Transforming Food Systems under Climate Change through Innovation

Edited by BRUCE CAMPBELL • PHILIP THORNTON • ANA MARIA LOBOGUERRERO DHANUSH DINESH • ANDREEA NOWAK

TRANSFORMING FOOD SYSTEMS UNDER CLIMATE CHANGE THROUGH INNOVATION

Our food systems have performed well in the past, but they are failing us in the face of climate change and other challenges. This book tells the story of why food system transformation is needed, how it can be achieved, and how research can be a catalyst for change. Written by a global interdisciplinary team of researchers, it brings together perspectives from multiple areas including climate, environment, agriculture, and the social sciences to describe how different tools and approaches can be used to tackle food system transformation. It provides practical, actionable insights for policymakers and advisors, demonstrating how science together with strong partnerships can enable real transformation on the ground. It also contributes to the academic debate on the transformation of food systems, and so will be an invaluable reference for researchers and students alike. This title is also available as Open Access on Cambridge Core.

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‘This fascinating - and rich - book deals with the entire food system and how it must be changed in the context of climate change and other urgent challenges in a complex socio-economic world. It is based on a solid foundation of transdisciplinary research and thus a model for how planetary changes should be addressed in the Anthropocene. A necessary book for scientists and multiple stakeholders concerned with ensuring a healthy diet for the global population.’

Professor Thomas Rosswall, former President of the Swedish University of Agricultural Sciences

‘The world is running short of land and water, climates are changing, and these threats challenge our ability to transform food systems to feed the world’s burgeoning populations. Transformation will not come through planned processes or silver-bullet technical innovations. The transformation that is required will need fundamental changes in the behavior of those who research, produce, transport, market and consume food. Campbell and his co-authors have brought together in a single volume the learning of a vast global program of innovation experiments each set in its local context and executed with key actors in the food system. The research described in this volume is excellent, but its value is enhanced from the way the research was deeply embedded in local context and the learning occurred through partnerships amongst the full diversity of people engaged in transforming food systems. Campbell *et al.* provide a unique source of evidence and the concepts needed to achieve the transformation that is vitally needed.’

Professor Jeffrey Sayer, University British Columbia

‘Innovation is an essential lever to transform food systems which are under the threat and reality of climate change. This inspirational book offers examples and guidance on how to accelerate innovation across four key action areas, designed to deliver a vision and approach to transformation that is urgent, ambitious, and inclusive.’

Lisa Sweet, Head of Climate and Nature, Food Systems Initiative at the World Economic Forum

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1

Fixing Our Broken Food System

The Why and How

VANESSA MEADU, CHARLES SPILLANE, ANDREW J. CHALLINOR,
AND PETER C. MCKEOWN

Highlights

- Our food systems have performed well in the past, but they are failing us in the face of climate change and other challenges.
- There is a broad consensus that transformation of food systems is required to make them sustainable and equitable for all.
- Transformation occurs via agents of change: individual behaviour, policies and institutions, research and innovation, and partnerships and alliances.
- Outcome-oriented agricultural research for development can help bring about directed transformation that maximises benefits and minimises trade-offs.

1.1 Introduction

More than twenty reports published in recent years and involving hundreds of scientists converge around a simple message: globally, food systems require radical change (EAT-Lancet, 2019; GLOPAN, 2020; HLPE, 2020; Pharo et al., 2019; Steiner et al., 2020). In 2021, the United Nations Secretary General convened the first of its kind Food Systems Summit towards this goal. The transformation of food systems can address sustainability and development challenges from local to global scales by moving these systems into more sustainable trajectories while at the same time empowering societies to address chronic undernutrition, overnutrition, and disease. By 2021, climate change had become a systemic driver of fundamental reorganisation of food systems while also acting as a risk-multiplier for the vulnerable.

The COVID-19 pandemic has starkly revealed the lack of resilience of our food systems to unexpected shocks, and the poorest and most vulnerable in society are worst impacted (Carducci et al., 2021). There is an urgent need – and a unique opportunity – for food-system transformation that 'builds back better' by mitigating vulnerability to shocks while delivering nutritional, environmental, social, and political–economic benefits. The pandemic has brought the lived experience of transformational societal shifts to the forefront of global discourse and unlocked unprecedented financial support for systemic transformation (Barrett et al., 2021). Nevertheless, food-system transformation will differ from the crisis management that has characterised much of the global response to COVID-19 by being far longer-lasting, enshrining environmental sustainability, and ensuring that nobody is left behind.

Food-system transformation that achieves many interwoven goals is likely to be complex, disruptive, and expensive, and some people may face risks. Inaction will result in far worse and more expensive outcomes for society and planetary health, however. Transdisciplinary approaches and highly focused research can help achieve the goals of sustainable and equitable food systems in the face of climate change and other global drivers of change, while identifying and minimising risks and trade-offs.

1.2 What Are Food Systems, and What Is Wrong with Them?

Food systems comprise all activities, institutions, and actors engaged in agricultural and food-related value and supply chains. They encompass production and the provision of associated inputs, consumption, food losses, waste management, policy and fiscal environments, and environmental and socio-economic drivers that bring about change and can create feedbacks (Figure 1.1). Food system outcomes contribute to human nutrition and health and to environmental and social welfare and thus can advance the Sustainable Development Goals.

Over the last 70 years, the global food system has provided adequate food for the human population to triple, and for much of this period, real food prices have been constant or declining. Overall, the prevalence of hunger and undernutrition has lessened, although substantial regional differences persist. In many parts of the world, increasingly unreliable weather and more frequent extreme weather events are changing the patterns of food production, with significant shortfalls in some places. Hunger still affects hundreds of millions of people – 768 million in 2020 – and another 2.37 billion lack access to adequate food and healthy, sustainable diets (FAO, 2021; Willett et al., 2019). Yet heightened food production comes with unsustainable environmental costs – natural resource degradation, disrupted nutrient cycling, and losses of biodiversity and ecosystem services (IPBES, 2019). In many lower- and middle-income countries with heavily agriculture-based

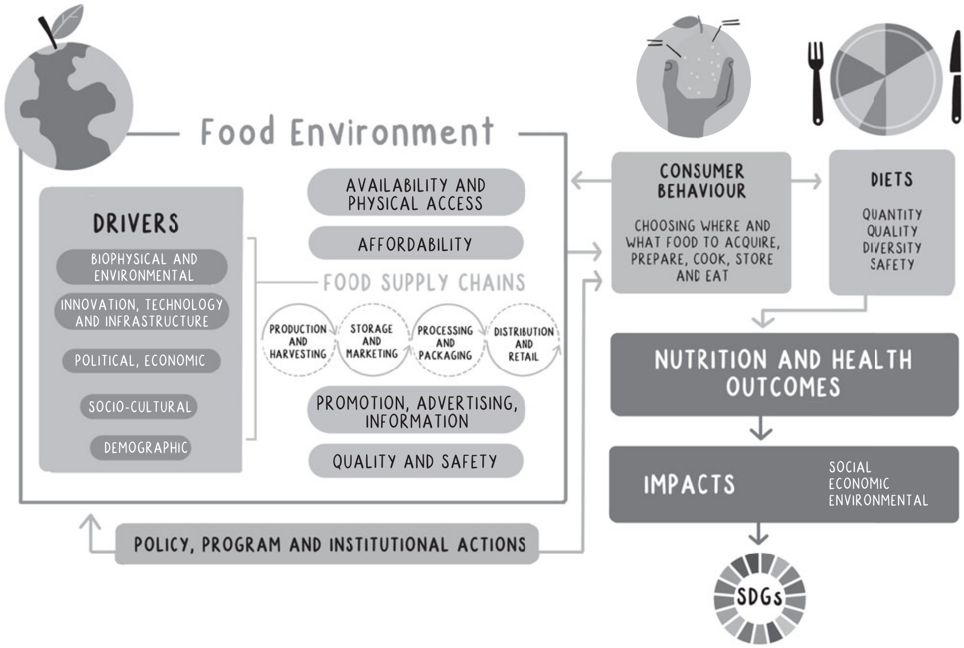

Figure 1.1 The food system.
Adapted from The Impact of COVID-19 on Food Security and Nutrition by the UN Executive Office of the Secretary-General, ©2020 United Nations. Reprinted with the permission of the United Nations

economies, a lack of employment and decent work in agriculture and rural communities is a factor driving rural-to-urban migration.

The risks to agricultural productivity are increasing, including climate-related shocks due in part to greenhouse gas (GHG) emissions from food systems (Cottrell et al., 2019; Masson-Delmotte et al., 2018; Springmann et al., 2016). From farm to fork, globally, these amount to 18 billion tonnes of carbon dioxide equivalents per year, representing 34 percent of the total anthropogenic GHG emissions (Crippa et al., 2021). Current pledges by national governments to reduce GHG emissions are insufficient for the planet to stay within a safe operating space of 1.5°C or even 2.0°C warming. The current trajectory as of 2021 is towards 2.6°C or 2.7°C of warming by 2100. We need a giant leap in global ambition to cut emissions.

At the same time, recognition is growing of the ways in which climate risks may affect food systems, human conflict, migration, health, and security, often in combination and across sectors and borders (Challinor & Benton, 2021). There are, however, other drivers of change in food systems besides climate (Figure 1.1). The biophysical dimensions of climate interact with the biological bases of agricultural productivity, and simultaneously, a wide array of socio-economic factors shape agriculture through on-farm management and policies. These interactions are strongly non-linear, giving rise to complex feedback relationships that impact food systems and their behaviour in response to change. Strengthening the ability of food systems to adapt to drivers of change is at the heart of the case for food-system transformation, along with the need to improve the sustainability and equitability of food systems and ameliorate the underlying limitations and justice issues in patterns of resource consumption.

1.3 What Is Transformation, and How Does It Happen?

In view of the complexities of food systems and the multidimensional risks they face, incremental innovation will be insufficient to address the challenges ahead; transformational change will be needed. 'Transformation' means a redistribution of inputs and outputs towards sustainable, inclusive, healthy, and climate-resilient food systems (Vermeulen et al., 2018). It thus entails, for example, significant changes in the structure of landholdings, in technologies and their uses, in the capabilities of and opportunities for women and men, in the flow of public and private finance, and in the distribution and dynamics of the population and labour force (Steiner et al., 2020). The many examples of transformations in human history have usually been undirected and intensely disruptive, with winners and losers emerging through time (Herrero et al., 2020). Better-directed transformation can empower women and youths while generating multiple crucial benefits such as improving education, nutrition, health, water access, sanitation, and incomes for small-scale agricultural producers including those engaged in fishing, pastoralists, and agri-foresters.

Transformation will inevitably generate trade-offs as well as benefits. Navigating food-system transformation requires an evidence base to enable the desired outcomes to emerge and may entail the provision of safety nets for those who lose out through potentially massive redistributions of land, labour, and capital. In addition, no transformation happens in a vacuum: transformations in other sectors such as in energy and information technology are already having huge impacts on food systems. By the same token, food-system transformation can cascade into improvements in many other aspects of society.

Transformative change may be driven by multiple 'agents of change' operating at different levels and dimensions of societal and economic systems and at various points throughout the food system. A shift in one component can trigger knock-on changes on other parts of the system, such as feedforward or feedback changes, either as a slow ripple effect or as a rapid tsunami. While transformation can be viewed through many lenses, in general there are four types of agents of change (Wilber, 2001):

Individuals and Behavioural Change: The behaviour of individuals is shaped by personal and collective values and worldviews and influenced by innovation and policy. Individual behaviour is aggregated through different social institutions, including households, communities, workplaces, and civil society. Understanding how individuals can be effective agents of change requires considering the various roles that they play within food systems as consumers, farmers, processors, retailers, and regulators (see Chapter 9 about how individual behaviour can drive change towards healthy diets). Transformative change can also occur through individual actors being empowered to affect the surrounding system, thus delivering scalable individual action (Chapter 13). Such empowerment can come through removing obstacles to change, such as entrenched policies and societal values that tend to stymie new developments (Hall & Dijkman, 2019). In the search for just and equitable food-system transformation, politics is key, including management of competing claims and objectives, and recognition of the diversity of actors and institutions and their interconnections across sites, scales, and sectors.

Policies and Institutions: Organisations and institutions arise from shared cultures; each has its own approach. In the context of food systems, relevant actors include consumers, retailers, processors, producers, research entities, governments, and multilateral organisations. By presenting new options, enabling action, rewarding progress, or penalising unwilling actors, organisations and institutions interact in multiple ways to produce food-system outcomes, which may cascade to other systems and sectors as well (Chapter 11). Public investments and policies will likewise stimulate necessary changes, including by de-risking the pursuit of transformative pathways through new incentives, infrastructure, and support (Chapter 5).

Research and Innovation**:** Organisations involved in research and innovation can drive transformation (Chapter 3). While research typically relates to the generation and application of original knowledge, innovation refers to the creation of new values or utilities by using or combining existing knowledge and processes. Innovation stimulates transformational change whereby one product or process can displace another to improve value for the end user. Research, meanwhile, informs transformative pathways to ensure that the most effective and impactful options are pursued through considered monitoring, evaluation, and learning with the goal of maximising co-benefits and managing trade-offs. Research and innovation can themselves be transformed (Chapter 14).

Partnerships and Alliances**:** Partnerships and alliances occupy the dynamic and evolving space where food systems, organisations, and society intersect. To transform food systems, governance and power relations must undergo reform, and actors will establish new and unconventional partnerships and coalitions that espouse sustainability and equity while working towards societal change. Governments at all levels will remain key innovation partners and enablers in creating policy and public investments. Investors – including donors, the private sector, and philanthropists – and public agricultural research organisations will engage and experiment with players whose pioneering activities could disrupt dominant market forces (Chapter 16) (Hall & Dijkman, 2019).

Numerous voices and discourses about the transformation of food systems advance agendas that range from human and planetary welfare to profit and political power. In this situation, a common vision may be difficult to achieve. Dialogues can forge common interests rather than only conveying or entrenching the positions of different and often opposing groups. The visions with the greatest leverage may be those where a broad range of views and components converge to identify common interests and modify structures that limit collective agency. The visionaries may include, for example, multinational corporations, food sovereignty movements, or animal welfare perspectives. Converting their transformative visions into action will entail an understanding of how existing power relationships may facilitate or hinder change in order to address disempowerment and marginalisation, so that our future food systems are sustainable and equitable for all.

1.4 Agricultural Research for Development and Food-System Transformation

Agriculture is an important sector in the economies of many lower- and middle-income countries and provides an entry point for effective strategies for poverty reduction. Working towards this goal, CGIAR is a large global collective of international, publicly funded agricultural research for development (AR4D) institutes. Since its establishment in 1971, CGIAR has spent about US$60 billion in present-value terms; this investment has returned tenfold benefits including greater food abundance, cheaper food, reduced rates of hunger and poverty, and a smaller geographical footprint for agriculture (Alston et al., 2020). Although funding of CGIAR represents only 3 percent of public investment in lower- and middle-income countries, the collective has delivered considerable international public goods and played a key role in building national research capacities to deliver impacts at scale (Beintema & Echeverria, 2020).

CGIAR sought to systematically address climate change through its Research Program on Climate Change, Agriculture and Food Security (CCAFS), which ran from 2009 to 2021. The Program invested around US$350 million in action research involving all the international agricultural research centres of CGIAR and integrating thematic work across multiple global, regional, and local partners. It identified and tested pro-poor adaptation and mitigation practices, technologies, and policies to enhance food systems, adaptive capacity, and rural livelihoods. In ways that benefit the rural poor, CCAFS also provided diagnosis and analysis to guide cost-effective investments, the inclusion of agriculture in climate change policies, and the inclusion of climate issues in agricultural policies, from the subnational to the global level (Vermeulen et al., 2012). For more than a decade, CCAFS and hundreds of its partners worked closely together on a food-system transformation agenda. Collectively, they showed how research can make an enormous difference over relatively short timelines, if the process is outcome-orientated and appropriate partnerships and mechanisms are in place (Chapter 3).

This book both distils lessons learned from this prominent effort to reimagine AR4D and lays out an agenda for the transformation of food systems. It has three sections. This first, introductory section sets out the 'what' of agricultural transformation and the four action areas that are needed to accomplish it (Chapter 2). These action areas are as follows: rerouting farming and rural livelihoods towards new trajectories; de-risking livelihoods, farms, and value chains; reducing emissions; and realigning policies, finance, support for social movements, and innovation. This initial section also demonstrates the key role of AR4D (the 'how', Chapter 3).

The second section lays out an agenda for transformation based on the four action areas, identifiying the priorities for eleven concrete actions and showcasing successful examples to demonstrate that change is feasible. These eleven actions relate to deforestation, agricultural production, market development, digital advisory systems, early warning, food loss and waste, dietary shifts, policy and institutional change, social movements, innovation systems, and financial mechanisms (Chapters 4–14).

The third section of the book discusses and illustrates four principles for outcome-orientated research for transformation: theories of change (Chapter 15), the critical role of partnerships (Chapter 16), working across scales (Chapter 17), and leadership and management (Chapter 18). Throughout these chapters, examples are drawn from research about the climate–food nexus. Some are from CCAFS and its partners, and some from other organisations and initiatives. The book ends with a short concluding chapter summarising its major points and looking forward towards requirements for food-system transformation (Figure 1.2) .

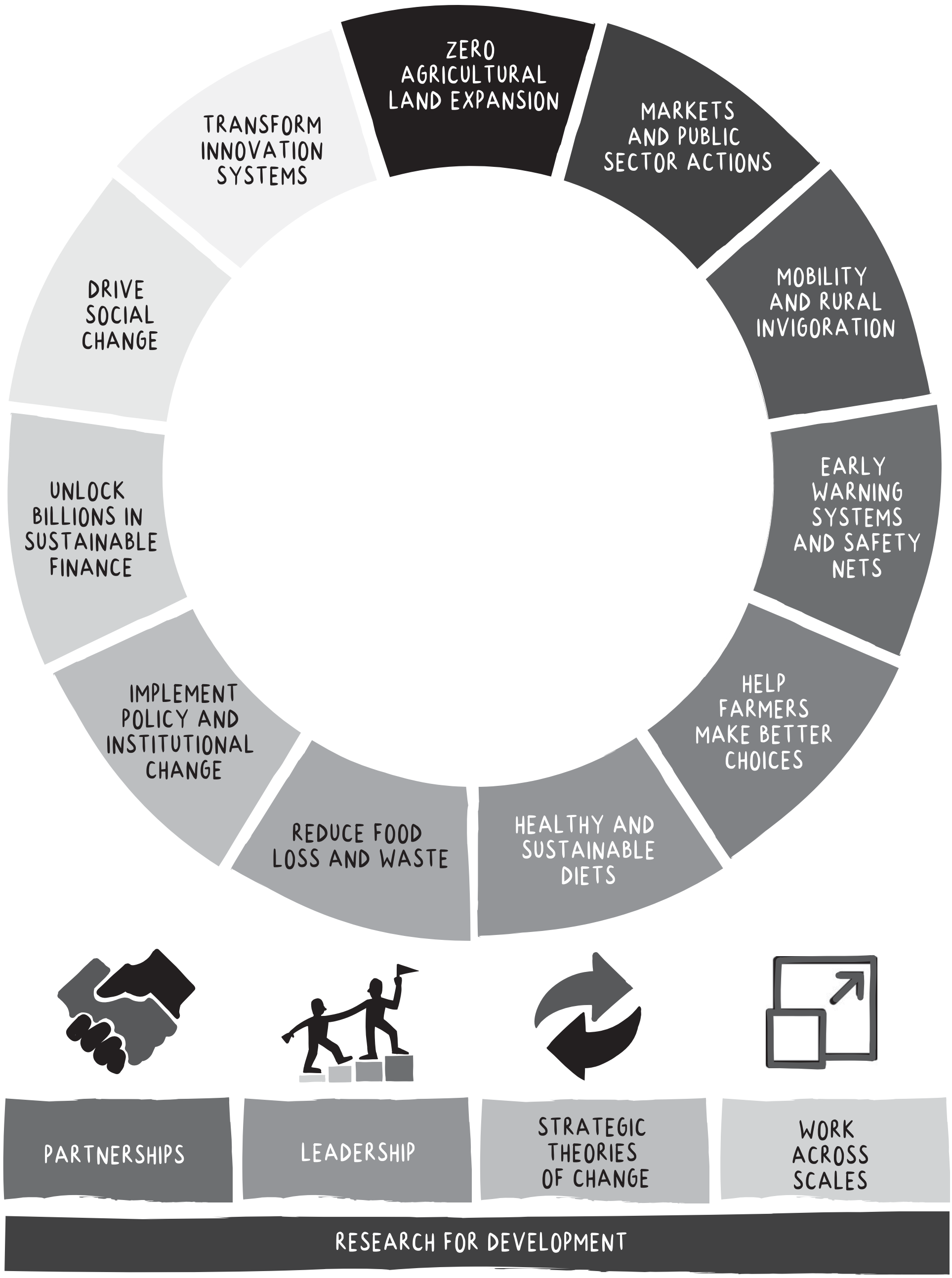

Figure 1.2 An illustrative summary of the book

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2

Where We Need to Drive Food-System Action

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Highlights

- Transformation is required in complex food systems; the key is to identify the best levers to achieve change.
- Food-system transformation has four major interlocking elements: rerouting systems into new trajectories; addressing climate impacts, thereby reducing risks; addressing new environmental issues, thereby lessening emissions; and realigning the 'enablers of change' such as policies, regulation, finance, and innovation.
- This book proposes 11 specific, concrete actions within these four areas.
- Achieving food-system transformation will require annual investments of US$1.3 trillion through the decade, with private-sector finance helping to fill current gaps.

2.1 The Vision

We envision a world where all people, including future generations, are well nourished and food-secure. This vision can be achieved through transformed food systems that sustainably manage current and future resources and stresses. Such food systems will be built by empowering people along the food value chain and strengthening their resilience to natural, social, and climate-related hazards, while contributing to emissions reductions, the capture of greenhouse gasses (GHGs), sustainable land use, and ecosystem and biodiversity protection (Figure 2.1).

Ambitious targets must be achieved if the Paris Agreement and the United Nations' Sustainable Development Goals (SDGs) are to be realised. Food and nutritional security targets are themselves challenging but are overlaid by the need to achieve global zero net emissions, with food systems requiring substantial emission reductions and carbon capture. In addition, global temperatures will

Figure 2.1 The vision for a transformed food system

overshoot the predicted 1.5°C warming scenario, and are highly likely to overshoot 2°C, meaning considerable adaptation to extreme events is necessary. Given these challenges, comprehensive changes are requisite across entire food systems.

New food systems will revolve around radical changes in the strategies and operations of all actors within the value chain, including how ecosystems are maintained and how policies, human behaviour, financing criteria, and political economies can solve the urgent problems of agriculture and climate change. A fundamental shift in the power balance of food system actors is required to achieve these improvements.

A primary challenge in transforming food systems under a changing climate relates to the scalability of successful adaptation and mitigation approaches; currently, too many successful pilots are not scaled up. Transformed food systems will be embedded in enabling environments where knowledge – including indigenous and local knowledge – policies and institutions, finance, the private sector, and civil society help overcome the scaling barriers in climate-resilient and low-emission approaches. This enabling environment will support all types and sizes of farmers and other food system actors, including women and youths, in accessing resources and decision-making power, to ultimately achieve productive, sustainable livelihoods. Developing economically attractive livelihoods that can encourage youth participation in food value chains would form part of this enabling environment. As technologies evolve and population distributions change, attaining this goal will likely require re-skilling and capacity building in new areas.

Alongside these supply-side changes, alterations in demand will be essential to achieving food-system transformation. The demand for sustainable ecosystem use and a massive shift in food consumption behaviour towards nutritious diets within planetary boundaries are critical to achieving global aspirations for sustainable development and healthy populations (Rockström et al., 2009). Transformation of diets will go beyond informing or nudging consumer choices towards a more systemic approach that encompasses regulation, infrastructure, private and public investment, and social movements that shape consumers' choices and options. Public-sector procurement may be as important in leading the way forward as private-sector food retail and food service industries. A fundamental shift in political economy, power relations, and behaviours must underpin such shifts, recognising that producers must adapt their skills and labour requirements.

2.2 Four Key Areas in Achieving Transformation

Food systems require transformation. Given the enormous complexity of food systems – not to mention the heterogeneity in the way food is produced, processed, distributed, and consumed among and within individual countries – the best levers to trigger transformative change need examining. Four action areas have been defined, drawing attention to four objective outcomes necessary for transformative change. These action areas include 11 key actions (Chapters 4–14), drawing on the work of Steiner et al. (2020).

2.2.1 Action Area 1: Rerouting Farming and Rural Livelihoods to New Trajectories

Significant investments can enable farming systems and rural livelihoods sources to course-correct towards a sustainable, climate-resilient future that benefits the environment, people, and animals. This future would involve reallocating and refocusing current investments, backed by supportive policies and institutional reforms. Expected outcomes include higher agricultural productivity, conservation of ecosystems and the natural resource base, low GHG emissions, reduced social inequality, food and nutrition security for all, and elimination of social conflict that generates pressure to migrate. Three actions are identified to reroute farming and rural livelihoods (Table 2.1), to foster the emergence of a reinvigorated rural economy where agriculture serves as a driver of inclusive rural development and sustainable growth.

Table 2.1. *The 'what', 'how', 'where', and 'who' aspects associated with each transformative food system action*

Actions	Goal ('*what*')	Actions and transformations ('*how*')	Geographical focus ('*where*')	Stakeholders ('*who*')
Action 1.1 Ensure zero agricultural land expansion in high-carbon landscapes (Chapter 4).	Avoid the conversion of 250 million ha of forests and 400 million ha of peatlands.	Integrate policy action across climate targets, subsidies, protected areas, and taxes. Implement innovative financial mechanisms such as debt for nature swaps, blended finance, and green bonds to radically increase the funds available for conservation and restoration.	Tropical developing countries, particularly Brazil, Indonesia, Peru, the Congo Basin, and Colombia	Stakeholders range from global policymakers and investors to indigenous communities and wild area stewards.
Action 1.2 Enable markets and public-sector actions to incentivise climate-resilient, low emission practices (Chapter 5).	Widely adopt climate-resilient innovations; integrate more farmers into inclusive, sustainable markets.	Strengthen public- and private-sector measures that incentivise the adoption of climate-resilient innovations and improve livelihood opportunities for farmers. Catalyse and leverage the resources and dynamism of local small and medium-sized agribusinesses to create inclusive, sustainable markets. Support community-based initiatives to enhance the livelihood, security, and resilience of marginalised and resource-constrained smallholder farmers.	Climate-change and poverty hotspots in Africa, Latin America and Asia	Stakeholders include government agencies, small and medium-sized enterprises (SMEs), farmer communities, and development partners.
Action 1.3 Support prosperity through mobility and rural reinvigoration (Chapter 6).	Reroute farming and rural livelihoods to new trajectories that enable farmers to 'step up' and 'step out'.	Invest in secondary and tertiary industries in rural areas. Revolutionise agricultural production systems towards greater automation. Increase youths' capacity for entrepreneurship. Establish safety net policies to facilitate migration out of failing farming systems.	Global scope, with a focus on the developing world	Youths and women in rural areas are the key stakeholders.

Action 2.1 Secure resilient livelihoods through early warning systems and adaptive safety nets (Chapter 7).	End dependence on humanitarian assistance for 40 million rural dwellers by 2030. Realign US$5 billion per year for adaptive safety nets.	Construct a tighter continuum from humanitarian assistance to development processes. Develop and improve early warning systems in climate risk hotspots. Align best-practice safety net programmes in climate risk hotspots. Support early action with risk finance. Undertake the following actions to build a climate security agenda: • Strengthen multi-level governance frameworks that help bridge the humanitarian–development–peace nexus. • Find ways to integrate climate security evidence in early warning and early action systems. • Design coherent and conflict-sensitive adaptive safety net policies and programmes. • Bridge innovations and social capital.	Countries exposed to climate extremes and variability, fragility, conflict, and socio-political insecurities	End users include policymakers and stakeholders from the climate-action and emergency sector.
Action 2.2 Help farmers make better choices (Chapter 8).	Scale climate services by connecting 200 million farmers and agribusinesses to information and communication technology-enabled bundled advisory services by 2030	Amplify farmers' voices and improve their capacity to use climate information. Bundle climate services with agri-advisories, inputs, and financial services. Invest in public institutions such as national meteorological services and extension services. Employ a diverse delivery strategy for climate services that exploit digital innovation. Embed services in a sustainable, enabling policy and governance environment.	Global scope	Stakeholders include farmers, government ministries and agencies, insurance providers, communications companies, universities, research organisations, non-governmental organisations, funders, and donors

Table 2.1. (*cont.*)

Actions	Goal ('*what*')	Actions and transformations ('*how*')	Geographical focus ('*where*')	Stakeholders ('*who*')
Action 3.1 Shift to healthy, sustainable, climate-friendly diets (Chapter 9).	Reduce red meat consumption in high-income countries to support healthier, low-emission, sustainable diets. Increase the availability of alternative protein sources.	Improve the cost, ease, and appeal of alternative meat products for large segments of populations in all countries. Promote policy targets and actions for reduced-meat diets in high- and middle-income countries with excessive meat consumption. Use public–private finance to drive more rapid improvements in alternative meat products and their sustainability. Enhance business opportunities, including the availability of open-source technologies for alternative meat production in low- and middle-income countries, such as for small-scale production.	High- and middle-income countries and C40 Cities with substantial meat and dairy consumption. Low- and middle-income countries for business opportunities.	Consumers of meat, companies, investors, donors, policymakers, and social movements are crucial stakeholders.
Action 3.2 Reduce food loss and waste (Chapter 10).	Reduce food loss and waste to improve food security, with trade-offs for climate impacts (shrink the percentage of global GHG emissions associated with food loss and waste).	Use regional and national hotspot analysis to derive priority product categories and chain stages. Identify solutions at the value chain level. Improve harvesting and on-farm handling. Enhance perishable cooling procedures across the value chain to minimise food loss and waste. Coordinate demand-driven planning and supply chain transformations to reduce waste, particularly when serving remote and urban markets. Develop business models in which costs and benefits are distributed among actors that invest and benefit from measures to decrease food loss and waste. Reduce food loss and waste from high-emission crops to substantially cut GHG emissions.	Situation-specific locations, including Africa broadly and all low-income countries	Policymakers, value chain actors, services providers, cooperatives, and investors comprise the major stakeholders.

Action 4.1 Implement policy and institutional changes that enable transformation (Chapter 11).	Utilise deliberative, multi-stakeholder approaches to produce collective knowledge, which increase the legitimacy of policy and help create buy-in for implementation. These approaches provide insightful ideas for rapid, effective transformations with long-term success.	Hold inclusive, participatory workshops with diverse stakeholders about specific current and future scenarios. Ensure policy can be implemented as necessary through multi-level government interaction and involvement. Advance gender and social inclusion to redistribute power dynamics and empower marginalised groups. Reconfigure funding mechanisms to improve policy processes and implementation.	Global public- and private-sector investors and SMEs	Essential stakeholders include governments, producers, businesses, civil society, international funders, and research organisations.
Action 4.2 Unlock billions in sustainable finance (Chapter 12).	Overcome barriers finance actors face in deploying sustainable finance to transform food systems under a changing climate.	Create attractive investment opportunities for mainstream investors. Build the capacity of financial intermediaries to accurately assess risk, lower transaction costs, and deploy risk-mitigating mechanisms. Utilise robust science-based metrics and standards to catalyse capital.	Global small-scale producers and small and medium-sized investees in low- and middle-income countries	Public- and private-sector investors and SMEs are the main stakeholders.
Action 4.3 Drive social change for more sustainable decisions (Chapter 13).	Promote organisational empowerment as a critical pathway to support sustainable transformation of food systems, mediated through different types of organisations.	Undertake the following actions to empower farmer and producer organisations: • Build capacity. • Support greater access to inputs and information. • Facilitate formation of agricultural enterprises. • Connect farmer and producer organisations to policy and markets.	Global	Farmers, women, youths, and communities are crucial stakeholders.

Table 2.1. (*cont.*)

Actions	Goal ('*what*')	Actions and transformations ('*how*')	Geographical focus ('*where*')	Stakeholders ('*who*')
		• Encourage youth membership and leadership. • Move beyond a focus on livelihoods, production, and poverty reduction in order to promote voice, agency, and influence on decision-making in households, communities, and nations. • Mobilise finance, support post-production activities and rural youth networks, and recognise the role of young women in food systems.		
Action 4.4 Transform innovation systems to deliver impacts at scale (Chapter 14).	Accelerate research, knowledge generation, and innovation to create large-scale impact, meet the Paris Agreement, and achieve the SDGs.	Transform innovation systems across three key dimensions: the design and management process, the culture and structures of organisations, and their engagement with the wider innovation ecosystem. Connect stakeholders across different dimensions, themes, and levels through the following actions: • Generate knowledge, tools, and methodologies that speak to each other. • Build structures for rapid testing, failure, and iteration. • Foster innovation capacities across all levels. These actions connect to the paradigm of 'Open Innovation 2.0' and both imply and require the upstream transformation of funding and incentive schemes.	Local to global networks and mesh-works	All actors along the food value chain are relevant, especially research and innovation institutions.

2.2.2 Action Area 2: De-risking Livelihoods, Farms, and Value Chains

Global food-system transformation will take place against the backdrop of a changing climate that is subjecting the entire food value chain to increasingly frequent and extreme weather events. These events depress productivity and cause widespread damage, sometimes inflicting catastrophic losses on individuals, families, and businesses. The uncertainty arising from future climate variables and current impacts can discourage farmers from investing in adaptive innovations, reducing their prospects for improving their livelihoods, including potential pathways out of poverty. In that context, measures to build resilience among food system actors would allow them to anticipate, respond to, and recover from climate-associated events. Two actions have been identified to de-risk livelihoods, farms, and value chains.

2.2.3 Action Area 3: Reducing Emissions through Diet and Value Chain Transformations

Global food systems are a leading contributor of GHGs, but two opportunities for reductions are waiting to be seized (Table 2.1). The first concerns dietary change; too many people currently consume foods that generate high levels of GHG emissions – either directly or indirectly – during production, processing, and distribution. The second concerns food loss and waste, with up to 40 percent of all food produced for people not being consumed by them; 8–10 percent of global anthropogenic GHG emissions are associated with these losses.

2.2.4 Action Area 4: Realigning Policies, Finance, and Support for Social Movements and Innovation to Build More Resilient, Sustainable Food Systems

The three action areas above include measures that can directly alter the trajectory of global food systems. These will depend on a conducive policy environment, adequate financing, innovative approaches that can replace 'business as usual', and support from both policymakers and broader society. Four actions have been identified to create an enabling environment, ensure the availability of financing, promote innovations, and mobilise support for transformative change (Table 2.1).

2.3 Eleven Key Actions for Transformation on the Ground

The four action areas encompass 11 transformative actions (Chapters 4–14). The 11 actions are developed extensively to understand the goal (the 'what'), the mechanisms to achieve it (the 'how'), the targeted geographic areas (the 'where'), and the key stakeholders (the 'who'). Table 2.1 summarises these points.

2.4 The Underlying Costs of Transformation

Considering the actions and targets, achieving the necessary transformation in food systems will require annual investments of about US$1.3 trillion through the decade (Table 2.2) (Steiner et al., 2020; Thornton et al., 2022). This figure is equivalent to less than 15 percent of the estimated US$9 trillion yearly monetary value of global food consumption or less than 7 percent of the hidden externalities generated by the current food system at US$19.8 trillion (Hendriks et al., 2021). Most of the US$1.3 trillion investment – US$1 trillion – would be for Rerouting, with the remainder for De-risking, Reducing, and Realigning aspects of food systems.

Between 2000 and 2018, the share of the global climate finance flow in the agriculture and land-use sector decreased from an average of 45 percent in the year 2000 to 24 percent in 2013, where it has since remained (Buto et al., 2021). In 2017–18, US$20 billion in climate finance flowed annually to the agriculture, forestry, and land-use sectors (CPI & IFAD, 2020; CPI, 2019). This amount is well below the US$1.3 trillion needed. It is not only the lack of sufficient investment in food-system transformation that should come as a wake-up call, however; the current dependence on the public sector as a source of financing is also of concern. Unlike other sectors that are less concessional and attract diverse types of finance flows, at present, more than 90 percent of tracked climate-finance contributions to agriculture and the land-use sector come from Development Assistance Committee (DAC) members and multilateral development banks, which contribute 67.5 percent and 23.8 percent respectively (Buto et al., 2021). Public sources alone are insufficient to meet the estimated costs, and private-sector investment will play a critical role in closing the gap; global wealth was estimated at US$431 trillion in assets in 2020 (Boston Consulting Group, 2021). A better understanding of how to build business cases to attract private investors, with risks and returns in line with comparable mainstream investment options, would be a pathway to mobilise and scale up finance, eventually lessening the heavy financial dependence on the public sector.

Geographically, the regions that are most vulnerable to climate change and urgently need food-system transformation are those without adequate assets under management. In our estimation, there is a massive need for annual investments worth US$165 billion in Sub-Saharan Africa. Leaving aside the investment needed for Action 1.1, this region has the greatest need in terms of investments for food-system transformation. These investments are needed because of the inadequate

Table 2.2. *The estimated annual cost of achieving food-system transformation from 2021 to 2030 (US$ billion). Source: Author's own calculations (see Thornton et al., 2022)*

	Action 1.1	Action 1.2	Action 1.3	Action 2.1	Action 2.2	Action 3.1	Action 3.2	Action 4.1	Action 4.2	Action 4.3	Action 4.4	Total by regions (exclude Action 1.1)
South Asia	0.40	27.46	52.52	1.55	1.44	0.00	0.23	13.38	13.21	4.89	5.26	119.93
Sub-Saharan Africa	96.45	62.20	50.41	3.43	0.49	2.67	2.81	34.96	3.37	3.01	1.90	165.26
Europe & Central Asia	177.02	6.43	0.57	0.00	0.02	7.81	4.80	31.47	0.00	2.35	1.52	54.97
Middle East & North Africa	0.27	3.16	3.73	0.20	0.09	0.10	1.06	1.38	1.33	1.19	0.72	12.96
Latin America & Caribbean	185.58	24.40	0.95	0.09	0.03	2.33	2.29	34.51	0.42	1.68	0.75	67.46
Southeast Asia & Pacific	151.60	57.52	8.00	0.36	0.35	2.53	0.81	35.39	1.33	1.77	1.49	109.54
East Asia	8.46	0.00	0.00	0.00	0.00	6.87	0.36	2.51	0.00	4.14	3.19	17.07
North America	133.37	0.00	0.00	0.00	0.00	12.67	0.25	23.41	0.00	0.96	0.45	37.73
Total by actions	753.15	181.16	116.18	5.63	2.42	35.00	12.62	176.99	19.67	20.00	15.27	**584.93**
Total by action areas	**753.15**	**297.34**		**8.05**		**47.62**		**231.92**				**1338.08**

rural infrastructure, large numbers of small-scale farmers, and slow progress towards alleviating poverty and achieving gender equity in this region. We need to reorient global finances to effectively connect North–South or South–South capital flows and assist developing countries. On the way to doing so, we must ensure that capital flows align with vulnerability levels and reach areas most in need. Constructing an architecture of global climate finance that includes diverse sectors and that collaboratively leverages financial resources to reach vulnerable areas will be a major challenge in realising food-system transformation.

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3

The Role of Research in Food-System Transformation

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Highlights

- Research is a fundamental catalyst for change in our food systems, playing a key role in diagnosing the problems, setting empirical targets and pathways, and developing and scaling solutions on the ground.
- Unlocking the transformative functions of research will require fundamental changes in the research agenda and the way knowledge is produced and disseminated.
- Research will need to be context-sensitive, inclusive, built on long-term strategic engagements, responsive and adaptive to emerging needs, and packaged in accessible formats.
- In some cases, participatory, action-oriented research will need to be combined with reductionist, technology-driven approaches to support the behaviour changes required for systems transformation.
- Additional efforts will be required to unlock and incentivise the transformative attributes of research, including relevant theories of change, strategic partnerships, nested scales approaches, and a creative leadership style.

3.1 Research as an Agent for Change

This book focuses on the actions needed to transform food systems (the 'what', Chapters 4–14), in addition to the researchers and research processes (the 'how', Chapters 15–18). Many would argue that researchers are not necessarily key actors when it comes to systems transformation. Research results can be slow to appear or hidden behind paywalls; researcher incentives are not aligned with societal needs – for example, they may focus on sourcing funding or on producing publications. Similarly, science can support the status quo rather than being disruptive (Kuhn, 1962). However, we would argue that research is a fundamental agent of change in our food systems. This is apparent in the intentions of research or the questions it addresses; its design and the methods it proposes; and how it is carried out, that is, the processes employed, such as nurturing partnerships, all of which can influence broader development processes and outcomes (Abson et al., 2016). A CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) funding partner once claimed that '. . . we need the discipline of thinking through how we think the world works and how you actually create change. Science has in many ways failed to create change so often – putting data in front of people does not create change.' It is not the act of science delivery that matters most; instead, its development, content, packaging, and the timeliness of its delivery to the reader, that helps determine whether science can fulfil its promise to move society in the right direction.

Most – if not all – actions intended to create an environment conducive for the transformation of our food systems (Chapter 2) are knowledge-intensive; there is a need for reliable, robust, readily available, and actionable evidence about *where*, *when*, and *how* actions will unlock the desired transformations. This presents several golden opportunities – and the responsibility – for science to act as a catalyst for change; to thoroughly diagnose the intertwined problems and drivers in the system; to set reliable, empirical transformation targets and pathways; to generate quick-win technological advances, and to play a key role in the development, testing, monitoring, evaluation, and scaling of on-the-ground solutions.

Chapter 3 is an introduction to the 'how' chapters. In the first section, we argue that research processes will need some fundamental changes to rise to the transformation challenge. In the following section, we demonstrate why we believe research can be a fundamental part of transformation, using CCAFS and other examples. In the third section, we distill key attributes of research to enable food-system transformation. The last section introduces each of the 'how' chapters.

3.2 Changing Research Approaches

We argue that unlocking the *transformative* functions of research will require fundamental changes in the research agenda and how knowledge is produced and disseminated, in order to narrow the gap between research and action. A prominent paradigmatic shift discussed in the agriculture research for development (AR4D) literature suggests moving away from reductionist, linear thinking models, which focus on studying food system elements in isolation, that is, production and consumption. Instead, systems thinking should be adopted, which allows understanding of interdependencies, feedback loops, and the dynamics of system elements, essentially taking a whole-system approach (den Boer, 2020). In terms of the knowledge co-design and diffusion process, this means – among others – integrating different knowledge systems, such as multiple disciplines, indigenous and local knowledge; methods, such as soft/qualitative and hard/quantitative research approaches; and stakeholders, including researchers, policymakers, civil society, the private sector, and farmers. Ultimately, this integrative approach can enrich the portfolio of transformative solutions and ensure more just food systems.

There are multiple signs that AR4D has evolved to incorporate systems thinking. Examples of this are the participatory agricultural research approaches developed in the 1980s, which aimed to replace traditional top-down technology transfer methods inherited from the Green Revolution (Chambers, 1994; Farrington & Martin, 1988). Early designs of participatory approaches – most often implemented in the form of on-farm trials or rural appraisals, based on farm surveys, group discussions, farming systems research, participatory mapping approaches, etc. – have allowed for more appropriate tools to understand local contexts and empower farmers. Through participatory agricultural research, farmers' role has shifted significantly, from mere consumers of research to active partners in the design, implementation, and evaluation of the research questions and solutions. Such approaches diversified their actors over the years, evolving to include community-based organisations, policymakers, investors, etc. Similarly, they have widened the scope of research into knowledge co-production, social learning, and capacity building. Some notable examples in this sense include farmer field schools, mobile-based crowdsourcing for seed selection, and participatory future scenarios for regions, countries, or communities (Kristjanson et al., 2014).

Likewise, integration of agriculture and climate change considerations through approaches such as agroecology, climate-smart agriculture, or climate-smart food systems, is another way research has evolved to include systems thinking. Using *hard* and *soft* research methods – from complex impact models and policy simulations to rapid appraisals, multi-criteria analyses – these approaches have facilitated a deeper understanding of linkages and feedback loops between climate, social, economic, policy, and institutional drivers of change. They have also drawn attention to a richer diversity of agriculture-related outcomes that go beyond yield and economic gains; these include aspects of resilience and adaptive capacity, human development, justice, equity, health, environmental sustainability, and mitigation, among others. Such approaches have been incorporated to varying extents into major global policy mechanisms, such as the Sustainable Development Goals and the Paris Agreement, as well as national policy agendas including climate adaptation plans, nationally determined contributions, etc., all of which reinforce the importance of integrated, systems thinking into policy and action.

To enable food-system transformation, the above approaches to research are critical but still insufficient. Rather than the exception, systems thinking needs to become standard in research design, implementation, and dissemination, to enable outcomes at scale. Research agendas and funding streams need to intentionally address the food system rather than parts of it, to unlock solutions that measure up to the magnitude of tomorrow's challenges (see the following chapters for a detailed overview of a transformative research agenda). Moreover, the intent and design of research need to reflect a more nuanced configuration, with a more diverse pallet of attributes and principles that can unlock the outcomes and impacts essential for system transformation.

3.3 Research Can Make a Difference

CCAFS (see Chapter 1) was a large programme, which, from the outset, was outcome-focused. Some of its achievements are summarised in Figure 3.1, and targets were exceeded for many indicators. Through engaging in policy processes and having an aggressive communication style that focused on actions, technologies, and institutional innovations, in collaboration with other players, CCAFS was able to inform US$3.5 billion of climate-action investments, and earn over 70 policy wins in ten years. On the ground, nearly 20 million farmers have benefited from innovations, based on research and the novel application of existing technology.

CCAFS was not the usual research project or programme, running long term 2009–21, and being well-funded to the figure of US$350 million. The programme could take risks; though several individual projects failed, its portfolio still exceeded expectations. While CCAFS was deeply rooted in its target countries, it had plenty of independence, with flexible team locations – the programme was largely virtual from 2009 – that allowed the hiring of top researchers. Opportunistic and adaptable, able to shift resources to new initiatives, CCAFS could practise outcome-based budgeting to mould the portfolio for optimal results.

CCAFS largely took a systems, participatory, action-orientated approach. We argue that this approach is vital to achieve transformation. However, reductionist high-tech approaches are also needed. This is best demonstrated in Chapter 9 where the exponential rise in plant-based meat innovations originated from considerable investments in more reductionist technological research. While CCAFS was undertaking participatory work with farmers, it was drawing on the technologies of more reductionist research from other research efforts, for example, development, release, and uptake of drought-adapted maize varieties, heat-adapted livestock breeds, alternate wetting and drying of rice paddies, etc. The systems-based approach also leveraged a legacy of policy and institutional innovations with proven potential to transform farmers' livelihoods, derived from the work of political scientists, social scientists, and gender experts, among others.

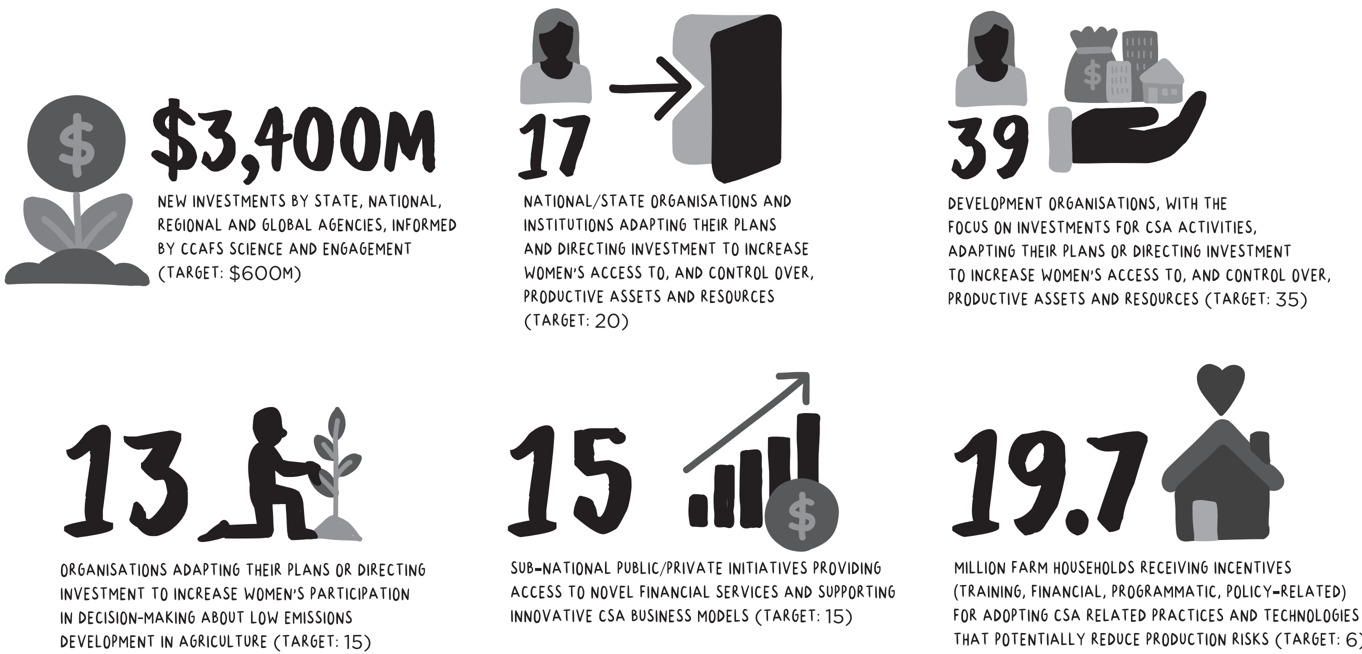

Figure 3.1 CCAFS's achievements during part of its second phase, 2017–20 (Nowak et al., 2021)

3.4 Distilling Key Attributes of Research to Enable Food-System Transformation

Transforming knowledge to action, to outcomes, and impacts has been the modus operandi at CCAFS, first established as a research theme and then mainstreamed in projects through a programmatic theory of change (Chapter 15). Over the years, research has proved its role as an active change catalyst, including through outcome-oriented and user-focused participatory engagement processes; transdisciplinary and social learning approaches to understand complex systems; innovative methods to communicate relevant, useful research; investments in capacity strengthening to empower users; and an army of partners across decision-making levels to bring results to scale (Dinesh et al., 2018; Kristijanson et al., 2014, 2009). Such factors have also been discussed widely in the literature, particularly regarding the science–policy interface (Ball & Exley, 2010; Bednarek et al., 2018; Dunn & Laing, 2017; Oliver & Cairney, 2019; Smith et al., 2021; Whitty & Wisby, 2016).

