facilitate learning and progress assessment. For
490 the system-level learnings, ToCs will also need to be broadened to incorporate more elements
491 that reflect the complexity of food systems dynamics, which are beyond the control of
492 localized actions, yet are highly relevant as they influence the local environment. Therefore,
493 it is crucial to make explicit assumptions regarding these interactions and subsequently
494 prioritize the assessment of their validity.

495 Projects will need to be learning oriented. They need to acknowledge the scarcity of system
496 capacity, be trust-based, build on local innovation and knowledge (Liverpool-Tasie et al.,
497 2020), and embrace adaptive, responsive management approaches and reflexive learning.
498 Over time, this learning-oriented approach will foster a deeper understanding of system
499 responses to local changes and facilitate the transformation process through adjusted sets of
500 local actions that trigger system changes in the desired direction. This broader learning
501 process should be cascaded, reflecting, and linking local learning. A multi-way coordination
502 and communication process, designed to facilitate diverse intersecting learnings, will support
503 these shifts and insights, and trigger a new set of changes within the evolving local
504 components of the system. It is critical to acknowledge and embrace uncertainty as an
505 inherent feature of this process. Rather than seeking to eliminate or control uncertainty, it is
506 crucial to recognize it as a key element that facilitates the learning journey and facilitates the
507 understanding of system change (Thompson and Scoones, 2009).

4.4 Evaluation approaches

509 In order to effectively harness the potential of localized insights, it is necessary to employ
510 evaluation methods that can handle complexity. The necessary tools already exist (see for
511 example Westhrope, 2012 or Molas-Gallart et al. 2021). However, reframing these tools to
512 align with more decentralized and locally-led initiatives, ensures the participation at all levels
513 and facilitates interpretations from diverse perspectives. A shift in focus to more
514 argumentative and formative types of evaluation, with a stronger orientation towards
515 processes rather than outcomes, is likely to be necessary. Reflexive learning by participants
516 rather than external assessment and control will help to overcome biases and shed light on
517 previous blind spots.

518 Transformative change in food systems takes time, likely extending beyond the duration of
519 standard project timelines. Consequently, the necessity arises for newly established process,
520 impact, and outcome indicators to be embedded at the institutional level rather than at the
521 project level, particularly for medium- to long-term timeframes. One example of this can be
522 found in UNDP's portfolio approach (UNDP, 2023) which aims to improve understanding of
523 how transformation takes place. Furthermore, their Causality Assessment for Landscape
524 Interventions (CALI) approach (UNDP, 2022) as one example of a participatory and complexity

525 aware program roll out highlighted the benefits to the participating communities. Not only did
526 their agency increase but additional perspectives offered improved the program itself (Bina,
527 2025). UNDP also offers guidance on the use and application of tools (Haldrup, 2024),
528 including ToCs and MEL systems, which need to put more emphasis on explicitly exploring and
529 learning about causal processes and mechanisms rather than narrowly focusing on outcome
530 and impact components.

4.5 Funding for new roles and functions

532 While there is scope to start the process within current mechanisms, new or adapted financing
533 mechanisms and approaches have the power to accelerate the process and effect deeper
534 changes. In a facilitative role, financing mechanisms and conditions should avoid glossing over
535 inherent uncertainties. The new functions of the transformative learning system will need to
536 accommodate two basic elements: 1. Institutional funding to allow learning functions to
537 perform beyond projects, 2. Funding for autonomous localized action in the absence of
538 predefined outputs and outcomes - this can be done directly or indirectly through other
539 institutional arrangements.

540 Opening up spaces for experimentation and localized muddling with a larger vision for food
541 systems transformation has the potential to accelerate the changes we urgently need. The
542 Think Tank Initiative, for example, highlighted that core funding, committed for 10 years,
543 enabled organizations to learn and implement strategic shifts (Christoplos et al. 2019).
544 Another strong example is the UN Forest and Farm Facility[4], a multi-donor fund and
545 partnership that provides direct support to forest and farm producer organizations. This
546 initiative has channeled more than 60 million USD to fund activities and priorities which are
547 annually determined—and adapted—by producers themselves. While donors have routinely
548 pushed for clearer, more measurable targets, the program retains a flexible window to fund
549 participatory and adaptive learning systems and ensures programmatic guidance by a Global
550 Steering Committee composed of local farmers and producers (FAO, 2025). Along with closer
551 vertical and horizontal coordination, and a focus on the comparative advantages of both
552 donor agencies and grantee organizations at all levels, a learning system could quickly gain
553 traction and effect change.

5. Conclusions

555 In order to effectively transform food systems, it is essential to navigate ever-increasing
556 uncertainties. The implementation of the proposed transformative learning system needs to
557 be an experimental and empirical process, unfolding in the context of perpetual uncertainty.
558 Indeed, uncertainty can be seen as a positive feature of systems, and by embracing it, we can
559 "transform[ing] our perspectives on uncertainty from ones of despair and fear to those of
560 hope and opportunity" (Scoones 2024, p2). The localized entry point is well-positioned to
561 facilitate this transformation, as solutions and options become more tangible and actionable.
562 This process requires significant changes at all levels and among all stakeholders. The
563 magnitude of required change may appear daunting, potentially leading to a reversion to
564 addressing problems in isolation within the process. However, the shift to a learning system

---

[4] "The FFF is a partnership launched in September 2012 between FAO, IIED and IUCN, and AgriCord. Its Steering Committee is formed by members affiliated with forest producer, community forestry, indigenous peoples' organizations, international research community, business development service provider organization, private sector, government, and donors." (FAO, 2025, About)

for transformative change could begin gradually and in a decentralized manner. Furthermore, this shift would not replace on-going efforts; rather, it offers additional perspectives and insights that have the potential to accelerate the transformation.

The new actions that emerge from new roles will differ from those previously employed. Changes in funding mechanisms, investments in R&D, infrastructure, and mindsets will be required as the process unfolds. More importantly, the argument here is that without an integrated set of learning and evaluation capacities that are locally rooted and reach across scales, choices, and priorities in different areas of investment and public debate, these choices will be blind to and unprepared for the uncertainty characteristic of reality as food systems undergo transformation.

This shift is redefining our notions of success and failure and broadening the range of actors driving change and the skills they need to effectively navigate uncertainty. Using the emerging mechanisms of localization and decolonization as a starting point, we proposed a new learning system that can facilitate a democratic approach to transformation and limit the risks of derailment by vested interests. Our proposed functions within this learning system include learning for continuous improvement at a local scale, with horizontal connections through peer-to-peer learning and vertical distribution of information through practice to policy learning. Furthermore we propose that the learning system should facilitate the tracking of directional change at a systems level, and should generate information for governance at multiple levels. We believe that these functions would build further capacity for localised action, would coordinate action and sensemaking across scales, and would build distributed trust and governance into transforming food systems.

We believe that any intervention, regardless of its size, can contribute to learning and system transformation during implementation. Each initiative should function as a systems probe that facilitates local progress and, more importantly, improves our understanding of the system itself, its reactions to the probe, and the underlying dynamisms. The focus should not be on the extent to which the system has changed, but rather on the manner in which it has been modified or remained locked-in. Through this process, we can learn how the entire system reacts to certain shifts and how these changes translate to different outcomes.

Small tweaks and shifts in focus may be insignificant in isolation, but when embedded in a larger learning system that spans all levels, they could become transformative. The argument presented is that we should not strive for perfection in innovation, but rather for perfection in learning. Food systems actors should embrace muddling as a new and valid approach that serves a learning purpose - purposeful muddling. For those providing funds for transformation initiatives, a shift in approaches and mechanisms is necessary. This involves embracing a higher degree of uncertainty in outcomes and an increased focus on the process. Achieving this objective and demonstrating its practical implementation will establish a new standard far beyond the food systems arena, potentially impacting other complex systems grappling with similar needs for transformative approaches and seemingly intractable challenges.

Statements and Declarations

The authors declared that they have no conflict of interest.

References

Ansari, N., Mehmood, R., & Gazdar, H. (2018). Analysing Pakistan's Modern Dairy Value-Chain Innovation. LANSA Working Paper Series No. 29. IDS. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/13809

Bacon, C.M., Sundstrom, W.A., Stewart, I.T., Beezer, D. (2017). Vulnerability to Cumulative Hazards: Coping with the Coffee Leaf Rust Outbreak, Drought, and Food Insecurity in Nicaragua. World Development 93, 136–152. https://doi.org/10.1016/j.worlddev.2016.12.025

Behar, A. (2022). Opinion: Decolonizing development is key to avoid path to irrelevance, devex Global View, Inclusive development. September 1st, 2022, https://www.devex.com/news/opinion-decolonizing-development-is-key-to-avoid-path-to-irrelevance-103912

Béné, C. (2022). Why the Great Food Transformation may not happen – A deep-dive into our food systems' political economy, controversies and politics of evidence. World Development 154, 105881–105881. https://doi.org/10.1016/J.WORLDDEV.2022.105881

Ben-Haim, Y. (2006). Info-Gap Decision Theory: Decisions Under Severe Uncertainty (Academic Press).

Bilsky, E., Moreno, A.C., Fernández Tortosa, A. (2021). Local Governments and SDG Localisation: Reshaping Multilevel Governance from the Bottom up. Journal of Human Development and Capabilities 22, 713–724. https://doi.org/10.1080/19452829.2021.1986690

Bina, A. (2025), Embracing complexity - The CALI methodology as a path towards Adaptive Management in Complex Setting, UNstuck Blog, https://unstuck.systems/embracing-complexity/, access: 17.01.25

Booth, D., and Unsworth, S. (2014). Politically smart, locally led development. ODI Discussion Paper. London, United Kingdom. https://www.odi.org/publications/8800-politically-smart-locally-led

Bossyns, P., Verle, P., (2016). From "planning for development" to "muddling through complexity," in: Bosmanns et al. (eds). Development Cooperation as Learning in Progress: Dealing with the Urge for the Fast and Easy. ITGPress, pp. 243–265.