More than a decade of user-focused, actionable AR4D at CCAFS has distilled a set of desired properties and attributes of the research process that help unlock its role in food-system transformation and reinforce systems thinking. Learnings and reflections from selected literature, paired with our own successes and failures, have provided a more neutral overview of what AR4D should look like in the context of food-system transformation (Table 3.1). The list of features is not exhaustive, but illustrates the diversity of important aspects in delivering transformative actions, outcomes, and impacts while providing practical examples of their use in research design, implementation, and dissemination.

3.5 Unlocking Research's Potential

As much as they are crucial for the transformation process, the traits in Table 3.1 are not native to the way we do research. Additional efforts will be required to unlock and incentivise these attributes and put research itself on the transformational pathways. These enabling elements are discussed in detail in Chapters 15–18. Useful, time- and resource-smart theories of change, that provide critical guidance on the engagements, partnerships, and research required for the transformation are discussed in Chapter 15. Chapter 16 discusses strategic, multi-actor, multi-level partnerships – sometimes informal – that build trust, address intertwined challenges, and foster outcomes and impacts. Chapter 17 discusses nested scales approaches to facilitate learning, maximise benefits, and achieve impact, while Chapter 18 explores the outward-facing, inclusive, creative, independent, and accountable leadership style used to unlock research's potential

Table 3.1. *Select attributes of research to enable food-system transformation*

Criteria	Description	Select references
Context-sensitive	Research questions and methodological choices should be based on an in-depth analysis of the context and/or use past diagnostic studies to understand all relevant context-specific factors. These include environmental, social, cultural, governance, policy, and economic factors, etc.	Hebinck et al. (2018) Oliver & Cairney (2019)
Inclusive	A diversity of actors, voices, values, and perspectives should be engaged during research design; knowledge co-creation and dissemination are key to reducing/eliminating power imbalances. Moreover, internal inclusiveness should be fostered through a diverse research team composition, e.g., senior vs junior researchers and multi-disciplinary teams, to enhance the credibility and legitimacy of the process and results.	Kristjanson et al. (2009) Dinesh et al. (2021) Ball & Exley (2010) Pearce et al. (2014) Smith et al. (2021)
Built on long-term, strategic engagements	Repeated, long-term engagement with immediate users should occur to forge trust and gain a deeper understanding of the issues at stake. Being and becoming solidly part of influential networks before, during, and after the research project is key to developing significant research outcomes.	Oliver & Cairney (2019) Ball & Exley (2010)
Relevant, responsive, and adaptive	Research should make active efforts to respond to policymaker and relevant stakeholder needs, by engaging during agenda-setting and responding to intermittent opening of windows of opportunity, i.e., the moments when scientific evidence can have the most impact.	Dunn & Laing (2017) Smith et al. (2021)
Available, accessible, and effectively communicated	Research results should be open-access and communicated to the relevant stakeholders in appropriate formats using knowledge transfer mechanisms, e.g., brokers, boundary spanners, gatekeepers, etc. Research should also use additional mainstream strategies to inform public opinion and other stakeholders, e.g., traditional media and/or social media.	Cvitanovic et al. (2014) Cvitanovic et al. (2015) Bednarek et al. (2018) Smith et al. (2021) Oliver & Cairney (2019)

for food-system transformation. Despite the required reforms in its content, intent, and design, research alone will still not trigger the transformations needed in our food systems. Other agents of change – including individuals, policy, institutions, and partners (Chapter 1) – will be equally important in driving transformation.

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4

Ensuring Zero Agricultural Land Expansion into High-Carbon Ecosystems

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Highlights

- Relative to agricultural systems, high-carbon ecosystems – such as forests, peatlands, and mangroves – store large amounts of carbon per unit area.
- Agricultural expansion often comes at the expense of high-carbon ecosystems, contributing to climate change.
- Ensuring no further agricultural expansion occurs in high-carbon ecosystems is a substantial climate change mitigation opportunity.
- The estimated costs of managing forests for climate benefits range from US$2 to 393 billion per year, depending on growth scenarios and carbon prices; this is a bargain compared to the leverage these systems have on climate change and its social costs.
- Individuals, indigenous people, policies and institutions, and investments are all agents of change and will need to work together to avoid further land conversion.

4.1 Leveraging High-Carbon Ecosystems

Alignment of global emissions trajectories with the Paris Agreement's climate targets will largely be dictated by phasing down (and out) of fossil fuels in the energy and transport sectors. However, food systems also require transformation to stand a chance at remaining below the 1.5°C threshold (Clark et al., 2020) reinforced by the Glasgow Climate Pact. Food systems currently contribute roughly 35 percent of the total global emissions (Crippa et al., 2021), with over two-thirds of that amount relating to agriculture, including livestock. Farming and changes in land use have expanded agriculture's production area, with expansion typically coming at the expense of high-carbon landscapes such as forests and peatlands, which store disproportionate amounts of carbon per unit area. Losses of the carbon reserves contained in these high-carbon ecosystems are in many cases 'irrecoverable' (Box 4.1); as such, conserving high-carbon ecosystems has emerged as a critical action for stabilising the climate (Griscom et al., 2017).

Agriculture in general, and specifically globally traded agriculture, drives the conversion of high-carbon ecosystems. Between 2001 and 2015 alone, 85 and 75 million ha of total global forest loss was due to commodity production (27 percent) and shifting cultivation (24 percent) respectively (Curtis et al., 2018). Agriculture's threat to high-carbon landscapes is not only restricted to upland forests. In Southeast Asia, for instance, of all the mangroves lost, nearly 50 percent were lost due to aquaculture and rice expansion (Bryan-Brown et al., 2020). In Latin America, beef is a primary driver of land-use change and loss of high-carbon ecosystems (Zu Ermgassen et al., 2020). The footprints of global supply chains – including beef, soy, cocoa, coffee, and palm oil – stretch deep into high-carbon landscapes (Henders et al., 2015).

Under this background of agricultural expansion for global markets, conservation of high-carbon ecosystems for mitigation can be viewed through three measures: (1) avoiding emissions, for example, through zero-agricultural land expansion, (2) enhancing carbon sequestration and reducing emissions, such as by rewetting and restoring peatlands, and (3) promoting sustainable agriculture management practices over previously converted high-carbon landscapes. The only option to sustainably manage high-carbon landscapes is to avoid conversion, stop deforestation, and, in the case of peatlands, keep them in their natural state. Therefore, in this chapter, we focus on actions to protect high-carbon ecosystems. Steiner et al. (2020) recognise this essential ingredient to the transformation agenda and suggested the agricultural sector must prevent expansion into 250 million ha of tropical forests and 400 million ha of peatlands.

Box 4.1
Irrecoverable Carbon

Forests and wetlands, including mangroves and peatlands, have a typical carbon density far greater than their agricultural counterparts. For example, peatland carbon stocks can exceed 700 tonnes of carbon/ha^{-1} per metre depth of peat, an amount nearly three times that stored in the most carbon-dense tropical rainforest. By contrast, the carbon density of global croplands is an order of magnitude lower for even the most carbon-rich agricultural systems, for example, multi-strata agroforestry. If released, carbon in high-carbon ecosystems cannot be restored by 2050, the deadline for averting the climate crisis. Their sequestration abilities make protecting high-carbon ecosystems from conversion for agriculture a particularly salient near-term climate solution (Goldstein et al., 2020).

4.2 Mitigation Potential and Economic Costs

Protecting high-carbon ecosystems from agriculture offers significant mitigation potential. Globally, eliminating their conversion could reduce approximately 17 percent of global emissions, or 8.4 billion tonnes of carbon dioxide equivalents per year (Roe et al., 2021). Nearly half of the potential benefits are derived from just three countries – Brazil, Indonesia, and the Democratic Republic of Congo – which represent 41 percent of potential mitigation opportunities. There are 11 agriculture-driven deforestation fronts that will be key deforestation hotspots by 2030 (Pacheco et al., 2021). They extend over dry ecosystems in Latin America and Africa, for example, Cerrado, Chaco, and Eastern African Miombo, as well as forest ecosystems in Choco-Darien, the Amazon, the Atlantic Forests, the Congo Basin, New Guinea, the Greater Mekong, Borneo, Sumatra, and Eastern Australia.

The conservation of peatlands represents another key mitigation opportunity. Peatland protection and restoration has the potential to mitigate 1.74 billion tonnes of carbon dioxide equivalents per year by 2050, or approximately 10 percent of the potential mitigation related to high-carbon ecosystems (Roe et al., 2021). Seventy-five percent of this mitigation potential is, however, related to the restoration of peatlands, which could mitigate 1.31 billion tonnes of carbon dioxide equivalents per year (Roe et al., 2021). Based on data on the extent of tropical peatland (Gumbricht et al., 2017) and cropland distribution (ESA CCI, 2017), approximately 25 million ha of peat are being used for agriculture in the tropics, with 54 out of 79 tropical countries hosting at least 5,000 ha of agriculture over peatlands. Unlike the predicted fronts of deforestation, agriculture-peatland hotspots are spread throughout the tropics though concentrated in Asia (Figure 4.1). Eighty-three percent of the total area is in just nine countries. Peat in other continents is still remote and under less pressure from population growth; for example, while Latin America hosts the largest fragmented areas of peat in the tropics (Gumbricht et al., 2017), the region only contributed 7 percent to the total area of agriculture-peatlands, though there are other threats to those peatlands. Similarly, Africa's top 10 countries only accounted for 5 percent of the total agriculture-peatland area.

Current agriculture over lowland peatlands globally is 23.9 million ha. The potential expansion area, assuming that in the baseline year of 2015 there was a 2.5 km buffer of agriculture-lowland peat areas, is equal to 45.5 million ha. This would represent a substantial increase in the total area, given not all the surrounding peatlands can host agriculture; some areas are protected, in complex terrain, or are too far from markets. However, a smaller, more targeted effort may be a more realistic short-term goal. Sixty-two percent of this avoidable expansion remains in Asia, 19 percent in Latin America, and 12 percent in Africa. The analysis is based

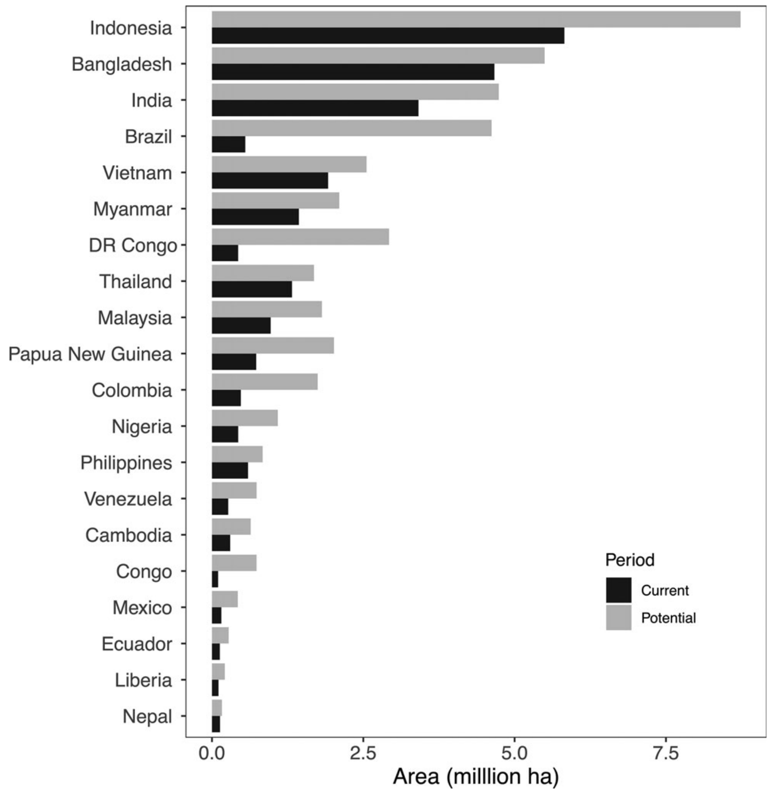

Figure 4.1 Top 20 countries with agricultural activities currently on peatlands and potential expansion into peatlands

on the tropical wetland and peatland map by the Center for International Forestry Research (CIFOR) (Gumbricht et al., 2017) and the distribution of croplands as per the European Space Agency's CCI-2015 land cover map.

Whereas the carbon benefits of ensuring zero agricultural expansion in high-carbon ecosystems are increasingly clear, the costs of doing so are much more uncertain. Several studies estimate the costs of reducing deforestation, with the results dependent on the location, growth scenarios, and carbon prices. A recent estimate suggests that managing global forest for carbon benefits – including deforestation, reforestation, and management – would cost between US$2 billion and US$393 billion per year (Austin et al., 2020). The cost of avoiding global peatland conversion is not available, with most economic research on peatlands focused on restoration and in countries in temperate latitudes, with Indonesia being the exception. Regardless, even higher-end estimates for avoiding deforestation can be viewed as a bargain. The conversion of high-carbon ecosystems has significant leverage on the global carbon budget and the costs of protection represent a relatively small percentage of the global economy or US$98 trillion in 2021. Furthermore, arresting agricultural expansion would have countless co-benefits, ranging from maintaining hydrology and biodiversity to reducing risks of zoonotic disease spillover, all of which have economic benefits.

4.3 Enabling Transformation

Several opportunities exist to transform food systems in ways that conserve high-carbon ecosystems. Suggested measures include actions that affect individuals and their behaviour, policies and institutions, investments and finance, and research. Rather than these factors working in isolation, change will be brought about by a mix of economic incentives, governance, capacity building, and the intensification of production, with the importance of any individual factor dependent on the local context. Here we discuss each of these actions through the *agents of change* lens presented in Chapter 1.

Individuals and Behaviour Change: High-carbon land conversion is a result of millions, if not billions, of individuals' decisions throughout food systems. Individuals send market signals on acceptable economic and environmental costs, and, by extension, the production practices for agricultural commodities. This includes whether growing crops on land that previously supported high-carbon ecosystems is considered acceptable. It stands that consumer choice can be a powerful mechanism for transformation. However, in practice, consumer choice towards deforestation-free consumption or other efforts to limit commodity impact have had minimal effects on the overall land-use trends. Certified shade-grown coffee, for example, is often lauded as a promising case study but the relative amount of area dedicated to shade- versus sun-grown coffee is decreasing. The market share of sustainable commodity production is simply too small to affect rapid change in producer behaviour.

Individual producers also have an important role in transformation regarding the conversion of high-carbon ecosystems. Throughout the tropics, indigenous people manage high-carbon ecosystems. Evidence suggests that, across the tropics, deforestation rates are lower in indigenous lands than non-protected areas, while in Africa, deforestation rates are also lower than in protected areas (Sze et al., 2021). These results suggest that creating programmes that support indigenous individuals and local communities' stewardship of high-carbon ecosystems will be an important transformational action.

Policies and Institutions: Transformative actions on land use for climate mitigation goals are multi-scale. These include the Nationally Determined Contribution (NDCs), which are international mitigation and adaptation commitments under the United Nations Framework Convention on Climate Change

(UNFCCC) that lay out the blueprints for national climate action. These plans will increasingly dictate activities as governments and investors align funding with these commitments. Unfortunately, analysis of the first NDCs indicates that only an estimated 30 percent of the countries that are home to significant tropical forest cover include forest protection and/or restoration, often without explicit targets (NYDF Assessment Partners, 2019). NDCs, however, are non-binding commitments, and as such have produced limited results for high-carbon ecosystems (Box 4.2). The inclusion of high-carbon ecosystems in NDCs is, therefore, a necessary action but is insufficient to drive change alone.

Alignment of policies across climate, conservation, and development is needed to balance competing interests and create the right incentives for conservation and land use. For example, in many countries, agriculture and forestry industries receive government subsidies such as tax exemptions or capital financing. These

Box 4.2

Lofty Promises and Empty Targets: The Case of the New York Declaration on Forests

The New York Declaration on Forests (NYDF) emerged from the sidelines of the 2014 United Nations Secretary General's Climate Summit. More than 200 governments, companies, civil society, and indigenous organisations signed up to voluntary, non-binding promises to halve tropical deforestation by 2020 and stop it entirely by 2030. That first promise has not been met. Between 2014 and 2020, tropical forest loss increased and was only encumbered by the global financial crisis brought about by the COVID-19 pandemic in 2020. The lack of action has been in part linked to a lack of finance; it was estimated that in 2019 only 5 percent of the funds necessary to tackle forest and climate issues had been mobilised, just US$175 million instead of US$24.5 billion. An assessment of 32 countries with the greatest forest mitigation potential found that only 10 had set forest protection targets in their first NDC (NYDF Assessment Partners, 2019). Forest protection is not occurring anywhere near the scale necessary. The progress, or lack thereof, highlights that agenda-setting commitments, while necessary, are often not sufficient to influence land-use decisions. Incentivising systems need to be put in place to change actions on the ground. At the 26th United Nations Climate Change Conference (COP26) in Glasgow, a new Declaration on Forests and Land Use was made, again to end deforestation and land degradation by 2030. People and institutions that take on this challenge would do well to consider the fate of previous commitments such as the NYDF and explore ways to solve the problems that stymied their progress, to build on previous efforts. Time will tell if the lessons learned from the NYDF will aid in deforestation targets being met.

policies can promote expansion into sensitive ecosystems. Where subsidies support intensifying agricultural production, they may help relieve the pressure for expansion into new lands, essentially ‘land sparing’. The effectiveness of intensification and land sparing for forests and other high-carbon landscapes for conservation is uncertain. Getting the incentives right and realignment of subsidies will be fundamental to shifting land use away from vulnerable ecosystems.

Governments have additional levers, besides subsidies, at their disposal. These include designating high-carbon areas as protected areas and restricting certain land-use activities that degrade through draining or burning. Protected-area designation only works when supported by sufficient monitoring and legal mechanisms for enforcement. The creation of protected areas may also increase the vulnerability of the small-scale producers and indigenous people that use high-carbon ecosystems by restricting access to productivity resources. As such, there is the need to account for equity in solution design and development.

Finance: Finance is one of the most significant constraints to conserving high-carbon ecosystems. The lack of finance limits everything from developing programming for alternative livelihoods and developing accurate accounting data, to limiting monitoring and enforcement abilities. New sources of funding must be made available for countries to appropriately manage these resources. Cooperation between governments, the private sector, and development organisations can help develop many of the structures necessary to stimulate new finance. This could include using benefits from cap-and-trade programmes or fuel taxes to support payments for ecosystem services, as occurs in Costa Rica (Table 4.1). Public institutions, such as the Green Climate Fund, and the private sector must consider the impacts of actions and funding on carbon reserves in their investment decisions and development plans. Protection may be best integrated as an explicit goal in investments and private-sector actions. Like recent changes with fossil fuels, government and pension funds should divest from companies that fail to act to protect high-carbon landscapes.

Research and Innovation: Scientific institutions will need to support government, private sector, and individual actions, to ensure zero-expansion of agriculture into high-carbon ecosystems. This will include addressing fundamental questions such as cost-effective approaches to monitoring forest loss or carbon budgets, which have previously received significant attention. Less well-studied questions, for example, those on the effectiveness of various incentives and instruments for conservation or the impacts on indigenous rights will also need scientifically addressing. The answers to these and other questions can help decision-makers pivot towards expansion-free agriculture and make best-fit investments. Research institutions such as CGIAR – formerly the Consultative Group for International Agricultural Research – and universities have a vital role

Table 4.1. *A selection of financial mechanisms to support sustainable management of high-carbon ecosystems*

Financial mechanism	Description	Peatland example	Forest example
Voluntary carbon markets	Markets for buying and selling emission reduction credits, or offsets.	Netherlands 'De Lytse Deelen'	Kasigau Corridor, Kenya
REDD+	Incentive framework for protecting, managing, and restoring forests in developing countries.	Indonesia's REDD+ National Strategy	Central African Forest Initiative
Debt-for-nature swaps	Transaction where a developing country's debt is cancelled or reduced in exchange for investment in conservation.	Seychelles coastal wetland and mangrove restoration	US Tropical Conservation Forest Act
Green bonds	Financial instrument created to raise money to support environmental projects.	Green 'Sukuk' Indonesia	Conservation funds Green Bond
Voluntary certification programmes	Programmes used to incentivise producers to use socially and/or envioronmentally sound production practice.	UK Peatland Code	Forest Stewardship Council

given their work on methodological innovations and deep multidisciplinary investigations. Over the past decade, however, this topic has received little attention from the CGIAR research community due to competing priorities and the siloing of research. Future climate-change research would be well placed to specifically emphasise the expansion of agriculture and conversion of high-carbon ecosystems in its agenda.

4.4 Way Forward

Ensuring zero agricultural expansion into high-carbon landscapes is a building block for transforming our food systems and meeting climate goals. The risk of inaction is clearer than ever before, yet conversion continues at alarming rates. The ways food systems touch this issue mean that every individual and most food system-linked institutions can be agents of change. To ensure no agricultural expansion into 250 million ha of forest and 400 million ha of peatlands will require a potent, fast-acting blend of policies, incentives, and behaviour change.

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5

Enabling Markets and Public-Sector Actions for Catalysing Transformation for Small-Scale Agricultural Producers under Climate Change

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Highlights

- Well-designed markets and public-sector actions can incentivise the adoption of climate-resilient agriculture and improve livelihood opportunities for farmers.
- Several novel initiatives to incentivise the adoption of sustainable practices have demonstrated potential to contribute to food system transformation.
- Private-sector co-investments with small-and-medium enterprises (SMEs) and farmer cooperatives aim to accelerate financial inclusion and scale climate-resilient agriculture.
- National policy should promote the adoption of low-emissions practices, such as alternate wetting and drying (AWD) innovations in rice systems.

5.1 Introduction

There is now widespread consensus to support transformative change processes in food and agricultural systems, to mitigate and adapt to climate-induced shocks and ensure equitable livelihood outcomes, particularly for small-scale agricultural producers (Steiner et al., 2020). Well-designed markets and public-sector actions can incentivise the adoption of climate-resilient practices and radically improve livelihood opportunities for farmers. Although numerous nascent initiatives have been deployed to incentivise adoption, far fewer have demonstrated the potential to catalyse transformation in the small-scale sector, to build resilience as well as place farming systems on low-emission trajectories, where possible.

This chapter outlines market-based and public-sector actions that have been implemented to drive adoption of climate-resilient practices by small-scale producers on a large scale and which demonstrate potential to contribute to food system transformation. Among these are public-sector market-based actions that unite farmers with small and fragmented landholdings in agricultural commercialisation clusters. In recent years, various countries have established agri-based clusters among small-scale producers, to create diversified markets that enhance household incomes. The emphasis on investing greater resources towards market-orientated opportunities for such farmers is partly in response to rapidly growing cities and urban food markets, particularly in Africa, which offer opportunities for stimulating local and regional markets (AGRA, 2020).

Other novel efforts comprise private-sector co-investments with small-and-medium enterprises (SMEs), or SME agribusinesses and farmer cooperatives to accelerate financial inclusion and the scaling of climate-resilient agriculture. A few leading financial institutions such as Rabobank have supported initiatives that leverage co-investments into small-scale agriculture while fostering inclusive business cases that build farmers' capacities and incentivise the adoption of climate-resilient practices. Finally, several developing countries, particularly in Southeast Asia, have taken public-sector actions to incentivise low-emission practices, such as alternate wetting and drying (AWD) innovations in rice systems (Enriquez et al., 2021; Tran et al., 2018). Such efforts are implemented as part of countries' Nationally Determined Contributions (NDCs) and policy goals to limit global warming to within 1.5–2°C. Public-sector support towards mitigation activities linked with adaptation co-benefits, for example, improvements in productivity and livelihood security, will be crucial given that reducing greenhouse gases (GHGs) is not usually a goal for small-scale producers.

5.2 Public-Sector Market-Based Actions

Small-scale producer participation in local and regional markets is often limited and impacted by volatile prices, high transaction costs, and unpredictable and unstable policy interventions. These risk factors associated with market engagement also tend to discourage small-scale producers from adopting well-known climate-resilient practices, particularly if they do not see immediate livelihood benefits. At the same time, supportive agricultural policies can also be a powerful tool to achieve market integration and food system transformation when they provide incentives and allocate resources to increase production, productivity, and value addition, while addressing the need for functioning markets and institutions (ASARECA, 2021). In the coming decade, one of the key challenges will be to bring about 200 million farmers into appropriate markets that can enhance rural incomes and incentivise the adoption of climate-resilient practices (Steiner et al., 2020). Various countries in Asia, Latin America, and Africa have implemented geographically focused commodity value-chain clusters to facilitate small-scale farmers' access to appropriate technologies, agronomic services, and markets, to drive agricultural transformation and rural industrialisation (Gálvez-Nogales, 2010).

One such initiative in Ethiopia, the Agricultural Commercialisation Clusters (ACC) initiative, targets nearly 5 million smallholder farmers in 24 geographic clusters, across 300 *woredas*, or districts, located within four major agricultural regions: Oromia, Amhara, Tigray, and the Southern Nations, Nationalities, and People's Region (SNNP) (Box 5.1). ACC take a value-chain approach to support activities in five priority areas, namely input supply and distribution; commodity production; aggregation, storage and transport; processing and value addition; and

Box 5.1

Agricultural Commercialisation Clusters in Ethiopia

In 2010, the government of Ethiopia established the Agricultural Transformation Agency (ATA) and its flagship programme, the Agricultural Commercialisation Clusters (ACC) initiative, as part of the national growth and transformation agenda. Specifically, the ATA supports the Ministry of Agriculture and partners in the agriculture sector to deliver multiple interventions and address systemic bottlenecks to achieve growth and food security. The ACC initiative targets 10 priority crop commodities – wheat, teff, maize, sesame, malt barley – and horticulture crops – tomato, onion, banana, mango, and avocado – in Ethiopia's four major agricultural regions. The programme brings together smallholders with fragmented landholdings to achieve economies of scale by sharing costs related to agronomic training, certification, and technology application, as well as to collectively market produce.

Recent studies on ACC's performance and livelihood impact show increases in productivity as well as economic growth. Simulations from a representative sample of farmers in the initiative indicate average productivity increases across all considered ACC scenarios for wheat, teff, maize, and barley, with productivity improved by 29.6 percent, 21.1 percent, 12.8 percent, and 12.6 percent, respectively (Louhichi et al., 2019). ACC also contributed to improvements in farm incomes, with gross income increasing by roughly 14 percent, as well as a reduction in the extreme poverty gap, at around 2.1 percent throughout the country (Louhichi et al., 2019).

Through its innovative and timely market integration, the ACC initiative is helping a country of more than 110 million people catalyse and endorse a transformational food system. Lessons from the ACC informed African Union efforts when launching a revolutionary new tool in 2018, the Africa Agriculture Transformation Scorecard (AATS), which aims to drive agricultural productivity and development. Such a tool shows the collective interest and importance given to government-led programmes that either incentivise or provide financial resource access to smallholder farmers.

marketing and export. ACC have benefited smallholder farmers in multifaceted ways, for example, better and timely distribution of improved seed, fertiliser, and agri-chemicals; easier access to input financing, for example, through input voucher sales systems; training and large-scale demonstrations; and contract farming agreements (Louhichi et al., 2019).

5.3 Private-Sector Co-Investments

In many developing countries, SME agribusinesses and farmer cooperatives serve as the primary linkage for small-scale producers to engage in markets and, increasingly, to use new technological innovations (Groot et al., 2019), while adding value to produce through cleaning, processing, and packaging. In Sub-Saharan Africa, for instance, SMEs make up about 80 percent of the private sector operating in the agricultural wholesale, logistics, and processing value chains (AGRA, 2019). However, SMEs face major obstacles in accessing financial services and growing their business. Financial institutions are often wary of serving them due to various risks associated with operating in smallholder agricultural value chains, such as numerous small-volume transactions, lack of traditional collateral, and geographic isolation.

Rabobank is among a few leading commercial financial institutions that have long recognised the potential and entrepreneurship of SME agribusinesses and farmer cooperatives in developing countries. It has supported micro-finance projects in Africa, Latin America, and Asia for nearly two decades. Today, Rabobank's foundation invests over 35 million Euros annually in financial services for SMEs and farmer cooperatives, which serve an estimated 3.3 million small-scale farmers in developing countries (Rabobank, 2019). Among the financial services offered are loans and entrepreneurial training to increase production efficiency and technology adoption, achieve economies of scale, and improve their bargaining power in value chains. With years of experience assisting SMEs and farmer cooperatives to develop viable business cases, Rabobank now works with a broad range of partners to facilitate private-sector co-investments in smallholder agriculture, catalyse even greater financial inclusion, and sustainably increase food production. Some of these efforts have the potential to aid food system transformation; this is particularly relevant in initiatives that leverage co-investments into smallholder agriculture from SMEs, farmer cooperatives, and other impact investors while fostering inclusive business cases that build farmers' capacities and incentivise the adoption of climate-resilient practices.

In East Africa, Rabobank is working with a consortium of partners as part of the Climate Resilient Agribusiness for Tomorrow (CRAFT) project, which in three years alone leveraged 12.2 million Euros in co-investments for 50 SMEs and farmer cooperatives (Box 5.2).[1] These actors have a targeted outreach of

Box 5.2
Empowering SMEs and Farmer Cooperatives in the CRAFT Project, East Africa

Running between 2018 and 2023, the CRAFT project supports inclusive agribusiness SMEs and farmer cooperatives to increase climate-resilient farming systems, through sustainable intensification along selected oilseed, pulse, and potato value chains in Kenya, Uganda, and Tanzania. The project implements the following activities to achieve its objectives (SNV et al., 2017):

1. Climate risk analysis of targeted value chains and identification of business opportunities that address climate change in agriculture.
2. Business case development and co-investment through the climate innovation and investment facility with the private sector, SMEs, and farmer cooperatives.
3. Levering investments by facilitating access to finance in collaboration with financial institutions.
4. Influencing policies to foster the large-scale roll-out of climate-smart agriculture in East Africa.

In less than three years, the project has awarded co-investment grants to 50 SMEs and farmer cooperatives to scale up the adoption of CSA-related innovations, not merely through the distribution of agri-inputs but via stimulating multiple support functions to build farmers' capacities and incentives for CSA uptake. Support functions include access to reliable markets through contractual agreements, CSA agronomic extension, and the related bundled service.

The CRAFT project aims to reach 300 000 smallholder farmers in the three countries by lending support to a total of 60 agribusiness SMEs and farmer cooperatives over a three-to-four-year period. Indeed, all CRAFT-supported SMEs and farmer cooperatives have committed to increasing the number of farmers they work with, usually from a baseline of 500 or 1,000 producers to over 3,000 over three years. Responding to these much greater numbers of clients and moving from pilot to scale required SME companies to enhance their in-house capabilities to meet various demands. As such, CRAFT-supported SMEs and farmer cooperatives have also outlined plans to expand or adjust their operations, such as by hiring more field staff or village agents who can provide sales and services on behalf of companies or by acquiring additional equipment and machinery to increase processing. Emerging evidence from the project shows that SMEs and farmer cooperatives are expanding financial inclusion for their farmer-beneficiaries through strong, integrated market relations, which are also an important entry point for scaling CSA practices.

251 809 smallholder farmers, using inclusive business approaches that provide information and skills training in climate-smart agriculture (CSA) practices, together with access to climate information services, credit, and to reliable markets

through contractual agreements. The theory of change underpinning inclusive business models in CRAFT is that market players can combine profitability targets with societal and environmental sustainability impacts to help build climate-resilient food systems that increase income and food security (SNV et al., 2017). Although still in its early stage, the CRAFT initiative demonstrates the power of so-called un-bankable small- and medium-market players to contribute to food system transformation in local and regional contexts. Where more broadly supported, these players can then accelerate greater financial inclusion for smallholder farmers and help catalyse sustainable agricultural development and lasting food security.

5.4 National Policy Adoption of Low-Emissions Practices

While some climate-resilient practices, particularly those with immediate productivity and income co-benefits, tend to be well suited for deployment through private-sector channels, others may require greater public-sector support and incentives for large-scale adoption among small-scale producers. This is particularly true for agricultural practices with mitigation benefits, where rewards for immediate livelihood security may not be great. As such, the most promising mitigation options in agriculture tend to be those facilitated through enabling policy incentives and with co-benefits or outcomes, including improved yields, incomes, and livelihood security, while lowering demand for inputs and labour (UNEP, 2015).

Mitigation efforts in agriculture are crucial given that the sector is a major driver of climate change, contributing to 21–37 percent of total anthropogenic GHG emissions (IPCC, 2019). Indeed, the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) obliges member states to limit global warming within 1.5–2°C above pre-industrial levels. Through NDCs and related policy goals, each country must develop and implement GHG mitigation options from different sectors, including agriculture. Many developing countries, however, face challenges in implementing large-scale agricultural mitigation options considering potential trade-offs against food security objectives or farmers' livelihoods (Tran et al., 2018; UNEP, 2015). Several rice-growing nations in Southeast Asia have adopted alternate wetting and drying (AWD) techniques in their rice production systems as a key climate mitigation action in line with NDCs (Enriquez et al., 2021).[2] Among them are Vietnam, Bangladesh, Philippines, and Thailand.

Alternate wetting and drying is a water-saving irrigation technique in rice production, which involves periodic drying of paddy fields during the growth period. This technology is estimated to reduce GHG emissions by up to 40 percent (Ishfaq et al., 2020), while helping farmers adapt to water scarcity conditions, such as drought (Enriquez et al., 2021). Alternate wetting and drying is also shown to increase overall production efficiency, through lower irrigation costs, and if implemented correctly can raise yields while improving grain quality (Lampayan et al., 2015). It was developed by the International Rice Research Institute (IRRI) and its partners in the early 2000s and is primarily promoted in Asia. However, after nearly two decades of successfully applying AWD, wide-scale adoption of the technology remains limited in most of these countries. In the Philippines, for instance, AWD adoption in 2016 was estimated at 60 559 farmers, covering 84 784 ha of land, which represented less than 5 percent of the total irrigated area of 1.86 million ha (Rejesus et al., 2017). Farmers were apprehensive of the technology, as reducing water and seeing dry soil phases starkly contrasts their traditional practice of continuous flooding (Enriquez et al., 2021). An exception has been Vietnam where AWD has spread more extensively (Box 5.3), mainly

Box 5.3

AWD as a Policy Priority in Vietnam

Vietnam is the world's fifth-largest producer of rice, growing multiple rice crops annually on 7.7 million ha of planted area, of which more than 90 percent, or 7 million ha, is irrigated; this includes irrigation through continuously flooding, recognised as a major source of GHG emissions (IRRI, 2020). The Mekong River Delta (MRD) accounts for more than half of Vietnam's rice production. IRRI initiated AWD in the Delta in 2003 and provincial MRD governments quickly incorporated the technology into their agrarian policies and extension programmes (Yamaguchi et al., 2016). By 2009, AWD was officially adopted as the primary water-saving technology, which the Department of Agriculture and Rural Development helped disseminate through training workshops and field exhibitions, as well as by provision of water channels for irrigation and drainage (Yamaguchi et al., 2016). Farmers in this region saw increases in rice productivity due to AWD and adoption of the technology also expanded. By the 2014–15 production season, over 120 000 farming households had implemented AWD on roughly 120 000 ha, accounting for 52 percent of the total paddy area (Yamaguchi et al., 2016).

The Vietnamese government was also early to recognise the benefits of large-scale AWD implementation, including reductions in water use and methane, as well as increased nitrogen-use efficiency. Alongside other water-saving techniques, since 2011, Vietnam's Ministry of Agriculture and Rural Development has also prioritised AWD as a key option for agricultural GHG reduction, a measure that has been reinforced under its NDC (IRRI, 2020). The government aimed for 3.2 million ha of rice cultivation areas to utilise AWD by 2020 and an additional 1.5 million ha by 2030 (CCAFS, 2014; IRRI, 2020). In recent years, various countries in Southeast Asia have also put in place national policies to scale-out AWD, considering it a key adaptation and mitigation measure for meeting their NDCs (Enriquez et al., 2021). The technology is now being mainstreamed in extension efforts by public institutions, as well as by multiple other stakeholders such as NGOs and research organisations.

because government policies identified it as a primary water-saving technology since the early-to-mid 2000s and provided the necessary incentives and support for its uptake (Yamaguchi et al., 2019).

5.5 Way Forward

We have shown that well-designed markets and public-sector actions can help small-scale producers improve their farm productivity and livelihoods while mainstreaming climate-resilience practices, both at the farm level and in the broader agriculture sector. In this respect, both public-sector and private-driven initiatives are critical to facilitating markets that benefit small-scale farmers in ways that mitigate the risks associated with price fluctuation, intermediary and transaction costs, and unpredictable government regulations. For instance, working together with partners, the Ethiopian government has implemented geographically focused commodity value chain clusters, ACC, to expand access to improved inputs and credit, extension services, and markets. Rabobank is working with a consortium of partners in several other countries in the region to facilitate private-sector co-investments in smallholder agriculture, with SME agribusinesses and farmer cooperatives, to accelerate financial inclusion and the scaling of climate-resilient agriculture.

Considering not all climate-resilient practices carry immediate productivity or other co-benefits – particularly mitigation interventions – public support and incentives will be crucial in facilitating large-scale adoption among small-scale farmers. Various rice-growing nations in Southeast Asia, namely Vietnam, Bangladesh, Philippines, and Thailand, have identified AWD as a key climate action in their NDCs and other policy provisions, and have set targets to scale-out the technology to more farmers. Overall, the most promising climate mitigation options likely to drive food system transformation tend to be facilitated through enabling policy incentives, while having adaptation co-benefits or outcomes, including improved yields, incomes, and livelihood security while lowering demand for inputs and labour (UNEP, 2015).

Notes

1 CRAFT is being implemented by a consortium of five partners: SNV, Wageningen University (WU) and Wageningen Environmental Research (WEnR), the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Agriterra, and Rabo Bank.

2 Rice cultivation, particularly flooding of irrigated rice fields, is a major source of methane emissions, accounting for 10–14 percent of total global anthropogenic methane emissions (Tivet & Boulakia, 2017).

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6

Supporting Prosperity through Better Mobility and Rural Reinvigoration

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Highlights

- Rerouting farming and rural livelihoods to new trajectories is urgently needed in the context of increasing youth unemployment and failing food systems.
- While agriculture must be made more attractive by promoting 'stepping up', alternative livelihoods based on allied economic sectors must be considered for 'stepping out'. This option includes exits from agriculture.
- Actions can be taken to bring about improved access to adequate financial services and skills, greater automation and better tools for more efficient development of agricultural activities, investments in training and re-skilling of the workforce for rural dwellers to engage in agribusinesses, and safety-net programmes to prevent 'falling down' and 'dropping out'.
- These actions must be inclusive of both women left behind in farming, and next-generation youths who are increasingly disenfranchised in rural areas and prone to migration.

6.1 Introduction

Poverty is particularly rural in the developing world, with two-thirds of those affected being youths. There is a sense of 'doom and gloom' around agriculture-centred livelihoods, and business-as-usual agriculture may not be an option in the future (Steiner et al., 2020; Stringer et al., 2020). According to IFAD (2019), agriculture-linked sectors alleviate the most poverty in rural areas, with youths and women central to rural development and food system transformation. Two-thirds of youths in developing economies live in areas with agricultural potential, which represents a considerable source of employment for jobless youths. Yet trends indicate that many young people are migrating in search of better economic opportunities. The structural weakness and limited diversification of these

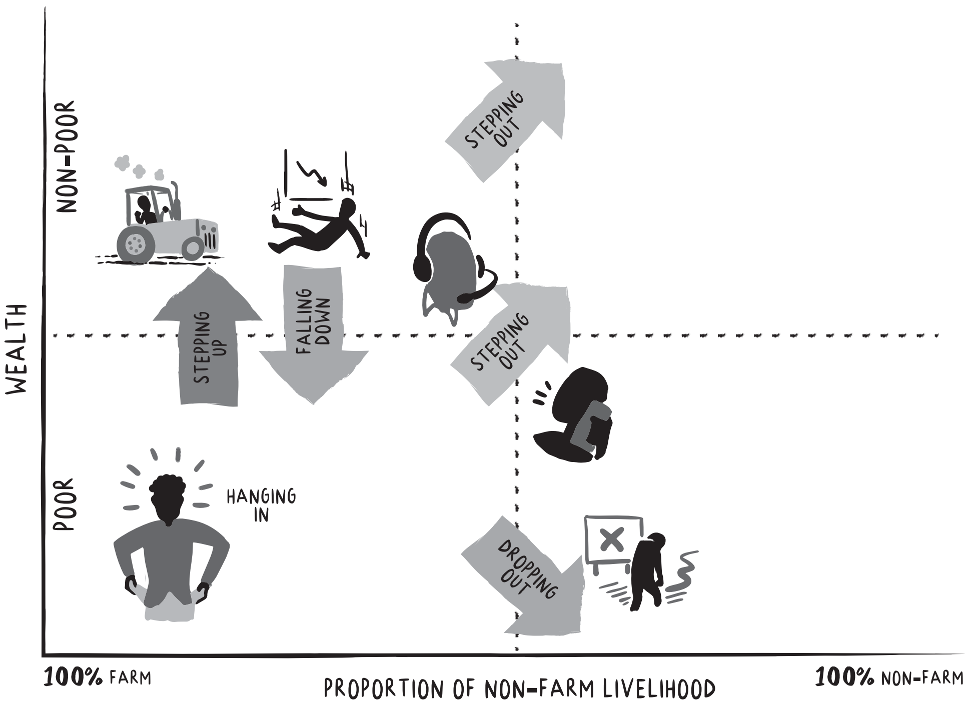

Figure 6.1 Potential livelihood pathways for smallholder farmers, after Hansen et al. (2018)

economies limit job creation and the absorption of the growing number of young entrants into the labour market. Indeed, marginalised farmers, youths, and women alike all face major challenges including inadequate access to information, education, and financial services; constrained access to markets; and suboptimal involvement in policy processes. A reinvigorated rural economy can spur agriculture to shift from being a direct, often subsistence, employer to a driver of rural development and growth (Steiner et al., 2020). The challenge is to create attractive rural livelihoods, in or out of agriculture, and to build skill levels and opportunities to ensure that large numbers of people in rural areas move out of poverty.

While agriculture is the sole livelihood activity of some farmers, others maintain highly diversified livelihoods, including beyond the agricultural sector, particularly where returns from agriculture are insufficient to survive (Dhanush et al., 2018). Hansen et al. (2018) proposed a typology for targeting resilience-building rural development interventions in the context of risk and poverty traps (Figure 6.1). The term 'stepping up' describes the situation of escaping poverty through changes to current farming activities, while 'stepping out' describes the process of escaping poverty by increasing incomes and assets through off-farm income opportunities or an exit from agriculture. 'Hanging in' describes the situation for farmers who are trapped in poverty, who seek to preserve their current meagre levels of welfare and assets in the face of stresses and shocks. Farmers who are 'stepping up' may 'fall down' into worsening poverty, and farmers who are 'hanging in' may 'drop out' of farming into a deeper, more intractable state of destitution. Therefore, the goal is rerouting farming and rural livelihoods to new trajectories that enable farmers to 'step up' or 'step out'.

This chapter will discuss alternative livelihoods within agriculture through value addition and diversification into allied economic sectors. It will demonstrate how to build attractive rural livelihoods, including exits from agriculture where necessary. Steiner et al. (2020) suggest that to foster transformation, we need to create 20 million rural jobs by 2030 by investing in infrastructure and youths. Below, we build on four mechanisms to transform food systems under climate change as defined by Steiner et al. (2020), namely investing in secondary and tertiary industries in rural areas, that is, in opportunities for 'stepping out'; revolutionising agricultural production systems towards greater automation, as part of 'stepping up'; empowering the youth; and establishing safety-net policies and programmes (Figure 6.2).

6.2 Investing in Secondary and Tertiary Industries in Rural Areas

Currently, limited employment opportunities exist outside of agriculture in many remote rural areas. This situation can change, however, if in order to diversify rural economies beyond their reliance on agriculture, policymakers at national and local levels co-develop shared visions of the future (Chapter 14) and identify the policies required to develop appropriate secondary and tertiary industries (Steiner et al., 2020). Effective secondary and tertiary services in rural areas will enable job creation and employment opportunities beyond agriculture, improve livelihoods and food security, generate inclusive growth, reduce poverty, and help build stronger, more stable rural economies.

An example of actions to build rural enterprises comes from the Nyando Basin, western Kenya, where environmental degradation and climate-change-induced threats are acute (Musyimi, 2020). Climate-smart agriculture (CSA) practices offer opportunities to address these challenges yet require access to adequate financial services and skills. In Nyando, one of the main barriers to upscaling CSA has been the constrained access to credit and savings. One initiative provided tailored financial products and services combined with competence building to support smallholder farmers in their efforts to invest in and set up CSA-based small and medium-sized enterprises and businesses. With small farm sizes and a subsistence orientation, opportunities for commercial business models and investment portfolios are few. Inclusive financial markets and services provide affordable and equitable access to financial products and services to rural people, including agricultural and non-agricultural entrepreneurs, and particularly the most marginalised and vulnerable (Corrado & Corrado, 2017). These services can scale up

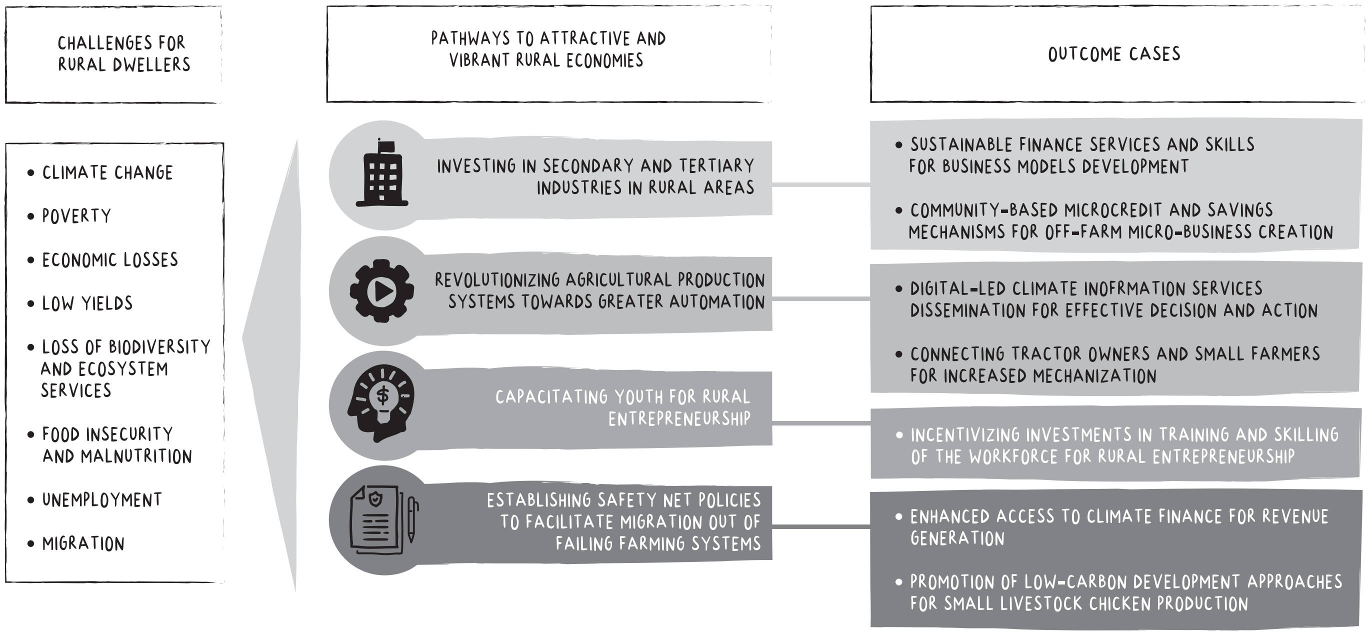

Figure 6.2 Impact pathways for reinvigorating rural economies

CSA and build rural livelihood resilience (Oostendorp et al., 2019). Two business models for CSA scaling were co-created through partnerships in the value chain (Wattel et al., 2021). Increases in smallholder farmer finance were made possible by linkages between banks and community savings groups, as well as through farmers' access to marketing contracts with off-takers (Wattel et al., 2021). A key output of the co-creation process was awareness raising and motivation among farmers and community-based organisations about alternative viable economic options. The stakeholders came to understand the new business models that could prosper in the drought-prone, micro-scale farming conditions of Nyando. As a result, about 3,525 households in Nyando are currently involved in the community saving and loans groups and benefit from credits. This scheme has been scaled to reach 2,700 households in Hoima in Uganda and 1,980 households in Lushoto in Tanzania, both of which are classed as climate-smart villages (Ogada et al., 2021).