Centola, D., Becker, J., Brackbill, D. and Baronchelli, A. (2018). Experimental evidence for tipping points in social convention. Science 360, 1116–1119. https://doi.org/10.1126/science.aas8827

Charter for Change (2024). https://charter4change.org

Checkland, P., Poulter, J. (2010). Soft Systems Methodology. In: Reynolds, M., Holwell, S. (eds) Systems Approaches to Managing Change: A Practical Guide. Springer, London. https://doi.org/10.1007/978-1-84882-809-4_5

Checkland, P.B. (1999). Soft Systems Methodology: A 30-year Retrospective. Wiley: Chichester.

Christoplos, I., Pain, A., Kluyskens, J. and Fruhling, P. (2029). External Evaluation of the Think Tank Initiative (TTI) Phase Two (2014-2019). NIRAS report, available online https://tti.idrc.ca/sites/default/files/tti-main-report-web.pdf, access 28.2.24

Clapp, J. (2021). The problem with growing corporate concentration and power in the global food system. Nat Food 2, 404–408 (2021). https://doi.org/10.1038/s43016-021-00297-7

Conti, C., Hall, A., Kok, K. P. W., Olsson, P., Moore, M.-L., Kremen, C., Laila, A., Gordon, L. J., Barnhill, A., te Wierik, S., Norberg, A., Carducci, B., Bajaj, S., Gibson, M., Oliveira, T. D., Bunge, A. C., Williams, T. G., Mazac, R., Scheuermann, M., and Fanzo, J. (2025). A quest for questions: A tool for navigating just food system transformations in an era of uncertainty. One Earth, forthcoming. preprint available from http://dx.doi.org/10.2139/ssrn.4980291

Conti, C., Hall, A., Orr, A., Hambloch, C. and Mausch, K. (2024), Complexity-aware principles for agri-food system interventions: Lessons from project encounters with complexity, Agricultural Systems, 220, 104080

Conti, C., Zanello, G. and Hall, A. (2021), Why are agri-food systems resistant to new directions of change? A systematic review, Global Food Security, 31, 100576. https://doi.org/10.1016/j.gfs.2021.100576.

Cronkleton, P, Evans, K. and Larson, A. (2022). Capacity building for ACM: Lessons learned from training in distinct contexts. Chapter 6 in: Pierce Colfer, C.J., Prabhu, R. and Larson, A. (eds). (2022) Adaptive Collaborative management in forest landscapes: Villagers, Bureaucrats and civil Society. Routledge, New York, USA.

Cuppen, E. (2012), Diversity and constructive conflict in stakeholder dialogue: considerations for design and methods. Policy Sciences, 45, 23–46. https://doi.org/10.1007/s11077-011-9141-7

DeMartino, G., Grabel, I and Scoones, I. (2024). Economics for an uncertain world. World Development, 173, 106426, https://doi.org/10.1016/j.worlddev.2023.106426

Domptail, S.E., Hirsch, J., Nuppenau, E.-A. (2023). Decolonizing Nature? Worldviews of Agroecological Farmers in Germany to Address the Global Environmental Crisis. in: De Santo, M.K., Domptail, S.E. (Eds.), Degrowth Decolonization and Development: When Culture Meets the Environment. Springer International Publishing, Cham, pp. 115–147. https://doi.org/10.1007/978-3-031-25945-6_6

Douthwaite, B., Hoffecker, E. (2017). Towards a complexity-aware theory of change for participatory research programs working within agricultural innovation systems. Agricultural Systems 155, 88–102. https://doi.org/10.1016/J.AGSY.2017.04.002

EEA (2024), Governance in complexity Sustainability governance under highly uncertain and complex conditions, EEA Report, 05/2024,European Environment Agency, Copenhagen, Denmark, https://data.europa.eu/doi/10.2800/597121.

Fanzo, J., de Steenhuijsen Piters, B., Soto-Caro, A., Saint Ville, A., Mainuddin, M., and Battersby, J. (2024). Global and local perspectives on food security and food systems. Communications Earth & Environment 5, 227. 10.1038/s43247-024-01398-4.

Fanzo, J., Haddad, L., McLaren, R., Marshall, Q., Davis, C., Herforth, A., Jones, A., Beal, T., Tschirley, D., Bellows, D., Miachon, L., Gu, Y., Bloem, M. and Kapuria, A. (2020). The Food Systems Dashboard is a new tool to inform better food policy. Nature Food 1, 243–246. https://doi.org/10.1038/s43016-020-0077-y

Fanzo, J., Haddad, L., Schneider, K.R., Béné, C., Covic, N.M., Guarin, A., Herforth, A.W., Herrero, M., Sumaila, U.R., Aburto, N.J., Amuyunzu-Nyamongo, M., Barquera, S., Battersby, J., Beal, T., Bizzotto Molina, P., Brusset, E., Cafiero, C., Campeau, C., Caron, P., Cattaneo, A., Conforti,