Other examples include the village-based microcredit and savings associations for building rural household resilience in drought- and salinity-prone areas of Cambodia (IIRI & CEDAC, 2019). In the context of climate-induced vulnerability, the risks of smallholder-based agricultural production have been mitigated through village development fund and savings groups (VDFSG). These are non-agricultural entities that create various off-farm micro-businesses. Members of the VDFSGs, half of whom are women and youths, have benefited from savings and local credit services (Box 6.1). The examples above show how investing in

Box 6.1

Creating Rural Jobs through Climate-Smart Agriculture Micro-Businesses in Cambodia

Members of a VDFSG deposit their cash savings on a monthly basis, then borrow money from the VDFSG to start micro-businesses to replace their lost jobs. These micro-enterprises mostly consist of small livestock production, intensive drip-irrigation-based vegetable gardens, homestead-based fruit agroforestry, and non-agricultural businesses. Once a certain amount of money has been saved for CSA purposes, the VDFSG supplements these savings, increasing the accumulated total capital. This structure has contributed to building community ownership, where communities manage collective funds and reduce the possible risks in loan repayment. As of June 2021, 37 VDFSGs have been established in 37 villages in the target community-protection area and community forest areas of Koh Kong and Mondul Kiri, with a total of 1,969 members, 69 percent of whom are women. Loanable funds have reached US$851 387, wherein US$444 820 has come from members' savings deposits, plus US$385 802 of Asia Development Bank funds. Additional funds are generated from the interest-based income from loans repaid by members. Women also benefited from the financial services of the VDFSGs (IIRI & CEDAC, 2019).

sustainable financing mechanisms can help farmers improve their climate-risk resilience and move from ‘hanging in’ to ‘stepping out’.

6.3 Revolutionising Agricultural Production Systems towards Greater Automation

Many rural dwellers see agriculture as drudgery, requiring heavy labour commitments often in hot climates. A combination of a lack of knowledge and limited opportunities for farmers and cooperatives to access start-up capital prevents greater automation, particularly in the context of climate variability. Greater automation and tools for farmers’ decision-making will allow more efficient development of agricultural activities, by facilitating access to information, reducing labour time, and increasing productivity.

An example from Colombia shows how automation has transformed production systems, where innovative work is being done to provide climate information and help farmers make better-informed decisions. A digital agroclimatic forecast system was developed to provide highly automated climate services for agriculture. The *Pronosticos AClimate Colombia* system was used to first understand the demand for climate information, then leverage this understanding to produce tailored information to support crop-specific decision-making (Sotelo et al., 2020). The system was applied to two of Colombia’s most important staple crops, rice and maize, both highly affected by climate (Sotelo et al., 2020). It is an interface for translating and transferring forecasts generated by the Colombian meteorological service and disseminated through Local Technical Agroclimatic Committees. The system implements seasonal climate forecasts using methods in line with those used by the Colombian meteorological service and connects them with crop-simulation models. The result is actionable decision-making information concerning planting dates and the crop varieties that best suit forthcoming climatic conditions. As a web-based platform, the system facilitates direct access to general and context-specific climate information that can be understandable and useful to the farmers and different users.

In 2014, Fedearroz – the National Federation of Rice Growers – advised 170 rice farmers not to plant in the first of the two annual growing seasons based on the forecasts and recommendations of the *AClimate Colombia* system, avoiding a yield loss of 1–2 tonnes ha^{-1} and economic loss of US$1.7 million (CCAFS, 2015). The use of *AClimate Colombia* is increasing, and a recent ex-post impact assessment indicated that 9 154 farmers have used agroclimatic forecasts to manage their crops. More frequent use of agroclimatic forecasts has positively impacted yield and harvest losses (INSUCO et al., 2020).

Another successful case to revitalise rural economies – through mechanisation and labour saving – comes from Hello Tractor Inc., an agri-tech company that connects tractor owners with smallholder farmers in Sub-Saharan Africa through a farm-equipment-sharing application (Hello Tractor, 2018). Headquartered in Abuja, Nigeria, Hello Tractor is active in Kenya, Mozambique, Senegal, and Tanzania. Many smallholder farmers in this region lack the capital to purchase machinery (Cabral & Amanor, 2021). Through Hello Tractor they can rent one at a fraction of the cost and reduce their physical labour. Hello Tractor is now providing services to more than 500 000 farmers in Sub-Saharan Africa, facilitating mechanisation and increased productivity while generating new employment opportunities for digital entrepreneurs in rural areas. By integrating ground intelligence with mechanisation, Hello Tractor enables owners to grow their business and creates equitable access to tractor services; by doing so, the company enables smallholder farmers to both earn and grow more, improving income and food security for their families and communities (Hello Tractor, 2018). The company is creating efficiencies that generate inclusive growth, reduce poverty, and help build stronger, more stable economies (Hello Tractor, 2018).

6.4 Capacitating Youth for Rural Entrepreneurship

Many young people view agriculture as economically unrewarding work. Strengthening their capacity to invest energy into starting agribusinesses, however, can create both jobs and wealth. Incentivising investments in training and re-skilling of the workforce can allow producers and rural dwellers to engage in new activities such as agri-processing, distribution, and provision of farm inputs, as well as being infomediaries and service-providers through information and communication technologies.

The West Africa Agricultural Productivity Programme (WAAPP) is an initiative that contributed to rural entrepreneurship through youth capacity-strengthening (Ouedraogo et al., 2019). One of WAAPP's aims is to train the youth to adopt CSA innovations for small agri-preneurship (Box 6.2) (CORAF, 2018). Based on WAAPP's success stories, the Economic Community of West Africa States (ECOWAS) decided to use this approach to run its youth employment strategy (ECOWAS, 2019). By 2022, an estimated US$300 000 will have been allocated to five centres of specialisation, to train at least 450 youths in technologies and innovations with high youth-employment potential. Indeed, 11 similar successful agri-preneurships were developed through this regional agricultural programme (CORAF, 2018).

Box 6.2
A Plantain Nursery Enterprise in Côte d'Ivoire

During 2018, the innovative Côte d'Ivoire agribusiness Canaan Agriculture Sarl had a turnover of close to USD$180 000 (CORAF, 2018). Canaan Agriculture Sarl is owned by a young Ivorian, Narcisse Aman, one of the nurserymen trained in producing plantain plants derived from stem fragmentation technology under WAAPP. Bananas and plantains are the fourth most important food crop in Côte d'Ivoire after yams, cassavas, and rice. Thanks to the training and the knowledge acquired, Aman started with three explants – the part of the plant from which a whole plant can be produced – from which he could develop seeds in the form of vivo-plants (CORAF, 2018). According to Aman, the WAAPP training was a defining moment for him. Today, Aman runs close to 60 operations across different locations in Côte d'Ivoire, with roughly 10 full-time employees and many more seasonal workers. For a company that started only a few years ago, this represents spectacular growth and speaks to the untapped potential of entrepreneurship in agriculture in Côte d'Ivoire and beyond (CORAF, 2018).

6.5 Establishing Safety-Net Policies and Programmes

When farming is not viable, we need safety-net programmes to keep producers from 'falling down' and 'dropping out'. Chapter 7 covers safety-net programmes in more detail and clearly explains that designing *adaptive* safety-net interventions requires the adoption of a holistic approach. This approach views agriculture as an integrated component of rural poverty reduction, urban food security, and inclusive economic growth, under natural-resource scarcity. Alternative programmes that facilitate households shifting to other parts of the food system beyond the farm can support the livelihoods of vulnerable populations. Policy and programmes can create jobs and encourage people to leave agriculture when necessary.

Carbon pricing – the generation of revenues to pursue economic and development objectives from reduced greenhouse gas emissions and carbon sequestration – is one financing mechanism that can help producers exit farming. For example, in collaboration with donors such as the Green Climate Fund and the African Development Bank, the West African Alliance on Carbon Markets and Climate Finance and the East African Alliance on Carbon Markets and Climate Finance are working to increase access to climate finance. Doing so will allow the scale-up of programmatic crediting approaches with high sustainable-development impacts, such as participatory land-conservation plans for biodiversity and ecosystem services (Gonzalez & Shelter, 2021). The targeting of land for conservation purposes and the establishment of non-farm activities, as seen in

Box 6.3

Targeting Land for Conservation and Establishing Non-Farm Activities Around the Pendjari Region in Benin

The Pendjari National Park was established in northern Benin in 1954 during the colonial period, without the consent of local communities, who were evicted from their farming lands to make way for it. Farmers were also forbidden from farming near the Pendjari conservation area, and local park officials destroyed farms around the park every year (Klein at al., 2013). Until 1992, the park was managed by the forest department in an oppressive manner, resulting in many clashes between the forest administration and local communities over resource use. After the Rio de Janeiro Summit in 1993, however, the participatory management of the Pendjari National Park began. According to the plan, local park officials were to allow sport-hunting of a limited number of animals annually (Klein at al., 2013). The hunting fees paid by tourists aid in the coordination and agreement of community development plans by involving the local population in some reserve-management tasks. Hunting enables 130 people from the surrounding villages to work as trackers, gamekeepers, and tourist guides, which has strengthened the rural population's awareness of the park's importance, resulting in farming ceasing around the park (Klein at al., 2013).

Benin, are examples of how safety-net measures can shift producers away from farming (Box 6.3).

Another successful example of safety-net creation can be seen in a Cambodian pilot project, which focuses on entrepreneurs adopting small-scale, climate-smart chicken production to improve local food systems. This initiative was created to promote low-carbon approaches for small-scale chicken production development, as a response to the climate-related risks of failing crop production (Manilay et al., 2021). In the provinces of Koh Kong and Mondulkiri, 39 households, two-thirds of which are led by women, have transformed their livelihoods through this initiative. Hatchery operators earned a total net income of US$10 136 and US$13 604 in 2019 and 2020, respectively, far more than the US$6,286 and US$8,003 sums for those without hatcheries (IIRR & CEDAC, 2020).

6.6 Way Forward

There is an urgent need for alternative economic livelihoods within agriculture through value addition and diversification across allied economic sectors. This chapter has analysed how innovative mechanisms can drive change and rural reinvigoration. These mechanisms include investing in secondary and tertiary industries in rural areas, revolutionising agricultural production systems towards greater automation, empowering the youth, and establishing safety-net policies. Implementing these mechanisms can reduce drudgery, broaden access to new tools that help farmers make more efficient decisions, and create enabling environments that encourage youths and women to participate in rural development. When given the right tools, youth and women can create successful rural businesses using agricultural technologies and innovations. Agriculture must be made attractive to the next generation as a sector with opportunities, not only in farming per se but also in a rural service economy. Agriculture must also be inclusive for both women left behind in farming and next-generation rural youths. This group is increasingly disenfranchised, making them prone to migration and conflicts. Where farming becomes unviable, safety-net policies and programmes can support these groups, including by shifting opportunity to other parts of the food system or out of agriculture entirely.

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7

The Climate–Security Nexus

Securing Resilient Livelihoods through Early Warning Systems and Adaptive Safety Nets

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Highlights

- Understanding the climate–security nexus requires framing risks and resilience, which often reflects a negative cycle of fragility, climate vulnerability, and human insecurity.
- Climate actions can enhance a society's climate resilience and generate pathways towards improved peace and security.
- These actions include early warnings for food security planning, building local capacity to translate early warnings and climate-informed advisories, climate-smart mapping and adaptation planning, safety-net programmes, and risk finance.
- Other changes and interventions are also needed to break the cycle between climate and conflict, align climate actions to peace objectives, and thereby contribute to a climate-resilient peace.

7.1 From Climate Resilience to Climate Security

Ambitions to increase resilience, transform food systems, and ensure an end to hunger and malnutrition are intrinsically linked with actions to keep countries, regions, and communities safe. To end dependence on humanitarian assistance for 40 million rural dwellers by 2030 and realign US$5 billion per year for adaptive safety nets, it is critical to embrace a climate-security lens, and in so doing ensure that climate action is aligned with conflict-prevention and peacebuilding objectives (Steiner et al., 2020).

Conceptualising the climate–security nexus requires framing risks and resilience. Such framing reflects a negative cycle of fragility, climate vulnerability, and human insecurity, all of which may worsen the risk of violent conflict. In this context, climate change is conventionally framed as a risk multiplier, exacerbating pre-existing risks and insecurities that ultimately form the root causes of conflict (Gilmore, 2017). Better resilience can be attained, however, by operationalising a virtuous cycle in which enhancing a society's climate resilience can also generate pathways to improved human security, stable and inclusive institutions, and stronger equity and peace. To realise and operationalise the double dividend of resilience-building for climate adaptation and peace, interventions must – where possible – consciously deploy a transformational lens and maximise the transformative potential of climate adaptation for other system dimensions. Climate action thereby offers an opportunity to build a 'climate-resilient peace', which involves leveraging climate adaptation for the renegotiation and reconstitution of key socio-economic, political, and institutional relationships and power asymmetries. These problematic dynamics both underpin the disproportionate exposure and vulnerability of certain societal groups *and* often form the root drivers of conflict (Nicoson, 2021).

The literature establishes key actions and targets to transform food systems in a climate crisis (Steiner et al., 2020). The main pathways to secure resilient livelihoods and value chains involve early warning systems and adaptive safety nets and are linked to the climate–security nexus. These pathways include (1) constructing a tighter continuum from humanitarian assistance to development processes, (2) developing and improving early warning systems in climate-risk hotspots, (3) aligning best-practice safety-net programmes in climate-risk hotspots, and (4) supporting early action with risk finance. These pathways follow analyses of the shortcomings of food systems for peace and security in a climate crisis, and of the connections between climate finance and peace in tackling climate and humanitarian crises (Läderach et al. 2021a; 2021b).

7.2 Pathways to Peace

Climate-security risks include competition over scarce resources, food insecurity and price shocks, livelihood insecurity and migration, unintended consequences of climate policies, and a lack of effective governance and legitimacy (Figure 7.1). The proposed pathways might feed into key climate-peace principles. Several examples of climate action in the agricultural research for development (AR4D) space tackle these four pathways with potential to contribute to a climate-resilient peace. The actions these examples showcase cover early warnings for food security planning, building local capacity to translate early warnings and climate-informed advisories, climate-smart mapping and adaptation planning, safety-net programmes, and risk finance. Each action might involve specific technologies, tools, and innovations.

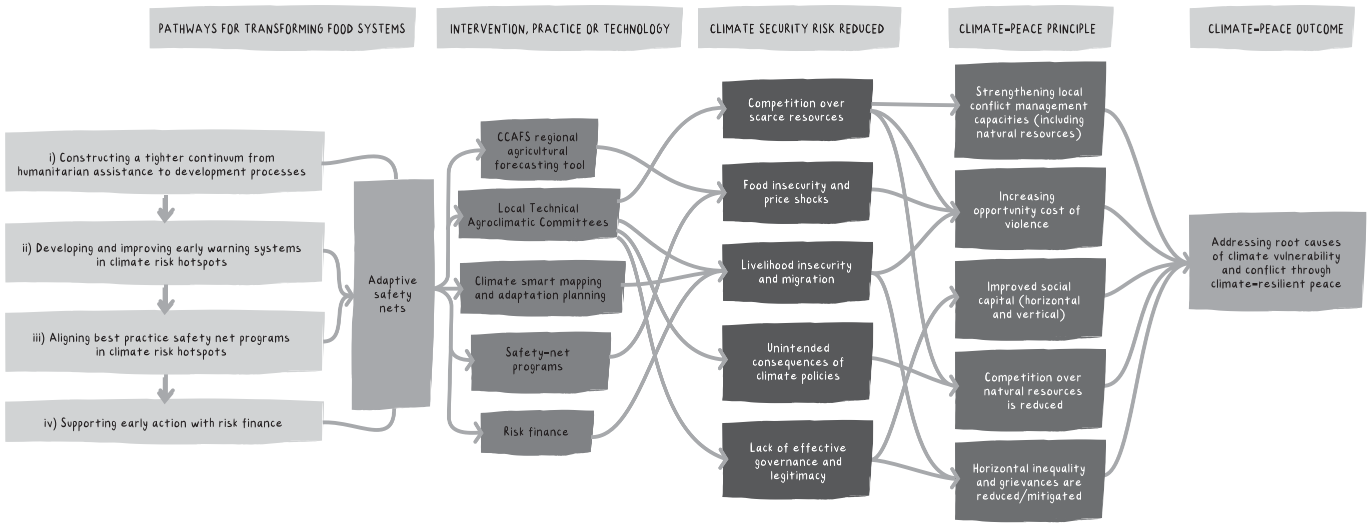

Figure 7.1 Pathways for transforming food systems and securing resilient livelihoods and their linkages with peace and security outcomes

These technologies, tools, and innovations can reduce several key climate-security risks (Figure 7.1), and in so doing, offer pathways from climate action to better peace and security. The different case studies in this chapter contribute to various aspects of the humanitarian–development–peace nexus by strengthening local conflict management capacities, increasing the opportunity cost of engaging in violence, lessening competition over scarce natural resources, improving social capital, and shrinking horizontal inequality. These pathways are also inevitably linked to each other in their potential contribution to peace and security because improving early warning systems, developing safety-net programmes, and risk financing are key building blocks in the creation of adaptive safety nets. When coupled with effective governance systems, these pathways help bridge the humanitarian–development–peace nexus, thereby ameliorating acute food insecurity, generating secure livelihoods, and addressing important conflict drivers. We conclude with some recommendations about how to build a climate action research agenda that responds to and accounts for climate-security risks.

7.3 Constructing a Tighter Continuum from Humanitarian Assistance to Development Processes

To reduce dependence on humanitarian assistance, a programmatic approach can strengthen climate resilience and risk mitigation. This objective can be achieved with new tools and risk reduction technologies together with stronger partnerships among governments, finance, humanitarian, and scientific and technological institutions. A case study from Nepal illustrates this pathway, wherein the Climate Change, Agriculture and Food Security Regional Agricultural Forecasting Tool (CRAFT) was used by the World Food Programme (WFP), the government of Nepal, and other stakeholders to support food security planning (Shelia et al., 2019).

Reliable, timely, and accurate crop yield forecasts can provide crucial information for food and livelihood security planning, particularly in the context of climate variability, change, and extremes. The crop yield estimation in Nepal has been based on traditional crop cuts, surveys, and reports from the District Agricultural Development Offices. These crop situation updates rely on sample crop cutting, which is used to verify the yields of key cereal crops. Though this process has its advantages, it is a time-consuming and costly exercise, and there can be delays in processing the results. Indeed, crop-cutting results can take six months to over a year to indicate a basis for area and production estimates, and results only become available after the crops are harvested. CRAFT was used by the WFP and the government of Nepal to estimate pre-harvest wheat and paddy production during 2015–20 for Nepal's Food Security Monitoring System (NeKSAP).

The CRAFT tool furnishes a systematic yield forecasting model based on real-time climate information, providing accurate, precise, and scientific estimates of crop yields for food security and early warning purposes. CRAFT also produces spatial in-season crop yield forecasts and includes a client application with a user-friendly interface and database implementation. It integrates two different external engines: a crop simulation model for spatial crop simulations and another for seasonal climate forecasts. CRAFT supports spatial input data, spatial simulations, the integration of seasonal climate forecasts, aggregation and calibration of model predictions from historical agricultural statistics, analysis, and visualisation.

To support food security planning, the WFP and NeKSAP successfully used CRAFT to forecast the crop production of rice and wheat, and estimates were disseminated within the government and to all concerned stakeholders as well as to the general public using the NeKSAP's website.[1] This tool also supported food security monitoring when field operations were hampered because of the calamitous earthquake in 2015, by COVID-19 in 2020, and during the 2017 federal restructuring of Nepal's government.

By enabling humanitarian and government actors to design more effective, locally relevant food security interventions and remain responsive to their operating environment, spatial in-season crop yield forecasts produced by CRAFT can address immediate food insecurity. First, CRAFT may reduce the urgent scarcity of resources and thereby prevent or lessen competition over access to natural resources and agricultural inputs between communities (Figure 7.1). Second, by indirectly keeping food costs from spiralling and contributing to the preservation of stable markets, CRAFT may increase the opportunity cost of engaging in violence (Figure 7.1). Food price shocks and food insecurity are well-recorded triggers of violence and conflict, particularly in environments characterised by pre-existing social, political, and institutional fragility (Winne & Peersman, 2021). The provision of a staple may, therefore, shrink the incentives for engaging in criminal activity or violent protest.

Timely assistance to those hit by an extreme event, also known as 'early action', helps build resilience. In the absence of assistance, households will in extreme cases sell productive assets to survive a crisis, pushing them further into poverty, exacerbating their marginalisation, and undermining their resilience to future shocks.

7.4 Developing and Improving Early Warning Systems in Climate-Risk Hotspots

Improved early warning systems that utilise climate forecasting and science-based solutions can trigger early action that builds pathways to climate resilience. Together with meteorological, humanitarian institutions, and innovative communication, the benefits of improved early warning systems can reach women, youth, and marginalised stakeholders and mitigate climate-induced tensions and conflicts. One approach successfully used to confront climate-change challenges in agriculture systems is known as the Local Technical Agroclimatic Committee or LTAC (Loboguerrero et al., 2018). LTACs are a systemic means to bring together the who, that is, agricultural value chain actors; the what, that is, extreme climate variability and a changing climate, and the context, that is, the agricultural landscape. Bringing together the who, what, and how can facilitate the co-development of consensus and recommendations around best practices to improve agricultural outcomes, ultimately bolstering community resilience.

The involvement of a broad array of actors that span farmers, local technical experts, and key institutional actors among others is key to a successful LTAC (Giraldo Mendez et al., 2019). This not only assures that consideration of local farmers and expert knowledge feeds into the consensus process but also aids wide diffusion of the committee recommendations, through the extensive networks associated with each participant type. In bridging across individuals and institutions, LTACs also foster the further development of social capital in the agriculture system, which ostensibly also has the potential to improve resilience and long-term outcomes (Martínez-Barón et al., 2018). We would argue that the highly networked, adaptive LTACs implemented throughout Latin America have contributed significantly to the resilience of the region's socio-ecological fabric. Their evolutionary nature allows LTACs to respond to regional needs, while their participant-driven approach assures that local context and perspectives are adequately considered. Whether or not LTACs can also specifically serve as a catalyst for peace has not been examined; however, lack of climate-change resilience has been shown to undermine negative peace (Sharifi et al., 2021).

LTACs also form a platform where conflicting or competing interests and concerns can be resolved, and synergistic objectives better detected and implemented. LTACs, therefore, are a potentially useful component in the development of context-specific conflict-prevention mechanisms. Additionally, by linking individuals and communities with institutions in a participatory manner, LTACs help empower local stakeholders, allowing perhaps conventionally unheard voices to be brought to the forefront. As such, LTACs can form a mechanism by which governance in agricultural systems can become more responsive to local political economies, unintended consequences of climate policies can be avoided, and local actors can have more power to inform governing higher-level structures (Figure 7.1: Climate-security risks 4 and 5; Climate-peace principles 3 and 5).

Another example of early warning systems development in climate-risk hotspots is Climate-Smart Mapping and Adaptation Planning in Vietnam. The process of preparing Climate-Smart Maps and Adaptation Plans (CS-MAP) engages experts from the national and local levels to identify climate-related risks; determine potentially affected areas and their risk levels using technical, infrastructure and topographic data, and local knowledge; assess and improve proposed adaptive measures, and develop integrated adaptation plans for rice production from regional to provincial levels.

Implemented during 2018–19 and 2019–20, the CS-MAP interventions were a valuable way to determine climate-risk-related areas. They facilitated decision-makers and agricultural planners in deploying suitable crop-adaptation measures to mitigate adverse climate conditions. Such conditions include salinity intrusion in the coastal provinces of the Mekong River Delta region over areas of more than 500 000 ha. This exercise demonstrated that real-world risk maps along with suitable location-specific adaptation options can be rapidly, economically, and efficiently developed and implemented. By helping the most climate-vulnerable households and communities to weather climate shocks – and thereby protect financial and social capital – the CS-MAP interventions arguably help mitigate the impact of climate on existing inequalities apparent at the household, community, and national scales.

Climate impacts and pre-existing inequalities are likely to feed back into one another, locking certain groups and their members into cycles of insecurity and vulnerability (Islam & Winkel, 2017). By building the absorptive and adaptive resilience capacities of individuals, households, and communities – thereby reducing livelihood insecurities – this cycle can be broken, and beneficiaries enabled to better accumulate social, financial, and political capital in the face of increasing climatic pressures (Figure 7.1: Climate-security risk 3). In turn, this is likely to either mitigate existing inequalities or prevent their further downward spiral (Figure 7.1: Climate-peace principle 5), particularly for rural communities, thereby helping lay the foundations for positive peace. This is particularly relevant for contexts without existing conflict or fragility and with no immediate risk of escalation, but where continued marginalisation and inequality may eventually lead to greater degrees of human insecurity, as in Vietnam.

7.5 Aligning Best-Practice Safety-Net Programmes in Climate-Risk Hotspots

Developing safety-net programmes is critical to foster food-system transformation and secure resilient livelihoods, particularly in highly fragile and conflict-affected countries. However, designing *adaptive* safety-net interventions requires a holistic approach that looks at agriculture as an integrated component of rural poverty reduction, urban food security, and inclusive economic growth under natural-resource scarcity. CGIAR has been working in several fragile countries in the Middle East and North Africa (MENA) experiencing conflicts, such as Syria, Iraq, Afghanistan, Yemen, and Palestine. In post-conflict countries, socio-economic restoration in agriculture is often an avenue for resilient job creation and economic revitalisation, one of the six main priority areas of peacebuilding as defined by the UN Peacebuilding Support Office (PBSO) (Al Maleh et al., 2020). Therefore, crops and food security may become one of the highest priorities when operating in post-conflict locations. In the MENA region, 50 percent of all food consumed is imported. The region is highly dependent on external drivers to ensure its food security, particularly for cereals, pulses, and forages/feed.

The stabilisation and reconstruction in MENA's Rainfed Systems are a good example of how developing innovative technologies with longstanding national partners in agricultural policy and research, donors, and humanitarian agencies has resulted in adaptive safety nets, and policy and institutional reforms in two critical areas. The first is the mainstreaming of climate adaptation and resilience innovations towards the reconstruction and stabilisation of rainfed areas in the MENA. This focuses on the cereal-based production systems that are crucial to ensure food security and the resilience of livelihoods (Figure 7.1: Climate-security risk 2), and sustainability of natural resources (Figure 7.1: Climate-security risk 1). The second centres on institutional arrangements to achieve equity and sustainability in agricultural reconstruction. In particular, the focus has been on supporting frameworks for successful water and seed governance in the region (Figure 7.1: Climate-security risk 5). Both actions combine the provision of evidence with informing policy and institutional reforms for climate-smart reconstruction, resilience, and stabilisation investments. The goal is to mitigate the risks of further conflicts by strengthening institutions, natural-resource management (Figure 7.1: Climate-peace principle 1), and minimising climate-induced land degradation, therefore contributing to stable and resilient livelihoods. For this purpose, these initiatives support the development of value chains and improve livelihoods through new ways of generating income, with an increased focus on gender and social inclusion (Figure 7.1: Climate-peace principles 3 and 5). By considering gender and social inclusion and integrating participatory processes from the beginning of such interventions, they become an important platform from which to pursue transformative action agendas. Ensuring natural-resource management decision-making bodies are inclusive and gender-balanced, for instance, or by ensuring a greater degree of state–citizen interaction, can help address inequalities and improve the responsiveness and legitimacy of government.

7.6 Supporting Early Action with Risk Finance

Early action with risk finance can help countries build resilience and put in place finance and systems that ensure they are better prepared to respond to emergencies.

Mobilising early action is not an easy task. It requires access to sufficient funds to finance early interventions, but such funds are often lacking, regardless of whether one focuses on governments, farming households, or meso-level institutions, allowing climate disasters to have enormous impact on the world's most vulnerable and the poor. Risk finance can help bridge this gap. For instance, by providing monetary compensation after a shock, insurance helps governments, farmers, and rural communities transfer the risk to global markets. Smart-risk finance contracts can provide governments with the funding for early interventions in anticipation of a disaster, and risk-financing instruments increase farmers' access to funds when otherwise they would resort to costly coping strategies that could lead them into poverty. The resulting reduction in risk exposure can also unlock credit and accelerate investments in high-risk yet productive agricultural and non-agricultural opportunities based on the predicted outcome in the absence of a shock, and stabilise rural economies.

Yet, risk finance has generally failed to reach smallholder farmers at scale, and where scale has been achieved, programmes were not necessarily designed to impact resilience and adaptation. Insights from AR4D can be leveraged to help address these challenges. Examples include the use of crowdsourced images for seasonal monitoring and claims settlement to improve product accuracy (Ceballos, Kramer & Robles, 2019); bundling risk finance with climate-smart practices and technologies (Boucher et al., 2021); using insurance to finance humanitarian response operations and scale up cash transfer programmes in the event of a severe drought (Kramer, Rusconi & Glauber, 2020), and the integration of insurance in social protection (Jensen, Ikegami & Mude, 2017).

The following example of index-based flood insurance (IBFI) is a relatively new approach to insurance provision that pays out benefits based on a predetermined index, for example flood level and duration, for loss of revenue in agricultural fields owing to floods. The IBFI product was created to reduce the impacts of floods on India's poorest farmers. The product combines 30 years of historical flooding data, hydrological modelling, and 10 m-resolution satellite images from the European Space Agency. In Bangladesh, the IBFI model works by calculating the proportion of land inundated in relation to the total geographical area in question, using satellite images. Between 2017 and 2021 more than 8 000 households were insured by the Agricultural Insurance Company of India Ltd, insurance companies HDFC ERGO and Green Delta Insurance Company Ltd, with Swiss Re as reinsurer. This was the first time satellite-based insurance had been employed in the country, resulting in compensation of US$170 000 being paid to farmers by insurers.

Such types of innovations in risk financing can minimise the long-term impacts of floods and other climate disasters faced by smallholder farmers. In doing so, threats to livelihood insecurity (Figure 7.1: Climate-security risk 3) are mitigated and the potentially long-term devastation caused by climatic shocks is minimised, allowing farmers to restore their financial and social capital (Figure 7.1: Climate-peace principle 3) more rapidly, as opposed to being pushed into persistent cycles of poverty and inequality in the aftermath of an exogenous shock. In the absence of such safeguards, rural livelihoods may become persistently unsustainable in flood-prone areas and the relative weight of migration-based remittances is likely to become increasingly important at the household level. IBFI helps ensure that the pace of socio-economic recovery in the aftermath of a climate shock is sufficient for farmers, not hostage to the slow, drawn-out turnover of support funds otherwise in place.

7.7 Building a Climate-Security Sensitive Agenda

A truly transformative shift towards resilience and sustainable land, water, and food systems that reduces the need for humanitarian interventions is a key challenge of the next decade. Climate is increasingly becoming the accelerator of many socio-economic insecurities that can cause grievances and conflict. Early warning systems and early action can significantly mitigate climate impact and help humanitarian organisations and governments prevent the expansion of climate-induced conflict. This chapter shows that this can be achieved in some contexts. Much more, however, is needed to break the cycle between climate and conflict, align climate action to the peace objective, and thereby contribute to climate-resilient peace. The following are useful factors in building a climate-security sensitive agenda:

Strengthening Multi-Level Governance Frameworks that Help Bridge the Humanitarian–Development–Peace Nexus: It is important to connect key stakeholders and approaches both vertically and horizontally, co-develop standards of practice with affected communities and the relevant institutions, and facilitate cross-siloed knowledge sharing and learning. By doing so, we can strengthen links between early warning and early action and continue to improve the effectiveness of both of these important mechanisms for peace and security.

Finding Ways to Integrate Climate Security Evidence in Early Warning and Early Action Systems: Stakeholders working in the climate-action sphere should have access to clear and user-friendly metrics, measures, and evaluation frameworks that help articulate how, why, and where their interventions are likely to produce tangible impacts for peace and security. This includes both programmatic outcomes – such as building resilient livelihoods and value chains – but also programmatic processes, such as participatory and multi-stakeholder-approaches.

Designing Coherent and Conflict-Sensitive Adaptive Safety-Net Policies and Programmes: A well-designed adaptation nexus – backed by coherent and conflict-sensitive policies – can synergise solutions and catalyse progress towards building inclusive and transformative resilience to the impacts of climate change. Enacted through the action tracks on food security and rural livelihoods, resilient infrastructure, finance, and locally led action, such an adaptation nexus can accelerate resilience-building agendas.

Bridging Innovations and Social Capital: Innovations, practices, and technologies to fight the climate crisis are not enough if enacted in isolation. To effectively achieve what can be termed a 'climate-resilient peace', climate action should be leveraged to simultaneously build resilience to both climate and conflict risks. Actions to promote climate adaptation and mitigation can foster neutral spaces for dialogue, build interdependence, help improve government legitimacy and trust, and help reduce structural inequalities.

Notes

1 www.neksap.org.np/.

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8

Helping Farmers Make Better Decisions Using Climate Services

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Highlights

- Climate services (CS) and agricultural advisory services (AAS) have the potential to play synergistic roles in helping farmers manage climate-related risk, providing they are integrated.
- For information and communication technology (ICT)-enabled, climate-informed AAS to contribute towards transformation, the focus must shift from scaling access to scaling impact.
- With expanding rural ICT capacity and mobile phone penetration, digital innovation brings significant opportunities to improve access to services.
- Achieving impact requires the following actions: building farmers' capacity and voice; employing a diverse delivery strategy for CS that exploits digital innovation; bundling of CS, agri-advisories, and other services; investing in institutional capacity; embedding services in a sustainable and enabling environment in terms of policy, governance, and resourcing.
- Recent experiences in several countries demonstrate how well-targeted investments can alleviate constraints and enhance the impact of climate-informed AAS.

8.1 Introduction

Accelerating climate change is increasing the urgency of transforming food systems into sustainable, inclusive, healthy, and climate-resilient models. Yet at the farm level, the risk associated with climate variability is a serious impediment to beginning that transformation. Farmers routinely make critical production and livelihood decisions in high-risk environments with inadequate information (Meijer et al., 2015). When faced with extreme events, such as droughts and flooding, farm households are often forced to employ strategies that enable them to survive the immediate crisis but erode their capacity to build a better life by depleting their productive assets and human capital (Hansen et al., 2019a).

The uncertainty from climate variability is a disincentive for risk-averse farmers to adopt innovation and for investment by value chain actors whose actions enable or constrain farmers. Smallholder farmers, in particular, tend to use precautionary strategies to protect against the possibility of catastrophic loss in the event of a climatic shock; therefore, they do not optimise management for average conditions, but for adverse conditions (Meza et al., 2008). Within farming communities, the negative impacts of climate risk are borne disproportionately by the poorest members, and often by women (Davidson, 2016). The effects of climate risk on both precautionary strategies for future events and post-event coping responses contribute to the persistence of poverty and impede the transformation towards sustainable, inclusive, and healthy food systems (Hansen et al., 2019a).

Climate services (CS) – for example, seasonal and weather forecasts – and agricultural advisory services (AAS) aim to support farmers through information. Both play synergistic roles in helping farmers manage climate-related risk and are, therefore, incomplete in isolation. In most developing countries, CS and AAS exist in some form but typically fall under different government agencies, ministries, and policy frameworks (Ferdinand et al., 2021).

Information and communication technology (ICT) tools are increasingly being used to overcome the challenges of reaching diverse rural populations, although these technologies introduce new issues that must be addressed, for example, partnerships with additional stakeholders, institutional arrangements, and data governance (Ferdinand et al., 2021). At the same time, there is growing evidence that face-to-face participatory communication processes – those that empower farmers to understand and act on climate information, alongside institutional arrangements that convene national meteorological services (NMS) and relevant agricultural stakeholders to co-produce climate-related information and advisories – can substantially increase the benefits that farmers experience.

The report *Actions to transform food systems under climate change* (Steiner et al., 2020) highlights climate risk as one of four targets for urgent action. This chapter deals with the report's call to 'take climate services to scale by connecting 200 million farmers and agribusinesses to ICT-enabled bundled advisory services by 2030' (Steiner et al., 2020, p. 35) as a pathway towards de-risking livelihoods, farms, and value chains. While the outcome of this action is framed in terms of scaling up access to high-quality, actionable, and real-time information, it implies that these services must be implemented in a way that empowers farmers to make better production and livelihood decisions. Scaling up information access does not guarantee that farmers will realise benefits at scale; *how* they are implemented matters. We discuss key areas of practice to address if investment in climate-informed, ICT-enabled AAS is to substantially improve the livelihoods of 200 million farmers by 2030.

8.2 Priorities for Scaling Impact

Climate-informed, ICT-enabled AAS involve coordination among a range of public- and private-sector actors, from international funders and policy platforms to national policy and technical institutions, farming communities, and the local intermediaries and service providers that support them. It is vital to understand the major actors involved and the factors that must be in place if these services are to empower farmers to make livelihood-improving risk-management decisions.

Five key areas of action can correct existing weaknesses that might otherwise limit the services' impact, even if farmers have access to them. All these actions relate to major actors and potential bottlenecks in the provision and use of ICT-enabled, climate-informed AAS (Figure 8.1). First, farmers must have the capacity to understand and act appropriately on complex information and to drive the co-production of improved services. Second, the communication channels used to deliver services must be accessible to a wide range of farmers and appropriate for the type and timescale of information. Third, information products and services must be bundled in a manner that exploits their potential synergies. Fourth, provider institutions must have the capacity to provide usable, credible, localised, timely information that aligns with the needs of farmers. Finally, the policy and resource environment must enable public and private information and service provider institutions to work together effectively.

The five key actions are informed by three case studies in Rwanda, Senegal, and India (Figure 8.1; Boxes 8.1, 8.2, and 8.3 respectively). Drawing from these case studies, we elaborate on how the five key actions can contribute to development activities.

8.3 Key Action 1: Building Farmers' Capacity and Voice

Farmers must have the capacity to use climate-related information in their decision-making for an impact to be realised (Vaughan et al., 2019). Similarly, farmers must have a voice in the information that meteorological and agricultural extension services provide, if they are to trust and act on that information (Carr et al., 2019; Hansen et al., 2019b). Despite growing recognition of the importance of co-production in aligning services with user demand, farmers and their representative organisations may not be able to express demand for information products or services with which they have no experience, and might not know

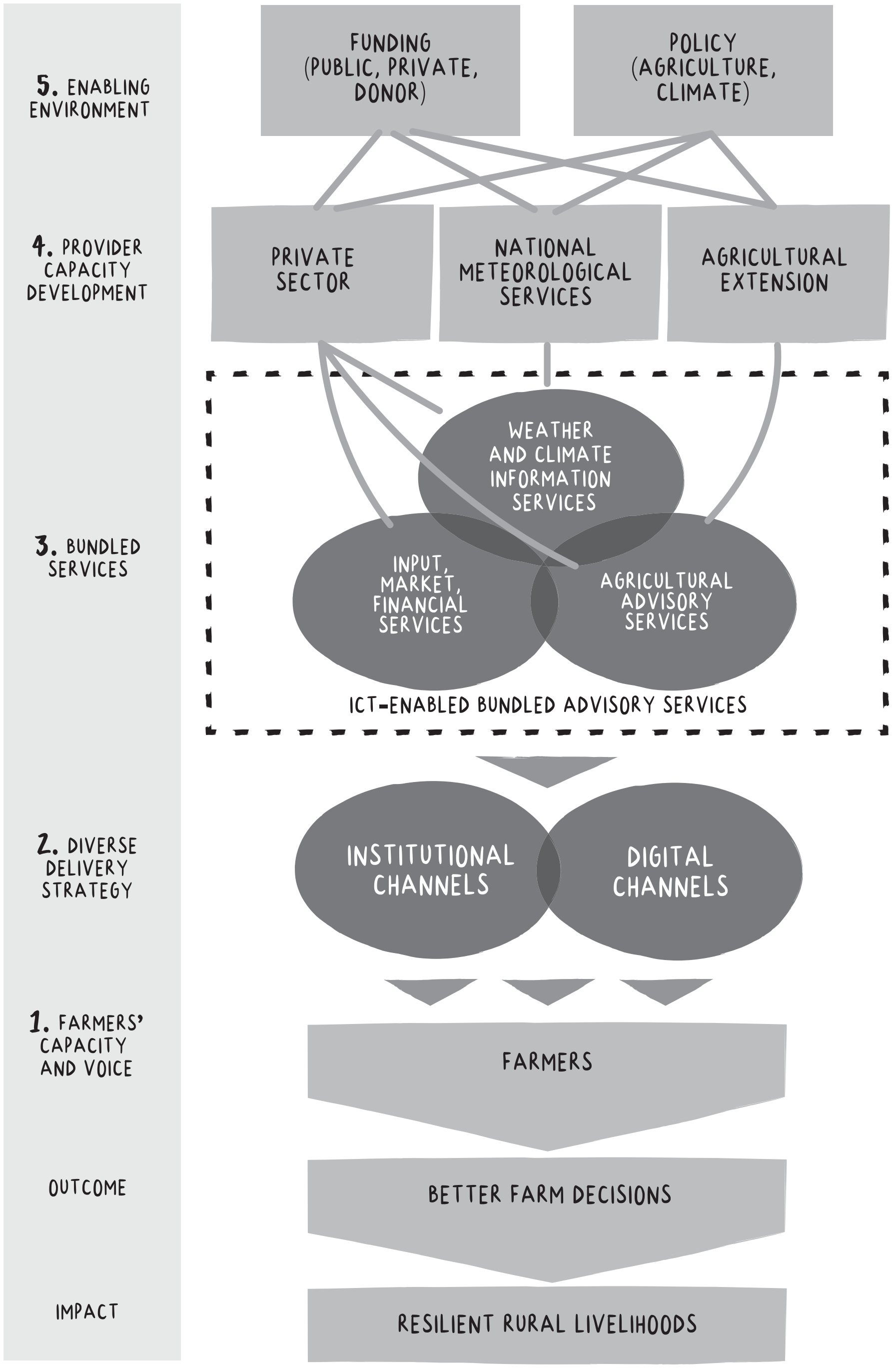

Figure 8.1 Impact pathway, key actors, and processes involved in information and communication technology-enabled, climate-informed agricultural advisory services; interventions to correct potential constraints (numbered in the left column).

Box 8.1
Rwanda Climate Services for Agriculture Project

Farmers in Rwanda face similar climate-related challenges to those encountered in many developing countries, including widespread droughts and heavy rainfall, which triggers flooding and landslides in upland regions. In the years 2016–20, the Rwanda Climate Services for Agriculture Project (RCSA) developed climate services for agriculture by strengthening both the capacity of the NMS to provide actionable information, and the agricultural sector's capacity to communicate and use climate information to manage risk. A participatory climate communication, training, and planning process, PICSA supports farmer decision-making with local climate information. The RCSA trained over 2000 extension staff and volunteer Farmer Promoters in PICSA, who then trained and facilitated 112 767 farmers to use climate services. A community radio network brought climate service programming to its estimated 3.1 million farmer listeners. Building on PICSA groups, Radio Listener Clubs (RLCs) were piloted and combined the benefits of radio programming with group participatory processes. Using the Enhancing National Services approach, Meteo Rwanda reconstructed its lost climate history – which was lost because of the destruction of assets during the 1994 genocide – by merging available station observations with satellite and reanalysis data. The resulting gridded temperature and rainfall data now serve as a foundation for a suite of historical, monitored, and forecast products, including the formatted graphs used in PICSA workshops, available for any location through online 'Maprooms'.

what could feasibly be provided, even if they would benefit from these services. This situation calls for increased investment in farmers' capacity both to use climate information and to engage in the co-production of improved services. Co-production approaches must be iterative, encourage joint learning, and allow for boundary organisations engaged in both climate science and agriculture to help negotiate improvements in NMS products.

Participatory processes are effective for building farmers' capacity to understand and use climate information. The Participatory Integrated Climate Services for Agriculture (PICSA) approach accomplishes this through a combination of training, participatory resource mapping, and calendar and budgeting activities that relate climate information to farm and livelihood decisions (Box 8.1).

To build farmers' capacity to understand and use CS in Rwanda, PICSA was scaled up. In 2020, a quantitative and qualitative evaluation showed that the participatory PICSA and Radio Listener Club (RLC) processes were effective in strengthening farmers' capacity to act on climate information. These methods led to a substantial increase in the proportion of farmers that reported changing crop,

Box 8.2

Climate Information Services for Increased Resilience and Productivity in Senegal

Running from 2016 to 2019, Climate Information Services for Increased Resilience and Productivity in Senegal (CINSERE) was developed with the Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM), the country's NMS, and aimed to increase the resilience of farmers, pastoralists, and fishers through climate services. It did this by focusing on building national capacity for the production, delivery, and use of climate services, and developing a sustainable framework for scaling up climate service use. Under CINSERE, 25 local MWGs were set up to analyse climate information and produce advisories based on local contexts (Ouédraogo et al., 2020). The MWGs have been operating in Senegal since 2008 and are a model of co-producing climate services at both the national and local levels. The national MWG is represented by government ministries, research institutes, insurance companies, extension agencies, and ANACIM, generating climate information and advice to be communicated to local users. Local MWGs – represented by farmer organisations, local administrative authorities, the media, non-governmental organisations, and farmers themselves – collect information from ANACIM and disseminate it to farmers. Advice from MWGs is intended to assist farmers in decisions about cropping operations and farming calendars. Pastoral committees were created in 2020 to provide information related to climate and the environment to livestock breeders.

livestock, and livelihood management practices. Women experienced increased participation and influence in household decision-making and better social standing in their communities (Hansen et al., 2021). One farmer was quoted as saying, 'I can take care of my kid because of higher production from the knowledge I obtain from the weather forecast' (women's focus group, Rwanda, RCSA project, Hansen et al., 2021). Another stated, 'I used to harvest two sacks of Irish potatoes, but now I harvest four sacks on the same plot' (men's focus group, Rwanda, RCSA project).

The Climate Information Services for Increased Resilience and Productivity in Senegal (CINSERE) project enlarged the number of local Multi-disciplinary Working Groups (MWGs) and used them as a mechanism to bring farmer and pastoralist organisations, local governments, and other local institutions into the co-production of CS (Box 8.2). The MWGs meet regularly throughout the growing season to interpret climate information, translate it into actionable advisories, and deliver it to users (Lo & Dieng, 2015). Through knowledge exchange, the success of the MWG model inspired the creation of Local Technical Agro-climatic Committees (LTACs) in Latin America and the Caribbean (Howland et al., 2016). LTACs are now used by over 190 institutions in the region, where they play a

Box 8.3
Meghdoot Mobile Application and the District-Level Agrometeorological Advisory Service in India

The crop-specific District-level Agrometeorological Advisory Service (DAAS) that serves farmers' needs is produced by Agro-Met Field Units (AMFUs) and disseminated through District Agro-Met Units (DAMUs), all operated by the India Meteorological Department (IMD). The DAMUs use local information, historical climate data, and weather forecasts from IMD and regional centres. They communicate the DAAS through radio, television, newspapers, the Internet, SMS, and interactive voice response, reaching around 42 million farmers across India. The efficacy of dissemination from AMFUs to farmers is variable, however, and depends on farmer networks and local extension institutions. While ICT and mass media provide improved dissemination pathways, they show suboptimal convenience, timeliness, and equity, resulting in limited success in communicating the gains made in meteorology to the agricultural sector. Additionally, none of the existing dissemination channels collects data about advisory uptake, the quality of information, or other farmer feedback (Dhulipala et al., 2021).

To overcome the challenges faced in the DAAS programme, a mobile application named Meghdoot was developed along with back-end technology support. Meghdoot takes advantage of the increasing smartphone penetration and mobile internet usage occurring in rural communities. The application offers forecasts, weather observations, and warnings generated by the IMD and the Indian Institute of Tropical Meteorology. It has been downloaded over 211 000 times and improves farmers' access to agri-advisories from AMFUs (Dhulipala et al., 2021). Meghdoot overcomes barriers to communicating AAS to farmers and applies user feedback to update the application and ensure its legitimacy.

similar role, translating climate information into relevant actions and facilitating co-production of improved services (Loboguerrero et al., 2018). In addition, CINSERE recognised the role of indigenous climate knowledge in farmers' risk management strategies and the need to understand how this shapes farmers' demand for climate information. Indigenous knowledge is commonly used by farmers in Senegal to adapt to climate variability. As such, biotic indicators present an opportunity to explain how scientific forecasts work, to build their trust in CS, and to engage them as partners in co-production.