P., Davis, C., DeClerck, F.A.J., Elouafi, I., Fabi, C., Gephart, J.A., Golden, C.D., Hendriks, S.L., Huang, J., Laar, A., Lal, R., Lidder, P., Loken, B., Marshall, Q., Masuda, Y.J., McLaren, R., Neufeld, L.M., Nordhagen, S., Remans, R., Resnick, D., Silverberg, M., Torero Cullen, M., Tubiello, F.N., Vivero-Pol, J.L., Wei, S., Rosero Moncayo, J. (2021). Viewpoint: Rigorous monitoring is necessary to guide food system transformation in the countdown to the 2030 global goals. Food Policy 104, 102163. https://doi.org/10.1016/J.FOODPOL.2021.102163

FAO (2025), About Forest and Farm Facility, https://www.fao.org/forest-farm-facility/about/en/.

Feola, G. (2015). Societal transformation in response to global environmental change: A review of emerging concepts. Ambio 44, 376–390. https://doi.org/10.1007/s13280-014-0582-z

Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD), United Nations Children's Fund (UNICEF), World Food Programme (WFP), & World Health Organization (WHO). (2023). The State of Food Security and Nutrition in the World 2023: Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum. FAO, Rome, Italy.

Foran, T., Butler, J.R.A., Williams, L.J., Wanjura, W.J., Hall, A., Carter, L. and Carberry, P.S. (2014). Taking Complexity in Food Systems Seriously: An Interdisciplinary Analysis. World Development, 61, 85-101.

Fritz, S., See, L., Carlson, T., Haklay, M., Oliver, J.L., Fraisl, D., Mondardini, R., Brocklehurst, M., Shanley, L.A., Schade, S., Wehn, U., Abrate, T., Anstee, J., Arnold, S., Billot, M., Campell, J., Espey, J., Gold, M., Hager, G., He, S., Hepburn, L., Hsu, A., Long, D., Maso, J., McCallum, I., Muniafu, M., Moorthy, I., Obersteiner, M., Parker, A.J., Weisspflug, M and West, S. (2019). Citizen science and the United Nations Sustainable Development Goals. Nat. Sustain. 2, 922-930. 10.1038/s41893-019-0390-3.

Gassner, A., Harris, D., Mausch, K., Terheggen, A., Lopes, C., Finlayson, R.F. and Dobie, P. (2019). Poverty eradication and food security through agriculture in Africa: rethinking objectives and entry points. Outlook on Agriculture, 48(4), 309-315. https://doi.org/10.1177/0030727019888513.

Glover, D., Mausch, K., Conti, C. and Hall, A. (2021), Unplanned but well prepared: A reinterpreted success story of international agricultural research, and its implications, Outlook on Agriculture, 50(3), 241-258.

Haldrup, S.V. (2022). Rethinking monitoring and evaluation in complex systems — when learning is a result in itself, UNDP Strategic Innovation. online https://medium.com/@undp.innovation/rethinking-monitoring-and-evaluation-in-complex-systems-when-learning-is-a-result-in-itself-3d1fc90d22fc, access 1.3.24

Hall, A., Clark, N. (2010). What do complex adaptive systems look like and what are the implications for innovation policy? Journal of International Development 22, 308–324. https://doi.org/10.1002/jid.1690

Hambloch, C., Mausch, K., Conti, C., Hall, A. (2023). Simple solutions for complex problems: What's missing in agriculture for nutrition interventions. Food Security 15(2). https://doi.org/10.1007/s12571-022-01324-6

Harris, J. (2023). Asymmetric Power in Global Food System Advocacy. In: The Political Economy of Food System Transformation. Resnick, D. and Swinnen, J. (eds). Oxford University Press, United Kingdom. DOI: 10.1093/oso/9780198882121.003.0008

Hebinck, A., Selomane, O., Veen, E., de Vrieze, A., Hasnain, S., Sellberg, M., Sovová, L., Thompson, K., Vervoort, J., and Wood, A. (2021). Exploring the transformative potential of urban food. npj Urban Sustainability 1, 38. 10.1038/s42949-021-00041-x.

Herrero, M., Thornton, P. K., Mason-D'Croz, D., Palmer, J., Bodirsky, B. L., Pradhan, P., Barrett, C. B., Benton, T. G., Hall, A., Pikaar, I., Bogard, J. R., Bonnett, G. D., Bryan, B. A., Campbell, B. M., Christensen, S., Clark, M., Fanzo, J., Godde, C. M., Jarvis, A., Loboguerrero, A. M., Mathys, A., McIntyre, C. L., Naylor, R. L., Nelson, R., Obersteiner, M., Parodi, A., Popp, A., Ricketts, K., Smith, P., Valin, H., Vermeulen, S. J., Vervoort, J., van Wijk, M., van Zanten, H. H. E., West, P. C., Wood, S. A., Rockström, J. (2021). Articulating the effect of food systems innovation on the Sustainable Development Goals. The Lancet Planetary Health, 5, 1, e50-e62. https://doi.org/10.1016/S2542-5196(20)30277-1