8.4 Key Action 2: Employing a Diverse Delivery Strategy for Climate Services that Exploits Digital Innovation

A diverse delivery strategy can strengthen existing meteorological and agricultural advisory institutions, address the differences between weather and climate timescales, build the capacity of farmers to understand and use probabilistic climate information, and foster access and use for disadvantaged populations (Hansen et al., 2019b). In some contexts, ICT tools are a key part of diverse delivery strategies; ICT infrastructure, including mobile phone connectivity, is expanding in most countries and offers an opportunity to reach more end users. Ideally, ICT tools will be part of a suite of digital and institutional communication channels appropriate to farmers and institutions. Digital tools can fortify institutions and complement other communication processes, instead of bypassing institutional communication processes or social learning.

In Rwanda, the broadcast and print media channels used to disseminate general forecasts did not equip farmers to understand complex information and concepts or voice their questions or concerns, and they provided little information about farmers' local conditions. The Rwanda project (Box 8.1) sought to establish which channels were suited to the local context and considered the potential role that gender might play in accessing channels and decision-making. The result was that broadcast media, mobile phones, and participatory communication processes embedded in agricultural extension improved farmers' access to climate information. For example, RLCs played a role in empowering farmers, and farmer promoters were trained to lead their village groups in weekly meetings. Farmers would listen to and discuss the radio programmes, participate in call-in programmes on a rotating basis, discuss and record plans to act on what they heard, and share the information with their village groups. The RLCs benefited women, eliminating the significant disparities in awareness of, access to, and use of climate information between male and female smallholder farmers in the general population.

Mobile phone-based advisories that disseminate weather and farming-related information can lead to enhanced yields, lower costs, and heightened knowledge among farmers (Baumüller, 2018). While ICTs can expand the reach of CS, however, their use requires consideration of who can access and use them, and of their potential to complement other communication channels. In India, mobile phone ownership is high and offers an effective communication channel for agri-advisories. The District-level Agrometeorological Advisory Service (DAAS) disseminates advisories to farmers through mass media and ICT, including Short Message Service (SMS) and voice messaging (Box 8.3). The Meghdoot app aimed to expand the reach of the DAAS by using smartphones, which have shown greater penetration in rural communities (Dhulipala et al., 2021). A caveat of communicating CS and agri-advisories is that often different channels have no mechanisms for soliciting feedback on the usefulness, uptake, or quality of information. Meghdoot allows users to provide feedback on forecasts and advisories, increasing their legitimacy and relevance.

8.5 Key Action 3: Bundling of Climate Services, Agri-Advisories, and Other Services

At the state level, CS and extension services typically fall under different ministries and policies. A country's NMS will usually be under its own meteorological ministry or a transport ministry, given the value of climate information in the aviation sector. Extension services typically fall under each country's ministry of agriculture, which results in siloed CS and AAS and an underexploited potential for integrating the two services. Addressing the siloed nature of extension and CS would improve the impact of both but requires a coherent national policy framework that enables co-ownership by the NMS and ministries of agriculture. Also key are the formal integration of weather and CS into agricultural extension – in the public, private, and non-governmental organisation sectors – and appropriate investment in extension capacity to address climate information, subject to the existing capacity of the national agricultural extension system. There are further opportunities for bundling CS with other services, for example, credit or insurance; with inputs such as improved seeds and fertiliser; or with data like market information (Bird et al., 2016). Bundling similar services aimed at agricultural risk management takes advantage of potential synergies and economies of scale, which in turn reduce scaling costs (Steiner et al., 2020).

Progress towards creating dialogue and breaking down silos between CS and extension services can be seen in Ethiopia, where the National Digital Agricultural Extension and Advisory Services Stakeholder's Forum was recently established. The Ministry of Agriculture and the Agricultural Transformation Agency collaborated with government partners, national and international research institutions, development partners, and private-sectors actors, with the primary objective of coordinating the resources, experiences, and capacities of different digital agricultural extension services and AAS in Ethiopia. Another Ethiopian example of breaking down silos is the bundling efforts of Lersha. This privately led digital platform supports Farm Service Centres and provides agroclimatic advice to smallholder farmers, as well as a call centre in Addis. The platform has incorporated a mobile banking service, named 'CBE Birr', to promote financial inclusion in rural areas. These public–private partnerships contribute to both sustaining CS and improving farmers' climate-risk management while generating an income for the NMS. Their feasibility and sustainability, however, require some years of operation before becoming apparent. The Senegal case also includes bundling based on public–private partnerships, such as that with an ICT-based company, myAgro, which aims to bundle CS with agricultural inputs, agri-advisories, and crop insurance (Box 8.2).

8.6 Key Action 4: Investing in Institutional Capacity

There is a need to engage and strengthen public institutions, particularly those that work on the upstream generation of information. When it comes to climate information, various institutions are responsible for its generation, namely NMS and the National Agricultural Research System; its translation, typically the National Agricultural Research and Extension Systems; its communication; and its use. These institutions can closely collaborate towards effective climate-informed AAS. The capacity of NMS to produce actionable information has some gaps, as does the agricultural sector's capacity to translate that information into AAS, communicate it, and use it to manage risk. These gaps are mutually reinforcing and best addressed in parallel. Both the Rwanda and Senegal cases included significant capacity development, both at national levels and more local levels, as with the MWGs in Senegal (Boxes 8.1 and 8.2).

Improving the technical capacity of NMS is an important step towards ensuring that climate information is relevant, salient, and legitimate. For example, NMS must improve their capacity to understand agricultural users' needs. Similarly, public extension agencies require capacity building that targets their ability to translate climate information into useful agri-advisories. The capacity of Meteo Rwanda was strengthened in the Rwanda Climate Services for Agriculture Project (RCSA) partly by using the Maproom portal, which is a product of the Enhancing National Services initiative (Dinku et al., 2018). Maprooms provide access to high-resolution climate information and products such as the season start, the risk of dry spells, and extreme rainfall events in the growing season. In the Rwanda project (Box 8.1), the Maproom is made available through Meteo Rwanda and benefits farmers indirectly through extension personnel accessing the portal, which includes the formatted graphs used in the PICSA process. Two of Meteo Rwanda's Maproom tools are aimed at government decision-makers who were trained in their use during workshops. The positive benefits for farmers include the provision of a maize-hybrid seed that was better suited to the local climate, and the pumping of water into a reservoir to offer supplemental irrigation to farmers, protecting them from prolonged dry spells.

A similar effort to improve technical capacity involves the Colombian meteorological service, the Instituto de Hidrología, Meteorología y Estudios Ambientales, (IDEAM) and its goal to improve co-production of climate information for the agricultural sector. It involved the implementation of the CS platform AClimate Colombia, which is available to farmer organisations like the National Federation of Rice Growers (Fedearroz) and the National Federation of Cereal, Legume and Soy Growers, (Fenalce) and to the Ministry of Agriculture and Rural Development. Based on the AClimate Colombia platform, Fedearroz co-designed a climate information portal to support farmers in climate-smart decision-making. The collaboration between farmer organisations, meteorological services, and ministries in co-designing and co-creating services has increased the capacity of each and extended the reach of these services to more farmers (see Chapter 6 for further details on AClimate Colombia).

8.7 Key Action 5: Embedding Services in a Sustainable and Enabling Policy, Governance, and Resourcing Environment

Effective institutional arrangements and accountable governance processes are vital to sustaining demand-led, effective, equitable services (Vaughan & Dessai, 2014). They should be developed to include private-sector actors, continued co-production, monitoring, evaluation, and learning. Relevant public-sector institutions can be sustainably supported through a combination of public investment and private-sector business models that are appropriate for each country's context. Influencing policy is a lengthy process that often extends beyond the lifetime of projects; it is, however, an important aspect of ensuring that CS and their impacts are sustained and that there is ownership over the policies and governance arrangements. The National Framework for Climate Services (NFCS) is the national-level implementation of the Global Framework for Climate Services and goes through several stages of planning and consultation before being launched, all to provide advanced CS to all sectors in each country. Senegal has launched its NFCS, which is expected to provide the policy framework and political buy-in necessary to support and sustain CS across all sectors. This high-level approach to influencing the availability and sustainability of CS is likely to manifest throughout the next few years, contributing to the enabling environment of other CS-based endeavours.

Sustaining CS beyond a project-by-project basis is a common problem that can be addressed from project design (Steynor et al., 2016; Vogel et al., 2019). There are several approaches to increasing services' sustainability, including investing in public–private partnerships that feature some element of sales in their supply of CS. Several such partnerships in Senegal are evident between the Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM), the country's NMS, and four private companies: myAgro, Jokalante, the Senegalese Agricultural Insurance Company, and MLouma. The partnerships aim to design and disseminate tailored CS through multiple approaches including the bundling of NMS climate information with fertiliser, improved seeds, and crop insurance; a subscription service for NMS-based CS; and in the case of the partnership with Jokalante, both bundling and a subscription service (Ouédraogo et al., 2020). Other public–private partnerships in the CINSERE project include collaboration between

ANACIM and the mobile phone companies Tigo and Orange to create a climate-information platform that provides specific information for fishing, agriculture, and livestock.

A strong enabling environment is essential for CS to scale and impact farmers' decisions and livelihoods and involves investment in requirements, including the capacity of institutions and farmers, institutional networking and governance arrangements, and digital infrastructure (Figure 8.1). In each country, these required investments will differ in starting points and thus the gap to be filled. The initial costs of filling major capacity gaps can be high but decrease with time. Costs per farmer also decline as services are scaled up. The nuanced estimation of investments required is difficult to generalise across contexts. A recent estimation by Ferdinand et al. (2021) in their blueprint for investment in scaling digital agroclimatic advisories suggested that a global upfront investment of US$2.2–7.5 billion is needed to reach 300 million producers. The blueprint notes that costs will be vastly different in each context.

The costs associated with the RCSA project provide a context-specific example; although this cannot be generalised across regions, this example generates a ballpark figure indicating where investments might fall. The project invested US$5 million over four years, with roughly 30 percent for strengthening farmers' capacity through agricultural extension; 20 percent for strengthening NMS capacity to provide actionable information; 10 percent for broadcast media and mobile phone delivery channels; 5 percent for strengthening climate-risk management capacity of national and local government; and the remainder for project management, monitoring and evaluation, and indirect costs. Based on the estimated US$3.9 million increase in net annual farm income from crops, attributed to the use of CS and aggregated across the 113 000 farmers who participated in participatory delivery channels, the benefit–cost ratio was 3:1 when considering the annual total project investment. In addition to costs decreasing after initial investments, costs will also vary according to the capacity and gaps evident in different contexts. For example, in Rwanda, donor investment required embedding capacity in the public sector, while in Senegal, CINSERE focused on the private sector and mobilising investment, given there were limited opportunities or capacity to engage the public sector.

8.8 Way Forward

Paired with agri-advisories, CS contribute to managing agricultural climate risk for smallholder farmers. Scaling out CS is an essential element of helping farmers to make climate-smart decisions that both capitalise on opportunity and avoid loss. Based on several projects across Latin America, Africa, and Asia, we recommend that investment in ICT-enabled CS in the future should consider some key facets that may contribute to scaling impactful, sustained services. These facets include investing in farmers' capacity, bundling CS with agri-advisories and other services, investing in institutional capacity, exploiting digital innovation as part of a diverse delivery strategy, and embedding services in a sustainable and enabling environment in terms of policy and resources. Strong partnerships (Chapter 16) are key to achieving and sustaining impact in CS.

The challenges and opportunities around climate-risk management for smallholders are context-specific and often require a concerted effort to establish how farmers operate in their circumstances before suitable strategies can be pursued. Institutional and political differences across countries and regions must also be considered in designing CS interventions. There is growing evidence that CS can improve farmers' yields, income, and well-being. We must continue to build the evidence base of CS and document quantifiable impacts, in whichever form they manifest, to show which types of information are valuable to farmers in which contexts. This goal is in line with heightened efforts in service monitoring and evaluation to assess impacts and benefits for target end users.

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9

Expansion of Plant-Based Meat and Its Impacts on Climate and Food Security

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Highlights

- To meet climate targets, a shift to low-emission diets that also support health and sustainability is necessary.
- A high-impact target is to reduce red meat consumption by 50 percent by 2030 in high- and middle-income countries based on the 2019 EAT-Lancet diet.
- Actions to reduce animal-based meat consumption (Table 9.1) could reduce dietary emissions by 3–8 billion tonnes of carbon dioxide equivalent per year.
- Scaling up plant-based meat (PBM) will require viable products, low costs, effective public policy to catalyse change, and strong markets.
- The priority actions are to facilitate consumer behavioural change for large segments of populations, promote policy targets and actions for reduced-meat diets in high- and middle-income countries, use public–private finance to improve alternative meat product nutrition and sustainability, and enhance affordable technology and business options.

9.1 Introduction

Scenario analysis shows that shifting diets to foods with lower emissions is necessary to meet climate-change mitigation goals, while also improving food systems' health, nutrition, and sustainability (Clark et al., 2020). Reducing demand for animal-sourced foods has received particular attention, as livestock contribute the majority of global food emissions and animal products have the highest greenhouse gas (GHG) emissions per kilogram among food products (Poore & Nemecek, 2018). Consumer interest in meat alternatives is also on the rise (He et al., 2020).

The rapid growth of innovations to reduce animal-based meat emissions has drawn attention to the potential for large-scale transformation of food systems. In

Table 9.1. *Dietary choices that reduce meat-related emissions*

Practice	Reduced frequency or amount of meat consumption	Lower-emission meat	Meat analogues	Plant-based, meat-free diets
What is it?	Regularly forgoing meat. Reduced meat waste.	Lower-emission meats, e.g., eating poultry, molluscs, or forage fish instead of beef; beef produced with lower emissions. Reduced meat loss in the supply chain.	Plant, mycoprotein, and cell-based foods that mimic meat, usually targeting meat consumers.	A vegan diet, i.e., no animal products; a vegetarian diet, i.e., no meat but includes animal products such as milk or eggs.
Status	Around 40 percent of the global population identify as flexitarian; 54 percent of these are under 30 years old, 34 percent are over 60.[1]	From 1990 to 2013, global poultry production increased by 165 percent, while global beef production increased by 23 percent.[2]	The worldwide PBM market was worth US$5.6 billion in 2020; it is forecast to reach US$14.9 billion by 2027.[3]	2–6 percent of the global population is vegetarian or vegan; India has the highest percentage of vegetarians, around 40 percent.[4]
Examples of efforts to scale up	Meatless day movements, e.g., Meatless Monday, and sustainable city policies, e.g., Ghent En Garde.	Public health campaigns. Adoption of cattle-feed inhibitors, e.g., JBS, the world's largest meat processor, will use Bovaer to reduce beef emissions.	Beyond Burger, Impossible Burger, Quorn, Mosa Meat, Memphis Meats, and Avant Meats.	Grassroots advocacy, e.g., People for the Ethical Treatment of Animals.

Challenges to wider adoption	Current dietary habits and identity, nutritional concerns, and a lack of awareness.	Current dietary habits and identity, motivation to reduce emissions, availability or cost of technical options, incentives for the adoption of mitigation practices, and nascent technology.	High production costs, particularly in cell-based meat, and retail price; nutritional value, taste, and sensory experience; market availability; the intensity of water and energy use in production; and nascent technology.	Current dietary habits and identity, nutritional concerns, and a lack of awareness.
Low emissions development implications	3–6 GT CO_2e avoided per year.[5]	Reduction of around 3.5 GT CO_2e. Substituting chicken for beef reduces emissions by 89 percent.	89–90 percent reduction of GHG emissions for Impossible Burger and Beyond Burger. Also depends on the substitution level.	4–8 GT CO_2e avoided per year.[5]

[1] Ho (2021).
[2] Ritchie & Roser (2017).
[3] GlobeNewswire (2021).
[4] Hargreaves et al. (2021).
[5] Schiermeier (2019).

this chapter, we review the state of the shift to decrease animal-based meat consumption and what is needed to achieve large-scale impacts. We give special attention to plant-based meat (PBM), a market attracting significant investment along with other plant-based proteins like dairy. In high-income countries, PBM can provide a substitute for animal-based meat, and in low- and middle-income countries (LMICs), it can help shift diet trajectories to avoid unhealthy US- or European-style meat consumption levels (Good Food Institute, 2021). We conclude with recommended actions.

9.2 Options for Reducing Meat Consumption and Climate Impacts

New technology has enabled the development of PBM analogues that more accurately mimic animal products compared to traditional substitutes like tofu. The main ingredients of PBM are plant proteins, such as soy, pea, potato, rice, mung bean, wheat, or fungus; fats, such as canola, coconut, soybean, cocoa, or sunflower oil; and small quantities of vitamins, such as B1, B2, B6, B12, zinc, and iron, alongside ingredients with binding, nutritional, sensory, or food-safety qualities. The technologies underlying PBM convert already edible protein into meat-like textures.

In terms of nutrition, PBM is designed to be nominally similar to meat. A comparison of PBM with other meat and mycoprotein products showed PBM was comparable to beef and pork across most nutritional elements, although lower in total fat and vitamins (Rubio et al., 2020). A more in-depth study, however, indicated that 90 percent of 190 metabolites differed in grass-fed beef and high-quality PBM (Van Vliet et al., 2021). Additionally, PBM is a highly processed food.

Dietary change can significantly reduce emissions, with a technical mitigation potential of 2.7–6.4 billion tonnes of carbon dioxide equivalent (GT CO_2e) per year and economic potential of 1.8–3.4 GT CO_2e per year at US$20–100 per tonne of carbon dioxide (Schiermeier, 2019). Transitioning to dietary standards such as the EAT-Lancet diet, which relies on more plant-based food, will reduce food system emissions by 70 percent by 2050 (Springman et al., 2016). Four behaviours cut emissions from animal-sourced foods (Table 9.1):

- Meat consumption remains, though the frequency or amount of meat consumed decreases.
- Consumption is shifted to lower-emission meats, such as from beef to chicken, or value chain food loss is diminished.
- Meat substitutes that mimic the nutritional and sensory aspects of meat are used.
- Meat-free, plant-based diets are adopted.

9.3 Impacts of Plant-Based Meat on Emissions and Sustainability Co-Benefits

Meat consistently has a larger environmental impact than other food items per kilogram of product or protein, with beef having the highest overall impact. In a review of 40 food products representing 90 percent of global protein and calorie consumption, GHG emissions from beef were 15 times higher than rice, the highest-emission crop, and 20 times higher than tofu (Poore & Nemececk, 2018) (Figure 9.1). Producing beef used 20 times more land than nuts or pulses, risking higher levels of land degradation, biodiversity loss, and land-use change. Substituting other meats, dairy, or plant-based proteins for beef offers the highest reduction in emissions per kilogram of food and per 100 grams of protein (Poore & Nemececk, 2018).

By contrast, PBMs use 47–99 percent less land and 72–99 percent less water, emit 30–90 percent fewer GHGs, and cause 51–91 percent less aquatic nutrient pollution than conventional meat (GFI, 2019, cited in Sha et al., 2021). Life-cycle analyses of meat and meat alternatives (Figure 9.2) show all products had significantly lower impacts than beef, with the exception of cell-based meat, which requires high energy inputs. The emissions and energy used for PBM were higher than for chicken (Rubio et al., 2020). Seafood was not examined in this analysis

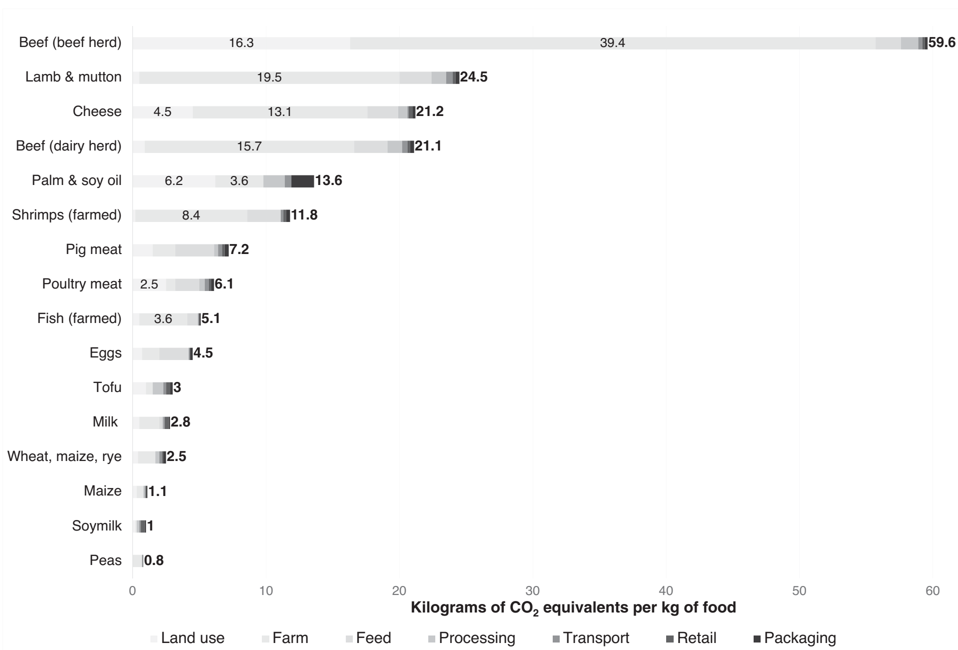

Figure 9.1 Kilograms of carbon dioxide equivalent per kilogram of food, including non-carbon dioxide greenhouse gases. Total emissions are indicated at the end of each row (Poore & Nemecek, 2018).

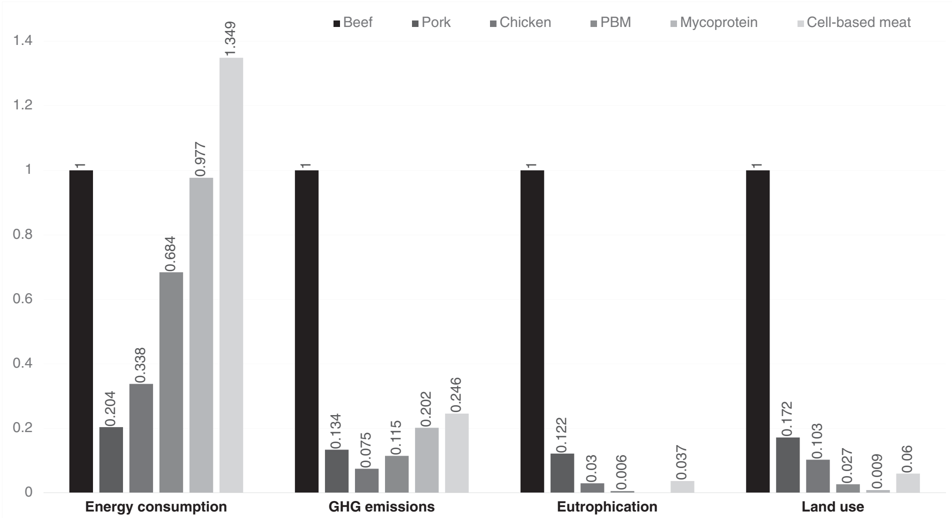

Figure 9.2 Comparison of the environmental impact of animal-based meat and meat analogues. Data are normalised to the impact of beef production (beef = 1). Eutrophication does not include mycoprotein.
Adapted from Rubio et al. (2020).

but is expected to have high impacts where deforestation occurs, for example, shrimp farming in mangrove regions, and similar or lower impacts than pork and chicken, depending on the level of inputs.

The primary protein ingredient, packaging, and energy used for processing are the largest contributors of life-cycle emissions of PBM, and choices about these inputs strongly affect PBM's GHG footprint (Heller & Keoleian, 2018). For example, PBM's emissions are lower where primary protein ingredients are deforestation-free, processing technology is energy-efficient, energy is renewable, and by-products and waste are used (Sha et al., 2021).

Projections of PBM's global impacts indicate the possibility of substantial mitigation outcomes (Kozicka et al., forthcoming). A 25 percent substitution rate of PBM for its respective meat will lead to an emission reduction of 1 GT CO_2e per year by 2050. Predictably, substituting PBM for beef will have the highest impact. If the land released through the shift away from beef production is used as forest, the mitigation impact of PBM is doubled. The potential for biodiversity co-benefits is significant due to the reduced area of cultivated land and a lower pressure for expansion into forests.

With respect to social impacts, PBM will likely negatively affect livestock farmers, as will any intervention to reduce meat consumption. High-quality PBM is also best suited to large-scale production to achieve economies of scale; business feasibility is discussed below. Industrial-scale PBM may lead to equity trade-offs if it displaces small-scale producers and farmers.

9.4 Priorities for Driving Change at Scale

The success of PBM's mitigation impacts will depend on how much PBM lessens animal-meat consumption (Wilkes, 2021). Reductions can occur via substitutions for current meat consumption or avoiding future higher levels of animal-meat consumption, for example in LMICs. Rising consumption of PBM is being driven by increased awareness of meat's impacts on health, the environment, and animal welfare, alongside the rising popularity of vegetarian and flexitarian diets, particularly among urban people under 30. Yet scaling production and consumption of PBM is challenging due to the current high cost of meat alternatives, a lack of easy and appealing choices, the social norms around animal-based meat, and political sensitivity about promoting meat alternatives (Kiff et al., 2016; Park, 2018).

To meet future climate goals, EAT-Lancet's 2030 recommendation to halve red meat consumption is a useful target (Willett et al., 2019). The target can be applied to reducing consumption where the future per-capita consumption of meat exceeds 80 kilograms per year, the current average in industrialised countries, and in cities. In 2050, 80 percent of global food consumption is expected to occur in cities.

The benefits of reducing meat consumption are clearest in high-income countries and urban areas of middle-income countries, where high meat consumption has led to negative nutritional and environmental consequences. Among rural populations in low-income countries, PBM may play a more important role as an additional protein source and business option but not as a substitute for meat, as livestock often play essential economic, social, and nutritional roles and meat consumption remains far below that of high-income-countries.

Below we look at the enabling conditions for reducing large-scale animal-meat consumption, namely influencing consumer behaviour, policy, industry and investment trends, markets, and business feasibility. We conclude with priorities for sustainable pathways towards low-emission diets.

9.5 Consumer Behaviour

Consumers will be more likely to reduce animal-based meat consumption when innovations for PBM address people's enjoyment of eating meat, their worries about the nutritional value of a vegetarian diet, the inconvenience of preparing vegetarian food, the lack of restaurant options, the attitudes of their family and friends, and the perceived higher costs of vegetarianism (He et al., 2020). Attitudes towards meat and meat alternatives can also differ by gender, age, identity, culture, and other factors. For example, plant-based consumers are less willing than omnivores to try cell-based meats (Rubio et al., 2020).

Appealing to consumers' need for low-cost, easy, and appealing choices that align with social norms is a priority for enabling diet shifts (Park, 2019). Measures include making products more visible in shops or menus; creating affordable portion sizes; enabling substitution of a product, for example, blending plant-based ingredients into burgers; avoiding segregating or labelling plant-based foods as niche or restrictive; and integrating them into social norms (Park, 2019). Targeting mass markets – as the brands Impossible Foods and Beyond Meat have done through fast-food chains and retail stores – seems to be effective, as do celebrity endorsements. Future technologies may alleviate some constraints, like sensory appeal and cost.

9.6 Policy

Policy measures include funding for novel meat research and development, subsidies, restricting advertising for red or processed meat, carbon footprint labelling and certification, taxing high-carbon products, economic development plans, and health and sustainable food campaigns; however, all of these measures vary in efficacy (Kiff et al., 2016). Better information about the relative climate impacts of food products, for example, can inform consumers' choices, while policies for PBM nutritional standards may allay concerns about nutritional value. A number of policies are already emerging, with some countries having proposed or piloted meat taxes or conducted public health campaigns to eat less meat. Taxes on food, however, are politically sensitive and can be socially regressive, while health campaign results have been mixed (Kiff et al., 2016; Wilkes, 2021). In 2021, Denmark committed €168 million to implement a national action plan for plant-based foods with production and sale targets (GFI, 2021).

9.7 Industry and Investment Trends

Investment in PBMs and other alternatives to meat and dairy products has skyrocketed since the late 2010s, making 2020 a record year for alternative-protein investment. Plant-based protein has seen the biggest investment in the decade to 2020 (Gaan et al., 2021). Considerable investment is flowing to PBM research and development. In 2020, Beyond Burger spent over US$30 million to improve their

Table 9.2. *Comparison of investment and market status for different types of meat analogues*

Technology	Invested capital 2010–2020 and market status
Plant-based	US$4.4 billion Plant-based meat and dairy products are available to consumers around the world in supermarkets and restaurants. Start-ups can be found globally.
Cultivated	US$0.49 billion Products are not on the shelf, but the first consumer testing has begun. The technology is rapidly advancing and beginning to gain investment.
Fermented mycoproteins	US$1 billion Fermented products are mainly marketed as additives for plant-based products. Impossible Foods uses a fermentation process to create heme proteins.

product line, while Impossible Foods raised over US$700 million for product development research. Table 9.2 summarises the total investment and state of the PBM industry compared to cultivated meat and mycoprotein additives such as heme – a molecule containing iron that is found in plants and the blood of animals. These investments reflect a level of consumer interest in PBM that few thought possible a decade ago.

9.8 Markets

Global sales of PBM grew by 24 percent, or US$4.2 billion, in 2020, while plant-based milk sales rose by 4 percent or US$16.9 billion (Gaan et al., 2021). While the largest markets for PBM and dairy are in higher-income countries, markets in LMICs have expanded since 2020, catalysed in part by COVID-19-related meat shortages. Youths are helping to drive the shift towards plant-based diets as the biggest consumers of PBM. Asia has one of the fastest-growing PBM markets, while in China the PBM market increased by 190 percent in 2014–19 to around US$1 billion (Zhiyan Consulting Group, 2020).

9.9 Business Feasibility

Analysis of the business feasibility of expanding PBM in LMICs, using Brazil, China, Nigeria, and Vietnam as case studies (Box 9.1), found that despite similar

Box 9.1
Plant-Based Meat and Dairy Company Case Studies

VeggieVictory, Nigeria
Global investors from the United States and Europe backed Nigeria's first PBM start-up, VeggieVictory. Africa is increasingly seen as a new frontier for plant-based protein investment, with a rapidly growing economy and a population seeking more dairy and meat. As well as expanding into US and European markets, VeggieVictory is growing in neighbouring West African countries and aims to focus on Africa through its restaurant in Lagos.

NotCo
The plant-based dairy product sector is growing rapidly, and innovation is driving investment. NotCo, a food-technology company producing plant-based milk and meat replacements, has seen huge investment since 2019, when the Craftory and Bezos Expeditions invested US$30 million in the company. In 2021, NotCo received US$235 million from thirteen investors. NotCo's attraction to investors is its patented artificial intelligence software that analyses an animal-based product at a molecular level and then generates recipes for NotCo chefs to try. NotCo sells plant-based burgers, ice cream, and mayonnaise throughout Latin America. In early 2021, the company started selling milk in several West Coast stores in the United States and is expanding distribution through Whole Foods. NotCo plans to grow its market in the United States, Canada, Europe, and Asia.

The New, Brazil
The New is one of Latin America's fastest-growing PBM brands and is attracting big-name investors. With over 700 retail locations after less than two years, The New's PBM products are gluten- and soy-free, making The New one of the few large-scale PBM brands to avoid these common allergens.

Oatly, Singapore
Oatly, a Swedish-based oat milk company, entered the Asian market by partnering with Singapore-based Yeo Hiap Seng, or Yeo's, and Starbucks. In late 2020, Starbucks launched a promotion for plant-based drinks and foods on its menus in Asia. Starbucks' promotion aimed to expand the Asian market using locally relevant recipes. In early 2021, Oatly and Yeo's jointly invested US$30 million in a production facility to service the wider Asian market, initiating the first plant-based dairy outside the United States or Europe.

production processes among countries, costs and revenues differed significantly (Kashi et al., 2021). Upfront capital was not a major constraint, as investment costs were small relative to operating costs. The cost of retrofitting a meat processing facility to produce PBM is nevertheless significant – around

US$63 million – indicating that only entities with access to significant capital are likely to produce high-quality meat analogues in the near future. Market price and sales volume were the main sources of risk, particularly where there was no current PBM market, for example in Nigeria. Off-take contracts and joint public investment could mitigate this risk. There is a need for better market research on revenue and integrated cost-benefit analysis of PBM that includes social and environmental impacts. Currently, PBM remains more expensive than animal-based meat, although PBM costs will likely decrease with future technology. In Brazil, China, Vietnam, and Nigeria, PBM was two to six times more expensive than conventional meat.

Based on these behavioural, policy, market, and business conditions, a number of priority actions would support consumers' shift to lower-emission PBM in high-income countries and middle-income cities. These include the following (Park, 2019; Steiner et al., 2020):

- Support labelling and certification of animal-based meat and other protein sources for GHG emissions, health, and other environmental factors, to raise consumer awareness.
- Develop incentives, enterprise support, and public–private investment for innovation and production of alternative meat and protein sources that are true, nutritional substitutes for meat, with smaller environmental footprints. Provide technical information and examples of investment to investors.
- Develop diverse, open-source technological options and business models that enable cost reduction for large- and small-scale producers.
- Promote awareness campaigns and social movements via science-informed celebrities, champions, and the media, driving alternative discourses, e.g., Greta Thunberg's 'School Strike for the Climate' movement, the C40 campaign, and the Meatless Monday movement.
- Increase the number of plant-based meat and dairy options on menus and in canteens and supermarkets. Display products prominently, and avoid segregating products or using branding or labelling that may alienate meat eaters. Address assumptions that meat is necessary for health and nutrition.
- Tax high-emission products, e.g., ruminant meat and dairy, or tax producers of these products to incentivise reformulation, such as by amending practices to reduce the carbon footprint per portion; subsidise innovation.
- Highlight social trends that normalise PBM consumption.
- Prioritise the production of PBM that can offer simple substitutions of high-volume, high-emission food items such as ground beef.
- Incentivise afforestation of lands released from feed production.

- In low-income countries, the priorities are to support investment in local industry development and research and to develop affordable, nutritious, sustainable forms of meat and protein alternatives.

9.10 Way Forward

Expected growth in meat and dairy consumption in the coming decades will exacerbate climate change, even if farm-level measures lessen GHG emissions. A transition to low-emission diets based on decreasing consumption of livestock products now in high-income countries or in LMICs in the future can accelerate progress towards global climate targets. Reducing beef consumption is a priority due to its high emissions impact. Alternative meat products are one strategy to help this transition, with PBM as the most prominent, quickly growing commercial option available. However, animal-based meat will continue to be important in some areas for its nutritional and economic roles.

Assessing emissions drivers and other environmental and social impacts of meat alternatives can inform future decision-making about sustainable PBM and its climate impact. In the next ten years, reducing land-use change and fossil fuels in alternative meat production will be a priority for minimising climate impacts. Monitoring PBM in diets can verify whether meat substitution is occurring. A more comprehensive analysis of the sustainability impacts of PBM is needed to assess trade-offs, including social dimensions. Comparisons must take better account of the different nutritional values and roles of PBM in diets to understand health impacts.

To achieve the impacts of PBM implemented at large scales will require viable products, effective public policy to catalyse change, and strong markets to expand transitions. Priority actions are to (1) improve the cost, ease, and appeal of alternative meat products for large population segments in all countries; (2) promote policy targets and actions for reduced-meat diets in high- and middle-income countries with excessive meat consumption; (3) use public–private finance to drive more rapid improvements in alternative meat products and their sustainability; and (4) enhance the availability of open-source technologies and the development of business opportunities for alternative meat production in LMICs, including large-scale and small-scale production (Figure 9.3). Research and development can enable the production of meat alternatives that are affordable, nutritious, safe, and appealing to the senses; that are easy to substitute for animal-based meat; that have low environmental impacts; and that are socially just. Improved nutrition and health impacts are foundational to ensure that PBM does not exacerbate existing dietary trends, such as excessive sodium and fat consumption. A vision for achieving low-emission diets is summarised in Figure 9.4.

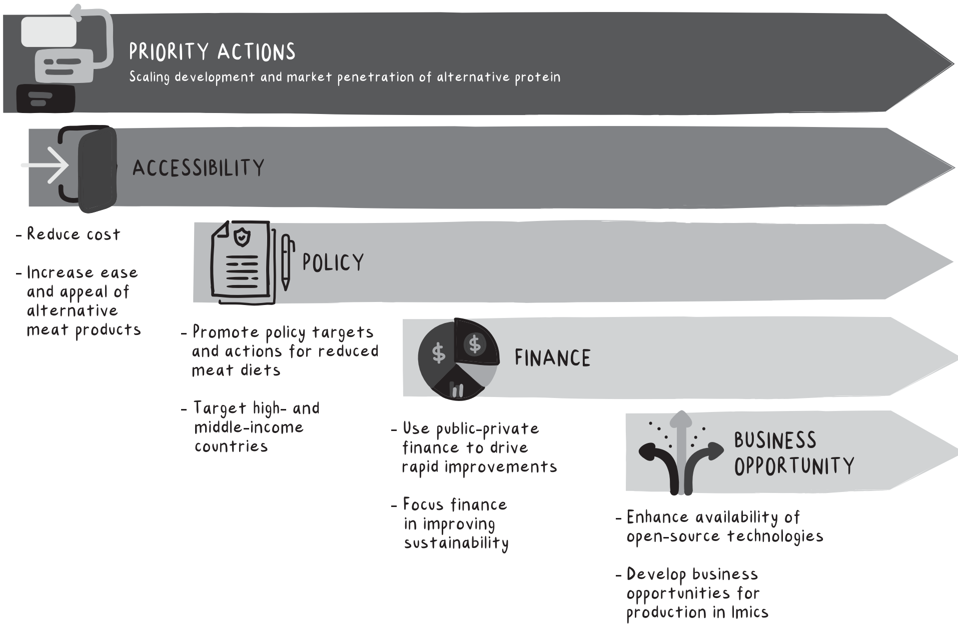

Figure 9.3 Priority actions to scale viable alternative meat products in all countries

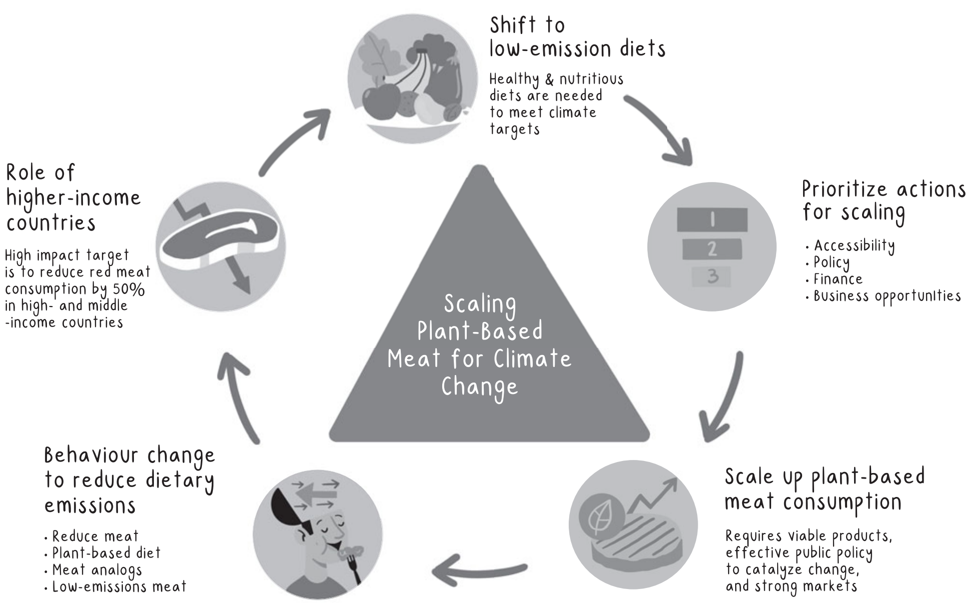

Figure 9.4 A vision for shifting to low-emission diets

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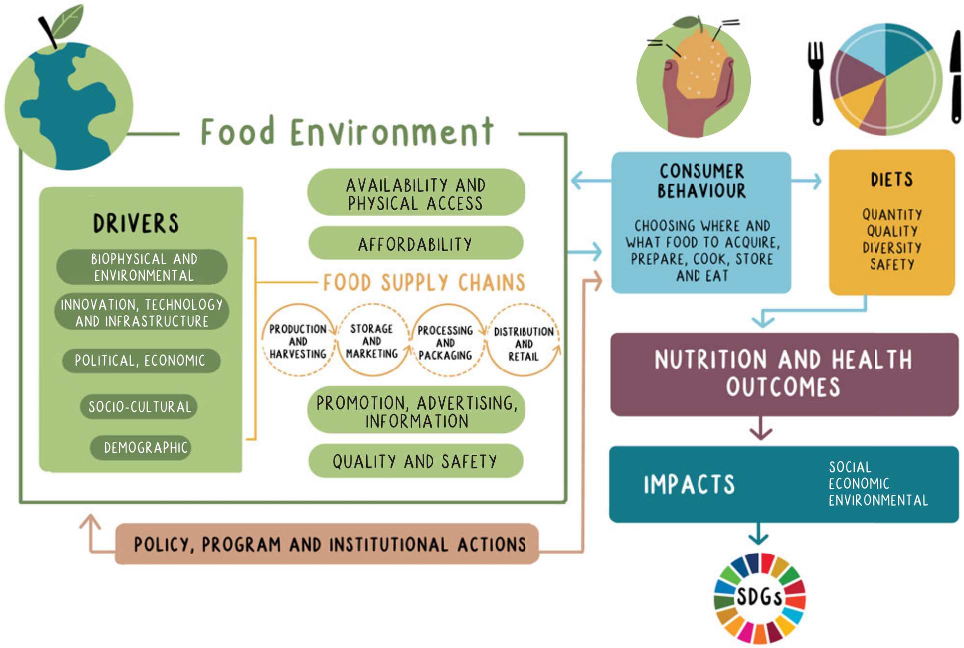


Figure 1.1 The food system.
Adapted from The Impact of COVID-19 on Food Security and Nutrition by the UN Executive Office of the Secretary-General, ©2020 United Nations. Reprinted with the permission of the United Nations

Figure 2.1 The vision for a transformed food system

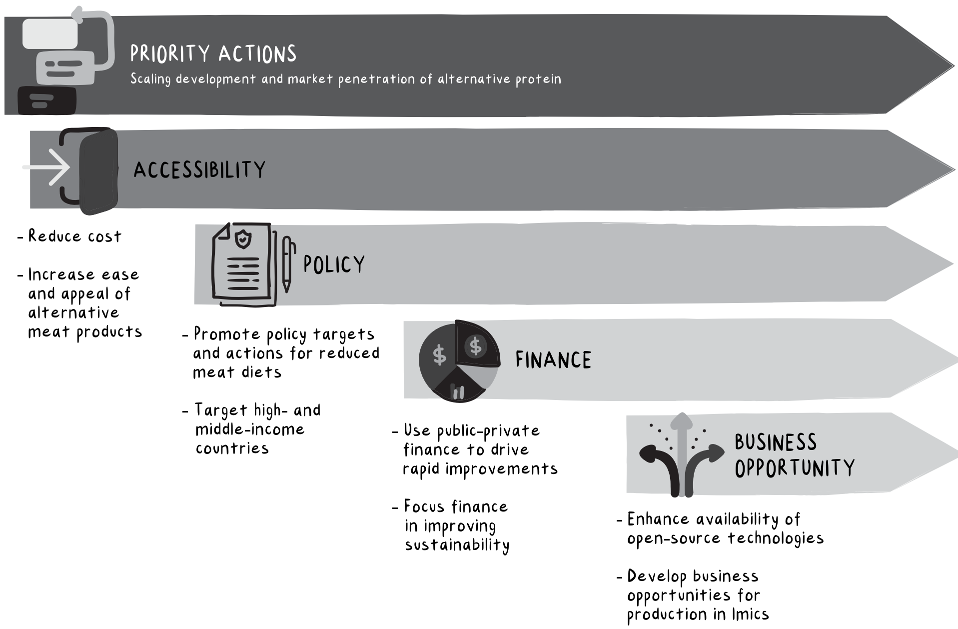


Figure 9.3 Priority actions to scale viable alternative meat products in all countries

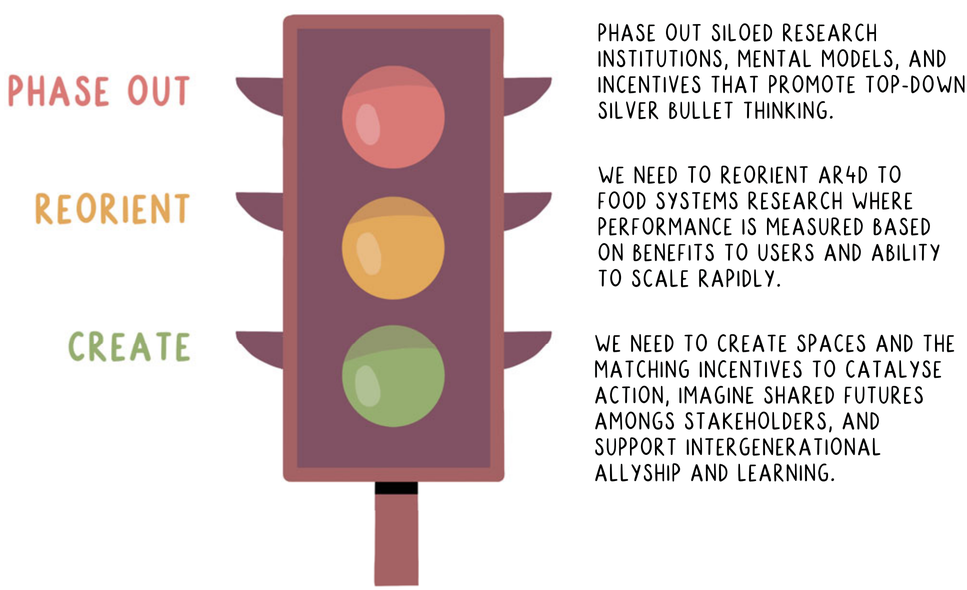


Figure 19.1 Create, reorient, phase out: The way forward for food-system transformation through research and innovation

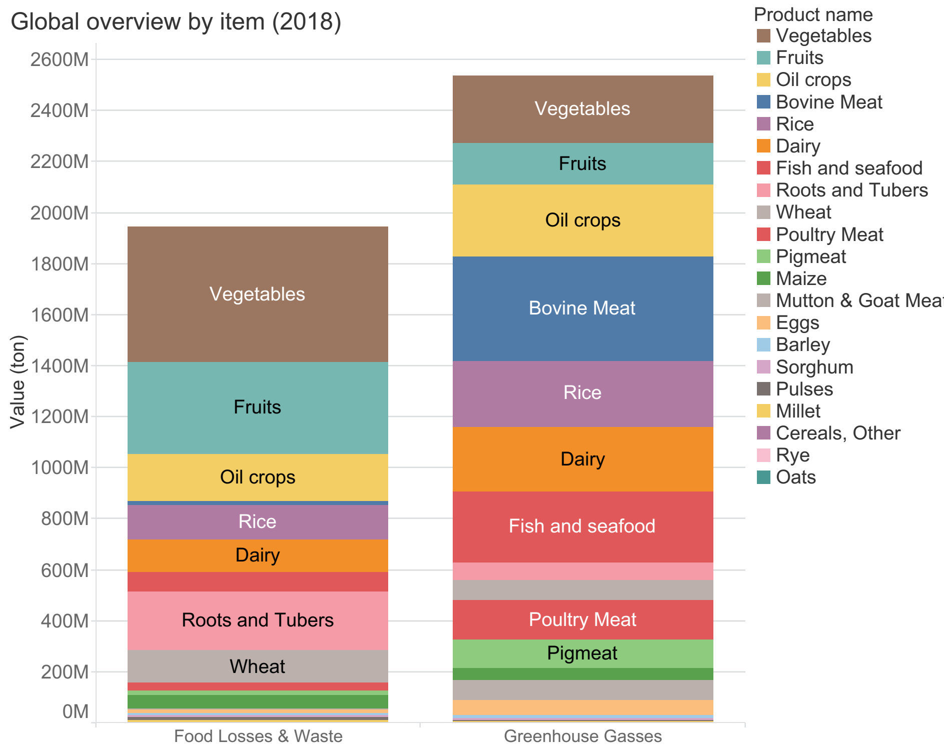


Figure 10.1 A global overview of food loss and waste in raw product equivalent, and associated greenhouse gas emissions in 2018

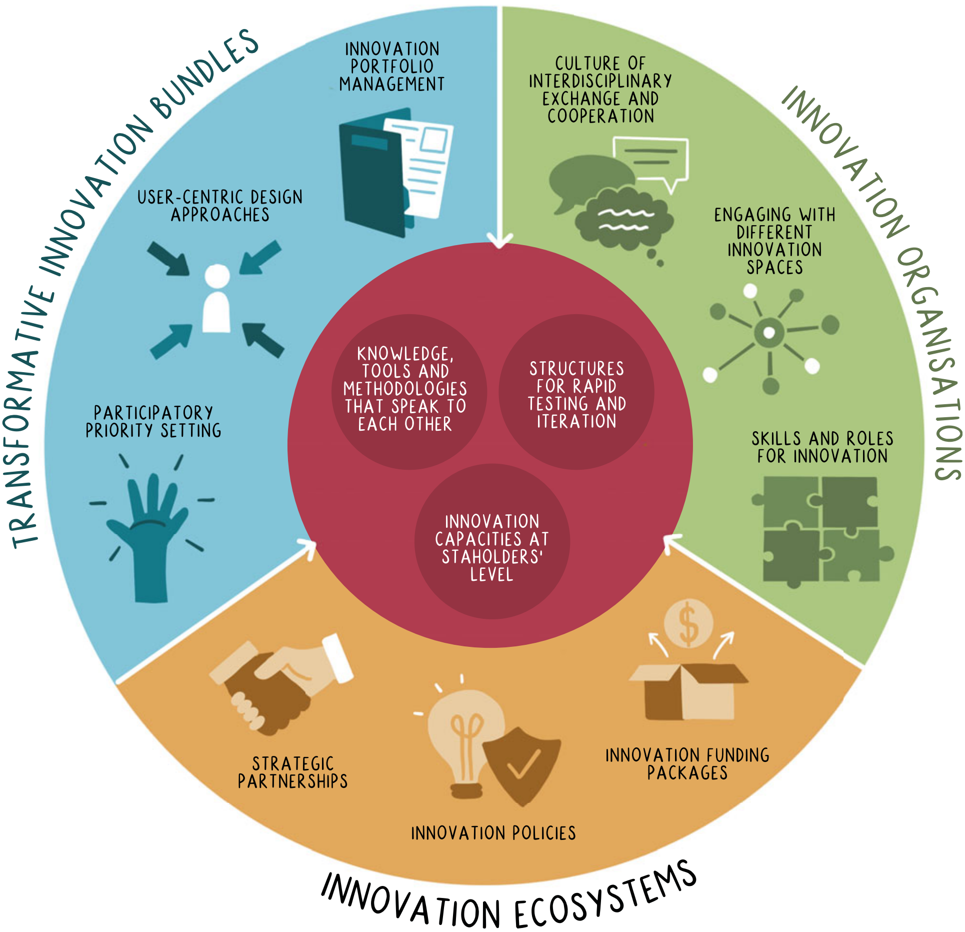


Figure 14.1 How an Open Innovation 2.0 System could look for research and innovation in development institutions

10

Reducing Greenhouse Gas Emissions by Reducing Food Loss and Waste

Value Chain Interventions from Farmer to Fork

JAN BROEZE, HEIKE AXMANN, BOB CASTELEIN, XUEZHEN GUO, BJOERNOLE SANDER, KATHERINE M. NELSON, REINER WASSMANN, AND NGUYEN VAN HUNG

Highlights

- Food loss and waste (FLW) strongly contribute to the climate impact of the food supply and impair food security.
- FLW and the associated climate impacts vary greatly among different types of adopted technology and value chain configurations. Solutions should be found per specific situation.
- FLW can be approached from a chain perspective; in many cases, reducing FLW at a certain chain stage is best achieved by interventions elsewhere along the chain.
- The Agro-Chain Greenhouse Gas Emissions (ACE) calculator supports the identification of FLW and greenhouse gas (GHG) emission hotspots along a chain, as well as estimating the net effects of interventions.
- FLW-reducing interventions mostly contribute to climate mitigations, as demonstrated for rice and various fruits and vegetables; however, some high-tech interventions may induce higher extra GHG emissions than can be mitigated by FLW reduction.