Herring, E., Ismail, L., Maydhane, Y., McNeill, S. (2020). Decolonising Development : Academics, Practitioners and Collaboration. Journal of Somali Studies: Research on Somalia and the Greater Horn of African Countries 7, 65–100. https://doi.org/10.31920/2056-5682/2020/7n2a4

Hertz, T., Brattander, E., Rose, L., 2021. Complexity-aware monitoring and evaluation. Journal Of MultiDisciplinary Evaluation, 17(41), 35-50. https://doi.org/10.56645/jmde.v17i41.679

Hirschman, A. O., & Lindblom, C. E. (1971). Economic development, R & D, and policy making: Some converging views. In A. O. Hirschman (Ed.), A Bias For Hope: Essays On Development And Latin America. Yale University Press.

Hubeau, M., Marchand, F., Coteur, I., Mondelaers, K., Debruyne, L., Van Huylenbroeck, G. (2017). A new agri-food systems sustainability approach to identify shared transformation pathways towards sustainability. Ecological Economics 131, 52–63. https://doi.org/10.1016/j.ecolecon.2016.08.019

IPES-Food & ETC Group (2021). Transforming Food Systems by 2045 A Long Food Movement. IPES-Food, Brussels. https://www.ipes-food.org/_img/upload/files/LongFoodMovementEN.pdf

IPES-Food (2015). The New Science of Sustainable Food Systems - Overcoming Barriers to Food Systems Reform. International Panel of Experts on Sustainable Food Systems. Brussels, 2015. https://www.ipes-food.org/_img/upload/files/NewScienceofSusFood.pdf

Jones, H., Root, H.L. and Wild, L. (2015). Managing Complexity and Uncertainty in Development Policy and Practice, ODI report.

Kampelmann, S., Kaethler, M., Vivkery Hill, A. (2018). Curating complexity: An artful approach for real-world system transitions. Environmental Innovation and Societal Transitions 27, 59–71. https://doi.org/10.1016/j.eist.2017.10.005

Knight, F.H. (1921). Risk, Uncertainty and Profit. Houghton Mifflin Company, The Riverside Press Cambridge, USA.

Korner, J. (2021). Facilitating design thinking to support food systems transformation: Dilemmas and strategies. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://hdl.handle.net/10568/117973.

776 Krishnamurthy, P.K., Choularton, R.J. And Kareiva, P. (2020). Dealing with uncertainty in
777   famine predictions: How complex events affect food security early warning skill in the
778   Greater Horn of Africa. Global Food Security, 26, 100374.

779 Lazurko, A., Moore, M.-L., Haider, L.J., West, S. and McCarthy D.D.P. (2025). Reflexivity as a
780   transformative capacity for sustainability science: introducing a critical systems approach.
781   Global Sustainability 8(1), 1-15. 10.1017/sus.2024.49

782 Leach, M., Nisbett, N., Cabral, L., Harris, J., Hossain, N., Thompson, J. (2020). Food politics and
783   development. World Development 134, 105024–105024.
784   https://doi.org/10.1016/j.worlddev.2020.105024

785 Lempert, R.J., Popper, S.W., and Bankes, S.C. (2003). Shaping the next one hundred years: new
786   methods for quantitative, long-term policy analysis (Rand Corporation).

787 Lindblom, C. E. (1959). The Science of "Muddling Through." Public Administration Review,
788   19(2), 79–88. https://doi.org/10.2307/973677

789 Liverpool-Tasie, L. S. O., Wineman, A., Young, S., Tambo, J., Vargas, C., Reardon, T., Adjognon,
790   G. S., Porciello, J., Gathoni, N., Bizikova, L., Galiè, A., & Celestin, A. (2020). A scoping review
791   of market links between value chain actors and small-scale producers in developing regions.
792   Nature Sustainability, 3(10), 799–808. https://doi.org/10.1038/s41893-020-00621-2

793 Marciniak, G., Urbach, D., Schneider, F., Krug, C., de Bremond, A., Stafford-Smith, M.,
794   Selomane, O., Fenn, R., Chong, N., and Paillard, S. (2024). Leveraging capacity for
795   transformative sustainability science: a theory of change from the Future Earth Pathways
796   Initiative. Global Sustainability, 7(21). 10.1017/sus.2024.19.

797 Mausch, K., Hall, A. and Hambloch, C. (2020). Colliding paradigms and trade-offs: Agri-food
798   systems and value chain interventions. Global Food Security, 26(C), 100439.
799   https://doi.org/10.1016/j.gfs.2020.100439.

800 Mausch, K., Harris, D. and Revilla Diez, J. (2021a). Rural aspiration – Reflections for
801   development planning and design. European Journal of Development Research, 33-4, 795-
802   808. https://doi.org/10.1057/s41287-021-00407-y

803 Mausch, K., Harris, D., Dilley, L., Crossland, M., Pagella, T., Yim, J. and Jones, E. (2021b). Not all
804   about farming: capturing aspirations is a challenge to assumptions about rural
805   development. European Journal of Development Research, 33-4, 861-884.
806   https://doi.org/10.1057/s41287-021-00398-w

807 Mayne, J., Mcdougall, C., Paz-Ybarnegaray, R. (2017). Evaluating complex interventions : A
808   theory-driven realist-informed approach. Evaluation, 23(3), 294-311.
809   https://doi.org/10.1177/1356389017714382

810 Moallemi, E. A., Bertone, E., Eker, S., Gao, L., Szetey, K., Taylor, N., & Bryan, B. A. (2021). A
811   review of systems modelling for local sustainability. Environmental Research Letters,
812   16(11), 113004.

813 Moallemi, E.A., Battaglia, M., Bruce, J., Craig, S., Farid, A.M., Gao, L., Hall, A., Leith, P.,
814   McMillan, L., Nong, D., Wise, R.M. and Whitten, S. (2024a). Coupling net-zero modeling
815   with sustainability transitions can reveal co-benefits and risks. One Earth 7, 175-179.
816   https://doi.org/10.1016/j.oneear.2024.01.009.

817 Moallemi, E.A., Hall, A., Leith, P., Miller, M., Sperling, F., Raven, R., Frantzeskaki, N., Palmer, J.,
818   Battaglia, M., Bruce, J., Hebinck, A., de Haan, F., Godde, C., Grigg, N., Boylan,S., Szetey, K.,

Chakori, S., LEma, Z., Onyango, E., Stafford-Smith, M., Whitten, S. and McMillan, L. (2024). Shortcuts for accelerating food system transitions. One Earth. https://doi.org/10.1016/j.oneear.2024.01.010.

Moallemi, E.A., Malekpour, S., Hadjikakou, M., Raven, R., Szetey, K., Moghadam, M.M., Bandari, R., Lester, R., and Bryan, B.A. (2019). Local Agenda 2030 for sustainable development. The Lancet Planetary Health 3, 240-241. 10.1016/S2542-5196(19)30087-7.

Moallemi, E.A., Malekpour, S., Hadjikakou, M., Raven, R., Szetey, K., Ningrum, D., Dhiaulhaq, A., and Bryan, B.A. (2020). Achieving the Sustainable Development Goals requires transdisciplinary innovation at the local scale. One Earth 3, 300-313. 10.1016/j.oneear.2020.08.006.

Mohamed, T.S. and Scoones, I. (2023). Kenya drought: Pastoralists suffer despite millions of dollars used to protect them – what went wrong?, The Conversation, 21st March 2023, online https://theconversation.com/kenya-drought-pastoralists-suffer-despite-millions-of-dollars-used-to-protect-them-what-went-wrong-200838, Access 24.2.24)

Molas-Gallart, J., Boni, A., Giachi, S. and Schot, J. (2021), A formative approach to the evaluation of Transformative Innovation Policies. Research Evaluation, 30(4), 431–442. https://doi.org/10.1093/reseval/rvab016

Molla, A., Beuving, J., Ruben, R. (2020). Risk aversion, cooperative membership, and path dependences of smallholder farmers in Ethiopia. Review of Development Economics 24, 167–187. https://doi.org/10.1111/rode.12628

Moore, M.-L., Hermanus, L., Drimie, S., Rose, L., Mbaligontsi, M., Musarurwa, H., Ogutu, M., Oyowe, K., Olsson, P. (2023). Disrupting the opportunity narrative: navigating transformation in times of uncertainty and crisis. Sustainability Science 18, 1649–1665. https://doi.org/10.1007/s11625-023-01340-1

Neely, C.L., Bourne, M., Chesterman, S., Vågen, T.-G., Lekaram, V., Winowiecki, L. A. and Prabhu, R. (2021). Inclusive, Cross-Sectoral and Evidence-Based Decision-Making for Resilience Planning and Decision-Making in a Devolved Context. European Journal of Development Research, 33(4), 1115–1140

Nelson, A., Edwards, F. (2020). Food for Degrowth: Perspectives and Practices. Routledge.

Newman, J. and Head, B.W. (2017). Wicked tendencies in policy problems: rethinking the distinction between social and technical problems, Policy and Society, 36(3), 414–429.

Norström, A.V., Cvitanovic, C., Löf, M.F., West, S., Wyborn, C., Balvanera, P., Bednarek, A.T., Bennett, E.M., Biggs, R., de Bremond, A., Campell, B.M., Canadell, J.G., Carpenter, S.R., Folke, C., Fulton, E.A., Gaffney, O., Gelcich, S., Jouffray, J.-B., Leach, M., Le Tissier, M., MArtin-Lopez, B., Louder, E., Loutre, M.-F., Meadow, A.M., Nagendra, H., Payne, D., PEtterson, G.D., Reyers, B., Scholes, R., Speranza, C.I., Spierenburg, M., Stafford-Smith, M., Tangö, M., van der Hel, S., van Putten, I.. and Österblom, H. (2020). Principles for knowledge co-production in sustainability research. Nature Sustainability, 3, 182-190. 10.1038/s41893-019-0448-2.