10.1 Introduction

Food loss and waste (FLW) are important contributors to food insecurity and have a considerable environmental impact by inducing extra crop production and post-harvest greenhouse gas (GHG) emissions. Emissions associated with FLW are responsible for 8–10 percent of anthropogenic GHG emissions, comparable to emissions from all global road transport (Guo et al., 2020; Lamb et al., 2021). Therefore, mitigating FLW and climate impact from food supply chains should be addressed coherently.

Mitigating FLW is a global priority. This chapter largely focuses on food loss (FL), although mitigating food waste (FW) is also crucial (Box 10.4). The United Nations Sustainable Development Goal (SDG) 12.3 – the ambition to significantly reduce FL along production and supply chains by 2030 – is supported by an increasing number of public- and private-sector stakeholders. Such efforts, however, should recognise trade-offs with other sustainability indicators such as climate change.

Most FL-reducing interventions will not only lower environmental impacts per unit of product available for consumption but also induce extra emissions, for example, through energy, fuel, and materials used for packaging. Estimating these trade-offs – and selecting interventions with the most positive balance accordingly – is far from easy but essential to best contribute to multiple SDGs. Moreover, barriers to implementation, in particular limited accessibility and availability, are persistent and should be addressed to realise sustainable food system transformations.

An important first step in shrinking FL with positive SDG trade-offs is identifying where action is needed. This chapter addresses the main actions necessary to address this challenge and scale a broadly supported, sustainable transition towards reduced FL. We discuss identifying loss and waste hotspots and examples of FL-reducing interventions in their wider food-system context. We discuss the required enabling environment and potential economic and policy voids, the relevant food system considerations needed for transformation, and the main policy implications.

10.2 Hotspot Analysis of Food Loss and Waste and Associated Greenhouse Gas Emissions

To design effective intervention strategies to reduce FL and associated GHG emissions, we need to identify and prioritise 'hotspot' regions, products, and supply chain stages. To set the right priorities, we assessed the worldwide hotspots of FLW and FLW-induced GHG emissions (Guo et al., 2020).[1] Our global hotspot analysis shows that in 2018, 29 percent of all food produced was lost or wasted. By volume, perishable fruits and vegetables account for almost half of the total FLW (Figure 10.1). Other items with high FLW volumes are roots and tubers, oil crops, and rice. In terms of FLW-associated GHG emissions, beef products are a major hotspot, despite not being an FLW hotspot in terms of volume. This reality reflects the high GHG-emission factors related to animal-based products, particularly beef.

Hotspots differ regionally; for example, in the two regions of Sub-Saharan Africa (SSA), and South and Southeast Asia, FL from post-harvest handling and distribution are higher than FW during the consumption stage. This situation

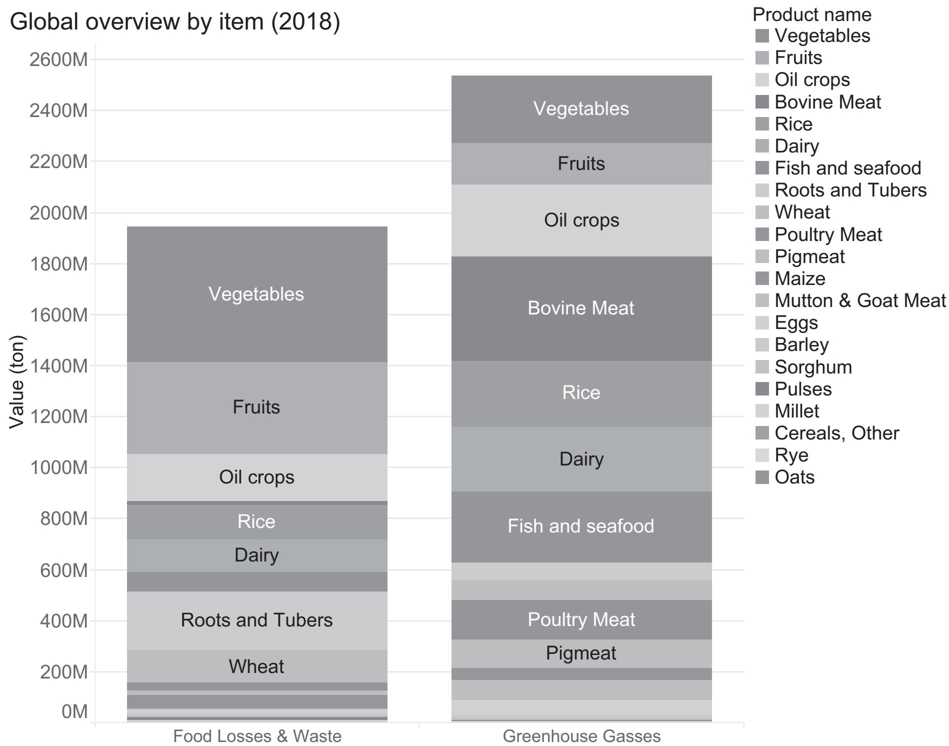


Figure 10.1 A global overview of food loss and waste in raw product equivalent, and associated greenhouse gas emissions in 2018

reflects the comparably poor post-harvest management and lack of infrastructure and technologies in those regions. Moreover, food is relatively expensive in developing countries compared to people's incomes, resulting in low consumer-level FW.

For SSA, roots and tubers are the largest hotspot for FLW and associated GHG emissions, whereas in South and Southeast Asia the hotspots are oil crops and rice. Losses mainly occur during harvesting, storage, and handling due to poor conditions and practices in the upstream chain. For both regions, rice involves high losses and emissions at their upstream chain stages but also has substantial losses and emissions at the distribution and consumer stages. Compared to other staple crops such as maize and wheat, rice produces two to five times more field-related GHG emissions (Poore & Nemecek, 2018). Therefore, rice warrants particular attention in the context of the 2030 target to significantly reduce losses in major supply chains where both GHG emissions and losses are high.

Most rice is grown in developing countries with relatively low average yields and high post-harvest losses. The loss of edible grain is considerably lower with

Box 10.1

Case Study: Rice Losses in Smallholder Farm Rice Supply Chains in Sub-Saharan Africa

Interventions on or near the farm – as a major upstream hotspot in most food chains – can have a major impact on overall FL and GHG emissions. However, including smallholder farmers in efforts to mitigate the climate impact of food supply chains in low- and middle-income countries can be a considerable challenge. Recent research into attainable intervention strategies for smallholder farmers shows the benefit of productivity-enhancing technology for farmers' incomes as well as a range of other food system outcomes, including environmental sustainability, food availability, and the socio-economic development of rural communities.

In a controlled experiment on smallholder rice farms in Nigeria, we measured the impact of mechanising farm activities (Castelein et al., 2021) (Figure 10.2). Results showed that switching to mechanised harvesting and threshing reduces harvest paddy losses from 9.6 percent to 0.9 percent, and increases threshing efficiency from 31.1 percent to 33.1 percent. An FL reduction – here defined as loss of the edible part of the crop – of almost one tonne (920 kg) can be achieved per farmer per harvest. After accounting for equipment costs, there is an associated income boost through yield increases and labour savings of approximately 16 percent, or US$400 (Table 10.1).

Mechanisation results in a net reduction of GHGs by 1 696 kilograms of carbon dioxide equivalent per hectare, even after accounting for emissions from the machinery itself. Scaling this impact to all rice farmers in Nigeria would reduce GHG emissions by 5.4 megatonnes of carbon dioxide equivalent. This case study shows how efficiently mechanisation can lessen environmental impact and FL, while increasing food production and farmer income.

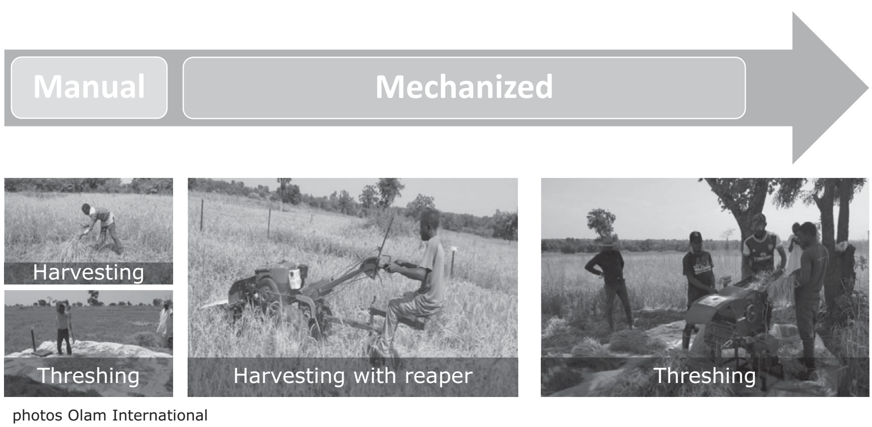


Figure 10.2 From manual to mechanised practices on Nigerian rice farms

Continued

Box 10.1 (cont.)

Table 10.1. *Impact of different intervention scenarios in smallholder rice farming*

Criteria	Baseline: Manual harvesting threshing	Scenario 1: Shift baseline to mechanised harvesting	Scenario 2: Shift baseline to mechanised threshing	Scenario 3: Mechanised harvesting and threshing
Loss reduction and profit increase ha^{-1} $year^{-1}$	-	299 kg US$126	180 kg US$75	479 kg US$202
Loss reduction and profit increase per farmer, olam $year^{-1}$ (1.92 ha)	-	575 kg US$243	346 kg US$146	921 kg US$389
Costs of buying machine	-	US$2 050 reaper	US$875 thresher	US$2 925
Labour hours saved ha^{-1} $year^{-1}$	-	144	62	206
GHG per kg produced paddy rice	4.4	4	4.1	3.7
Climate impact of mechanisation (emissions avoided in kg CO_2eq)				
Ha^{-1} $year^{-1}$	-	1 042	716	1 696

mechanisation. Retaining more grain results in overall lower emissions per unit of product, and, generally speaking, the value of these avoided losses covers the economic expense of mechanisation (Castelein et al., 2021; Gummert et al., 2020; Nguyen-Van-Hung et al., 2018). Likewise, plant breeding for high-yielding, short-duration, and stress-tolerant varieties is an investment in mitigation, alongside agronomic management interventions, despite not often being construed as such (Ortiz-Monasterio et al., 2010). These interventions provide considerable potential to improve food security and farmer livelihoods while reducing rice's current carbon footprint (Box 10.1).

10.3 Highlights of Other Case Studies

Potato Value Chain in SSA*:* In the smallholder potato value chain in Kenya, we evaluated farm-level interventions and their effect on the yields, losses along the chain, GHG emissions per unit food supplied to consumers, and the business case for farmers (Soethoudt & Castelein, 2021). Results show that mechanisation, adopting certified or clean seeds, and appropriate fertiliser and crop protection can reduce the yield gap and FL by 71 percent and GHG emissions per unit of marketed food by 51 percent, that is, the net effect of all interventions. Farmer income almost quadrupled. Mechanisation in particular significantly increases the yield per hectare and reduces crop damage – resulting in further rejections along the chain – even while inputs per hectare remain the same.

Export Chain for Dragon Fruit from Vietnam to Europe*:* 'Small' tropical fruit categories like dragon fruit are exported to other continents by air. With increasing volumes, however, alternative modalities with reduced GHG emissions are required, specifically reefer container transport. With the fruit collection system, however, the lengthy transportation phase results in high losses in the transportation and distribution phases. This not only leads to considerable losses but also substantial loss-associated GHG emissions. A third scenario that combines reefer containers for intercontinental transport with quick post-harvest refrigeration was identified as the best solution for FLW and GHG reduction (Table 10.2) (Axmann et al., 2021).

Increasing the Shelf Life of Cut Vegetables by Lowering the Cooling Temperatures*:* Through lowering the cooling temperature, the shelf life of cut vegetables is extended, thereby reducing FLW in retail (Broeze et al., 2019; see also Box 10.4). This results in less loss-associated GHG emissions but at the cost of additional energy use due to deeper cooling as well as a slightly extended

Table 10.2. *Food loss and waste and greenhouse gas emission results for different scenarios for transporting dragon fruit from Vietnam to Europe*

Scenario	Total losses along the chain (%)	Total GHG emissions per kilogram of fruit distributed (kg CO_2eq kg^{-1})
Traditional collection chain + air transport	15	26
Traditional collection chain + reefer container sea transport	44	24
Cooling in collection chain + reefer container sea transport	13	15

Table 10.3. *Food loss and waste and greenhouse gas emission results for different cooling temperatures for cut vegetables. GHG emissions are quantified as kg CO_2eq. per kg vegetable sold in retail.*

Scenario	Total losses along the chain (%)	Total GHG emissions (kg CO_2eq per kg vegetable sold in retail)
Reference: Storage at 7°C	11.8	0.53
Reduced storage temperature: 4°C	9.4	0.55

average shelf period. One case study seemingly shows a negative trade-off between FLW reduction and GHG emissions reduction (Table 10.3).

10.4 A Generic Approach for Analysing Food Loss and Waste and the Climate Impact of Reduction Interventions

The above case studies illustrate that FLW often has positive trade-offs on food supply climate impact. However, the last example demonstrates that negative trade-offs may also occur. The significance of the trade-offs will mainly depend on specific conditions of the case study, that is, the actual crop GHG intensity in the particular situation, specific post-harvest operations, and level of FLW reduction.

Such analyses are mainly facilitated by tools that identify hotspots and support analysis of the effects of FLW-reducing interventions on climate. This will aid the decision-making process for both the private sector and policymakers. Such decision-support tools need to comprehensively show emissions across the chain so that decisions can be made with accurate, complete information and contribute to progress towards a food-secure, climate-conscious future. Two such tools – developed by this chapter's authors – include the Agro-Chain GHG Emissions (ACE) calculator and a Carbon Foot (CF)-rice production calculator (Boxes 10.2 and 10.3).

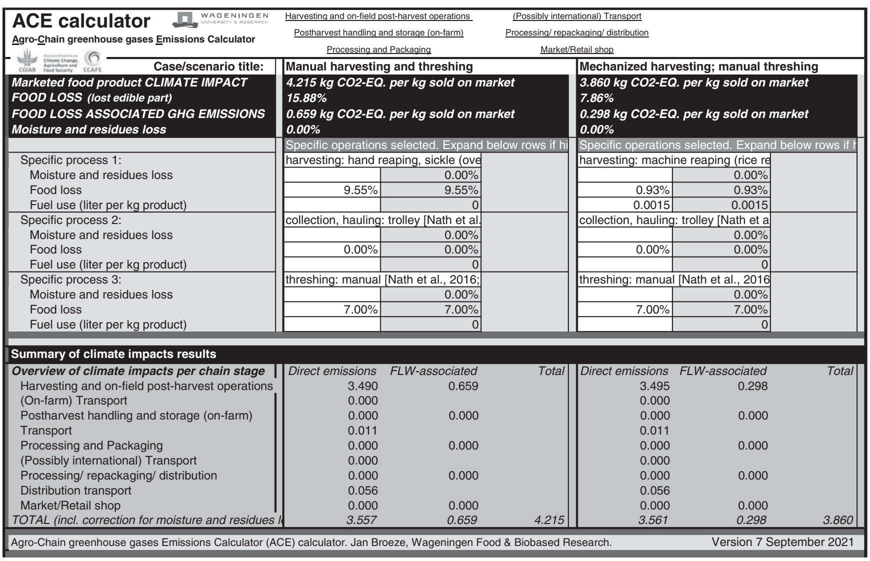
10.5 Food System Challenges

The rice case study raises the question of why farmers in SSA still primarily produce with manual labour and inferior inputs when the positive business case for other practices is clearly in place, with a relatively short time to impact (Daum & Birner, 2020). The case study findings highlight that the upfront costs are prohibitive to farmers, indicating that technology alone is not a sufficient solution; we must consider the food-system context in which the farmers operate, and how the availability and accessibility issues regarding inputs and equipment can be addressed.

Box 10.2

The Agro-Chain Greenhouse Gas Emissions Calculator: Assessing Agro-Chain Greenhouse Gas Emissions

In GHG accounting of food supply chains, losses in production and along the entire post-harvest chain must be addressed comprehensively, in order to assess trade-offs between FL and GHG emissions. For that the Agro-Chain GHG Emissions (ACE) calculator[1] combines emissions and losses per chain stage from production to the consumer to estimate total GHG emissions per unit of sold product, as well as FL and GHG emission hotspots along the chain (Figure 10.3). Since the calculator is fitted with average crop GHG intensity data and FL estimates per chain stage specified for seven global regions and commodity groups, estimates can be made with limited primary data (Porter et al., 2016). When available, data from direct measurements, expert estimates, or reference literature can make estimates more specific. Technology-specific data can be inserted for comparing different scenarios.



Case/scenario title:	Manual harvesting and threshing		Mechanized harvesting; manual threshing	
Marketed food product CLIMATE IMPACT	4.215 kg CO2-EQ. per kg sold on market		3.860 kg CO2-EQ. per kg sold on market	
FOOD LOSS (lost edible part)	15.88%		7.86%	
FOOD LOSS ASSOCIATED GHG EMISSIONS	0.659 kg CO2-EQ. per kg sold on market		0.298 kg CO2-EQ. per kg sold on market	
Moisture and residues loss	0.00%		0.00%	
	Specific operations selected. Expand below rows if hi		Specific operations selected. Expand below rows if h	
Specific process 1:	harvesting: hand reaping, sickle (ove		harvesting: machine reaping (rice re	
Moisture and residues loss		0.00%		0.00%
Food loss	9.55%	9.55%	0.93%	0.93%
Fuel use (liter per kg product)		0	0.0015	0.0015
Specific process 2:	collection, hauling: trolley [Nath et al.		collection, hauling: trolley [Nath et a	
Moisture and residues loss		0.00%		0.00%
Food loss	0.00%	0.00%	0.00%	0.00%
Fuel use (liter per kg product)		0		0
Specific process 3:	threshing: manual [Nath et al., 2016;		threshing: manual [Nath et al., 2016	
Moisture and residues loss		0.00%		0.00%
Food loss	7.00%	7.00%	7.00%	7.00%
Fuel use (liter per kg product)		0		0

Summary of climate impacts results

Overview of climate impacts per chain stage	Direct emissions	FLW-associated	Total	Direct emissions	FLW-associated	Total
Harvesting and on-field post-harvest operations	3.490	0.659		3.495	0.298	
(On-farm) Transport	0.000			0.000		
Postharvest handling and storage (on-farm)	0.000	0.000		0.000	0.000	
Transport	0.011			0.011		
Processing and Packaging	0.000	0.000		0.000	0.000	
(Possibly international) Transport	0.000			0.000		
Processing/ repackaging/ distribution	0.000	0.000		0.000	0.000	
Distribution transport	0.056			0.056		
Market/Retail shop	0.000	0.000		0.000	0.000	
TOTAL (incl. correction for moisture and residues l	3.557	0.659	4.215	3.561	0.298	3.860

Agro-Chain greenhouse gases Emissions Calculator (ACE) calculator. Jan Broeze, Wageningen Food & Biobased Research. Version 7 September 2021

Figure 10.3 Part of the Agro-Chain Greenhouse Gas Emissions calculator user-interface for rice case comparison of technology scenarios [1] https://ccafs.cgiar.org/agro-chain-greenhouse-gas-emissions-acge-calculator

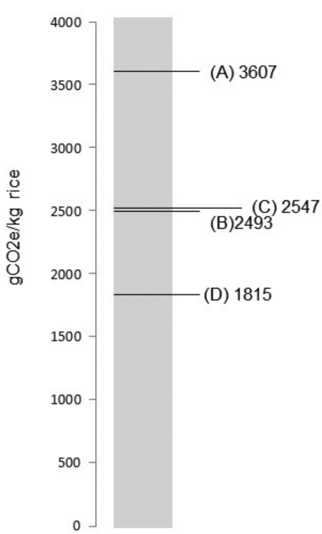
The evidence of lagging mechanisation in SSA highlights that incentives, financing, business models, capabilities, and chain arrangements are important factors in accessing and successfully implementing technology. Technology in itself is rarely a ready-made solution, but a more comprehensive systemic

Box 10.3

Carbon Footprint-Rice Production (CF-Rice): An Emissions Calculator for Rice Production

CF-Rice is a new emissions calculator that accounts for different field management practices, production technologies, and post-harvest practices along the rice value chain to provide a comprehensive product-scaled carbon footprint output. Users can compare different scenarios with data from scientific literature to highlight points along the chain where interventions would deliver the most emission-reduction impact, including those from FLW. Alternatively, users can add data from their own operations to tailor results to specific conditions.

Figure 10.4 shows the product-scaled carbon footprint for four scenarios in Southeast Asian rice production: (A) lower yield of four tonnes per hectare with traditional practices, that is, continuous flooding, manual harvesting, sun drying, and farmer storage; (B) higher potential yields of six tonnes per hectare from improved varieties without management changes; (C) improved yields of six tonnes per hectare with conditions the same as scenario B plus improved harvest and post-harvest techniques, that is, continuous flooding, mechanised harvesting and drying, and hermetic storage; and (D) improved yields of six tonnes per hectare with conditions the same as scenario C plus the application of alternate wetting and drying (AWD) during



Management	A	B	C	D
Segments and Product				
Cultivation	3189	2126	2027	1295
Harvest & Post harvest	418	367	520	520
Carbon footprint of product (gCo2e/g rice)	3607	2493	2547	1815
Stage-specific for Cultivation				
Crop establishment	206	138	131	131
Water management	2561	1707	1628	895
Fertilizer application	287	191	183	183
Equipment operation	134	89	85	85
Stage-specific for Harvest and Post-harvest				
Harvest	37	24	23	23
Straw mangement	117	78	74	74
Drying	0	0	168	168
Storing	24	24	16	16
Milling	200	200	199	199
Packaging	2	2	2	2
Transport	38	38	38	38

Figure 10.4 Example output of CF-Rice, comparing the carbon footprint of four rice production scenarios

Box 10.3 (cont.)

production. Reaching yield potential through improved varieties has a mitigation benefit of 31 percent, switching from scenario A to B. Although there is significant FL reduction from switching from scenario B to C, the emissions mitigation is negligible at under 2 percent. This is mainly a result of lessening emissions by saving food, while balancing increased emissions from mechanisation. In scenario D, the application of AWD, with improved varieties and better harvesting and post-harvesting techniques, has the most mitigation impact at 50 percent.

approach – including the creation of the appropriate capabilities, arrangements, and supporting markets and institutions – is needed for an effective transition. The success of technical solutions depends on adequate business models and chain arrangements in which all chain actors benefit.

Interventions with a positive business case still often encounter difficulty in accessing finance, especially interventions that require systemic changes. We identify three types of arrangements that can ensure access to finance. Needless to say, the following financial arrangements should be combined with capacity development.

1. While market-based financial services are often absent in rural communities, with the right conditions and supporting policy, they can exploit the untapped potential of smallholder mechanisation.
2. Farmer cooperatives can be a vehicle for collective procurement or for organising a sufficiently large market for rental equipment.
3. Financial support of smallholder farmers from larger buyers or input suppliers can assist in the upgrading of farmer practices.

Losses often arise elsewhere along the chain, outside of where the causes originate. Urbanisation and changing consumption patterns with informal chain arrangements result in increasing disconnection between producers and consumers, where demands from the consumer are not recognised by producers. Shrinking losses in a certain part of the chain through actions elsewhere in the chain will require collaboration, transparency, and chain–actor coordination.

10.6 Way Forward

By 2030, SDG Target 12.3 aims to halve FL. To reach that goal, loss-reducing interventions are critical. Besides cutting FL, most interventions will also mitigate food-supply GHG emissions. Understanding the effectiveness and trade-offs of such interventions is essential for FLW reduction decision-making and policy. Based on the experience in the case studies presented above, we recommend the following actions:

- Identify FLW and loss-related GHG emission hotspots and priorities. For policy-makers, this step occurs at the country or region level; for chain actors, it occurs along the chain.
- Identify hotspots and priorities per product type or product category.
- Distinguish different chain stages: harvesting, storage and handling, processing, food distribution, and, optionally, the consumption phase.
- Prioritise hotspots through the following actions:
  - Select hotspots with the highest loss volumes or for which interventions are available.
  - Compare FLW with various production practices, in different supply chain configurations, or with alternative technology or supply chain management practices.
  - Identify promising interventions based on an inventory of technology or management methods used in other situations, on a literature scan, or using other methodologies.
  - Estimate the interventions' effects on FLW along the supply chain.
  - Estimate the interventions' trade-off for climate impact, for instance through CF-Rice and/or ACE.
  - Narrow down the list of interventions to those that contribute significantly to FLW or GHG emissions reduction.
  - Estimate the business case for a realistic implementation model.
  - Examine how the intervention(s) can fit in the food system context; address the involvement of stakeholders and distribution of costs and benefits for actors along the chain; identify leverage points to stimulate actual implementation and success.
  - Develop a business model for the intervention.

Ideally, the focus will be on climate-positive loss-reduction interventions related to food products that are hotspots for FL and GHG equivalents. Globally, these are fruits and vegetables, rice, oil crops, and animal products. For most products, most emissions are related to agricultural production, meaning interventions in this sector can create a large impact. Any loss along the value chain induces extra production, however, which also requires consideration. In the case of smallholder farmer systems in low- and middle-income countries, the availability, accessibility, and longevity of FL-reducing interventions are significant barriers to transformation and can be addressed systematically.

This chapter provides a perspective on the requirements to foster lasting change: essentially, the right technology, supported by the right capabilities, financing options, and institutional arrangements. The case studies show that while technology does not have to be sophisticated, it needs to be available, accessible, and context-suitable. Currently, significant economic, institutional, and governance bottlenecks impede adoption. The availability and accessibility of technology and other interventions often hinder farmer adaptation, particularly in covering the upfront cost of equipment, inputs, and systems.

Financing options could be broadened, considering the wide impacts of FL reduction including implications for food security, resource use, and GHG emissions. Envisaged carbon credit schemes for shrinking FL-induced GHG emissions can motivate action. The right intervention, when effectively implemented, can positively impact all these outcomes, making FL reduction a major contributor to progress on multiple SDGs. Removing financial barriers to FL-reducing interventions helps include farmers in supply chain transformation, and leverage efforts towards more sustainable, equitable food systems.

Emissions calculator tools can support decision-making in food value chains. The two examples discussed in this chapter – the ACE calculator and CF-Rice – allow users to assess the carbon footprint impact of different intervention strategies and highlight points along the chain where interventions would be most impactful in reducing emissions, including those from FL. These tools integrate available statistical and research information into a comprehensive calculation model. This gives users the option to make the analysis more context-specific with data from their own operations. Through data from alternative chain configurations or with adapted data for comparing chain scenarios with different interventions, alternative configurations can be created.

On a global level, developed and emerging economies are responsible for the majority of FLW and associated GHG emissions. In low-income countries, however, FLW reduction relates directly to food and nutrition security and resource use efficiency. In line with the Paris Agreement, developed countries should therefore take the lead in improving climate mitigation and food security by cutting FLW. This effort should go along with financial support to less endowed, more vulnerable countries.

Box 10.4
Tackling Food Waste by Charlie Pye-Smith

In high-income countries, most food is wasted beyond the farm gate by households, manufacturers, the hospitality and food industry, and retailers (Steiner et al., 2020). Measured in calories, consumers account for around 20 percent of all FW, of which three-quarters comes from the quarter of the world's population living in Europe and the Americas. Steiner et al. (2020) outline a number of mechanisms to achieve the target of reducing FW by 50 percent by 2030. These include developing early warning systems and information management to match food supply with demand, using smart marketing and information platforms, optimising inventory movement in warehouse storage, and reducing waste-related costs along the value chain. They advocate introducing incentives to encourage manufacturers to supply smaller portions and adopt more efficient management of waste, for example by using it in anaerobic digesters and as compost rather than sending it to a landfill. They also support the creation of incentives that encourage companies to measure FLW.

There is a powerful business case for reducing FW, as illustrated by a nationwide initiative in the United Kingdom. Between 2007 and 2012, a basket of measures introduced by the private sector, local governments, community groups, and households led to a 21 percent reduction in household FW. Every £1 invested resulted in savings of £250. The waste reduction initiative was worth £6.5 billion of savings to households and £86 million of savings to local authorities over that five-year period. It decreased GHGs by 3.4 million tonnes per year, equivalent to taking 1.4 million passenger cars off the road. It also helped to save 1 billion m^3 of water.

An analysis of nearly 1 200 business sites involving 700 companies in 17 countries found that 99 percent of the sites showed a positive return on investment in waste management, with half boasting a 14-fold return. In other words, for every US$1 invested in FLW reduction, the average company made a return of US$14. This sort of evidence has convinced many companies to tackle FW.

One of the most successful companies to tackle FW has been the furniture retailer IKEA. Almost 1 billion people visit its 420 stores each year, some two-thirds of whom eat in its food outlets. In 2016, IKEA launched its Food is Precious initiative with the aim of reducing FW by 50 percent by 2020. Activities included using a smart scale system to monitor FW and appointing FW champions to motivate colleagues at work and at home. By 2019, the initiative had been implemented in half its stores, with many reducing FW by 50 percent or more. Indeed, IKEA experienced a 20 percent reduction in FW within just 12 weeks of launching the initiative.

Another company that has successfully reduced FW is Unilever. Its Future Foods initiative has adopted the target–measure–act approach recommended by the Champion 12.3 initiative, with the aim of cutting FLW in half by 2025. Among other things, it also involves making better use of waste products. In 2020, 19 percent of FW

Box 10.4 (cont.)

went to anaerobic digestion, 14 percent was used as compost, 26 percent was applied to the land as a fertiliser, and 37 percent was sent for incineration with energy recovery. None was sent to a landfill.

Many other companies and institutions have dramatically reduced their FW in recent years by adopting a variety of measures. For example, the Danish bioscience company Chr. Hansen has used food cultures to extend the shelf life of its yoghurt, reducing waste by 40 percent between 2016 and 2019. The Swedish restaurant company Max Burgers launched the world's first climate-positive menu in 2018. Less than 1 percent of food is now wasted in its kitchens, and its operations are powered entirely by renewable energy.

Awareness campaigns in school feeding programmes and institutions are also helping to lessen FW on a significant scale. For example, reducing waste, as well as malnutrition, is an integral part of the Brazilian School Feeding Programme, which supplies some 42 million children with one or more healthy and nutritious meals every day in 160 000 public schools. Awareness raising was also a central part of the 'Love Food Hate Waste' campaign, which led to a 21 percent reduction in FW in the United Kingdom between 2007 and 2012.

Notes

1 Following Porter et al. (2016) and the Food and Agriculture Organization of the United Nations FLW definition, in this research we counted FLW in raw product equivalent.

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11

Policies and Design Processes to Enable Transformation

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Highlights

- Climate change and food security are 'messy' policy issues; policies need to be effectively shaped and fit for purpose across different scales, geographic areas, and sectors.
- Policy implementation necessitates coordination across multiple perspectives towards a common goal; an anticipatory governance approach can enable this.
- Working against the status quo is not an easy task but can be achieved through truly engaged and inclusive stakeholder processes.
- Redistribution of power entails employing a gendered, socially inclusive lens in the development of food system transformation policies.
- Establishing an enabling policy environment for transforming food systems requires diverse approaches and multiple perspectives.
- Appropriate facilitation and coordination of multi-stakeholder engagements is key to clear communication between participants and to support learning.

11.1 Introduction

Working to transform global food systems to meet sustainability and justice outcomes under climate change requires engaging with complex multi-level governance while appreciating specific local contexts. This is complicated by the fact that climate change is a 'messy' policy issue. The contextual nature of climate impacts means policies need to be effectively shaped and fit for purpose across different scales, geographic areas, and sectors, a challenge compounded by human society becoming increasingly complex, interconnected, and interdependent (Rijke et al., 2012). Actions undertaken at one level or in one sector are therefore likely to have significant and unpredictable effects elsewhere (Chapter 17).

Continued awareness of these dynamics is critical for two reasons. Firstly, climate-related policies designed and enacted in isolation of these broader interconnections have the potential actively to undermine agricultural development, food security, human welfare, and ultimately human security (Rüttinger et al., 2015). Policies that are insensitive to local social–ecological, politico-economic, or conflict dynamics may increase conflict risk by distributing resources along the lines of a pre-existing division - for example, by inadvertently providing legitimacy to questionable actors, changing local markets with an influx of resources, or replacing previously existing and functioning social–ecological systems (UNDP, 2016). Secondly, a transdisciplinary lens is crucial for climate action to maximise transformational co-benefits for other societal challenges. As the root causes of climate vulnerability overlap significantly with drivers of conflict and poverty, integrated climate-related policies can simultaneously contribute to poverty alleviation, while building long-term resilient food systems and societies.

A key aspect of implementing policy is targeting the reconstruction of the origins of social–ecological relationships that cause vulnerability and inequality. This requires working against the status quo, which is not an easy task, but one that can be achieved through truly engaged and inclusive stakeholder processes. Mechanisms for implementing transformational changes include participatory scenario planning, tailoring support to countries rather than employing a ‘cookie-cutter approach’ to challenges, prioritising gender and social inclusion to ensure more equitable outcomes, and creating learning platforms across sectors, actors, and geographies.

In this chapter, we unpack how transformation theory and transdisciplinary approaches around co-creation can mobilise these mechanisms, primarily through the development of anticipatory governance. In the next section, we lay out the theoretical background on transformations, transdisciplinary research, and anticipatory governance. We then examine case study examples that illustrate how policies that enable transformation can emerge from inclusive multi-stakeholder processes that use future-thinking tools to systematically consider the interventions needed at different scales. We discuss the importance of addressing power dynamics and political economy in the context of gender and social inclusion, before concluding with some key take-home messages on implementation and process.

11.2 Transformation Theory and Transdisciplinary and Anticipatory Governance

Transformation theory demonstrates that to shift from the current trajectory into an alternative system, it is necessary not only to break down the current dominant regime, but also to expand the foundations of a different future. In food systems, this would entail incentivising climate-resilient and low-emission practices for markets and the public sector, while shifting away from policies that result in environmental degradation and social marginalisation - for example, subsidies that support deforestation. For institutions and actors to create enabling environments for transformations, they must employ some key capacities, laid out in detail below. These are: (1) adopting a transdisciplinary lens to policy research and development, (2) employing an anticipatory governance approach, and (3) focusing on implementation gaps, co-production across scales, and dealing with power imbalances.

Transdisciplinary research calls for researchers and policymakers to transcend siloed, single-academic-disciplinary research (Chilisa et al., 2017) and move beyond single-actor-driven interventions. Doing so will allow the solving of complex, multifaceted real-world problems in new and productive ways (Chapter 14). These processes increase legitimacy, ownership, and accountability for both the problem and for the possible solutions, given they incorporate diverse scientific and societal actors' perspectives (van Breda & Swilling, 2018).

The second key capacity is anticipatory governance, a concept that stems from an emerging field examining how imaginings of the future are governed in the present, to realise desired transformations (Muiderman et al., 2020). Different perspectives exist particularly in terms of how the future can be known and managed, and how imagined futures should impact policy choices in the present (Vervoort & Gupta, 2018). A socially inclusive, futures-thinking process should create a safe space for diverse stakeholders to express different views and ways of knowing, to inspire action (Pereira et al., 2019).

Thirdly, implementation presents a gap in effective transformative policy. There is often a scale mismatch whereby national governments tend to set policy for implementation at local levels, but the policy is not translated into local contexts, nor does it always come with the necessary finance or capacities. Building buy-in from the beginning is therefore critical to achieving implementation. It is also important to get the process of development right so that the resulting policies do not entrench power inequalities. Transformative processes should therefore embrace co-production, engaging diverse stakeholders across scales to open up new spaces for collaborative, transformative action. Most importantly, encouraging multiple viewpoints and opinions can shed light on pre-existing power dynamics and work towards the productive resolution of conflicts.

11.3 Case Studies Operationalising Participatory Futures Methods for Policy Development

11.3.1 Participatory Scenarios in Costa Rica to Strengthen National Climate Ambitions

An illustrative example of transformative foresight comes from Costa Rica, demonstrating the importance of including diverse stakeholders, such as NGOs, citizens, and government representatives, in key policy-making and other negotiation processes to create buy-in and increase ambition. The Ministry of Environment and Energy started applying anticipatory governance practices during 2015 while developing their Intended Nationally Determined Contribution (INDC). There was a discussion about whether existing foresight methods could support transformative ambitions for the INDC, given that the modelling at that time, based on the extrapolation of data about past emissions, did not show a significant decrease in GHG emissions. A participatory process was initiated to work on the desired, transformative futures, involving all major institutions and civil-society representatives. The process used qualitative foresight approaches that allowed for exploration of futures beyond what was possible based on historical data.

This multi-stakeholder platform unearthed potential areas of collaboration or synergies between the participants but also areas of conflict that could be resolved through constructive dialogue. Participants in the visioning process found common ground in ensuring that no one should be left behind as the country adapts to and mitigates climate change. This led to social and economic development goals being placed at the heart of the Nationally Determined Contribution (NDC), enhanced in 2020 by incorporating an inclusive approach to build adaptive capacity, reduce climate vulnerability, and strengthen resilience. This adoption of socially inclusive values helped secure stakeholders' commitment to achieving an outcome to which they could all contribute. In essence, the process was moved from a 'prediction to mitigate risks' approach to an approach of 'mobilising action toward pluralistic transformative futures', which fitted the requirements and ambitions of the INDC and NDC process (Muiderman et al., 2020).

11.3.2 Multi-Stakeholder Platforms for Decision-Making in Africa

Two illustrative case examples come from East and West Africa. In East Africa, the Programme for Climate Smart Livestock brought together diverse actors, including academics, government officials, representatives of international institutions, and civil society, to reflect on transformative climate-smart futures for livestock in Kenya, Uganda, and Ethiopia. Futures-thinking was a key tool to engage with national stakeholders. This case exemplified how talking about the future with diverse stakeholders can unearth conflicts and synergies about desired trajectories and enrich the scope of policy development. Emphasising desirable futures for livestock can create a sense of common purpose that guides policy-making and everyday action in the present. Simultaneously, gradual 'back-casting' from the future to the present helps navigate systems complexity, while cultivating a more systemic way of thinking that links social, economic, ecological, and technological systems across space and time (Pereira et al., 2019). Creating such stakeholder-diverse spaces – where conflict is mediated constructively and the value of productive dialogue is emphasised – is an essential feature of social–ecological transformations. Following the completion of the futures workshops, outcomes were iteratively discussed with participating stakeholders during multiple feedback rounds. This provided the space for stakeholders to further develop some of their ideas, allowing the team to capture many of the nuances that arose from a diverse, multi-stakeholder discussion of this complex topic.

A second case from Africa shows the necessity for national-level policymakers to work collaboratively with local stakeholders to ensure that policy is more responsive to the lived experiences of citizens and can, therefore, be implemented more effectively. The CGIAR Research Program on Climate Change, Agriculture and Food Security established national-level exchange platforms in Ghana, Mali, and Senegal to enable and strengthen discussions on agriculture and climate-related issues (Zougmoré et al., 2019).

Participants from diverse institutions participated in the platforms; Ghana's work is a good example (Figure 11.1). All the platforms had considerable success

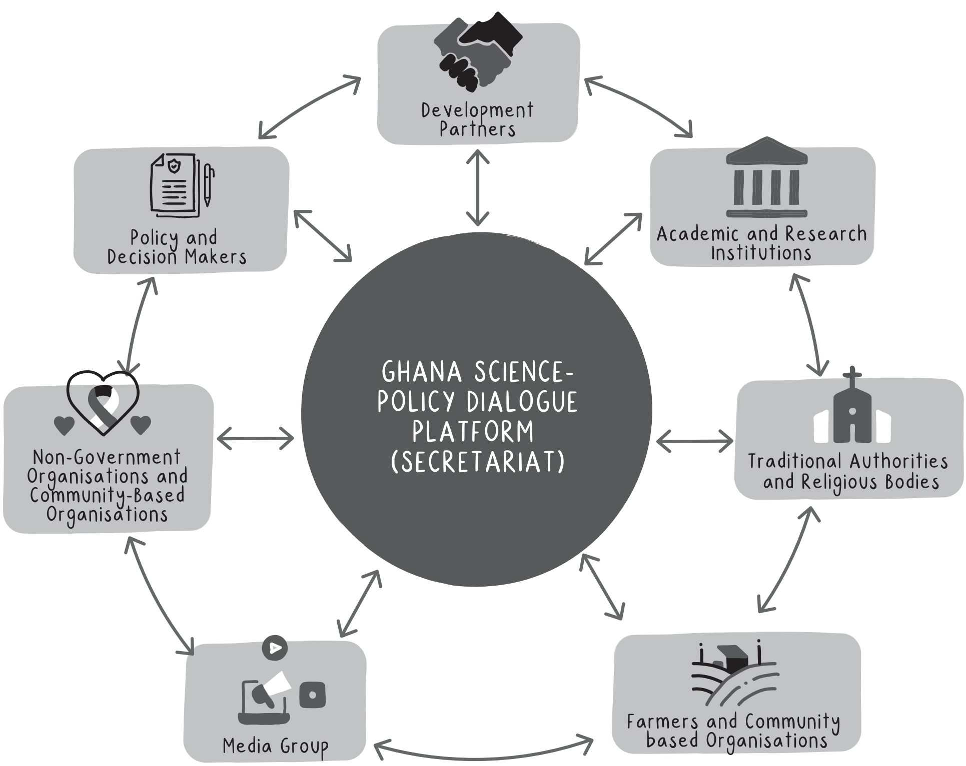

Figure 11.1 Composition of the Ghana National Science–Policy Dialogue Platform on Climate Change, Agriculture and Food Security (source: Zougmoré et al., 2019)

in advancing policies, strategies, or programmes. In Ghana, the platform led to the development of the first National Climate-Smart Agriculture Action Plan, targeted at ensuring ground-level operationalisation in the agriculture and food security focus areas, within Ghana's National Climate Change Policy. The Climate-Smart Agriculture Action Plan is recognised by all stakeholders as the operational policy document for agricultural development in Ghana. This linkage between the national and subnational levels helped ensure that policies designed at the national level would be implemented and avoid the creation of policies that would not reach on-the-ground implementation.

11.4 Addressing Power Dynamics and Other Barriers to Transformation

While the above examples provide insights into some of the approaches and their outcomes in particular settings, it is not always straightforward for stakeholders to unite to support transformation. Barriers to transformation can take a variety of forms, be they legal, social–cultural, resourcing, financial, political, and institutional. Power permeates each of these categories. Entrenched power dynamics can lead to transformation failures, particularly in the context of climate-resilient food systems, where the power balance is skewed in favour of a small number of very large enterprises and is concentrated in particular supply chains (Nicol & Taherzardeh, 2020). Social transformation is created through the reallocation of power. Transformation requires power to be enabled, yet power is dynamic, relational, distributed, complex, and multidimensional. Who is involved – and who is not – matters when unblocking potential pathways where power has become entrenched, as well as for broadening power redistribution opportunities.

Redistribution of power entails employing a gendered and socially inclusive lens to food-system transformations. It means going beyond just having more women and marginalised groups 'having a seat at the table' (Chapter 13). Genuine redistribution of power requires upending entrenched power structures and pursuing food systems that prioritise human well-being and ecological sustainability over mere private profit (Bell et al., 2020). Similarly, simply consulting with indigenous and local stakeholders is insufficient for creating true food-system transformation. Deeper transformation requires the operationalisation of indigenous knowledge strands and their dictums, on sufficiency for example, lifestyles, land stewardship, biodiversity conservation, and food sovereignty.

The transformation of agricultural production systems needs to be inclusive and participatory. To achieve this, Lyon et al. (2020) identified the need for an understanding of stakeholders that includes agency, power analysis, and the identification of stakeholders' systems roles, dynamics, interests, moral orientation, alignment with sustainability, and readiness to transform. In some cases, strategic alliances between stakeholders can produce the pressure necessary to drive the kinds of social–ecological transformations required to support wider system change. For example, food movements that challenge the current corporate regime, combined with movements that support rapid climate-change action could shift the system away from societies embedded in market economies towards economies and markets embedded in society and the environment (Holt-Giménez & Shattuck, 2011).

Policy stakeholders are often those who set the rules of the game and assign responsibilities; they therefore have the greatest opportunity to establish an enabling environment for transformation by shaping the landscape of power. While the specifics might differ across contexts, key components of an enabling environment generally involve creating a suitable mix of policies across agriculture and other sectors, as well as appropriate incentives supported by capacity building for implementation. Appropriate policies include those that reorient the power balance and include measures to mitigate any resultant undesirable impacts on producers and consumers, as well as those distributed along the value chain. Examples of such interventions can be seen in Box 11.1. They can also address issues of the need for decent jobs, orientating to tackle multiple UN Sustainable Development Goals simultaneously, by removing perverse incentives that cause damage in other sectors. Policies, however, require resourcing for their implementation, and this can present another challenge for transformation (Chapter 12).

11.5 Implementing and Financing Transformative Policies

Considerable awareness centres on the need for investing in policy implementation. This includes the need for private-sector action, as well as the reorientation and realignment of public subsidies to accelerate private-sector investment in more sustainable food systems. Such changes are anticipated to help realign the balance of power, by facilitating sustainable finance mechanisms, upscaling suitable technologies, improving access to knowledge and other inputs, and designing context-appropriate safety nets, such as insurance (Makate, 2019). It nevertheless remains unclear how issues such as the elite capture of benefits can be addressed, including issues of gender and other socio-economic inequities.