North, P., Longhurst, N. (2013). Grassroots Localisation? The Scalar Potential of and Limits of the 'Transition' Approach to Climate Change and Resource Constraint. Urban Studies 50, 1423–1438. https://doi.org/10.1177/0042098013480966

861 OECD (2024). Pathways Towards Effective Locally Led Development Co-operation: Learning by
862   Example, OECD Publishing, Paris, https://doi.org/10.1787/51079bba-en.

863 Oliver, T.H., Benini, L., Borja, A., Dupont, C., Doherty, B., Grodzińska-Jurczak, M., Iglesias, A.,
864   Jordan, A., Kass, G., Lung, T., Maguire, C., McGonigle, D., Mickwitz, P., Spangenberg, J.H.
865   and Tarrason, L. (2021). Knowledge architecture for the wise governance of sustainability
866   transitions, Environmental Science & Policy, 126, 152-163.

867 Patton, M.Q. (2023). Evaluating Transformation Means Transforming Evaluation. In:
868   Edmondson, B. (eds) Sustainability Transformations, Social Transitions and Environmental
869   Accountabilities. Palgrave Studies in Environmental Transformation, Transition and
870   Accountability. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-18268-6_2

871 Ramalingam, B., Jones, H., Reba, T. and Young, J. (2008). Exploring the science of complexity:
872   Ideas and implications for development and humanitarian efforts. ODI Working Paper 285.

873 Reddy, P.S. (2016). Localising the sustainable development goals (SDGs) : the role of local
874   government in context. African Journal of Public Affairs Vol 9 No 2.
875   http://hdl.handle.net/2263/58190

876 Robillard, S., Atim, T. and Maxwell, D. (2021). Localization: A "Landscape" Report. Boston, MA:
877   Feinstein International Center, Tufts University, 2021.

878 Rockström, J., Gupta, J., Qin, D., Lade, S.J., Abrams, J.F., Andersen, L.S., Armstrong McKay, D.I.,
879   Bai, X., Bala, G., Bunn, S.E., Ciobanu, D., DeClerck, F., Ebi, K., Gifford, L., Gordon, C., Hasan,
880   S., Kanie, N., Lenton, T.M., Loriani, S., Liverman, D.M., Mohamed, A., Nakicenovic, N.,
881   Obura, D., Ospina, D., Prodani, K., Rammelt, C., Sakschewski, B., Scholtens, J., Stewart-
882   Koster, B., Tharammal, T., van Vuuren, D., Verburg, P.H., Winkelmann, R., Zimm, C.,
883   Bennett, E.M., Bringezu, S., Broadgate, W., Green, P.A., Huang, L., Jacobson, L., Ndehedehe,
884   C., Pedde, S., Rocha, J., Scheffer, M., Schulte-Uebbing, L., de Vries, W., Xiao, C., Xu, C., Xu,
885   X., Zafra-Calvo, N., Zhang, X. (2023). Safe and just Earth system boundaries. Nature 619,
886   102–111. https://doi.org/10.1038/s41586-023-06083-8

887 Rogers, P. (2007). Theory-based evaluations: Reflections ten years on. New Directions for
888   Evaluation, 114, 63–67.

889 Ruggeri Laderchi, C., Lotze-Campen, H., DeClerck, F., Bodirsky, B.L., Collignon, Q., Crawford,
890   M.S., Dietz, S., Fesenfeld, L., Hunecke, C., Leip, D., Lord, S., Lowder, S., Nagenborg, S.,
891   Pilditch, T., Popp, A., Wedl, I., Branca, F., Fan, S., Fanzo, J., Ghosh, J., HarrissWhite, B., Ishii,
892   N., Kyte, R., Mathai, W., Chomba, S., Nordhagen, S., Nugent, R., Swinnen, J., Torero, M.,
893   Laborde Debouquet, D., Karfakis, P., Voegele, J., Sethi, G., Winters, P., Edenhofer, O.,
894   Kanbur, R., & Songwe, V. (2024). The Economics of the Food System Transformation. Food
895   System Economics Commission (FSEC), Global Policy Report.
896   https://foodsystemeconomics.org/wp-content/uploads/FSEC-Global_Policy_Report.pdf

897 Sanga, U. and Schlüter, M. (2025), Stories, simulations and narratives: Collaboratively
898   exploring food security and agricultural innovation in sub-Saharan Africa. Agricultural
899   Systems, 224, 104241, https://doi.org/10.1016/j.agsy.2024.104241.

900 Sayer, J., Bullb, G., Elliottc, C. (2008). Mediating Forest Transitions: 'Grand Design' or 'Muddling
901   Through'. Conservation and Society 6, 320. https://doi.org/10.4103/0972-4923.49195

902 Scoones, I. (1994). Living with Uncertainty: New Directions in Pastoral Development in Africa.
903   Intermediate Technology Publications.

904   Scoones, I. (2024), Navigating Uncertainty. Polity Press, Cambridge, UK.

905   Scoones, I., Stirling, A. (2020). The Politics of Uncertainty, ans. Routledge, London.
906   https://doi.org/10.4324/9781003023845

907   Scoones, I., Stirling, A., Abrol, D., Atela, J., Charli-Joseph, L., Eakin, H., Ely, A., Olsson, P.,
908   Pereira, L., Priya, R., van Zwanenberg, P., Yang, L. (2020). Transformations to sustainability:
909   combining structural, systemic and enabling approaches. Current Opinion in Environmental
910   Sustainability 42, 65–75. https://doi.org/10.1016/j.cosust.2019.12.004

911   Sengers, F., Wieczorek, A.J., and Raven, R. (2019). Experimenting for sustainability transitions:
912   A systematic literature review. Technological Forecasting and Social Change 145, 153-164.
913   https://doi.org/10.1016/j.techfore.2016.08.031.

914   Singh, B.K., Fraser, E.D.G., Arnold, T., Biermayr-Jenzano, P., Broerse, J.E.W., Brunori, G., Caron,
915   P., De Schutter, O., Fabbri, K., Fan, S.G., Fanzo, J., Gajdzinska, M., Gurinovic, M., Hugas, M.,
916   McGlade, J., Nellemann, C., Njuki, J., Tuomisto, H.L., Tutundjian, S., Wesseler, J., Sonnino,
917   R. and Webb,P. (2023). Food systems transformation requires science-policy-society
918   interfaces that integrate existing global networks and new knowledge hubs. Nature Food.
919   4, 1-3. s43016-022-00664-y. 10.1038/s43016-022-00664-y.

920   Stirling, A. (2008). "Opening Up" and "Closing Down": Power, Participation, and Pluralism in
921   the Social Appraisal of Technology. Science, Technology, & Human Values, 33(2), 262-294.

922   Stirling, A. (2009). 3Ds Direction, Distribution and Diversity! Pluralising Progress in Innovation,
923   Sustainability and Development. Sussex.

924   Stirling, A. (2010). Keep it complex. Nature 468, 1029-1031.

925   Stirling, A. (2014). Emancipating Transformations: from controlling the transition to culturing
926   plural radical progress. STEPS Working Paper 48–48.

927   Strasser, T., De Kraker, J., and Kemp, R. (2022). Network leadership for transformative capacity
928   development: roles, practices and challenges. Global Sustainability, 5(11), 1-12.
929   10.1017/sus.2022.6.

930   Sultana, F. (2019). Decolonizing Development Education and the Pursuit of Social Justice.
931   Human Geography, 12(3), 31-46. https://doi.org/10.1177/194277861901200305

932   Thompson, J. and Scoones, I. (2009). Addressing the dynamics of agri-food systems: an
933   emerging agenda for social science research, Environmental Science & Policy, 12(4), 386-
934   397.

935   Thompson, J., Millstone, E., Scoones, I., Ely, A., Marshall, F., Shah, E., Stagl, S. and Wilkinson,
936   J. (2007). Agri-Food System Dynamics: pathways to sustainability in an era of uncertainty.,
937   STEPS Working Paper 4, Brighton: STEPS Centre

938   Thornton, P. (2023). Innovations for Reconfiguring Food Systems. in: Bansal, K.C., Lakra, W.S.,
939   Pathak, H. (Eds.), Transformation of Agri-Food Systems. Springer Nature, Singapore, pp. 1–
940   7. https://doi.org/10.1007/978-981-99-8014-7_1

941   Tschersich, J. and Kok,K.P.W. (2022), Deepening democracy for the governance toward just
942   transitions in agri-food systems, Environmental Innovation and Societal Transitions, 43,
943   358-374.https://doi.org/10.1016/j.eist.2022.04.012.

944   UNDP (2022), Causality Assessment for Landscape Interventions (CALI) - methodolody
945   guidebook, UNDP, New York, USA.

946 UNDP (2023). Portfolio Approach: Rethinking policy and development in times of uncertainty,
947 UNDP Primer. available online https://drive.google.com/file/d/1mOVog1-
948 sNhb8OI1j2wffoDOCYYIdoI4G/view, access 28.2.24

949 Wanzenböck, I., Wesseling, J.H., Frenken, K., Hekkert, M.P., Weber, K.M. (2020). A framework
950 for mission-oriented innovation policy: Alternative pathways through the problem–
951 solution space. Science and Public Policy, 47(4), 474–489.

952 Webb, P., Benton, T.G., Beddington, J., Flynn, D., Kelly, N.M. and Sandy M. T. (2020). The
953 urgency of food system transformation is now irrefutable. Nature Food 1, 584–585 (2020).

954 Westhorp, G. (2012). Using complexity-consistent theory for evaluating complex systems.
955 Evaluation, 18(4), 405-420. https://doi.org/10.1177/1356389012460963

956 Woltering, L. and Boa-Alvarado, M. (2021). Insights on scaling of innovations from Agricultural
957 Research for Development: views from practitioners. Knowledge Management for
958 Development Journal, 18(1).

959