Meeting targets such as the realignment of US$300 billion of agricultural subsidies to a climate-change agenda by 2025 and improving ‘ease of doing business’ in Sub-Saharan African countries (Steiner et al., 2020) will require reconfiguration of the global funding regime. The reallocation of perverse subsidies offers a concrete source of finance for the interventions needed for food-system transformation. There have been various calls to end harmful fishing

Box 11.1

Examples of Steps to Enshrine Multi-Stakeholder Participation for Transformative Policy Implementation

1. Establish producer cooperatives, federated into a larger body that can leverage pressure in political negotiations and advocate in particular for small-scale producers and groups who have been traditionally underrepresented.
2. Implement quotas for the representation of youth, women, and other groups on the boards of these cooperatives.
3. Incorporate in all levels of education the added value of combining indigenous local knowledge and modern scientific expertise to cultivate a new pedagogy around the importance of new, pluralistic knowledge production.
4. Tackle political capture and corruption, and separate development agendas from political influences by establishing independent expert bodies tasked with monitoring policy development and implementation.
5. Establish far-reaching policies that ensure fair and distributed land tenure and prevent the annexing of productive lands; this will be key to ensure that marginalised groups, like youth or women farmers and those engaged in fishing, have access to these fundamental assets. Supporting small-scale land tenure creates a safety net that builds resilient livelihoods and addresses structural barriers to the market.
6. Couple land reform, grazing, and fishing rights with sustainable finance policies, such as redirecting subsidies and tax incentives that favour consolidated, industrialised agri-food systems, and financial support – for example, tax credits, specialised insurance schemes, and grants – towards small-scale producers. Combining land tenure and finance reforms would address the key structural drivers of de-agrarianisation and promote rural reinvigoration (Chapter 6).
7. Implement social protection schemes to ensure that basic needs are met and people can escape poverty, particularly in currently under-resourced rural areas (Chapter 7).

Generating adequate finance to implement the above policies and achieve low-carbon, resilient development remains an important challenge (Chapter 12).

subsidies, which in 2018 stood at US$35.4 billion (Sumaila et al., 2019) and fossil fuel energy subsidies, which in 2020 stood at US$5.9 trillion (IMF, 2021). Ending these, moving towards renewables, and reallocating subsidies can enable transformation, rather than maintaining the status quo.

Foreign direct investment is another potential funding stream. Improving business conditions, however, needs to be done cautiously to ensure investment gains accrue to the people and places where transformation is needed, rather than benefiting foreign interests. Private-sector investment could take the form of microcredit access for smallholders who are seeking to improve their sustainable productivity in a climate-smart way and to access markets. Setting up institutional structures whereby finance is properly channelled to achieve multiple outcomes or co-benefits – for example, finance for female-led agri-processing of adaptive indigenous species for national markets – can promote gender inclusion as well as other social–ecological benefits. Furthermore, this can build capacity to move beyond agricultural production and promote diversification into more locally resilient and/or indigenous species (Agarwal et al., 2017). Finance is thus another locus of power and key leverage point for transformations into climate-smart and inclusive farming systems (Jouffray et al., 2019).

11.6 Way Forward

Two characteristics are important in creating an enabling policy environment for transforming food systems. The first is to recognise diversity and include a plurality of perspectives. 'Having a seat at the table' is inherently a political process mired in privilege, which emerges from entrenched power structures. Enabling transformation means moving away from business-as-usual responses and opening up to novelty and innovation. This often requires a radical approach that conventional actors are generally unable to provide. As well as providing more transformative solutions, inclusive governance also requires procedural justice that accounts for all interests. Not only is involving diverse voices essential to a just and fair policy formulation process, but an ongoing iteration of the results allows for learning and adaptation. A true representation of needs allows for easier development of policy that can achieve outcomes across different sectors and address multiple needs in an intersectional and transdisciplinary approach. Collaboration between a wide variety of stakeholders also paves the way for a broader coalition that is ripe to move forward with transformative approaches.

The second is experienced facilitation and coordination. With the need to include multiple voices, particularly of marginalised groups, appropriate facilitation is key to clear communication between different participants and to support learning. While there will still be conflicting perspectives, an enhanced understanding of others' views and identification of common ground can lay a foundation where compromises can be reached and where entrenched power balances can begin to change. This is where transdisciplinary research, participatory futures methods, and anticipatory governance can be useful in bringing multiple voices together. Furthermore, employing stakeholder engagement processes, like participatory scenario planning, in policy processes that are already underway can strengthen their impact in these spaces. Transformation is not necessarily a fast process, yet in the context of climate change, it does need to be rapid. Similarly, multi-stakeholder, deliberative approaches might necessitate special attention and time investment, but the collective knowledge they produce increases the legitimacy of the final plan. In addition, these approaches can also provide unexpected, insightful ideas for rapid, targeted transformative actions that are likely to be more effective over the long term. Researchers need to improve information-sharing around what works where, when, how, why, and for whom in terms of methods that guide transformation. This is critical for the optimal allocation of finance and other resources to effect the systemic changes needed for a more sustainable food system.

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12

Sustainable Finance for the Transformation of Food Systems

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Highlights

- Development finance actors and the private sector will need to work cohesively to reduce the funding gap, reorient current financing, and increase capital resources for food-system transformation.
- Utilising innovative financing instruments and mechanisms to create attractive investment opportunities can catalyse food-system transformation through both public- and private-sector capital.
- Building the capacity of financial intermediaries to accurately assess risk and deploy appropriate risk-mitigation mechanisms can improve risk perception and lower the transaction cost for deploying capital.
- Robust, science-based metrics, cost-effective data collection, and monitoring systems are critical to mobilising capital and safeguarding sustainable finance against greenwashing.[1]

12.1 Introduction

One of the main challenges for transforming food systems relates to successfully scaling adaptation and mitigation actions (Chapter 2). Here, governments and public institutions play a key role in creating an enabling environment (Chapter 11) for overcoming funding barriers and scaling climate-resilient, low-emission approaches.

To better understand these barriers, a large market consultation with more than seventy public and private investors was carried out, to identify the key market failures that prevent investors from financing food-system transformation. This led to the first strategic sustainable finance roadmap for food-systems transformation, ‘Financing the Transformation of Food Systems Under a Changing Climate’ (Limketkai et al., 2019). The roadmap highlights a diverse set of policy options, innovative financial solutions, and strategies for how stakeholders can support the transformation to low-carbon and resilient food systems.

This chapter considers sustainable finance for the transformation of food systems. We consider the key barriers to engaging sustainable finance and how actors within the development finance landscape can address these. Thereafter, we focus on the three core mechanisms for mobilising sustainable finance: (1) creating investment opportunities attractive for mainstream investors, (2) building the capacity of financial intermediaries to accurately assess risk, lower transaction costs and deploy risk-mitigating mechanisms, and (3) utilising robust, science-based metrics and standards to catalyse capital, attribute accountability, and safeguard impacts, to overcome the barriers finance actors face in deploying sustainable finance for food-systems transformations.

12.2 Barriers to Deploying Sustainable Finance for Food-System Transformation

The cost of implementing 11 high-priority actions under four key areas to transform food systems – re-route, de-risk, reduce, and realign – is estimated to be US$1.3 trillion annually through the decade (Chapter 2), with current financing falling woefully short.

To transform our food system, we need to target the current major sectoral sources of finance and identify new funding sources. There is a clear need to reorient current financing and mobilise more capital resources to reduce food systems' vulnerability to the effects of climate change and minimise their negative impacts on climate change. Beyond the funding gap, the longer-term goal is to institutionalise and mainstream sustainable finance throughout the financial ecosystem, whereby environmental, social, and governance (ESG) aspects are considered when making investment decisions in the financial sector. This in turn can lead to more long-term investments in sustainable economic activities and projects.

In the case of food systems, institutionalising sustainable finance within the financial ecosystem could contribute to country-based environmental objectives, increase the flow of capital towards such endeavours, and avoid harming other environmental objectives. However, investing in sustainable food systems in developing countries is challenging owing to several barriers. These include: (1) high country- and sector-specific risks, (2) poor primary data and information asymmetries between financial institutions and potential borrowers, (3) the mismatch between investment needs and different pools of capital, and (4) high transaction costs in conjunction with small ticket sizes, that is, the amount of money a single investor invests. These barriers result in the lack of deep pipelines for bankable projects that are attractive for mainstream investors.

Two important streams to increase climate mitigation and adaptation finance to transform food systems have been identified (Limketkai et al., 2019). Firstly, we must embed climate considerations into the underlying financial system architecture, through effective government policy and regulatory frameworks. Secondly, we must address core market challenges to create new sustainable investment opportunities that incentivise private capital flows and strengthen the underlying economics of making financial systems climate-conscious. Figure 12.1 illustrates the development finance landscape and highlights the interdependency of the financial and development sectors in achieving mutually beneficial outcomes.

The supply-side of capital consists of two categories, namely, the capital owners, and the capital managers, or financial intermediaries. Both consist of private and public players, who rely on each to de-risk investments as well as to reach sufficient scale. However, different types of capital flows and return expectations create systemic complexity, which requires structured approaches and clear alignments on objectives.

The demand-side of capital is made up of private companies, retail finance companies, and individual end users. Private companies meet investment targets, retail finance companies provide private companies and individuals with financial services, and individuals are the consumers of financial products and services. In development agriculture, the core challenges to investment in the demand-side of capital are the high transactions costs and individuals' comparatively low purchasing power. The following sections consider these flows in the context of three core solutions to overcome the barriers finance actors face.

12.3 Creating Investment Opportunities Attractive for Mainstream Investors

Although there has been a shift in business and investor communities towards considering climate change and its implications, the gap between high-level interest and concrete investment opportunities – and, more importantly, action on the ground – still exists. To date, one of the biggest challenges to private-sector investment in food-system transformation is the identification of bankable projects with attractive risk-adjusted returns.

There are several pathways through which the ecosystem of actors operating in the food systems sphere can create more attractive investment opportunities. Corporates should continue to internalise and implement ESG commitments across their supply chains and operations while setting higher sustainability standards for business-as-usual investments. Green financing that is explicitly linked to climate outcomes can be scaled up, such as green bonds, carbon markets, climate-linked insurance, concessional loans, and grants to achieve climate adaptation or

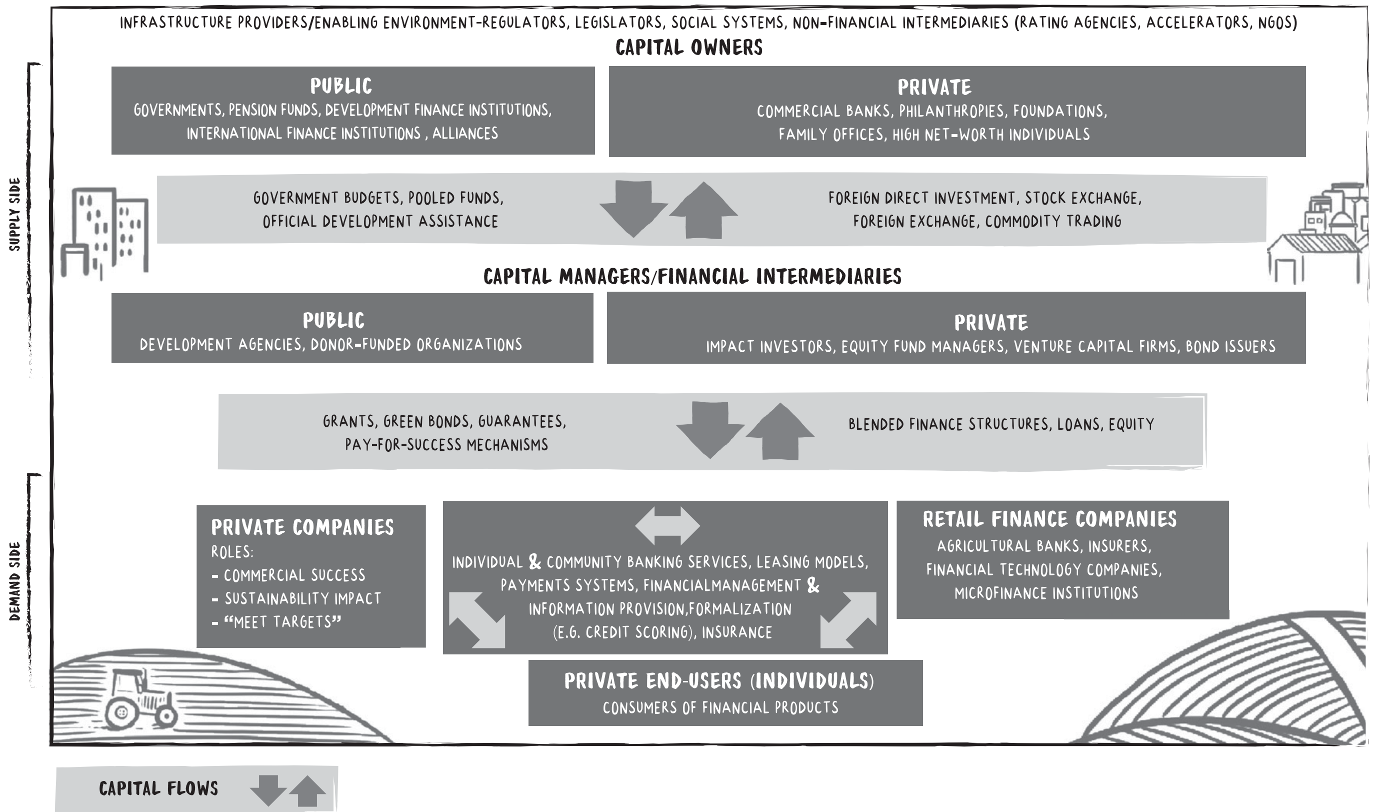

Figure 12.1 Development finance landscape: Categories, players, and flows

mitigation objectives, as well as guarantees for adequate risk-adjusted returns in climate-focused investments. Governments can propel subsidy reform to stop those harming the environment and reorient this capital to focus on positive environmental actions. They can create market incentives for new sustainable opportunities and support this burgeoning market through levers such as taxation and regulation, while also ensuring that decision-making explicitly incorporates the costs of unsustainable food systems (Limketkai et al., 2019). Table 12.1 outlines examples of the types of innovative financing instruments and mechanisms that should be scaled up (see also Chapter 4, Table 4.1 for select financial mechanisms to support the sustainable management of high-carbon ecosystems).

Innovation in how finance is mobilised is needed, such as blended finance structures. These approaches can help overcome the high costs and risks often associated with sustainable finance investments. Investment opportunities need de-risked structures, given the often-high country and borrower risk, which is further intensified by uncertain economic returns of many sustainable production models. Strategically blending public funding and philanthropic capital with private-sector resources can overcome some of these challenges, allowing the scaling of sustainable investments. The blended-finance approach utilises the large resources of the private sector and banks, in combination with impact financing – the public catalytic concessional finance – which can only come into effect when blended with commercial finance. Blended finance can assist in creating investment opportunities for investors through the actions below (Apampa et al., 2021):

1. Promote bankable projects: Utilising blended finance mechanisms will increase capital flow, and investment in bankable projects, and can upgrade near-bankable projects to become bankable.
2. Demonstrate a track record: Successful blended-finance investments will have a demonstrable effect, which should reduce the perceived investment risk of private investors, leading to more investments.
3. Phased out over time: Once sustainable food-system investments have passed the ‘proof of concept’ stage by becoming profitable, and once the reduction of credit risks is achieved at scale, more commercial capital will become available without the need for concessional capital. As such, blended finance can be phased out.

Blended finance requires a multi-stakeholder, partnership approach between the food and agriculture industry, NGOs, financial actors, donors, investors, and the technology sector to create an enabling environment. By promoting partnerships among ‘unusual suspects’, the combined knowledge, capabilities, and financial resources of all of these actors can be harnessed towards a common goal. Research organisations have an important role to play in developing tools and frameworks that can lower the transaction costs for investors, improve risk assessments, and

Table 12.1. *Examples of innovative financing instruments and mechanisms*

Financing instrument/ mechanism	Description	Example
Green bonds/ climate bonds	A green bond or climate bond is a type of fixed-income instrument, which functions mainly the same way as a regular bond. The major difference is that proceeds are earmarked for investments that will positively impact the environment or climate change. The bond can be issued by governments or private actors such as banks and corporates.	Green Bond Issuance by FIRA – Development bank of Mexico. In 2018, FIRA issued Mexico's first green bond focused on agriculture, worth MXN2.5 billion, or US$130 million. The proceeds will be used for financing 11 shade houses and 28 greenhouses that emit fewer greenhouse gases than open agriculture.
Carbon credits/ carbon offsets	Carbon credits and carbon offsets are market mechanisms for the minimisation of greenhouse gases (GHGs). Carbon credits are measurable, verifiable emission reductions from verified projects.	Anourok Cambodia Forestry Project Anourok, a Forest REDD+ conservation project, prevents deforestation of a unique and biodiverse region under significant pressure from illegal logging and poaching. The project is certified under the Verified Carbon Standard.
Guarantees or risk insurance instruments	Guarantees or risks insurance instruments are credit-enhancing mechanisms, where a third party acting as a guarantor assumes responsibility for a debt should a borrower default.	The Swedish International Development Cooperation Agency (SIDA) Guarantee to Mali agriculture and women entrepreneurs. SIDA provides guarantees as a financial instrument to mobilise additional capital for development projects. One such project is the guarantee provided to the Bank of Africa to enable the bank to lend to agriculture sectors and women entrepreneurs in Mali.
Pay for success tools/results-based financing instruments	According to Social Finance, 'Pay for Success' is a set of innovative outcomes-based financing tools that measurably improve outcomes by driving	Ashaninka impact bond for sustainable cocoa and coffee production in Peru. The Ashaninka impact bond is the first in Latin America and was raised to support

Table 12.1. (*cont.*)

Financing instrument/ mechanism	Description	Example
	resources towards results. Examples include social impact bonds, development impact bonds, and outcome-based contracts, contracts.	sustainable cocoa and coffee production within the indigenous Ashaninka community living in the Peruvian Amazon.
Payment for ecosystem services (PES)	PES is a financial mechanism whereby the beneficiaries of an ecosystem service, such as watershed protection, carbon sequestration, or forest conservation, make payments to the provider of these services.	Payment for carbon sequestration by the Norway government. The government of Norway incentivized farmers in the region of Rogaland, Trondelag, and Nordland to plant spruce on fallow agricultural land. It refunded farmers for the costs incurred to plant spruce and allowed farmers to keep the income from the harvest once the trees reached their annual mean growth.

safeguard impacts, particularly when the target beneficiaries are smallholder farmers, including women and youth (see Box 12.1).

12.4 Building the Capacity of Financial Intermediaries

Investing in the capacity building of financial intermediaries to accurately assess risk, lower transaction costs, and deploy risk-mitigating mechanisms is key to scaling up financing. One of the biggest barriers for mobilising finance in the sector in low-income and developing countries is not necessarily high return expectations but rather high actual or perceived investment risk and/or high transaction cost. For example, disseminating large-ticket investment sizes to financially benefit and commercialise low-income end users is costly and acts as a deterrent to finance being committed to such projects. Similarly, high investment risk can be a result of inappropriately incorporating climate-change impacts and unsustainable practices in the risk assessment and management process of financial intermediaries. Furthermore, since the central role of banks includes protecting capital entrusted to them, regulated financial institutions are

Box 12.1

The First Science-Based 'Climate Smart Food Systems Fund' Is Launched

CGIAR and prominent asset manager, responsAbility, joined forces to unlock sustainable finance potential, designing an innovative blended investment fund that can channel capital to transform food systems in developing countries. It aims to do so in a commercially and financially attractive manner, while also delivering science-based transformational impact. The Fund will be the first to integrate a science-based food-system approach into a fund investment strategy and actively target the main drivers of climate change. The Climate Smart Food Systems Fund will provide long-term, expansion-debt financing to 20–30 small-to-medium enterprises (SMEs) operating in Asia Pacific, Latin America, and Africa, which will all contribute to healthier diets and promote climate-change adaptation and mitigation in their food systems. CGIAR's science and research expertise allows the Fund to integrate a science-based prioritisation strategy to identify companies with the highest impact potential. The Fund will implement climate-smart interventions to help its investee companies transition to a sustainable food system. Grant-based funds for the technical assistance facility will be provided by governments, philanthropic actors, and foundations, and support investees and smallholder farmers to strengthen their capacities to implement robust climate-smart agriculture solutions. The Fund will provide financing and technical assistance climate-smart interventions, such as regenerative agriculture in the value chain, reduced food loss post-harvest, more energy- and water-efficient processing, and improved logistics. The Fund will also incorporate a gender investment strategy. Its end goal is to demonstrate investment viability in sustainable food systems to catalyse more capital at scale.

subject to heavy monitoring, creating a 'risk appetite' that limits committing funding to high-risk countries or sectors. Moreover, farmers who wish to innovate in food-system transformation, for example by using reforestation approaches or silvopastoral practices, are perceived as higher risk owing to deviating from 'business as usual'.

Investment is needed to strengthen the innovation ecosystems that enable the scaling of private-sector solutions and to overcome several barriers related to high investment risk and high transaction costs. This includes taking a system-wide view of risks and costs and recognising the roles of policymakers, infrastructure, and industry standards. By building capacity to accurately assess risk and deploy appropriate risk-mitigating mechanisms, as well as by equipping investors with data and risk tools, risk assessment can be improved, investments de-risked and private capital catalysed (Box 12.2). The development and sharing of primary data

Box 12.2
The First Climate-Adaptation Credit Facility for Agriculture in Africa

CGIAR set out to overcome some of the financial barriers to climate-smart agriculture by partnering with an Impact Investor in East Africa to launch Africa's first climate-adaptation credit facility for agriculture, ADAPTA.EARTH. The key innovation is a climate-scoring algorithm and agriculture- and risk-management framework that can be embedded into local and regional banks' risk assessment process to transform how agricultural risk is assessed and managed. Through a simple dashboard, the automated Climate Score Model will provide an overview of risks associated with a potential borrower, based on a commodity and/or location-specific risk assessment, alongside guidance on a potential action plan to address climate-change-derived risks. Firstly, the Climate Score Model will leverage satellite-derived data sets and others measuring vegetation, soils, hydrology, climate, energy, and water efficiency, as well as social and gender dimensions, to assess risk and identify adaptation options within value chains. Secondly, by working with primary producers and agri-SMEs to assess their climate-change risks and resilience, the financial institution can embed an adaptation plan into their growth strategies. It may also indicate whether a project carries unsurmountable climate-change-derived risks and, as such, should not be pursued further. Lastly, an automated portfolio management monitoring system will provide the borrower/investee with information about the action plan implementation, weather-related climate risks, hydrology, soil, pests, and harvest information, etc. The goal is to reduce the need for regular physical monitoring while creating a transparent communication channel for all parties.

can reduce information asymmetries, build benchmarks for investor due diligence, and create publicly verifiable investment data platforms. Investor due diligence can facilitate public and private investors to assess risk-return profiles and incorporate climate considerations into the investment process more accurately (Limketkai et al., 2019). The public sector can play a leading role by strategically funding technical assistance, to facilitate the development of viable business models. In partnership with entrepreneurs, this can de-risk markets to help businesses access follow-on financing. The public sector can also aid in developing tools and frameworks to enable the collection, assessment, monitoring, and sharing of data to assist in de-risking investments and to create a viable, sustainable finance ecosystem for both public- and private-sector actors (ClimateShot, 2021).

Local and regional financial intermediaries such as banks, micro-credit providers, insurance providers, and venture capital funds investing in digital services business models all provide a pathway to scale funding and services to smallholder farmers. For example, bundling climate information services or technical assistance on climate-smart practices with loans provides a cost-effective approach for financial intermediaries to deploy risk-mitigating mechanisms. Lastly, leveraging digital solutions is key to reducing risks, costs, and building data hubs for finance and decision-making. This includes harnessing digital technologies to obtain more granular farmer-level views of impact and risks, addressing the cost barriers to be overcome to reach underserved communities, developing alternative credit scoring systems, strengthening formal property rights, and creating alternative forms of collateral (ClimateShot, 2021).

12.5 Robust Science-Based Metrics and Standards

Robust, science-based metrics and cost-effective data collection and monitoring systems are crucial. Firstly, metrics and data help channel and attract more funding from larger and wider sources of capital. New regulatory requirements and ESG-based commitments, as mentioned above, are instigating alignment within the industry on definitions and classifications, to provide ubiquitous reporting and narrative on sustainable finance (Table 12.2). It is hoped that the data and metrics gathered as a result of such regulations will help mobilise further capital. One major hindrance is the lack of reliable, harmonised, and cost-effective metrics within food systems. Investors who are sector agnostic or indifferent to climate-finance mitigation or adaptation are more likely to invest in renewable energy, for example, as it is far easier to quantify outcomes and calculate the impact of their capital. Additionally, the high costs associated with collecting data to measure impact add to the operating cost of asset managers and financial institutions.

Secondly, there is currently no adequate valuation of natural capital, that is, the world's stock of natural resources, which includes geology, soils, air, water, and all living organisms (Natural Capital Forum, 2021). Inadequate valuation leads to an underestimation of nature's role in the economy and human well-being, meaning that the services natural capital provides are often traded away without due consideration or appropriate cost-benefit analysis. Similarly, there is no generally accepted appraisal methodology to measure climate outcomes and the value provided to – or removed from – businesses. This lack of a market-accepted climate valuation methodology prevents investors from embedding climate considerations into investment decision-making, as underlying business valuations cannot justify the additional costs of sustainable practices (Limketkai et al., 2019).

Thirdly, although there is a great need for sustainable finance for small-scale farmers to large corporates, we must consider whether financing and commitments are genuinely contributing to sustainability goals. As ESG investing becomes mainstream, many asset managers are marketing new 'green' products, raising the risks of 'greenwashing'. In the agriculture and food sector, utilising robust science-

Table 12.2. *Example initiatives used across the financial ecosystem addressing impact and ESG metrics*

Initiative	Description
International Finance Corporation (IFC) performance standards	The IFC's Environmental and Social Performance Standards define IFC clients' responsibilities for managing their environmental and social risks.
UN Principles for Responsible Investment (UN PRI)	An UN-supported international network of investors working together. Its goal is to understand sustainability implications for investors and support signatories to incorporate these issues into investment decision-making and practices.
IFC Operating Principles of Impact Management (OPIM)	These make up the international organisation's framework to provide regulations, transparency, and trust in the global impact investment market. The principles stipulate specific ways to assess the impact management of financial institutions.
IRIS+ by the Global Impact Investing Network	The IRIS+ Thematic Taxonomy document describes the generally accepted definitions of Impact Categories and Impact Themes, providing a shared language for describing, assessing, communicating, and ultimately comparing impact performance.
Social Performance Task Force (SPTF)	The SPTF engages with stakeholders to develop, disseminate, and promote standards and good practices for social performance management and reporting. It encourages sectoral self-regulation to improve the credibility and effectiveness of inclusive finance.
Carbon Disclosure Project (CDP)	The CDP is a not-for-profit charity that runs the global disclosure system for investors, companies, cities, states, and regions to manage their environmental impacts.
The Sustainability Accounting Standards Board (SASB)	The SASB provides a complete set of globally applicable, industry-specific standards that identify the minimal set of financially material sustainability topics and their associated metrics for the typical company in an industry.
Global Reporting Initiative (GRI)	An international independent standards organisation that helps businesses, governments, and other organisations understand and communicate their impacts on issues such as climate change, human rights, and corruption.

Table 12.2. (*cont.*)

Initiative	Description
Harmonised Indicators for Private Sector Operations (HIPSO)	The Harmonised Indicators MoU reflects the commitment of 28 development finance institutions towards long-term collaboration and, most importantly, a focus on better serving their clients.
Global Impact Investing Rating System (GIIRS)	GIIRS is a rating system that tracks the level of impact of investors' money. Using additional criteria, it builds on the IRIS Catalogue of Metrics to generate an overall fund score for a variety of business models in which the fund invests, allowing investors to objectively understand the environmental and social impacts.
Taskforce on Climate-Related Financial Disclosures (TCFD)	The Financial Stability Board created the TCFD to improve and increase reporting of climate-related financial information. It can more effectively evaluate climate-related risks to companies, their suppliers, and competitors.
Climate Disclosure Standards Board (CDSB)	The CDSB is an international consortium of business and environmental NGOs committed to aligning the global mainstream corporate reporting model to equate natural capital with financial capital.
Taskforce on Nature-Related Financial Disclosures (TNFD)	The TNFD will deliver a framework for organisations to report and act on evolving nature-related risks, to support a shift away from nature-negative outcomes.
Partnership for Biodiversity Accounting Financials (PBAF)	The PBAF Standard enables financial institutions to assess and disclose loans and investments impact and dependencies on biodiversity.

based metrics, reporting, and verification systems that can inform investors and corporates on their investments' and projects' environmental impacts can help overcome some of these concerns. To create transparency for investors, the public sector can introduce regulatory requirements for adherence by actors across the financial industry. The public sector can also provide funding to assist the design and development of low-cost monitoring, reporting, and verification solutions. The sustainable finance community needs to prioritise the following actions:

- Clearly define green investments: Regulation can help form a universal understanding of definitions, classifications, and how actions are understood and considered. An example is the new European Union Sustainable Finance Disclosure Regulation, which, will require all financial actors to disclose how green their investments are based on the EU taxonomy.

- Innovate in impact measurement and verification, to develop new ways and cost-effective solutions: This involves collecting data on multiple impacts beyond those covered by traditional ESG metrics, including on adaptation and natural landscapes; working with existing initiatives to contribute towards global best practice on impact measurement and priority-impact metrics.
- Strike a balance between the range of reported metrics and associated data-collection costs: Metrics should not be so burdensome that they become uncommercial and detract investment.
- Promote transparency and accountability in impact reporting: This should aim to account for impacts in ways that resonate with farmers, consumers, and all key stakeholders, as well as provide support to initiatives that seek to improve impact accountability.
- Support harmonisation of impact standards: Impact standards should be simplified to increase the reporting efficacy and attract additional impact-focused financing.

12.6 Way Forward

Sustainable finance has great potential to fund the necessary food-system transformation and innovations under a changing climate. To effect this transformation, current major sources of finance in the sector need to be targeted, new sources of funding identified to mobilise additional capital resources, and current financing reorientated to reduce the food system's contribution and vulnerability to climate change. To achieve this, three core areas should be focused on. Firstly, attractive investment opportunities for finance actors must be created, to deploy sustainable finance through leveraging innovative financial instruments and mechanisms. Secondly, the capacity of financial intermediaries to accurately assess risk and deploy risk-mitigating mechanisms must be built, to mobilise additional capital. Thirdly, robust, science-based metrics and cost-effective data collection and monitoring systems should be championed, to safeguard positively impactful finance.

Notes

1 Greenwashing is defined as behaviour or activities that make people believe that a company is doing more to protect the environment than it really is (Cambridge English Dictionary, 2022).

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13

Organising for Change

Empowerment for Farmers, Women, Youth, and Communities

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Highlights

- Organisational empowerment is a critical pathway to support the sustainable transformation of food systems, mediated through different types of organisations.
- Collective action can be an effective strategy to include marginalised groups who may otherwise be excluded from agricultural development, extension, financing, or other aspects of climate-resilient food security.
- Key empowerment actions by farmer and producer organisations include building capacity, supporting greater access to inputs and information, facilitating the formation of agricultural enterprises, connecting to policy and markets, and encouraging youth membership and leadership.
- A focus on livelihoods, production, and poverty reduction can be a basis for increased agency and influence in decision-making.
- Women's collective action is a platform to access information, technology, and a share of finances, which can lead to agency and leadership in local decision-making.
- For youth organisations, it is important to mobilise finance, provide support to post-production activities, support rural youth networks and recognise the role of young women in food systems.

13.1 Introduction

Working with women, youth, and marginalised people both in collective organisations and individually is a critical pathway to support the sustainable transformation of food systems and can empower at individual, community, and national levels. Collective action can be an effective strategy to include marginalised groups who may otherwise be excluded from agricultural development, extension, financing, or other aspects of climate-resilient food security.

Organisational empowerment considers the collective creation of opportunities for members to achieve individual and collective goals. Agriculture-related organisations address farmers' priorities of resources and knowledge for increased production, providing a platform for their voice and representing them in both policy and public contexts. They promote group agency in the process and results of collective action. In this chapter, we focus on the interrelationships between individuals and community organisations, as well as between organisations and the larger environments in which they exist (Kabeer, 1999; Rothman et al., 2019).

Organisational empowerment in agriculture and food security is mediated through four types of organisations: farmer or producer organisations/cooperatives, women's organisations, youth movements, and community-based organisations (CBOs). These organisations can be active at local, national, or global levels, such as the National Women's Union in Vietnam, the Asian Farmers' Association for Sustainable Rural Development, or the World Farmers' Organisation. The models for organisational empowerment discussed here all move towards empowerment from a base of economic support and access to resources. This base is then combined with empowerment aspects such as participation in household or community decision-making, increased voice and agency, or the ability to influence decisions in local or national contexts (Huyer et al., 2021). It is crucial to engage young people for food-system transformation in the face of climate change, their vulnerability to both current and future impacts of climate change, and given they may also offer ways forward as potential agents of change (HLPE, 2021).

13.2 Empowerment for Climate Resilience: Farmer and Producer Organisations and Cooperatives

These organisations can consist either of mixed-gender groups or have a majority of women or men, while some are also youth cooperatives. In many regions, they are driven by poverty alleviation and advancement of farmers and the rural poor, as well as by access to markets and inputs. Farmer and producer organisations and cooperatives also express voices at different levels, strengthening members' political power so that their concerns and opinions are heard by both policymakers and the public. These organisations mediate access to production information and add production value, as well as developing links with financial service providers. Marketing-oriented organisations facilitate the purchase of inputs and equipment by members, helping them meet quality standards and manage product drying, storage, grading, cleaning, processing, packing, branding, collection, marketing, and transportation. The organisations enable economies of scale, ensuring a more reliable supply to buyers in larger quantities. Importantly, organised farmers have greater bargaining power and can negotiate with powerful market players, increasing profits to farmers rather than to intermediaries or buyers (Penunia, 2011). Actions to empower such organisations include building capacity, supporting greater access to inputs, and facilitating the formation of agricultural enterprises.

Membership in mixed-gender farmer or producer organisations or cooperatives can empower women (Mwambi et al., 2021). Frequent and notable outcomes of cooperative membership for women include increased participation in decision-making, either at household or local levels, a greater ability to express their voice and act on their own behalf, that is, self-agency, and increased income and production, which improve women's household and community status (Ferguson & Kepe, 2011).

Cooperatives have been an effective mechanism for engaging young people in agriculture and increasing both on- and off-farm employment. Youth can also be encouraged to join existing farmers' organisations or cooperatives, in order to gain access to inputs, services, finance, and markets. In Lesotho and Uganda, Hartley (2014) found that cooperatives encourage youth members to learn 'from' and 'with' each other, leading to new ways of thinking and action. In existing cooperatives, generation-based power relations sometimes constrain young people's potential to assume leadership opportunities, as was found in Kenya dairy cooperatives (Bullock & Crane, 2021). These findings reinforce the need for a legal framework in cooperatives that supports youth engagement.

A notable example of organisational capacity building comes from the Adaptation to Climate Change in the Mekong Delta (AMD)[1] project in Vietnam, supported by the International Fund for Agricultural Development (IFAD). It focused on capacity building for farmers, producers, women, and youth organisations by combining knowledge about climate-smart practices with access to finance for implementation through Climate Change Action Funds (CCAF). AMD's commodity-producer groups, linked with businesses in value chains, constituted new institutions that benefited rural poor households, particularly through 'group funds', a strategy that informed national policy on collaborative groups. The AMD project also created new financial institutions in rural areas, such as the Women's Development Fund and Saving & Credit Groups, improving poor households' access to credit. The project also increased the representation of women in leadership roles: nearly 40 percent of common-interest group leaders in the two provinces were women, and the AMD project was acknowledged by district authorities as a catalyst of empowerment.

The Asian Farmers' Forum supports national farmers' organisations by providing capacity and economic development support. Capacity development support from IFAD strengthened the organisation and its operations, such as engagement in policy processes and member services. Actions and achievements included access to mobile applications for information and communication in Laos; establishment of a national platform, the Laos Farmers' Network (LFN), that provided visibility and networking with donors and the public sector;[2] partnerships and cooperation with other agencies and countries in Vietnam; information for accessing government and local service providers, and for advertising farmers' products in Bangladesh. It also took concrete steps to increase women's participation and leadership: between 2014 and 2019, female membership more than quadrupled from 4.5 million to 21 million. Women's representation in leadership also increased from 24 percent in 2014 to 63 percent in 2019. One important step has been to set up women's committees and desks in farmers' organisations (FOs) (Firmian et al., 2020).

In Uganda, membership in the Manyakabi Area Cooperative Enterprise generated increased income and expanded production for women farmers (Ferguson & Kepe, 2011), including through sales of maize and beans to the World Food Program (WFP), empowering household and community members. Other benefits of cooperative membership included improved connections with traders from local and external regional markets for maize and beans, pre-market production planning, quality-control training, training on post-harvest handling of specialised crops, plus inputs including seeds and seedlings for maize and bean gardens. Farm productivity increased, improving food security. The social benefits included information dissemination and community development in education, health and hygiene, and financial savings. There were significant empowerment results, including women members reporting greater independence and status, new leadership and business skills, and improved coping strategies.

In summary, key actions to empower farmer and producer organisations include building capacity, improving access to inputs and information, facilitating the formation of agricultural enterprises, connecting to policy and markets, and encouraging youth membership and leadership.

13.3 Enabling Agency: Women-Focused Organisations

Women-focused organisations can be enabling platforms for capacity development that go beyond agriculture to increase resilience as well as empowerment. Women's organisations enable the sharing of experiences, supporting each other in revolving credit, improving production or processing, entrepreneurship, and/or information provision. In this way, collective action can alter women's self-perception by increasing their confidence, improving their negotiating skills, encouraging the transfer of skills to non-members in their networks, and by better influencing household decisions (Ferguson & Kepe, 2011).

Membership in a women's cooperative for sunflower production in Uganda led to concrete economic and empowerment results; membership significantly reduced food insecurity and supported livelihood diversification through the production of other staple crops as well as poultry; members' knowledge of innovative farming techniques and improved seeds increased. Membership in the cooperative significantly enlarged women's influence on decisions in households, local groups, and the wider community (Lecoutere, 2017).

Self-help groups are another widespread form of collective action. A project in Madhya Pradesh, India, funded by the United States Agency for International Development (USAID), worked with women farmers on the development of women-led groups, building their capacity and involving them in the provision of climate-smart agriculture (CSA) technologies, practices, and services. Participation in committees to manage and implement CSA practices and technologies empowered women, integrating them into a prestigious and successful village activity. Their knowledge of climate-resilient practices increased and their access to information improved, resulting in increased community visibility and leadership. Two types of women's groups played a prominent role in the project: one to coordinate management and implementation of climate-smart interventions in Village Climate Management Committees, and the other through custom-hiring centres (CHC), which rented out climate-smart technologies to farmers at affordable rates. Meetings with technical experts, practical demonstrations, experience-sharing, and demonstrations built technical knowledge and adaptive capacity. Entrepreneurship and business management training was provided to run the CHCs, with more than 3 700 women involved (Huyer et al., 2021).

An initial challenge for the CHC in Madhya Pradesh was to convince farmers, particularly men, to use the services provided by their centres. Inability to travel outside their villages limited interaction with farmers from neighbouring villages, affecting the start-up of the CHC. Assistance from NGO partners and participation in multiple-stakeholder forums convinced farmers in and around their village to take advantage of the technologies available at CHCs. Other challenges might include an increase in women's work, given that work in the organisation added to women's other tasks, creating a 'triple burden'. Commercialisation of production in producers' organisations may reduce women's control of farm production; disadvantaged groups, especially older women, may not be able to participate fully in cooperative activities, and low literacy levels may limit people's ability to access market information (Lyon et al., 2017; Mwambi et al., 2021; Ngomane & Sebola, 2019).

Key actions for women's collective efforts include the provision of resources, inputs, technology, and information while increasing their profile and interaction in public community life. This example demonstrates how women's community organisations increase women's recognition and leadership, improve participation in household decision-making, and afford access to climate information and CSA technologies.

13.4 Youth Agency through Movements

Young people are vulnerable to the current and future impacts of climate change but are also agents of change for sustainable food systems (HLPE, 2021). Youth agency, or the ability to set goals and act upon them, is often influenced by intersecting power relations and social factors, such as gender, age, ethnicity, and education level (Glover & Sumberg, 2020). Effectively harnessing youth skills and energies for sustainable food systems will require significant efforts to redistribute power and transform existing social, political, and economic relationships and conditions within and across countries. Barriers such as access to resources, education, and dignified work within complex political and socio-economic landscapes are often the results of inadequate legal frameworks, insufficient domestic and international resource mobilisation, and political commitment. Engaging young people, particularly those living under the poverty line, in nature-based, cost-effective solutions such as regenerative agroforestry is a sustainable response strategy. Loans specifically targeted at youth for land acquisition are also needed; however, some youth-specific funds such as the Youth Enterprise Development Fund in Kenya have complicated application procedures and low amounts of available capital (Amsler et al., 2017).

Accessibility to resources is highly gendered (HLPE, 2021). In many developing countries, young women's participation in policymaking at household and community levels is particularly challenging owing to gender norms about women's role in decision-making, as well as persistent gender inequalities regarding household assets, information, and access to technology, etc. (Amsler et al., 2017; Huyer, 2016).

Youth movements are one avenue for young people to become agents of change, raise awareness about the need for a food-system transformation, and demand climate-change action (HLPE, 2021). These types of social movements are often self-organised and led by young activists and campaigners from around the globe. One example of a youth movement is the initiative Act4Food Act4Change, launched in May 2021. It is led by young people aiming to create a long-term, global youth movement. With roughly 30 core youth leaders, 105 145 pledges as of November 2021, and more than 200 youth advocates around the world, the initiative encourages young people to pledge and contribute to creating systemic change. It also encourages youth to vote on the actions they would like businesses and governments to take to transform food systems.

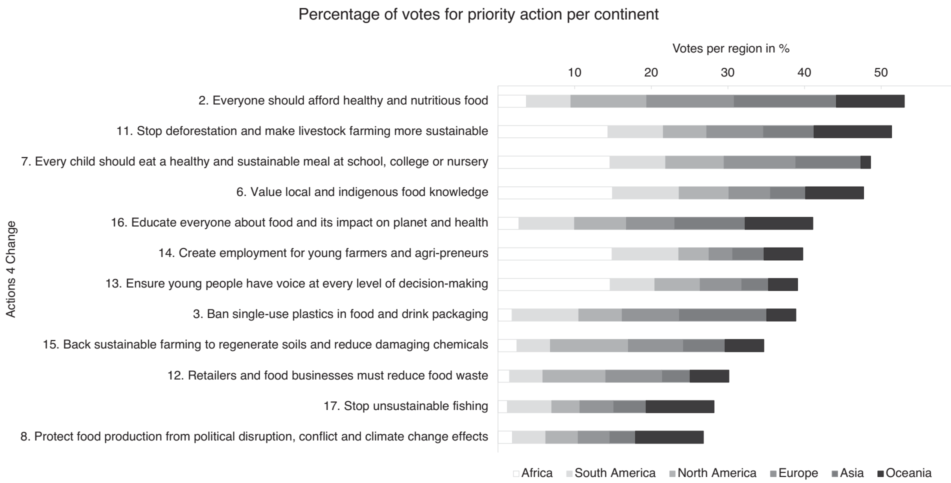

Figure 13.1 Ranking of the top three priorities from each region (four in place of a tie). Preliminary results from online voting on food system actions (n = 20 220)

By November 2021, 17 priority actions were identified through online voting (Figure 13.1). Preferences vary by region. For example, African youth prioritised participation in decision-making, employment, and local knowledge, while in Europe respondents focused on healthy diets, packaging, and education. Actions 2, 6, and 14 are ranked highly across all regions and should be prioritised by policymakers and other key players. These are:

- Everyone should be able to afford healthy and nutritious food,
- Actions should value local and indigenous food knowledge, and
- Create employment for young farmers and agri-preneurs.

Another example is the Climate Smart Agriculture Youth Network (CSAYN), which works with an adaptive mindset, a desire to transform food systems, and an interest in technology. With a passion for sustainable approaches, CSAYN creates awareness and builds the capacity to adopt and benefit from CSA. This network catalyses youth engagement in CSA to unlock decent employment opportunities in the agricultural sector and to transform young people into active agents who cultivate a food-secure world. CSAYN equips students in agricultural sciences and CSA with the knowledge to optimise major agribusiness opportunities. To this end, CSAYN convened a CSA Campus Forum that acted as a showcase for agriculture professionals and successful young farmers who offered peer-to-peer learning and mentoring to students. Research trends reveal a steady decrease in students motivated to become the next generation of agricultural professionals and agri-preneurs. Degree enrolment in agricultural courses is on the decline as students at the Forum reported a lack of motivation and a negative perception of future career prospects in agriculture (Mugo et al., 2019). Through a novel approach of practical on-farm technological demonstrations, innovations and management practices, CSAYN has established Climate Smart Agriculture Excellence Centres (CSAECs). These act as centres of knowledge transfer for locally appropriate and environmentally sound farming approaches and technologies. Run and led by the youth, they support peer-to-peer learning opportunities and facilitate the scaling of CSA practices among young farmers.

Act4Food Act4Change, CSAYN, and other youth movements demonstrate how youth can make an impact through different pathways. These includes: (1) raising awareness about the urgency of taking immediate climate action; (2) supporting older generations through an intergenerational partnership, where youth can reach out and facilitate discussions within food-system organisations; (3) supporting and aiding the development and adoption of digital technologies in agriculture; and (4) ‘cutting through the baggage’ and bringing crucial networks to the table.

Digital tools and social platforms can be used to create and support youth networks that share advice about climate-adaptation strategies, such as drought-tolerant varieties, as well as agri-climatic and marketing information. Social platforms activated by young people can promote sustainable change.

Young people alone cannot transform food systems, and empowering youth as agents of change will require governments, businesses, and organisations that include both young women and men in decision-making forums across sectors. Governments need to listen to, empower, and engage youth, to ensure that new policies fit the realities of youth. Increased investment and network building is needed to help youth advance their agenda and achieve impacts (Bullock et al., 2020; HLPE, 2021), particularly since ‘young people are disproportionately left out of the financial system’ (ibid., p. 63). For example, climate funds targeted specifically for youth initiatives can support youth agency and capacity. Intergenerational alliances enable youth empowerment for food-system transformation. In the field, generated knowledge and experience from older community members can be used in CSA training and adoption by young farmers (HLPE, 2021).

Generating evidence to support the understanding of young women and men’s opportunities and constraints in food systems is key in climate mitigation and adaptation. Aside from generating knowledge, sharing knowledge can also build youth capacity and support efforts to increase climate-change resilience (Bullock et al., 2020). Through activities such as farmers’ field days and capacity enhancement for teachers, agricultural communities have a better chance of meeting their livelihood needs. Further, youth themselves have emphasised the importance of education and knowledge dissemination. This can improve youth agency to achieve food-system transformation by (1) emphasising environmental values to raise environmental consciousness; (2) teaching youth to observe problems from a transdisciplinary perspective; and (3) enhancing self-confidence in forums, to convince youth they have the power to shape their own future (Singh, 2021).

Key actions to support youth organisations include:

- Mobilising finance: Large amounts of capital are required to invest in improved seeds, fertilisers, and other agricultural inputs, that are not easily accessible to people in rural areas. This is particularly true for youth who may have limited knowledge and experience of financial systems.
- Supporting post-production activities: Young farmers need support in their entrepreneurship and post-production value-addition activities. Policies should be put in place to support innovative ideas and solutions across the agricultural value chain.
- Supporting rural youth networks: Only a small number of organisations represent rural youth, and those that do often lack financial resources, are small, informal, operate at the local level, and have little bargaining power in policy processes. Rural community networks should be established and strengthened by various stakeholders including government and businesses, to provide better access to loans from financial institutions (Jepson et al., 2014).
- Recognising the role of young women in food systems: Access to resources and participation in decision-making is gendered, while other gender norms such as division of labour affect young women's potential to participate and benefit from organising.

13.5 Innovation for Resilience: Community-Based Organisations

Women's organisations and community-based organisations (CBOs) can carry forward social or environmental objectives and enable access to credit through revolving credit or village savings and loan associations (Pamuk et al., 2021), and support other collective action goals that lead to empowerment. They can stimulate inclusive economic growth and poverty reduction in poor rural communities by improving access to productive infrastructure and the services that lead to sustainable agricultural production. They often tackle the lack of access to modern farming technologies of smallholder farmers in remote villages and support private-sector mechanised service providers and maintenance services. They can be an effective platform for introducing new agricultural practices and technologies, generating and sharing resources, and community-building.

From 2011, CCAFS has collaborated with CBOs in Kenya, Tanzania, and Uganda to develop platforms for agricultural learning, farmer advisory services, delivery of agricultural inputs, accessing loans and mobilising farm labour for the construction of soil and water conservation structures. They were also used to promote demonstration farms and act as agricultural knowledge hubs on CSA technologies and innovations, such as resilient crop varieties (Radeny et al., 2018). These groups enable men, women, and young farmers to build social capital and an asset base that increases resilience. For example, in Nyando, ten youth groups have begun horticultural farming using smart farms that consist of greenhouses and solar irrigation, generating produce for local markets all year round. In Nyando, umbrella CBOs consisting of more than 50 mixed farmer and youth groups served 106 villages. About 80 percent of the membership is women or youth below the age of 25. In Lushoto, Tanzania, three CBOs, established in 2012 and in 2014, were transformed into village-savings and credit-cooperative societies; these cover 29 villages and have a direct membership of 1 980 households, with 55 percent being women. In Hoima district of western Uganda, two CBOs organised a membership of 2 700 households in 2018, with 60 percent being women.

Collective action in community organisations in CSA has increased sustainability in rural areas through natural-resource management and conservation structures, tree nurseries, promoting innovation and knowledge in the community, enhancing the bargaining power of rural farmers, paying school fees, and promoting small-scale trade. Challenges for the success of CBOs include lack of organisational experience of volunteer leaders, lack of access to formal finance as members are perceived as financially risky, and inexperience in strategic planning.

13.6 Way Forward

Organising at the community and national levels increases access to resources, promotes social and environmental action, acts as a platform for agricultural innovation and resilience, and promotes agency and voice for groups who may otherwise be left out of climate policy and action.

Farmer organisations, producer organisations, cooperatives, women's organisations, youth-based movements, and CBOs encourage producers, business owners, researchers, investors, and policymakers to innovate in ways that are socially inclusive, reduce poverty, and encourage resilience. They can address major barriers and constraints by increasing access to financial resources, making available technologies that suit women's and youth preferences and tasks, supporting access to markets, and backing their decision-making power at different levels. While youth engagement is crucial in food-system transformation, it should be a multi-generational effort. Youth challenges – fewer resources, knowledge, and influence in politics – limit their ability to be agents of change (Glover & Sumberg, 2020). Thus, considerable attention to youth issues is needed by many actors in the food system.

Strengthening organisations and their networking at all levels is key to transformation. However, to empower actors it is necessary to move beyond a focus on livelihoods, production, and poverty reduction and also promote voice, agency, and influence on decision-making in households, communities, and nations. Organisations provide the base of economic stability necessary for food security and livelihood development and act as a stepping stone to agency, resilience, and empowerment.

Notes

1 www.ifad.org/en/web/operations/-/project/1100001664.

2 www.ifad.org/documents/38714170/39148759/MTCP2_apr.pdf/d9ca7f99-1c5e-4925-8962-d02646b66934.

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14

Transforming Innovation Systems to Deliver Impacts at Scale

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Highlights

- Transforming our food systems will require changing our innovation systems, in which organisations on agricultural research and innovation can play a crucial role.
- Key success factors for change can be organised into three dimensions: designing and managing transformative innovations, culture and structures of innovation organisations, and their engagement with the wider innovation ecosystem.
- Failures are crucial elements of innovation processes. It is key to rapidly test, share, build on and learn from successful, and failed, innovations.
- This connects to the paradigm ‘Open Innovation 2.0’, which is widely applied in the private sector but not yet applied and evaluated for research and innovation organisations in the public sector or tertiary education.
- Four key principles emerge: (1) big-picture action-oriented thinking, (2) entrepreneurial organisational culture, (3) close attention to partnerships and contexts, and (4) diverse investment portfolios, with different levels of risk. These also imply – and require – the upstream transformation of funding and incentive systems.

14.1 Fit-for-Purpose Innovation Systems to Accelerate Sustainable, Equitable, and Resilient Food-Systems Transformation

> *Do research to create knowledge. Do innovation to create impact.*
> *Marco Ferroni, Chair, CGIAR System Board*

Innovative opportunities for food-system impact range from land use and food production to distribution, consumption, and waste management. While many climate-resilient technologies and practices already exist, adoption rates and their corresponding impacts remain low. Responding to local needs will require the bundling of innovations into different technological components – for example, finance products with insurance or climate information – while considering context-specific and social factors such as policies, social licence, and competing actors (Barrett et al., 2020). Innovation, however, has not always led to positive outcomes. Evidence shows that previous growth-driven approaches have made food systems a major driver of habitat degradation, climate change (Bene et al., 2020), and social inequalities (Box 14.1), with innovation sometimes further exacerbating negative externalities. To transform food systems, innovation must be fit-for-purpose – for example, using artificial intelligence to track deforestation or satellite monitoring of land-use emissions for transparency and better reporting – and able to address inequalities and imbalances of power.

In that context, transforming food systems also requires a transformation of the underpinning innovation systems (Steiner et al., 2020). As part of the UNFSS Innovation Lever, four areas have been identified as critical to building fit-for-purpose innovation systems: (1) the development of national and regional ecosystems to improve how we innovate; (2) better collaboration through societal and institutional innovation; (3) improved knowledge systems, including different

Box 14.1
Addressing Power Issues in Innovation Systems

The 2021 UN Food Systems Summit (UNFSS) process reminds us how important and how difficult it is to frame innovation broadly and inclusively to enable countries and communities to transition to more sustainable and equitable food systems. Integrating different ways of knowing, including traditional and scientific knowledge, is key to understanding power dynamics in food systems. This requires involving all social actors – including those who have yet to benefit from the various services that food systems provide – in building the evidence base for transformation. Furthermore, this also means fostering co-creation, knowledge-sharing, and explicit power-sharing in the development of innovations, across entire value chains. Indeed, innovations can be designed and used to rebalance power relations within value chains, to ensure there is fairness, equity, and transparency in the distribution of risk, and to empower farmers to adopt, scale, and ultimately benefit from innovation. At the same time, as part of a full value-chain approach, consumers must be accounted for, as they will ultimately drive demand for more sustainable, climate-resilient practices, while at the same time being subject to continuous – hidden or open – external influence through aggressive advertising and lifestyle models, for example.

kinds of knowledge, that is, scientific, indigenous, and other types; and (4) a better integration of data and digital systems.

As highlighted in Chapter 12, a large investment gap in research and innovation – typically associated with high investment risk – has hindered progress in these four areas. The existing investment does not support sustainable or equitable futures. Of the US$50–70 billion annual public spending on agricultural innovation in low- and middle-income countries, only 7 percent explicitly targets environmental outcomes, of which only around half include social or human objectives. An additional US$10.5 billion per year – combining US$4 billion for research and development and US$6.5 billion for uptake of climate-smart technical options – would deliver significant progress towards zero hunger and limiting global warming to 1.5°C, through redirecting incentives and/or unlocking private finance (CoSAI & FCDO, 2021) . The need to increase investment efforts is at the core of the ClimateShot campaign and its Global Action Agenda for Innovation in Agriculture launched at COP26 (Box 14.2).

Box 14.2

The ClimateShot Campaign and Global Action Agenda for Innovation in Agriculture

Launched at COP26 in Glasgow, the Global Action Agenda for Innovation in Agriculture is the culmination of a year-long global campaign co-chaired by CCAFS and the UK Foreign, Commonwealth, and Development Office, which set out a vision to transform agricultural innovation for people, nature, and climate. In line with the Glasgow Agriculture Breakthrough, the ClimateShot campaign brings a wide range of stakeholders into an informal alliance that draws from across the climate, agriculture, and food sectors, and which calls for collective action to achieve four key objectives:

- Increase investment in agricultural research and innovation to create more climate-resilient, low-emission technologies and agriculture practices.
- Focus at least a third of agricultural research and innovation investments on delivering demand-driven solutions across food systems that protect nature and limit climate change.
- Showcase successful business models and promote public–private partnerships that deploy these innovations on the scale needed to meet the climate and food security challenge.
- Forge consensus on the evidence of what works where, and facilitate inclusive dialogue among food and climate champions around the world on appropriate public, private and civil society solutions.

A set of priority initiatives as well as contributions from the campaign's 'allies' – nearly 200 organisations, including 20 countries – will ensure the successful implementation of the Global Action Agenda's vision and objectives.

For further information, visit www.climateshot.earth.

Provided sufficient investment is unlocked, research programmes have an essential role to play in further supporting change-makers and facilitating food-system transformation. Research can provide evidence, tools, and methodologies for planning change and measuring impacts, co-developing and scaling innovative technologies and practices, and informing and building capacity for different purposes, stakeholder groups, aspects, and levers of food-system transformation. To do this, however, agricultural research and innovation institutions must be fit-for-purpose (CoSAI & FCDO, 2021) .

As highlighted in Chapter 3, the successful uptake of knowledge requires demand-driven, targeted, co-produced, and timely evidence. This chapter offers some insights on the changes required in the procedures and institutional set-up of agricultural research and innovation organisations, and how they engage with the enabling environment. It then reflects on the importance of failing, and distils key mechanisms that connect stakeholder groups across these dimensions, aiming to rapidly share, build on and learn from successful and failed innovations. We discuss these practical learnings under the concept of Open Innovation 2.0 and present four principles for rethinking research and innovation as part of wider, systemic change. We conclude that such change both entails and requires an upstream transformation of funding and incentive systems.

14.2 Lessons of the CGIAR Research Program on Climate Change, Agriculture, and Food Security Enacting Transformative Change

> *Problems do not come in disciplinary boundaries. Solutions don't, either.*
> *Walter E. Baethgen, Director, Regional and Sectorial Research Program, International Research Institute for Climate and Society, Columbia University*

Both the UNFSS and the ClimateShot campaign emphasise that transformative changes will cut across many different dimensions, levels, and geographies. The impulse for innovations will often emerge as a need from the wider innovation system, in which the agricultural research and innovation institutions form only part of the puzzle. As part of this broader puzzle, research and innovation actors must work together with the wider stakeholder community (Chapter 16), fostering coherent and joined-up research design, implementation, and funding strategies that address the needs of the many (Steiner et al., 2020). The scale and pace of identifying, bundling, and scaling innovations that can drive food-system change depends largely on how compatible these innovations, and different innovators, are within their respective contexts, and with each other.

Such innovation approaches would require research and innovation organisations to rethink and accelerate their processes of innovation development and scaling, shifting from a rather technology-centric perspective to one that embraces sustainable change at scale (Woltering et al., 2019). To do so, we must ensure that research is more action-oriented and identify the best practices that improve knowledge generation, exchange, and use processes, ultimately supporting the food-system transformation (Steiner et al., 2020). In parallel, finding innovative ways to integrate and leverage policies and finance, alongside private-sector and civil-society actions is essential.

Systemic approaches that have been proposed to tackle these questions can be challenging for research and innovation institutions to implement (Govaerts et al., 2021). In the following sections, we aim to provide guidance on how research and innovation organisations could accelerate the transformation of innovation systems, with lessons derived from multiple evaluations, learning events, and synthesis documents from the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), and articulated through examples of ten years of CCAFS implementation (CGIAR-IEA, 2016; Koerner et al., 2020; Nelson & Morton, 2020). These are grouped into three dimensions: the process of designing and managing transformative innovations, the characteristics of successful innovation organisations, and their engagement with the wider innovation ecosystem.

14.3 Designing Transformative Innovations

Innovations must be useful for end users in practice, not only in theory. At the same time, decisions on what to invest in will depend on the goals and priorities of each individual, public, and private decision-maker. A balance is to be struck between desirability, scalability, and the possible impact of the respective innovation bundles. At the same time, particularly at moments of agenda-setting and prioritisation, power relations and the inclusion or exclusion of respective stakeholder groups need to be monitored, made transparent, and accounted for. The following are examples of good practices:

Participatory Priority Setting: Participatory prioritisation tools can help stakeholders at different levels identify their climate vulnerabilities, assess coping strategies, and evaluate impacts and trade-offs. Application areas range from countries' determining their contributions to the Paris 2015 Agreement to participatory rural appraisal tools applied at farmer and community levels.

User-Centric Design Approaches: Agricultural research and innovation institutions increasingly apply methodologies like co-design or co-creation, particularly when innovations have a direct user interface, as for example in climate or financial services. These methodologies increase the potential for later uptake of the innovation, involve users from the very beginning, and can be adapted to different, multi-stakeholder groups and contexts. Examples include co-designing farming systems with farming communities, addressing sectoral bottlenecks with value-chain actors, and defining pathways for transforming innovation networks at the policy level.

Innovation Portfolio Management: Well-balanced innovation portfolios can increase the efficiency of research and innovation institutions in several ways. For example, they can balance investments in innovations that are likely to be successful, with innovations that have high-impact potential but that are not yet fully proven. Countries or research and innovation institutions could also have regional or thematic portfolios, thus directing bundled efforts towards key areas for change (Box 14.3).

14.4 Designing Organisations as Innovation Environments

Becoming an innovation organisation will become a matter of self-interest for agricultural research and innovation institutions that wish to remain relevant, competitive, and be able to keep contributing to accelerated food-system transformation. To become an innovation organisation, a key shift is to nourish a culture of innovation that depends on investing in both people and spaces, as follows:

A Culture of Transdisciplinary (Knowledge) Exchange and Cooperation: Innovations should be viewed in a transdisciplinary way, involving multiple stakeholders, integrating different forms of knowledge, and fostering transitions across different food-system dimensions. Creativity is unleashed in safe spaces, which can be both physical or temporal, with the quality of interaction being more important than the quantity (Gloor, 2007). Transdisciplinary design is fostered by a shared vision, trust, complementary roles, and easy communication, yet also requires 'hard factors', like the innovation of intellectual property management practices, and incentivising and tracking the generation of societal outcomes.

Skills and Roles for Innovation: Engaging in innovation partnerships and communities also requires actors to take on different roles and skills, like

Box 14.3
Bundling and Scaling Innovations in the Program Accelerating the Impact of CGIAR Climate Research for Africa

In 2020, the World Bank funded the three-year Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA) program, to bundle and scale climate-smart technologies in six African countries and beyond. Innovation bundles could, for example, be coupling agricultural credits with climate services (CS), or coupling CIS with agricultural advisories. Using experiences from CCAFS, workshops were held on how to prioritise and bundle innovations, offering sets of different tools for each step. These tools are tailored to the needs of different stakeholders and user groups, from farm to landscape levels, market actors or regional, national, and global policies. The tools are freely accessible online and can be used in complementary ways. For example, Climate-smart Country Profiles can be complemented by Country Investment Profiles and/or scaled down to Community Adaptation Plans, and vice versa. An example of this is the AICCRA Zambia program, which developed a portfolio of four innovation bundles around solar pumps for specific value chains, integrated aquaculture-agriculture systems, seed varieties, and diversified integrated chicken/goats/legume systems, which it now aims to link to end-user finance approaches to reach scale.

convening, facilitating, negotiation, and change management (Wigboldus et al., 2016). A special challenge for agricultural research and innovation scientists can be the so-called expert–learner duality (Pugh & Prusak, 2013), that is, the capacity to easily switch between the roles of expert and learner. To attract young people to scientific careers, it is crucial to offer and invest in positions that require more general skills and knowledge, rather than specialised but siloed ones.

Orchestrating and Engaging with Different Innovation Spaces: Innovation spaces, such as multi-stakeholder networks, can play different roles in articulating, designing, mainstreaming, or creating an enabling environment for innovations. Depending on their respective goals and member compositions, such innovation spaces can take on different forms and dynamics, and work on different levers of food-systems transformation by promoting sector development, cross-sectoral cooperation, policy incidence, or social mobilisation, for example (Koerner et al., accepted).

An example of fostering a culture of innovation through investing in both people and spaces can be seen in Box 14.4.

Box 14.4
The CGIAR Research Program on Climate Change, Agriculture and Food Security as an Innovation Organisation

CCAFS exemplified its status as an innovation organisation by establishing a core team matrix of country and flagship programs, led by both CGIAR centres and partner institutions, and guided by a shared vision spelled out in the program-wide theory of change. This set-up provided a safe space in which knowledge, tools, and methodologies could be shared and adjusted to the respective contexts, across themes and disciplines. The mix of core- and project-funding provided both the continuity and the flexibility to develop, test, and evaluate new initiatives with small grants and seed funding. The outcome-oriented planning, reporting, and allocation of budgets incentivised an increasing number of people to engage in scaling activities, adding the roles of designers, conveners, and facilitators to their roles as scientists and experts. These factors also enabled program activities to span from farmer- and community-levels up to national policy or private-sector engagements, and linked these to global dialogues and innovation platforms (Koerner et al., 2020).

14.5 Engaging with the Wider Innovation System

Innovations are not designed or scaled in isolation. Crucial elements of wider innovation ecosystems are strategic partnerships, funding packages, and policies that create an enabling environment for deploying and scaling innovation. Another accelerator can be fostering local and national innovation capacities (Box 14.5). Below are some transferable lessons from the experience of CCAFS and CGIAR:

Strategic, Complementary, Out-of-the-Box Partnerships: Partners are increasingly chosen to open new use areas for scientific contributions in the sustainable finance or humanitarian sectors, for example. Important criteria for choosing, managing, and communicating partnerships are due diligence, clear roles and responsibilities, transparency, and clear future-use agreements.

Innovation Funding Packages: Funding is one of the main bottlenecks for developing and scaling innovations. Funding or financing packages should allow for and cover initial risks of early innovations while providing the needed safety and continuity to achieve transformative change. For example, funding packages based on theories of change allow adaptive management, flexible pathways, and reflexive monitoring and reporting (Schneider et al., 2019).

Innovation Policies: Policies that foster innovation need to provide and protect spaces both for innovation and for diverse opinions and approaches towards food-

Box 14.5
The Philippines Department of Agriculture's Adaptation and Mitigation in Agriculture program

Since 2015, the Philippines Department of Agriculture (DoA) has mainstreamed climate-resilient agriculture across all its programmes, functions, and agencies through the national and system-wide Adaptation and Mitigation in Agriculture Program. Supported by the International Center for Tropical Agriculture (CIAT) and CCAFS Southeast Asia, the DoA partnered directly with the CCAFS' partner-NGO, the International Institute for Rural Reconstruction, to institutionalise their bottom-up Climate-Smart Village approach in 17 of its provinces. For that purpose, the DoA provided funds for learning and capacity building for their Regional Field Offices and extension services, to support farmers in identifying, assessing, testing, iterating, and scaling their own climate-resilient community adaptation plans (Koerner et al., 2019).

systems transformation, including the demand side of innovations. Another lesson is to invest in the informed decision-making capacity of policymakers with regard to food-systems transformation. Likewise, long-term, coherent policy signals are needed to attract the necessary investments to scale innovation (Dinesh et al., 2021).

14.6 The Importance of Failing Fast and Intelligently

While the factors above will shape innovation systems that deliver successful innovation, failures are an inevitable and crucial part of realising those successes. This is especially true for the uncertain, complex dynamics in which food-system innovation takes place, as these require exploratory and diverse innovation avenues (Cannon & Edmondson, 2005). Inevitably, some efforts will fail. However, if anticipated and understood, failures can be a key, and sometimes the only, source of information and inspiration for learning. Of course, avoidable failures can be identified at the start of the innovation pipeline through research and adopting best practices. In addition, conversations around failure need to move beyond first-order causes and specific and/or individual blame to enable in-depth learning (Box 14.6). Both individual and organisational leaders should push for and showcase a profound change in the appreciation and response to failures.

Unforeseeable failures deserve a space in the innovation system as a valuable resource for learning. Early recognition of failures, through explicit lean or intelligent experimentation and fast feedback loops, is crucial to limit sunk costs

Box 14.6
Setup for Failure: Balancing Short- and Long-Term Priorities

An outcome-orientated research program such as the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) that is focused on informing policy and decision-making at the farm level often faces challenges in balancing defined priorities. For example, activities in necessary foundational work may be penalised for being too slow to demonstrate evidence of its impacts, given the urgency of doing so. A typical, additional challenge for balancing priorities arises when a concrete opportunity is identified to effectively inform policy. In some cases, eagerness to take advantage of those opportunities jeopardises the required process of technical validation, meaning steps are prone to criticism by external experts.

and manage limited resources (Blank, 2013). Hence, innovation systems and the organisations in them need built-in processes for systematically and rapidly recognising and analysing failures. The following three key mechanisms can be distilled from the previous section's lessons learnt and examples, connecting stakeholder groups across dimensions, themes, and levels, to rapidly share, build on and learn from (un)successful innovations:

Knowledge, Tools, and Methodologies that Speak to Each Other: One way of accelerating food-system innovation is to generate knowledge, tools, and methodologies that can flow relatively freely across organisational boundaries, with actors sharing and building on each other's generated – or discarded – innovations. Examples of this could be open-source data, peer-to-peer platforms, waiving patents, and private copyright predatory practices, and allowing also for crowdsourcing of data, information, and activities. Such open innovation platforms could then allow for flexible adaptation of innovations, embedded within existing national investment strategies or scaled-down based on country-specific development plans (Box 14.3).

Structures for Rapid Testing and Iteration: Flexible and iterative tweaking of the innovation, based on frequent check-ins and feedback, can aid early and robust responses to failure. Supporting structures can be formal innovation pipelines with stage gates, or less formalised 'pit stops' focused on frequent check-ins, adaptive benchmarks, and flexible course correction, supported by funding schemes flexible enough to allow for trial and error (Box 14.4).

Innovation Capacities across Levels: Capacity building for innovation users is often limited to guidance in the use of the innovation. To accelerate the transformation of our food systems, it can be more effective to explore and build up users' capacities to innovate, and to increase the role of farmers and other food-system participants, shifting them from end users or implementers to co-designers, owners, and decision-makers. This will allow them to adapt innovations to context-specific conditions and uses (Box 14.5). Another effect of involving users, in crowdsourcing activities, is the increase of data points and the democratisation of data generation and use (van de Gevel et al., 2020).

14.7 Underpinning the Practical Lessons with the Concept of Open Innovation 2.0

The lessons and best practices above allude to the concept of Open Innovation 2.0, which gained momentum in the private sector with the arrival of large-scale digitalisation. The main idea of Open Innovation 2.0 is that all actors – including business, society, research, and policies – have the opportunity to create, share, and improve transformative solutions more quickly for recurring societal problems. Starting with a shared purpose, and resulting in shared outcomes, the main characteristics of Open Innovation 2.0 are (1) innovations that explicitly plan for adoption and create value for the respective stakeholders and visions; (2) an agile 'production style' that promote transdisciplinary, non-linear roles and networks; and (3) ecosystem orientations that foster formal and informal collaboration, leading to win-win solutions. Central to innovation systems that follow the Open Innovation 2.0 principles, would then be innovations. Knowledge, tools, and technologies with exchangeable components or modules, and structures for rapid experimentation and learning, allowing for the equal sharing and growth of the competencies and capacities of innovating actors (Curley & Salmelin, 2018).

Translated to the context of research and innovation organisations, as outlined in the previous section, an Open Innovation 2.0 system can be illustrated as in Figure 14.1. However, the concept of Open Innovation 2.0 is not necessarily fully transferable to reality. For example, it assumes that all stakeholders' visions and inputs will be on an open and even playing field, whereas our lived experience tells us that power imbalances are the norm (Box 14.1). In such models, failing, or 'trial and error', is often embedded in the design phase of new technologies, by using stage gates or pit stops. However, failures are far less visible and accepted in downstream innovation processes such as scaling-up or science-policy engagement.

14.8 Way Forward

This chapter has explored recent lessons – both from the literature and from the authors' working experience – on why innovation systems matter for creating sustainable, equitable, and resilient food systems, and how research and innovation organisations can become better innovators. However, we recognise that not all

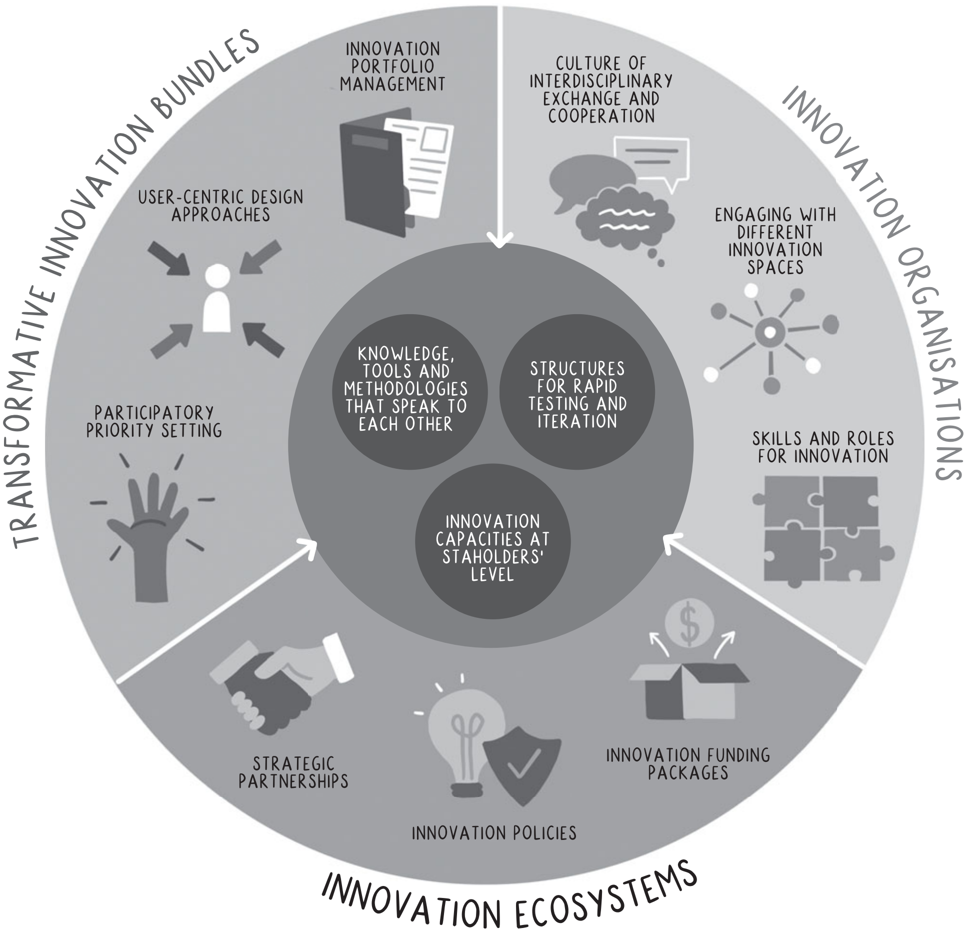

Figure 14.1 How an Open Innovation 2.0 System could look for research and innovation in development institutions

aspects of innovation are under our control. Rather, we outline a number of deliberate approaches that we can take in our own organisations and with our partners, to cultivate innovation systems likely to deliver positive, scaled impact.

Four key principles emerge. The first is big-picture action-oriented thinking, setting a shared ambition to solve societal challenges, not just to develop a technology or pilot an intervention. This also includes the academic institutions where researchers are educated. Societal challenges are not organised in typical academic disciplines. A new culture is needed in both academic and research institutions, one that continues to ensure advances in disciplinary knowledge but that also makes significant effort to create the right environment to integrate transdisciplinarity.

The second is to nurture a creative and entrepreneurial organisational culture. This should provide a safe space to pursue new ideas, implement nimble budgets and staffing, focus on rapid learning, and allow pivoting without fear of failure. This also implies breaking disciplinary silos as early as possible in young scientists' education and formation, and incentivising transdisciplinarity throughout their careers.

The third is to pay close attention to partnerships and contexts. Listening carefully to stakeholders' often unfamiliar priorities and needs, undertaking purposeful design with clients and beneficiaries, understanding that every scaling context and geography is different, and supporting experimentation and adaptation in new settings are all crucial to success. This includes improving the interaction of research institutions with user communities, from policymakers to farmers. Interactions with users establish and strengthen trust, leading to participation in co-design, which ensures that innovations are locally adaptive and quickly adopted.

The fourth is to stimulate diverse investment portfolios, with different levels of risk. This entails running a portfolio of work that combines higher-risk, higher-pay-off options with more reliable but incremental outputs, alongside the targeting of a diverse set of co-investors who accept risk-taking.

Transforming research and innovation organisations to improve innovation systems also requires transformation among public and private financiers. Investment agendas aimed at societal changes would need to balance the two priorities of financial returns on investments and social and ecological impacts. They further need to promote transdisciplinarity and diverse incentive systems. The finance ecosystem would also need to adopt an innovation culture, including embracing early failure and learning from experience.

Finally, mapping out a shared future vision can help to anticipate risks and provide a safe space for transformative change. The path of innovation is uneven; impacts might not be readily obvious and there might even be a plateau or 'backtracking' phase where projects seem stagnant or worse than at their starting point. For example, a shift from intensive to organic farming might mean lower yields for one to three years. A first step that research and innovation institutions could undertake together with their food-system innovation partners could be to build trust and a shared understanding with funding institutions about the complex, messy, and unpredictable character of innovation processes.

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15

Theories of Change for Transformation

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Highlights

- The agricultural research for development (AR4D) domain is becoming increasingly complex, and theory of change (ToC) approaches can provide critical guidance through the transformation maze concerning engagement, partnership, and research.
- Most of the major benefits that accrue to the use of ToCs relate to internal learning within project teams.
- Finding the balance between applying a ToC that is both useful and time- and resource-smart is challenging and may need iteration to get right.
- Quantitative impact assessment methods must be blended with qualitative methods in ToC-based AR4D so that evaluation becomes about both process and numbers, and new methods are needed for blended evaluation.
- The evidence base concerning the efficiency, efficacy, and failings of ToC-based AR4D urgently requires further development and synthesis.

15.1 Introduction

Despite the substantial improvements in human well-being that have occurred over the last thirty years, there is broad agreement that our food systems are not on track to reach the Sustainable Development Goals by 2030. Several different reports published since 2020 address the sustainability, economic, and policy aspects of food systems. These reports converge on one core message: we need to transform our food systems.

Agriculture is generally recognised as a key entry point for effective poverty-reduction strategies, and the adoption of improved practices, technologies, and policies has had strong, positive impacts (Alston, 2020; Christiaensen et al., 2006). Even so, food insecurity and rural poverty are persistent challenges (FAO et al., 2021). The reasons are many and complex but can be encapsulated in the observation that the rate of change in many socio-economic and Earth system trends appears to be accelerating to the point where the past is no longer a good indicator of the future (Steffen et al., 2015). Agricultural research for development (AR4D) faces big challenges in prioritising, targeting, and implementing activities of a type and scale that can make the best use of the many billions of dollars required to ensure food and nutrition security for all in the face of economic and zoonotic shocks and of a warming and increasingly variable climate (GCA, 2019).

The CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) was a relatively early adopter of theory of change (ToC) and impact pathway thinking as a way to orientate research, engagement, and capacity-development activities, in the quest for a food-secure future and 'best use' of financial resources. Robust evaluation of the effectiveness of a ToC approach is still some way off; CCAFS's experience of it has, however, generated lessons that could enhance its effectiveness at scale. In the next section, we provide some background on the theory of change and briefly discuss its implementation in CCAFS, including how the approach was modified through time, driven by the need for pragmatism and nimbleness in reacting to change. We draw out some of the lessons learnt regarding monitoring, evaluation, and institutional and behavioural change. Examining some implications for partnerships, engagement, research, and institutional structures, we conclude with a discussion of the future implementation of ToCs in AR4D food-system transformation programmes.

15.2 Theory of Change Background

The process of AR4D is a set of research activities that produce the outputs used to contribute to behavioural change, or outcomes, via changes in the knowledge, attitudes, skills, and practices of development practitioners, extension services, farmers, and policymakers. These behavioural changes lead to impacts such as increased food security and reduced poverty. The processes that link inputs, outputs, outcomes, and impact are usually much more complicated and iterative than this (Thornton et al., 2017). How this process has been framed has changed through time, driven mostly by development and funding agencies seeking to heighten accountability to their constituents, attribute impacts, aggregate results, and establish incentives and processes to stimulate the use of performance information in management decision-making (Binnendijk, 2000).

With roots in program theory of the 1960s, ToCs have expanded to encompass a range of evaluation approaches introduced to explain why some development interventions created impact while others did not. The call for ToC-informed intervention design was triggered by the needs of evaluation practitioners who sought to understand how outcomes arise (Maru et al., 2018). Another contribution to the evolution of ToCs was the rise of participatory approaches that catalyse positive development outcomes via social learning (Kristjanson et al., 2014). There is no single definition of a ToC and no set methodology; rather, the approach allows flexibility according to the needs of the user or implementer (Vogel, 2012). A ToC provides a detailed narrative description of a hypothesised impact pathway – the logical causal chain from input to impact – and how changes are anticipated to happen, based on assumptions as to how the world works. The process of developing a ToC ideally involves a range of stakeholders who try to articulate the linkages and assumptions between inputs and outcomes (Figure 15.1). Progress is continuously monitored and the ToC modified in light of unexpected or unforeseen changes. Approaches based on ToCs hold out considerable promise,

Figure 15.1 Theory of change cycle (Omore et al., 2019, from O'Flynn & Sonderskov, 2015)

even if more robust evidence for their effectiveness in delivering the desired outcomes is needed (Alvarez et al., 2014; Thornton et al., 2017). A ToC is no panacea, but it can facilitate broad commitment to learning from individuals and organisations, widely seen as an essential element of sustainable development.

There are several implications of implementing ToC approaches in practice. First, there is the need to formalise a project's ToC by involving a wide range of stakeholders in its design. Second, the assumptions that underlie the ToC should be examined regularly, and adjustments made if needed – for example, new or different partners may be added, or a particular assumption may simply not hold. Third, an effective and efficient monitoring system must be established, which may be qualitative as well as quantitative. Fourth, space must be provided for project reflection and learning. We revisit such practical issues below.

15.3 Application of Theories of Change in the CGIAR Research Program on Climate Change, Agriculture and Food Security

At different stages in CCAFS's evolution as a research program, from its design in 2008 to its end in 2021, it utilised various program theories (Figure 15.2 and Table 15.1). At the start, a log frame approach[1] was used to plan and monitor project activities across the portfolio. Projects' annual plans and reports were collected, harmonised, and consolidated manually (Figure 15.2). Because project teams could make individual adjustments to shared templates, submissions lacked standardisation across the project portfolio. It became clear that another way of planning for and capturing outcomes was required, including engagement and capacity enhancement as key strategic elements of the work. Partners started experimenting with learning-based approaches within AR4D, recognising the need to include mechanisms that challenge 'business as usual' and support institutional learning and innovation, to ensure research contributes to development outcomes.

In 2013–14, the program piloted ToC approaches in one thematic area, involving six new multi-annual projects selected via a competitive process in two regions for gender-focused research (Jost et al., 2015; Thornton et al., 2014). These activities helped support a stronger focus on outcomes, especially behavioural changes in people, and made partners, engagement, people, and actors for change central to implementation following the 'three thirds' principle: a third of the effort spent on working with next-users to build relationships and define their needs, a third spent on the research itself, and a third spent on enhancing next-users' capacity to take up research outputs (Vermeulen & Campbell, 2015). A key element was encouraging the program's researchers to consider and plan for the use of their research results by partners and stakeholders and to take responsibility for the findings being used. Reporting on project progress and results was designed

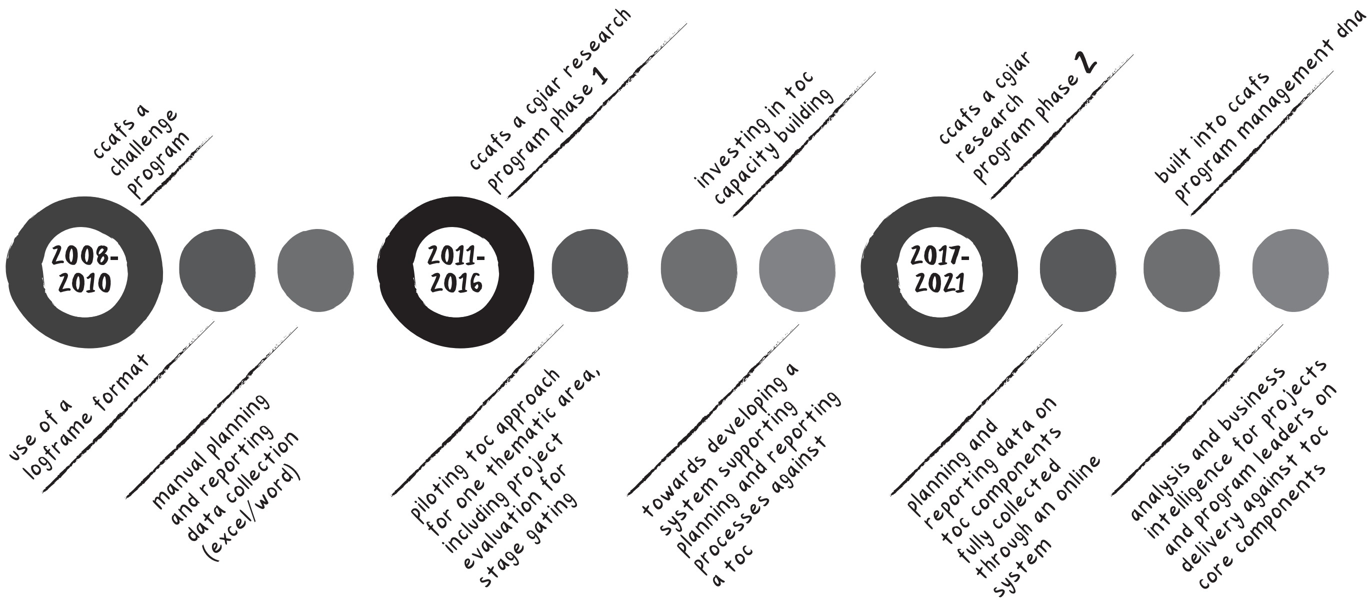

Figure 15.2 History of the use of theories of change in the CGIAR Research Program on Climate Change, Agriculture and Food Security, 2008–21

Table 15.1. *The evolution of theory of change implementation in the CGIAR Research Program on Climate Change, Agriculture and Food Security*

Elements	First period, 2008–10	Second period, 2011–16	Third period, 2017–21
Links to the complementary lenses of transformation (Scoones et al., 2020)	Structural approach: How we change things	Systemic approach: Brought in partners and project leaders	Enabling approach added: All projects applying it, even if only implicitly
Agents of change ToC	Funders: Demand for log frames	Leadership: Program, region, and project	Effect rippled out to project teams and partners
Capacities	Absorptive capacity	Adaptive capacity: Became fit for purpose and meeting needs	Moved towards transformative capacity
Tools for implementation	Log frame	Invested in ToC capacity building for program leadership Piloted a ToC approach for one thematic area, including project evaluation for stage-gating	Built into CCAFS Program Management DNA ToC expanded to partners
Tools and processes for planning and reporting	Manual planning and reporting data collection	Developed a preliminary online system to support planning and reporting processes against planned ToC	All planning and reporting data on ToC components collected through the online system Analysis and business intelligence provided to project and program leaders on delivery against core ToC components

regarding the key elements of a ToC: outcomes, outputs, compliance with program core values such as gender and social inclusion, and partnerships. Reporting was complemented with ‘outcome stories’ in which projects could explain the behavioural changes they observed and present evidence of their contribution to these changes. The program invested in building capacity to train project, thematic, and regional portfolio managers in using the ToC approach. The approach was extended to the entire project portfolio after one year of the pilot.

To strengthen the institutionalisation of ToC approaches, the program combined them with an explicit results-based, adaptive management monitoring, evaluation, and learning framework (Schuetz et al., 2017). This allowed the program to continuously refine both the ToC and project plans, to react in an agile manner to lessons and opportunities as they arose. ToCs were essentially nested at multiple scales: global, regional, country, and project scales. The program invested in the development of an online system to collect planning and reporting data and information. This system enabled implementation of standards, aggregation of results, and guidance of processes in planning and reporting for accountability, learning, and decision-making. Allied with this functionality was a process of annual project performance evaluation. Projects were scored based on their contributions to outcomes – a heavily weighted variable – delivery of outputs, use of inputs, and compliance with key program values such as gender and social inclusion. The evaluation drew on internal leadership and external reviewers.

Several of these elements were modified and expanded in later years, by which time the ToC and adaptive-management approaches had been adopted throughout the program (Box 15.1). Annual planning and reporting were carried out using the online system, which was also adopted by several other research programs as well as CCAFS. The online system was further developed to provide some analysis and business intelligence information for project and program leaders, which could be evaluated against plans on a regular basis. Outcome stories became a key component of annual reporting, and planning and reporting templates stabilised, resulting in a largely consistent set of plans and reports in several programs' latter years, covering a substantial proportion of the CGIAR system's work. Project evaluations informed the stage-gating of investment decisions, that is, whether projects were to be stopped or continued.

15.4 Lessons for Success

Regarding ToCs within CCAFS, several factors contributed to their relatively successful use. Mistakes were certainly made, but the program embraced ToCs, including mainstreaming research that focused on linking knowledge with action, leaders who championed the approach, identification of key leverage points in program-impact pathways, and inclusion of local partners to ground the theories in reality and challenge the assumptions. The successful creation and use of ToCs require mindful and intentional implementation by a program's leadership (Chapter 18). They must lead by example and demonstrate the necessary internal

Box 15.1
Reflections on Theories of Change at a Regional Level

The program leader for West Africa guided the development of a ToC that brought together many different elements along the impact pathway. It encompassed projects that were implemented in the region across several different thematic areas and scales. The projects were funded by different donors, but through the ToC they were brought into a coherent programmatic portfolio, complementing each other to address a common challenge within the same geography. Through the ToC approach, the program leader and projects together built synergies and identified gaps and ways to fill them:

> In our TOC it was clearly mentioned that for the uptake of climate services we would work with AGRHYMET as a regional climate centre and with national meteorological agencies to improve climate information services, to ensure that they innovate in terms of partnerships with other stakeholders for dissemination. This was part of the ToC. And it is through this that we built new partnerships – for example, with mobile phone companies and rural radio across Senegal – to disseminate climate information. So definitely it was very useful. (Robert Zougmoré, personal communication, 2021)

knowledge, skills, and attitudes towards processes for the creation and use of ToCs (Box 15.1).

In terms of using ToCs to lead transformation, identifying transformational leverage points is critical (Chapters 4–14), along with the partners who can deliver change. As such, ToCs that are more specific in pinpointing partners and desired changes will be likelier to lead to success. Strategic partners and targeted tactics to influence the behaviour of key persons and institutions, that is, 'leverage points', are essential, and ToC-process teams must consider these. For example, better sourcing transparency along food supply chains will require engaging with the private sector, but a ToC that specifies 'the private sector' as a partner will inherently be less successful than one that clearly names a major supplier in a specific chain, and possibly even identifies an individual or unit within that company as the leverage point on which to focus. In the South Asia regional program, for example, efforts to increase the uptake of index-based crop insurance were successful following direct engagement with one of the major insurance companies and its team. This process helped develop new thresholds for determining when policy payouts should occur. Different types of partners will play a role at different stages along impact pathways; therefore, the leverage points will also differ. For example, establishing local relations for site-based participatory research requires a very different leverage point than convincing a ministry of agriculture to include specific climate actions in its upcoming strategic plans. A ToC is useful to help teams think through these processes as clearly and intentionally as possible.

In these planning processes, ToCs can be generated using a top-down approach, involving only key project team members. However, undertaking a bottom-up participatory, inclusive approach that achieves critical buy-in from key stakeholders for implementation can be more rewarding, despite its challenges. In practice, both top-down and bottom-up approaches are needed. The bottom-up approach can provide insights from a broader group of stakeholders that highlight realities not apparent to those who first envisioned the project and that may have hampered success if not understood from the planning stage onwards. The top-down approach keeps sights set on the overall goals and targets that donors expect to see met. The ToC established at the beginning of a program or project may need to be reviewed at intervals, allowing for course corrections with partners before actions lag too far behind or veer off track. At the same time, keeping accountability at the level of outcomes is key for success; taking accountability to a more granular level may compromise the ability of projects to be agile and take advantage of opportunities as they arise, leading to potentially cumbersome administrative adjustments.

Setting up ambitious science-based goals is important for measuring targets with metrics that cover diverse outcomes – for example, productivity, nutrition, gender, and climate – but are also relevant to specific contexts. For a large research program, this may mean setting up a broad, inclusive results framework.

Adherence to a ToC approach requires investments of time and financial resources. It also necessitates persistence and purposeful revisiting of the ToC on an annual or regular basis to adjust as needed, given that it may be difficult to get right the first time. This can mean getting heavily involved in what can be a complex process for relatively short-term projects. For longer-term projects, the investment can pay off when there is enough buy-in from senior management, the process remains flexible, and critical leverage points and partners are identified from the beginning.

Having ToCs at multiple levels with numerous assumptions, ideally co-produced with partners, can be burdensome; some partners, such as the private sector, may prefer extreme streamlining of the ToC approach. In fact, ToC language may never be used when working with such partners but is nonetheless inherent in the collaboration. The bottom line is that a ToC approach must be as simple as possible while still adding value.

15.5 Theories of Change Looking Forward

Recent experience highlights the need for transformation, both of our food systems and how AR4D is done. Below we pose six questions related to key gaps and the next steps in optimising these approaches to foster transformation.

1. How Broadly Do Theory of Change Approaches Need to Be Designed?

For any large, complex AR4D program with multiple activities and partners, a 'portfolio' approach to ToC is appropriate, meaning not all activity areas in such a program need a ToC. For example, while upstream genomics research on organisms may not benefit much from a ToC, downstream plant breeding for traits such as drought or heat resistance would benefit greatly. In that case, a ToC could match the key characteristics of new varieties with the needs of a diverse range of small-scale farmers, to hasten and widen uptake.

2. Is There Adequate Organisational and Institutional Support for Utilising Theory of Change Approaches?

In designing and implementing new projects and programs, further investment in capacity development will likely be needed. The benefits for researchers and research partners seem clear, though institutional culture itself may need to be transformed for advantages to be realised. The funders of AR4D seem fully on board with the ToC approach and the benefits it can provide (Box 15.2).

3. How Can We Build Theories of Change for Multiple Interventions at the Same Time?

Transformation of food systems will likely involve bundling, including the bundling of technical interventions such as climate information services plus climate-smart agriculture (CSA), socio-technical bundles, or technology interventions plus their enablers (Barrett et al., 2020; Herrero et al., 2020) (Chapter 8). Examples from the literature of ToCs that address bundling are currently limited. Good examples that could be shared widely and modified for similar challenges and contexts could save research teams considerable time.

4. How Ready Are Agricultural Research for Development Organisations for Transformational Change?

Historically, AR4D organisations have been very effective in fostering incremental change. Such organisations may need to consider how best to work for transformational change and create enabling environments, including ToCs, that allow it. One challenge for large AR4D organisations working in geographically and politically targeted environments is linking the different initiatives and projects operating in the same environment to maximise synergies among them; pragmatic ToC approaches can help achieve this objective (Box 15.3).

Box 15.2
Views from the Funders

We interviewed a diverse range of funding partners, and all indicated that their own institutions are using ToC approaches, although for some they are quite new. Some, including the Australian Centre for International Agricultural Research, stressed their strategic and team-building value, and how a ToC approach can dampen top-down efforts to control the science agenda, which runs the risk of supporting existing injustices and behaviours that need to change. Others, for example the World Bank, had a more practical focus on how it strengthens projects' results frameworks and the monitoring of results. Some donors, such as the Dutch Research Council and the British Foreign, Commonwealth, and Development Office, used the CCAFS approach with ToCs as an example of good practice, including the use of outcome and impact stories. There was also a recognition that project funders and implementers were able to draw on wide networks of policymakers and negotiators and build on the many partnerships based on close engagement. A ToC was thought to aid linking high-quality quantitative work with an understanding of how to motivate and change behaviour; CCAFS was appreciated for taking a holistic, outcome-focused approach that embedded the uptake of results.

Looking forward, issues to address include how to foster the consistent application of ToCs across large research systems; continued resistance to ToC application by those that want to focus only on the science and do not want to engage in bottom-up processes or be responsible for uptake; and fostering regional and country-level consultations with intended users and beneficiaries. Funders also mentioned that some ToCs get too complicated and cover areas beyond the immediate control of researchers, that is, the outcome-to-impact level is not very rigorously considered. Some funders expressed a desire to see assumptions more meticulously tracked during project life, from outputs to outcomes. Pursuing opportunities for incorporating social or triple loop learning (integrating diverse knowledge and value systems through a sequence of learning cycles), going beyond outcome stories, and using ToCs to reflect on learnings and adapt approaches in response needs to be encouraged. As one funding partner put it, 'We need the discipline of thinking through how we think the world works and how you actually create change. Science has in many ways failed to create change so often – putting data in front of people does not create change.'

5. What Are Suitable Monitoring and Evaluation Methods?

We need new tools for the monitoring and evaluation of transformation beyond the so-called gold standard econometric approaches, which may miss many of the complex impacts of the work of AR4D organisations. Examples of such tools are provided by Carneiro et al. (2020) using web analytics and high-level syntheses of

Box 15.3

What May a Theory of Change Approach Add to an Agricultural Research for Development Organisation to Enable Food-System Transformation?

A key question in CGIAR's 2030 Research and Innovation Strategy[1] is how to change from an organisation that sees impact as an add-on to research to one that designs research impact from the start. Innovation and impact run all the way through the new strategy, and a ToC is a key organising principle for deliberate transformation into a more impact-oriented organisation:

- A ToC helps researchers think of themselves as part of an ecosystem of change, rather than centring them, and encourages strategic consideration of how to work as a partnership player. It also reminds researchers to humbly consider the role of science: generated scientific outputs are only useful within the context of what everyone else is already thinking about.
- A ToC is a tool that can be used to share a common vision with partners and a common strategy to achieve it. It can provide a constant resource to check progress on the journey.
- For CGIAR, a ToC is a dynamic, learning-enabling tool that can help determine what is being done well, what is being learnt, whether investments or resources are being allocated in the right place, or whether alternative thinking is required to achieve longer-term goals.

Sonja J. Vermeulen, personal communication, 2021

[1] www.cgiar.org/how-we-work/strategy/.

outcome stories (Nowak et al., 2021), and there is considerable potential for other big-data-assisted methods. Regarding the power of outcome stories, as noted above, these have developed over time, and their standards have improved. These do not replace impact assessments but are complementary, broadening the evidence base of impacts and increasing inclusivity. One example is the Kenya CSA work, where impacts were assessed using a mixture of soft and hard approaches (Okumu, 2021).

6. What Is the Value Added by Using Theory of Change Approaches?

We must continue strengthening the evidence base for the effectiveness of ToC approaches. Transformation takes time if it is not to be utterly disruptive, and rapid transformation without all enablers in place may be relatively ineffective. On the other hand, doing all the groundwork with well-facilitated, inclusive participatory processes can take considerable time, yet also contributes to the enabling conditions needed for interventions to succeed. There is little current evidence concerning the trade-off between the degree of use of a ToC, its utility, and its costs; this evidence would be very useful in future food-system transformation projects and program design.

15.6 Way Forward

The AR4D domain is becoming increasingly complex as it grapples with the need for food-system transformation. A ToC can provide critical guidance in planning and implementing projects and programs with respect to engagement, partnerships, and research. To make ToC-based approaches as effective as possible, two gaps in particular must be filled. First, quantitative impact assessment methods can be blended with qualitative methods so that evaluation becomes about both the process and numbers. At the same time, new methods need to be developed for blended evaluation. Second, the evidence base concerning the efficiency, efficacy, and failings of ToC-based AR4D urgently requires further development and synthesis, and the lessons must be applied broadly.

Notes

1 A log(ical) frame(work) is a planning tool consisting of a matrix that gives an overview of a project's goal, activities, and anticipated results. The tool helps the planner to outline the components of a project and to identify the ways that will be used to monitor the project's anticipated results.

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16

Partnerships to Achieve Impact

Five Principles

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Highlights

- Partnerships are crucial for outcome-focused research.
- The selection of diverse strategic partners is key and should be guided by theories of change.
- Complementary visions are important but do not always need to be tightly structured.
- Multi-level partnerships help promote action at different levels.
- Collaborative arrangements are important but can be informal and flexible.
- Many successful longer-term partnerships are deep and trustful at their core, often with informal relationships.

16.1 Partnerships Are Crucial for Outcome-Focused Research

Partnerships are crucial for fostering change in society, particularly in the solving of complex problems such as climate change. They are particularly important for researchers interested in societal change, given that research in the strictest sense is only about knowledge generation. While this is one element for driving societal change, we also require knowledge dissemination, the mobilisation of public opinion, the change of narratives, the implementation of solutions, and the scaling of solutions, processes, and finance. Previous chapters have given examples of partnerships that are tackling diverse challenges such as food loss and waste, dietary change, the improvement of agricultural markets, and the expansion of digital advisories.

The Sustainable Development Goals (SDGs), and in particular SDG 17, show the importance of partnerships, for example, calling for 'effective public, public–private, and civil society partnerships'. Leda Stott and colleagues suggest that the SDG 17 text leaves one with a rather empty understanding of partnerships, failing to convey the vibrant, multi-level, multi-actor, strategic, interpersonal character-

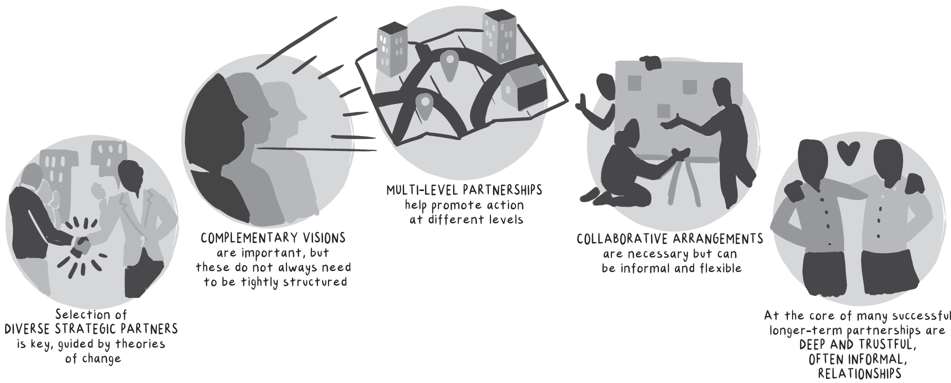

Figure 16.1 Five key principles for research partnerships to achieve societal outcomes

istics needed in partnerships (Stott & Murphy, 2020; Stott & Scoppetta, 2020). Collaboration among stakeholders with different functions, skills, and perspectives generates an atmosphere that allows for sharing, exchange, and creative problem-solving, though power differences can be problematic.

This chapter aims to bring partnerships alive. These partnerships can focus on implementing specific time-bound activities at the local level, or on influencing and realising transformations through longer-term strategic partnerships. In the following sections we focus on five key principles for research partnerships to achieve societal outcomes. These are drawn from the experience of implementing the CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS), and cover the following points (Figure 16.1):

1. Strategic selection of diverse partners
2. Complementary visions
3. Multi-level partnerships
4. Collaborative arrangements
5. Deep and trustful relationships

Selection is obviously a key step, but the other theme running through all the above-mentioned features is the tendency towards informality rather than a formalised partnership approach, and we underline that trust – and deeply interpersonal relationships – is in many cases the key to success. Several case studies are used to illustrate the principles (Table 16.1).

16.2 Principle 1: The Selection of Diverse Strategic Partners Is Key

Outcome-focused research – as was the objective in CCAFS – needs theories of change (ToCs) (Chapter 16). Preliminary ToCs were the starting points for

Table 16.1. *Examples of partnership reasons drawn from different partner types, plus lessons learnt*

Partners	Examples of partnership results	CCAFS[1] reason for partnership	Partners' reasons for partnership	Lessons learnt
ANACIM,[2] URACS,[3] MoA[4]	7 million rural persons received climate-informed advisories.	MoA and ANACIM ensured in-country capacity and sustainability. URACS enabled wide reach.	ANACIM and MoA benefited from scientific and technical capacity building; URACS gained capacity to deliver probabilistic weather forecasts.	Strategic selection of partners is crucial; commitment to the long term helps ensure change.
University of Leeds	CGIAR scientists made a major contribution to IPCC[5] reports; many high-impact journal articles were published.	The university was a source of cutting-edge science.	CCAFS helped ground Leeds' work in local realities and provided opportunities for students in developing countries.	Strategic partnership selection helps cover diverse roles, from knowledge generation and policy advocacy to on-the-ground implementation.
CARE	The partnership shaped CCAFS global gender messaging and delivered impacts on the ground in Tanzania and Vietnam.	CARE gave CCAFS global credibility related to social outcomes and helped CCAFS reach farmers on the ground.	As a knowledge partner, CCAFS provided science-based evidence and enabled CARE to reach new audiences.	Multi-level partners deliver actions at different levels, e.g., among farmers and in terms of global policy processes.
World Bank	US$250 million was invested in climate-smart agriculture in Kenya; multiple joint submissions were made to the UNFCCC COP.[6]	World Bank was a key partner on the impact pathway through its investments in climate change action in different countries.	CCAFS offered a source of cutting-edge knowledge relevant to the Bank's operations.	Multi-level partners deliver actions at different levels, e.g., national investments and global policy processes; collaborative arrangements can be relatively informal.

Table 16.1. (*cont.*)

Partners	Examples of partnership results	CCAFS[1] reason for partnership	Partners' reasons for partnership	Lessons learnt
Southern African Confederation of Agricultural Unions (SACAU)	The concept of climate-smart agriculture was taken up by farmer organisations; SACAU's capacity for climate programming and advocacy was enhanced.	SACAU helped CCAFS understand farmers' needs, shaped possible solutions to climate challenges, and built the legitimacy of CCAFS.	CCAFS was a source of knowledge about climate change relevant to farmers and of content development for programming and advocacy.	Deep and trustful relationships help maintain effective partnerships.

[1] CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS).
[2] Senegal National Meteorological Agency (ANACIM).
[3] Union of Rural Community Radios of Senegal (URACS).
[4] Ministry of Agriculture (MoA).
[5] Intergovernmental Panel on Climate Change (IPCC).
[6] UN Framework Convention on Climate Change, Conference of the Parties (UNFCCC COP).

Box 16.1

Partnering with the Senegal National Meteorological Agency (ANACIM), the Union of Rural Community Radios of Senegal (URACS), and the Ministry of Agriculture (MoA) (Chiputwa et al., 2020)

To deliver climate-informed agricultural advisories to as many households in rural Senegal as possible, a partnership was fostered with ANACIM, URACS, and the MoA. This partnership also involved local farmers groups, local extension workers, the International Institute for Climate and Society, and even the regional research organisation (CORAF), so that successful models of such work would be applied in other jurisdictions.

As the agency responsible for delivering weather forecasts in Senegal, ANACIM was a key partner. The International Institute for Climate and Society brought in some of the latest technologies to improve forecasting and helped build ANACIM's capacity to deliver such forecasts. The MoA was crucial given its role in the national extension service. URACs was key to reaching households in Senegal through its 82 community radio stations.

CCAFS and its partners helped build the capacity of the radio broadcasters to deliver probabilistic radio messages; on the ground, messages were translated to farmers by multi-disciplinary working groups, involving local civil society organisations, for example women's groups, extension workers, etc.

This multi-level, multi-actor partnership resulted in roughly 7 million people in Senegal receiving climate-informed agricultural advisories. Impact studies showed significant changes in farm management by users, for example, a 23 percent increase in the use of rainfall onset forecasts to inform the timing of planting.

selecting partners by identifying the stakeholders that can bridge existing gaps towards realising the identified goals. In Senegal, for instance, the ToC focused on reaching millions of households with climate-informed agricultural advisories. To cover the whole country, the ministry of agriculture, the association of community radio stations, and the national meteorological agency were selected as key partners to make that happen (Box 16.1).

The ToCs included generating new knowledge, scaling up, enhancing capacity, bringing in new resources, and advocacy aspects, etc. All these roles had to be covered through the partner selection process. Later, the ToCs would be modified as partnerships emerged and as partners introduced new perspectives. To cover the multiple roles needed, diverse partnerships emerged, for instance, with policy think-tanks, civil society organisations, multilateral and bilateral development agencies, government agencies, financial institutions, philanthropic organisations,

Box 16.2
Partnership Selection in the CCAFS Global Policy Team

At the global level, the one objective of the CCAFS ToC was to contribute to a changed global narrative where agriculture would be seen as key means to solve the climate crisis. This narrative would shape global policy debates on food and agriculture, and ensure that resources flowed to tackle the crisis. To realise this ambition, CCAFS needed influence in multiple areas of the food system: in discussions among farming organisations, private-sector players, major development agencies, and the major funders of development and climate action, as well as in processes under the United Nations Framework Convention on Climate Change (UNFCCC).

To build credibility and consensus in all these areas, partnerships with a diverse set of actors were needed. Thus, CCAFS set about identifying one to three key strategic partners to have from each group of actors: the private sector, multilateral financial institutions, farmers' organisations, multilateral development agencies, bilateral development agencies, and non-governmental agencies. This was done in internal workshops with core CCAFS staff of 5–20 persons on different occasions. During the workshops, several possible partners for each category of actors were identified and then each possible partner was analysed for their capabilities in relation to our needs.

private-sector umbrella organisations, private-sector partners, and farmer organisations. Some partnerships were in essence based on single individuals in partner organisations, while others had multiple connection points within partner organisations. Some were structured through detailed work plans and accompanied by funding, while others were unstructured and relied on informal relationships. The reasons for partnerships were as diverse as the partners (Table 16.1).

There is literature on partner selection, particularly from the business community, that documents the aspects requiring consideration, including an extensive due diligence process. The CCAFS process was more informal and relied on the knowledge, experience, and intuition of the core staff (Box 16.2). Thus, the process was relatively quick and consumed few resources, though experienced and open-minded staff members were crucial. In a few cases, the due diligence process was insufficient and partners had to be dropped; these cases, however, rarely involved funded partnerships. For example, one multi-level strategic partner had complex distributed power structures, which came with high transaction costs to making relationships at different levels.

Partner selection was not a static one-time process. Some partnerships were ineffective and decisions were taken to drop partners and seek others; in other cases, new opportunities arose and new partnerships developed. However, having too many, poorly serviced, non-strategic partnerships should be avoided.

To bring about the needed transformations, strategic and diverse partnerships based upon identified ToC needs and goals are required. The process of selecting the right partners is iterative, ongoing, and often dominated by experience.

16.3 Principle 2: Complementary Visions Are Important, but Do Not Always Need to Be Tightly Structured

The importance of complementarity is widely recognised in partnerships (Mousavi & Bossink, 2020). Pattberg and Widerberg (2016) suggest that jointly setting high ambitions and precise targets is conducive to successful multi-stakeholder partnerships. In time-bound projects, activities, and campaigns, CCAFS and its implementation partners would agree on specific deliverables and goals, for example, reaching at least 100 000 farmers in Rwanda with climate-informed advisories, and campaigns to introduce the concept of climate-smart agriculture into the global development community narrative. However, for longer-term strategic partnerships, this was often different. Specific longer-term goals and targets were not spelt out, or spelt out in very generic terms. In these cases, our overall ambitions often aligned. For example, CCAFS had the aim of building the resilience of millions of small-scale agricultural producers, which aligned with similar objectives of other partners such as the Southern African Confederation of Agricultural Unions (SACAU) and the World Bank. Longer-term partnerships were often built on mutual trust rather than formal agreements, a theme we will revisit in Principle 5.

16.4 Principle 3: Multi-Level Partnerships Help Promote Action at Different Levels

Transformative climate actions that impact farmers and farming systems need enabling conditions and resources. To deliver such impacts, action is needed at multiple levels (Chapter 18). Through multi-level partnerships, these actions can be connected and supported. Currently, literature on multi-level partnerships is scarce, though most present in forestry management where higher-level forest governance is seen as crucial for success in managing local forests (Ros-Tonen et al., 2007).

It is possible to work with different partners at different levels, for example, with producer groups at the local level and national agencies to facilitate national strategies, but multi-level partnerships can be particularly successful. In strategic partnerships with CARE and the World Bank, we both worked to inform and influence global processes, for example through joint products and events, and to deliver national or local actions (Table 16.1 and Box 16.3).

Box 16.3
A Multi-Level Partnership with the World Bank

The CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) decided early on that the World Bank should be a strategic partner, given its huge investment portfolio in low- and middle-income countries. In the first year of the partnership, together with the World Bank, CCAFS put on the first ‘Agriculture Day’ at a UN Framework Convention on Climate Change Conference of the Parties (UNFCCC COP), at COP 15 in Copenhagen. This brought together 450 persons to debate the role of agriculture in climate change, as part of the problem but also part of the solution. The joint work on Agriculture Day continued until 2015. This was followed by many joint submissions by CCAFS and the World Bank to the agricultural negotiations at UNFCCC COPs.

In the mid-2000s, two CCAFS staff were seconded into the World Bank. Their work in the Bank helped inform CCAFS scientists about the Bank’s knowledge needs to drive action on the ground. The World Bank and CCAFS jointly prepared a web-based guide to facilitate the implementation of climate-smart agriculture.

The global work led to many country-focused opportunities:

- Climate-smart agriculture profiles were prepared for dozens of countries to help shape investments.
- CCAFS evidence from Niger’s climate-smart villages was used to inform the World Bank’s multi-million-dollar investment in Niger.
- Similarly, risk profiles conducted in multiple counties in Kenya helped inform the multi-million Kenyan Climate-Smart Agriculture project.

16.5 Principle 4: Collaborative Arrangements Are Important but Can Be Informal and Flexible

Pattberg and Widerberg (2016) and other analysts suggest there is a clear correlation between the effectiveness of a partnership and its process management. They note that inadequate resources, time, and thinking are spent on the managerial aspects of a partnership. Suggested governance structures and collaborative arrangements that may promote effectiveness include small governing boards, common strategic plans, a clear division of roles and responsibilities, and multi-level forums to coordinate funding and resources.

In general, the approach adopted by CCAFS, particularly with longer-term strategic partnerships, was much simpler and less structured. In most of these cases, a single CCAFS person was identified as a partnership relationship manager with a particular partner, their task being to foster a successful partnership. It was

Box 16.4

Success Factors for the Partnership between CCAFS and Southern African Confederation of Agricultural Unions (SACAU)

Several factors were behind the mutually reinforcing, rewarding, decade-long CCAFS–SACAU partnership. These include:

- The vision's alignment and ambition informed and capacitated farmers on climate-change issues, as well as recognising the importance of farmer-centric climate change policy advocacy.
- The partnership highlighted SACAU's respect for knowledge-based advocacy, programming and service provision to farmers.
- Both partners complemented each other: SACAU needed CCAFS's technical capabilities while CCAFS needed SACAU's outreach platforms to disseminate work to support farmers and policymakers.
- Both partners mutually respected the other for the equal value each brought to the arrangement.
- There was an environment of openness and transparency, with no hidden agendas, suspicion, nor imposition, and a deep mutual trust built over the years.
- SACAU appreciated that the science was always in the background and never at the centre or forefront of the partnership.

A further factor related to the modus operandi of the partnership, which came with very low transaction costs. Arrangements were flexible, with limited structured programming, and with joint activities based on specific needs. No financial commitments were involved and each party financed its own costs. This also led to limited power dynamics.

up to those individuals and the partners to find the best collaborative arrangements. In some cases, this was based on Memoranda of Understanding and legal contracts, but in many cases, on more informal mechanisms. For example, with the global partnerships with the World Bank (Table 16.1; Box 16.3) this was mostly based on a single yearly in-person meeting between CCAFS and World Bank staff, where some key deliverables and activities were selected for that particular year. The relationship with SACAU was even more informal, and yet extremely rewarding (Box 16.4).

As Macdonald et al. (2019) note, a considerable amount of energy needs to go into partnership-fostering, and while initially there may be great enthusiasm this can wane over time, requiring extra effort to maintain momentum. We at CCFAS have found that trust and friendship help nurture partnerships over a longer period (see Principle 5). Where partnerships with relatively unfamiliar stakeholders are established, extra effort – as well as conflict resolution arrangements – may be more important. In general, flexible, agile, and opportunistic arrangements allow partnerships to best respond to changing circumstances, the needs of different stakeholders, and opportunities.

16.6 Principle 5: Deep and Trustful Relationships, Often Informal, Are at the Core of Success

Atouba and Shumate (2020), in their analysis of hundreds of partnerships, showed that trust and communicative effectiveness were related to satisfaction with partnership outcomes. In much earlier writing (Campbell et al., 2006), we wrote that '. . . partners feel motivated to collaborate with each other due to mutual trust, respect for differences, transparency and openness'; '. . . face-to-face activities should be sufficiently frequent to enable more in-depth communication and strengthen relationships'; and 'Activities together would go beyond exchange of information and seek to generate creativity and enthusiasm for problem solving.' The CCAFS experience has supported those earlier writings, with the most effective and impactful partnerships resulting from very strong individual relationships and friendships. Stott and Murphy (2020) contend that much greater consideration needs to be given to personal connections in organisational relationships.

Building trusted partnerships was helped by allocating a relationship manager to a particular partner, and by the approach towards partners, including to be inclusive on authorship, logos, and activities; to be attentive to partnership needs rather than pushing the 'CCAFS agenda'; to be behind the scenes rather than steal the limelight; to be attentive to power differentials and help empower weaker partners; to be transparent, particularly around resources, and to meet partners outside office hours, when diverse interests could be pursued and relationships strengthened. A more formal mechanism used was to second CCAFS staff into other agencies (e.g., Box 16.3). Another mechanism was to initiate a CCAFS student-training programme on low-emissions development. The students helped foster the links between CCAFS and their home agencies.

With a limited set of high intensity strategic partners, there is the possibility of developing deeper and more trusting relationships. This makes selection of that limited set of partners – Principle 1 – a key success factor. One challenge for personalised partnerships is that when there is a high turnover in staff, there are resultant 'costs' of starting over to develop the necessary relationships.

16.7 Way Forward

CCAFS partnerships, particularly the longer-term, more strategic ones, tended to be quite informal rather than relying on highly structured arrangements. This goes against what is commonly found in the literature. For example, Pattberg and Widerberg (2016) write that the effectiveness of a partnerships depends on a high level of precision in rules and norms, meaning that there is only limited room for interpretation. They state that lower degrees of precision open the space for discretion and interpretation, or even render the rules so vague and broad that they impede compliance, monitoring, reporting, and evaluation, consequently limiting accountability and transparency. Their writings do apply to projects, often short-term, where one partner is funding the other. For longer- term, more strategic partnerships, however, we found that such precision was unnecessary. We also had rather informal mechanisms for selecting partners, relying on experienced staff to make judgements about which partners to pursue. Formalisation takes time that could otherwise be well spent on delivering outputs and outcomes. The core team of CCAFS and many of its partners contained experienced individuals with a 'good feel' for what would work. In addition, personalised partnerships meant that formality and structure were often not needed; rules to maintain accountability were replaced by relationships that fostered accountability.

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17

Working across Scales and Actors for Transforming Food Systems

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Highlights

- Although complex, working across scales and actors is critical for food-system transformation.
- In most cases, working at the local scale, that is, with farms and districts, is the most important, as this is where action is required.
- Through effective cross-scale work, lessons from local levels can shape the thinking of regional and national governments, as well as the private sector.
- Involving multiple and ideally nested scales, designing sets of solutions, and developing actionable, fundable, and implementable solutions is likely to provide rich food-system outcomes.
- Partners need to provide the tools, signals, and resources so that local people, communities, and policy planners are empowered to drive transformation.

17.1 Introduction

There have been several calls for transformation in food systems to address the challenges of climate change, hunger, continuing population pressure, and to meet the Sustainable Development Goals (SDGs) (see Chapter 1, also Herrero et al., 2021). This would require more interactive, participatory, and cross-scale processes linking value-adding activities and systems (Abel et al., 2016). Multi- and cross-scale linkages are common in both agroecological research and analyses of socio-ecological processes. A cross-scale approach connects actions across local, national, regional, and global levels, capturing convergences and divergences in transforming agriculture and food systems. However, these interactions come at a high transaction cost as it is effort-intensive and requires actors to learn how to engage policymakers through scientific and technical language (Adger et al., 2005). The transaction cost also increases owing to mismatches of cross-scale dynamics problems, such as when there is a poor institutional fit between the management and bio-geophysical systems (Cash & Moser, 2000).

Climate-smart agriculture (CSA) is an important component for building resilience and for mitigating greenhouse gas (GHG) emissions in agricultural systems. Several key CSA options have been proposed, including technologies such as zero tillage, residue management, micro-irrigation, and improved and stress-tolerant seeds and breeds. The success of these technological interventions has been demonstrated globally in the thousands of pilots that have been undertaken. Yet, even today, most of these technologies have not reached the necessary scale. Cross-scale work that supports decision-making at different scales by various stakeholders is needed for transformation, alongside understanding the entry points. More so, these technologies need evaluating across climatic risks, soils, and management practices at different scales, plus a comprehensive understanding of farmers' resource bases, institutions, financial systems, and policies. The CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS) has worked across scales, from the global level to the community level, engaging a wide range of actors. This chapter reviews several case studies from this program, carried out in different regions of the world, to assess how working across scales and actors has helped achieve climate-resilience outcomes for millions of farmers, private sector agencies, and governments.

17.2 Farmer-to-Farmer Scaling of Climate-Smart Agriculture

CCAFS developed the climate-smart village (CSV) concept as an agricultural research for development (AR4D) approach to test technological and institutional options for dealing with climate change in agriculture through participatory methods (Aggarwal et al., 2018). The key focus of this approach is to generate evidence on synergies and trade-offs between different options in terms of productivity, adaptation, and mitigation at the field and/or village scale. The lessons learnt in terms of suitable portfolios of CSA technology options and institutional and financial mechanisms are then scaled horizontally and vertically.[1] In this section, we look at horizontal scaling by local government, community organisations, NGOs, and private sector actors.

Horizontal scaling involving multiple actors was fostered widely in India and Nepal (CIMMYT-CCAFS, 2014), with similar approaches also used in Africa and Latin America (Aggarwal et al., 2018). In India, CSV pilots were set up at field/village community scale in the states of Haryana, Punjab, Madhya Pradesh, Bihar, and Maharashtra, and in Nepal's Rupandehi district. The CSVs involved participatory evaluation of all locally relevant technological and institutional

Box 17.1
Farmer-to-Farmer Learnings Used by the Private Sector in India

The evidence-backed success of the CSV approach has attracted private sector players to make investments in CSA/CSVs. ITC Limited is a large Indian company present in multiple sectors, including agribusiness. Its business model is sustainability embedded in its strategy, encompassing economic, environmental, and social objectives along its supply chain. ITC has taken several steps to strengthen resilience and reduce GHG emissions, to combat its agribusiness supply chain's vulnerability to increasing climatic risks. To strengthen resilience at the farm level, ITC managers adopted the CSV approach, merged it with their ongoing programs, and transferred it to several of the company's sites. These interventions led to a substantial increase in yield and income, climate-risk reduction, and GHG mitigation. In the last five years, the program has been expanded to around 1 762 villages, using the hub-and-spoke approach, covering over 200 000 farmers. With these encouraging results, ITC is now set to scale out the CSV approach in its core agribusiness catchments, aiming to cover over 1 million hectares across 15 Indian states by 2030.

adaptation options (Box 17.1). Individuals and collectives of farmers, local governments, private sector actors, various CGIAR centres, and national agricultural research systems have been involved in this evaluation. Farmers' fairs, video testimonials, and village bulletins were organised to scale-out CSA practices and promote farmer-to-farmer learnings within the study region and other similar agroecological regions. The use of a climate analogue tool further supported horizontal scaling in Rupandehi, Nepal. The tool assisted the identification of homologous regions in Nepal where the future climate of Rupandehi exists today. Young farmers of Rupandehi stayed with the farmers of the analogue region to learn the agriculture adaptation strategies that they could utilise in the future.

While this is referred to as horizontal scaling, inevitably there is some cross-scale interaction, for example between the local level and the district level, with even national actors playing a role in fostering horizontal scaling. For example, the results of the CSV evaluations have been integrated into village and district agriculture development plans and linked with local and national adaptation plans. As Schut et al. (2020) imply, there is a strong link between horizontal and vertical scaling.

17.3 Vertical Scaling of Lessons from Climate-Smart Villages

The work done at the village scale has also fostered the uptake of CSA ideas and influenced policy and investment decisions at sub-national, national, and regional scales in Asia, Africa, and Latin America. In Ghana, for example, the sub-national and national science-policy platforms took up lessons learnt from the CSVs (Table 17.1). The national science-policy dialogue platform is a multi-stakeholder body hosted by a national government institute. The platform has 100 participating stakeholders, including NGOs, policymakers, academics, traditional authorities, and farmers. The platform co-produced the National Climate-Smart Agriculture and Food Security Action Plan and operationalised the National Climate Change Policy. The stakeholders prioritised CSA solutions for the different ecological zones in Ghana (Essegbey et al., 2015).

In Nepal, climate-smart investment profiles were prepared, inspired by work at the local level. These guided three provincial governments and the federal government to invest a part of their agriculture budget to implement the CSV approach in a few hundred villages.

17.4 Multi-Scale Research and Engagement

In transforming food systems, we can seldom consider purely horizontal or vertical scaling. Scaling is often much more complex, involving work at multiple levels. Hierarchy theory suggests that minimal complexity when problem-solving involves three hierarchical levels: the focus level, a level below, and a level above (Allen & Starr, 2017). Therefore, if we want to alter farming practices and work at the focus level, we must understand stand-level processes at the level below, as well as explore the enabling policy environment at the level above. Even this notion, however, is too simple for most AR4D challenges, where problems need to be dealt with across a multi-levelled domain of interest. This can be seen in the Ghana example (Table 17.1), where considerable work was done at the local, national, and regional levels. The West African work also included collaboration with national negotiators, who then transferred lessons to the global negotiating processes; based on their experience in the global forums, negotiators undoubtedly applied the lessons learnt back home (Simone & Rusdal, 2017). Alongside experience gained from other countries, the work in Niger helped the West African regional team to inform the design of the World Bank's US$100 million CSA investment in Niger (CCAFS, 2016).

Working at multiple levels is not simple and comes with the high transaction costs of managing multiple partnerships. Although the national platform of Ghana gathered multiple stakeholders and engaged high-level decision-makers, thereby influencing national policymaking, it also lacked a closely coordinated cross-scale communication process among the national and sub-national platforms and local CSVs. This limited the possibilities for upscaling and mainstreaming solutions from the local level to national, regional, and global levels.

Table 17.1. *The multiple scales and actors linked to the Ghana CSVs*

Scale-spatial	Scale-domain	Key activity	Key partners	Knowledge provided by
Local, CSV[1] in Doggoh, Jirapa district, and Bompari, Lawra district	Largely agroecological	Participatory evaluation of technological interventions	Savana Agriculture Research Institute, CCAFS,[2] Ministry of Food and Agriculture, the Esoko company.	Research stations evaluation
Sub-national platform at Lawra	Agroecological, socio-economic	Science-policy dialogue; 21 environmental committees, the yearly harvest Kobine Cultural Festival.	Lawra district assembly	CSVs of Bompari
Sub-national platform at Jirapa	Agroecological, socio-economic	Science-policy dialogue; tree planting, information dissemination.	Ministry of Food and Agriculture	CSVs of Doggoh
National science-policy dialogue platform	Agroecological, socio-economic, financial	Informing policies and plans of international and bilateral agencies. Upscaling sub-national and local solutions, national climate-smart plan, investment decision-making for Niger.	World Bank, CCAFS, NGOs, government, farmers	CSVs, sub-national science-policy dialogue platforms
Regional	Socio-economic, financial	Information dissemination, management of national initiatives, coordination between regional and global initiatives.	CCAFS, West African Alliance for Climate-Smart Agriculture	National initiatives, sub-national initiatives, and CSVs in the region

[1] Climate-Smart Villages (CSVs).
[2] The CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS).

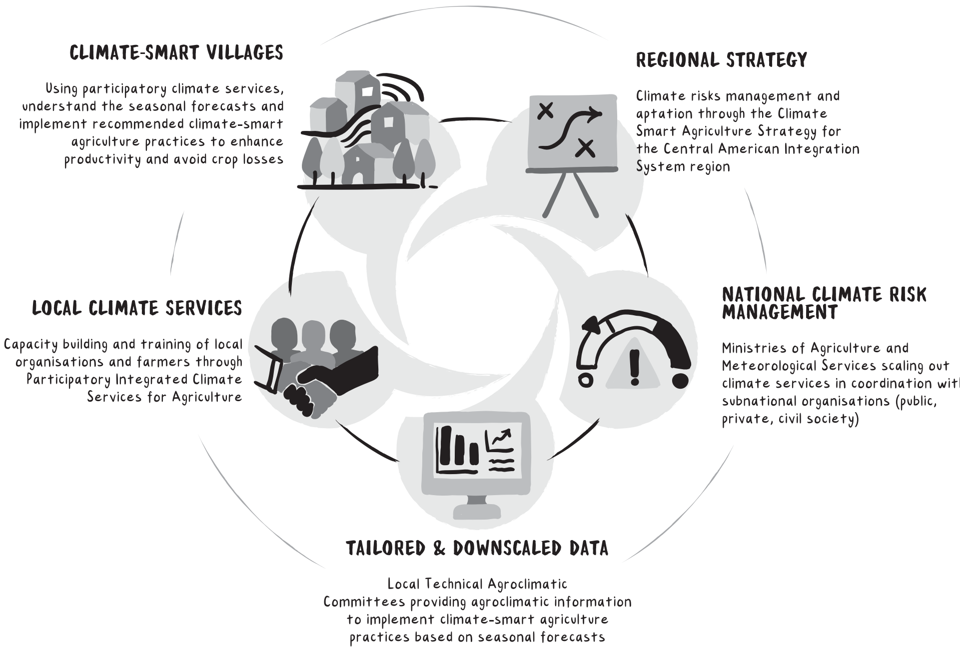

Figure 17.1 A cross-scale process in implementing climate information services in Latin America

Other examples of multi-scale research and engagement come from Latin America. Farmers in Central America are highly vulnerable to climate variability. They lack the weather, climate, and tailored local information necessary to make best-bet decisions and manage different types of agroclimatic risks. This gap has been identified as a key action point in the Climate-Smart Agricultural Strategy for the Central American Integration System (SICA) region, 2018–30. CCAFS and the International Research Institute for Climate and Society worked together with regional, national, and local partners within the SICA region to co-develop, test, and scale-out approaches to assess, co-produce, translate, and transfer climate information to enable agricultural decision-making (Martínez-Barón et al., 2021). At the regional level, the meteorological services of all eight SICA countries have enhanced their capacity through 'next generation' climate forecasts (Muñoz et al., 2019) through the Central American Climate Outlook Forum, allowing the generation of a consistent and high-performance climate outlook with local relevance (Martínez-Barón et al., 2021). At the national and sub-national levels, regional and national partners have scaled out Local Technical Agroclimatic Committees (LTACs). There are many linkages between the different levels (Figure 17.1).

LTACs have regular meetings to share agroclimatic forecasts, a result of downscaled seasonal predictions and modelling (Loboguerrero et al., 2018).

Participants discuss how crops might be affected based on the forecasts and their own experience and agree on best-bet climate-smart recommendations to reduce potential crop losses, increase productivity, and enhance management efficiency. Through local agroclimatic bulletins, local technicians, community leaders, and producers can access the forecasts and recommendations needed to support climate-change-related decision-making. Today, over 50 LTACs have been established across 11 countries in Latin America, including six in Central America, which reach out to about 300 000 farmers across the region (Giraldo et al., 2019). To scale the knowledge generated by the LTACs at the farm level, a Participatory Integrated Climate Services for Agriculture (PICSA) approach is used (Chapter 8). PICSA involves agriculture-extension staff working with farmers ahead of the agricultural season to firstly analyse historical climate information, then use participatory tools to develop and choose the crop, livestock, and livelihood options best suited to individual farmers' circumstances. Local technicians and farmers use the information on the local agroclimatic bulletins produced by the LTACs and the participatory tools support farmers in making timely decisions to mitigate climate risks. Based on such work, CCAFS gained legitimacy with national and regional governments, leading to several initiatives that inform policy processes. In this case, coordination between stakeholders across scales informed local decision-making processes and needs, as well as higher-level governance processes.

In some cases, research engagement results in more top-down impacts. Experience from other regions and countries has helped researchers inform national-level policies, strategies, and projects. CCAFS developed a national CSA profile for Kenya and, thereafter, many county-level climate risk profiles (World Bank & CIAT, 2015). Such work contributed to the Kenya Climate-Smart Agriculture Project (KCSAP) 2017–22 implemented in more than twenty counties across diverse agroecologies under the framework of the Agriculture Sector Development Strategy and National Climate Change Response Strategy (www.kcsap.go.ke/). To date, CCAFS has completed CSA profiles for 30 countries.

Vietnam's climatically vulnerable Mekong River Delta (MRD) region provides another example of multi-scale resilience-building work with multiple partners. A participatory Climate-Smart Mapping and Adaptation Planning (CS-MAP) was used to map key climate-risk-prone areas and potential adaptation interventions for them (see Chapter 7 for a more detailed description). This involved mapping work at local levels and setting up an early warning system at local and provincial government levels. The implementation of CS-MAP during 2018–19 and 2019–20 provided the basis for adjusting the rice cropping calendar in salinity-affected areas; this resulted in a 70 percent reduction in losses in affected areas, despite high salinity intrusion owing to substantially lower rainfall and a significant reduction in river flow (CCAFS SEA & DCP-MARD, 2020). As engagement was also carried out at the national level, 13 MRD provinces in Vietnam are now implementing the recommended CS-MAP actions for climate-risk management.

Another example from Vietnam concerns GHG mitigation in rice production. Alternate wetting and drying (AWD) in rice farming, originally developed as a water-saving irrigation practice, has a positive impact on GHG mitigation. In recent years, the mitigation benefit has been well demonstrated in farmers' fields, resulting in strong endorsement by multiple institutions and many national scientists. In Vietnam, AWD was integrated into the crop-management packages promoted in provincial and nationwide technology campaigns. The Department of Agriculture and Rural Development (DARD) in the Vietnamese MRD, and the International Rice Research Institute (IRRI) co-developed the 'One Must Do, Five Reductions' (1M5R) program (Flor et al., 2021). One of the reductions concerns water use, facilitated through the application of AWD. This best-practice recommendation was also adopted as an integral part of the World Bank's 'Vietnam – Sustainable Agricultural Transformation' program. Following these efforts, AWD is now the recommended water management practice throughout the Mekong Delta and has also been introduced in other rice-growing regions in Vietnam, as well as in neighbouring countries. This is the result of work at the plot, farm, irrigation, provincial, and national levels, though the work also involved engagement in global processes. AWD was integrated into the first standard for sustainable rice production developed by the Sustainable Rice Platform (SRP), a multi-stakeholder platform with strong private sector involvement (SRP, 2020). The wide scope of SRP members that cuts across different stakeholders in the rice value chain, along with its reach-out to different rice-exporting and -importing countries enables broad awareness of AWD as a beneficial production practice. Given the involvement of supermarket chains and consumer groups, the scaling of AWD under the SRP umbrella represents a quantum leap forward.

While national governments must specify their reduction targets through their Nationally Determined Contributions (NDC), AWD can be considered both an adaptation and mitigation strategy. As for Vietnam, the NDC has incorporated ambitious targets for the implementation of AWD and similar water-saving practices, aiming to cover 1.7 million ha by 2030 (MARD, 2016). This target, as well as the geographic focus for AWD, has been substantiated by an analysis of biophysical factors for its application. The large-scale implementation of AWD will require a paradigm shift in government policies that, to date, have mainly been driven by production targets.

17.5 Way Forward

Through the case studies, we have shown that working across multiple scales and actors, although complex, is critical to make an impact from local to global levels, and from farmers to global negotiators. The transformation needed to attain CSA-related development outcomes requires transformative thinking. We need to recognise that science and technology are just one part of the whole development puzzle. Focusing on innovations at one scale can sometimes be successful but, in general, one needs to have a clear theory of change for outcomes (Chapter 15), which includes appropriate partnerships with national and local next users (Chapter 16), raising their capacity, understanding the policy processes, and facilitating the finance (Chapter 12) required to implement at the desired scale.

Our case studies suggest three key lessons in guiding AR4D.

1. Always consider the **local scale, particularly farms and districts; that is where the farmers are and where activities must occur**.

   Interventions need to focus on the problem to be solved and to identify which scale is the most critical entry point. As AR4D is ultimately about farming practices and farmer livelihoods, a focus on the local scale is essential. For direct benefits to farmers, local and sub-national scales are most important. The critical elements here are raising the capacity of farmers to understand new technologies and to access available incentives and climate finance to adopt these. Even at the policy level, CSA adoption at different scales is linked to a profound evidence base created in the field – in CSVs, for example – that demonstrates performance under the given local context, constraints, and opportunities. The case studies also show how crucial it is to use local–national experience to help frame global narratives, as in the case of Ghana and AWD in the Mekong. These learnings also shape the thinking of the private sector, to promote investments that use a scientific approach to build climate resilience, as in the case of India.

2. **Enable coordination and facilitate effective communication at least one level above the level of interest and one level below.**

   There is often an optimal scale for a specific decision and/or intervention that needs to take place (Gunderson & Holling, eds., 2002), but it is likely to interact with at least two more scales. As a minimum, we generally need activities and engagement at three levels. Figure 17.2 summarises the most important scales to focus on for climate-smart technologies, climate information services, and climate policies. Partnerships are essential for working across such levels, and require tailored, timely, and understandable information for all parties involved.

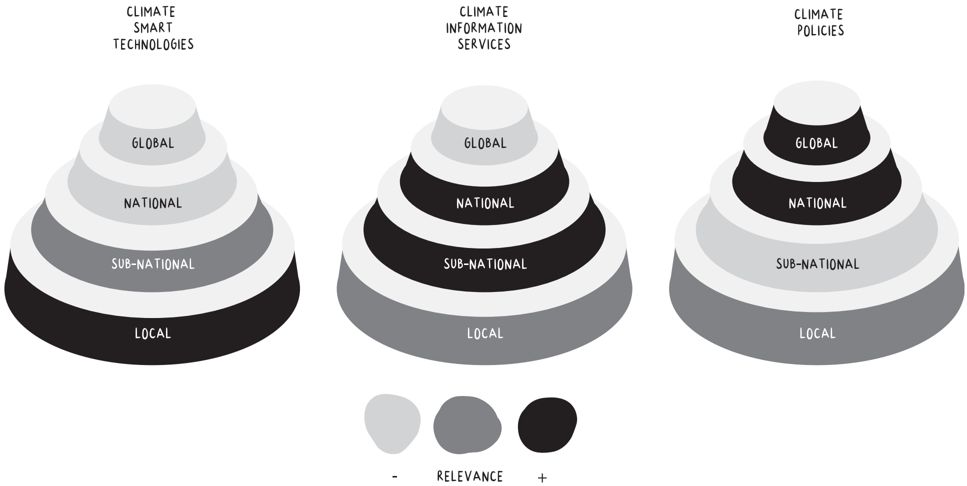

Figure 17.2 Diverse scales as entry points for reaching impact in respect of climate-smart technologies, climate information services, and climate policies

3. **Work will inevitably be required at multiple levels for significant change to be fostered.**
   The examples of climate-information services in the Latin America region and AWD in Vietnam demonstrate the value of working at multiple levels, creating impacts in places ranging from farmers' plots to global processes. Such cross-scale approaches involve interactions with different stakeholders at different levels and consequently have large transactions costs, including the requirement of substantial investments in social capital. As can also be expected, there are often conflicting interests across multiple levels and actors in the desired outcomes of climate-change adaptation actions. Even within national governments, several institutions are mandated to perform active roles and responsibilities in climate-change policy definition and implementation. As illustrated by the Latin America case study, a well-coordinated effort to facilitate communication among stakeholders across scales is crucial to informed local decision-making, as well as informed higher-level governance processes. In Vietnam, several line ministries cutting across the national, regional, and local levels are involved in developing policies for mitigating GHG emissions from rice production. While the guideline competencies rest with the national agencies for specifying NDC targets, the system has various iterative elements, that is, checks and balances, to ensure participation in subordinate levels. In Ghana, however, scaling was associated with the high transaction costs of managing partners at multiple levels, and the lack of a closely coordinated cross-scale communication process was problematic (Simone & Rusdal, 2017).

Although multi-scale efforts are complex and have high transaction costs, we conclude that these are needed to address complex problems such as food-system transformation in a changing climate. Research for development initiatives needs to focus on increased cross-scale interactions, particularly between the sub-national, national, and global levels, by building informal networks of partners at all stages of the research cycle and impact pathway. The art of communicating between multiple actors across different scales requires more investment and attention. All the relevant partners need to provide the right tools, signals, and resources so that local people, communities, and policymakers are empowered to make the right decisions themselves, thus driving transformation.

Notes

1 Horizontal scaling – outscaling – is a geographical spread to cover more people and communities. Vertical scaling – upscaling – is the uptake of ideas to higher levels of governance, which in turn can influence what happens in wider geographical areas.

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18

A New Vision for Leadership in Food Systems Research

BRIAN KEATING, RUBEN ECHEVERRIA, HOLGER MEINKE, DHANUSH DINESH, MARY SCHOLES, AND ANGELE TASSE

Highlights

- Effective and authentic leadership is needed to deliver societal outcomes that respond to the urgent need to transform food systems under climate change.
- We need a new vision for leadership in the context of food systems research, which includes strategic goals of 'looking out', 'getting different', and 'focused experimentation'.
- Key cultural attributes as part of this new vision for leadership include diversity and inclusion; a 'service from science' ethos, and creativity, independence, and accountability.
- Implementing such strategic goals and cultural attributes must be complemented by systems leadership capacities.

18.1 Leadership in Theory

Much is written of how leadership and related management attributes and strategies can contribute to success in the business world. There is an extensive range of popular literature published by business consultants and leadership gurus, with a search of a well-known online bookshop revealing 2 537 titles on leadership in business and 391 titles specifically focused on leadership in research organisations and academia. Both strategy and culture are given attention in this voluminous literature.

In terms of strategy, creating a unique offering that is ahead of the forces of change is a consistent message; for instance, see Hamel and Prahalad (1994) on 'Getting Smaller, Getting Better and Getting Different' and Chan Kim and Mauborgne's (2015) work 'Blue Ocean Strategy'. Other prominent contributions include those on leadership styles, transforming good organisations to great ones, the practices of effective executives, the '80/20 principle', and the challenge of 'herding cats' in academia (Collins, 2004; Drucker, 2011; Garrett & Davies, 2011, 2021; Goleman, 2000; Koch, 2017).

In terms of culture, the focus is on that complex mix of values, norms, and behaviours that get deeply ingrained in an organisation's DNA and shapes its abilities to adapt and innovate. The consistent message from this literature is that culture can't be simply dictated by edicts from on high nor can it be changed quickly. It can, however, evolve in response to a consistent set of drivers and interventions, including structures, incentives, procedures, and the modelling of desired behaviours from leaders.

Despite this extensive literature on leadership theory and practice, many end up in research leadership roles without deep reading or training in organisational leadership, deferring to intuition and the 'school of hard knocks' as their training ground. This chapter seeks to offer a new vision for leadership in food-system research, and guidance on applying these in the context of food-system transformation. It also sets out the characteristics of leaders who are best positioned to implement this guidance and drive transformation. As outlined in Chapter 14, three dimensions are critical in the successful transformation of innovation systems: designing and managing innovations with potential for transformative impact, the culture and structures of innovation organisations, and their engagement with the wider innovation ecosystem. All of these dimensions demand strong leadership to foster their development, to connect them to each other, and to help promote the delivery of innovation at scale.

18.2 Leadership Theory and the Changing Context for Leadership

Many have tried to define what being a good leader means. The Indo-European root of to lead, 'leith', means to step across a threshold, and to let go of whatever might limit stepping forward. Within the extensive leadership theory, some key characteristics have been identified, including developing new understandings, new skills, and new capabilities for individual and collective learning (Senge, 1995).

In particular, Senge and his team have identified three essential types of leaders who build learning organisations, roughly corresponding to three different organisational positions:

1. Local line leaders have the opportunity and autonomy to test and experiment at their organisational level, independent of the larger organisation they belong to. Line leaders play an essential role in the design and implementation of new learning processes and in their wider deployment.

Box 18.1
Systems Analysis: A Necessary Step towards Effective Leadership

Systems analysis is a broad term that can be found within multiple fields and many schools of thought. System dynamics is the understanding of the relationship between integrated system elements and how they impact each other's behaviour. Numerous different approaches exist for undertaking systems analyses, crossing many conceptual and disciplinary boundaries. Systemic analysis and systems dynamic modelling are, respectively, an approach and a tool with which to comprehend a system's structure across disciplines, by modelling complex social and ecological events, patterns, and processes, along with their key feedback loops, using systems thinking principles (Elsawah et al., 2017). Systems dynamics can help leaders to better represent, analyse, and understand systems, including those characterised by uncertainty.

2. Executive leaders stand as key mentors and thinking partners for line leaders. Such leaders have the bigger picture in mind and can help innovative local line leaders understand the sometimes complex broader processes, as well as communicate their ideas to engage those not yet involved.
3. Internal networkers or community builders have no positional authority but can navigate informal networks and understand how innovative practices naturally diffuse within organisations. They are key to finding those who are genuinely interested in bringing about change, and aid organisational experiments and the diffusion of new learning.

Rising global challenges over the past decades have challenged many aspects of our society and highlighted the need to rethink what constitutes good leadership. As the interconnected nature of societal and environmental challenges have become more evident, a growing number of people have understood that siloed strategies are no longer effective, and that a systemic approach aimed at deeper change is urgently needed. Tools for systems analysis can help leaders navigate interconnected systems (Box 18.1).

Such systemic challenges – like climate change, nature loss, growing poverty, and inequality – are to be addressed beyond the reach of existing organisations. They require unprecedented collaboration among different organisations and sectors at all levels, locally, regionally, and globally (see Chapter 17 for working across scales). To foster collective leadership within and across such varied organisations, a systems approach to leadership is valuable. In their book, *Leading from the Emerging Future*, Scharmer and Kaufer (2013) identify three key 'openings' necessary to transform systems: opening the mind, that is, challenging our assumptions; opening the heart, that is, accepting vulnerability and truly hearing one another; and opening the will, that is, letting go of pre-set ideas and goals, and understanding what is both needed and within reach. Building on these advances in leadership theory, in food-system research we propose a new vision for leadership that mobilises collective action to address common challenges through opening the mind, heart, and will.

18.3 Applying This New Vision for Leadership in Practice: Emerging Principles

To link theory with practice, we examined three prominent leadership efforts within agricultural research for development (Box 18.2). These efforts highlight certain common principles, which may be grouped into two broad headings. The first relates to strategy, that is, the key strategies for effective and authentic leadership, while the second relates to culture. The strategy includes a focus outwards from the organisation to identify and tap into opportunities, that is, a 'lookout strategy'. The second strategy principle relates to 'getting different', that is, ensuring that the organisation has a niche and a value proposition in place. In the case of the International Centre for Tropical Agriculture (CIAT), for example, the focus on science for impact allowed it to differentiate itself from other organisations. The final strategy principle relates to 'focused experimentation', meaning a strong focus on the identified value proposition but one complemented by giving researchers space to experiment and fail, advancing the mission of the organisation.

Culture change is also an important part of effective and authentic leadership, and for the successful implementation of the strategy, culture change is a prerequisite. Culture in the context of transformation in agricultural research for development (AR4D) organisations includes the complex mix of values, norms, and behaviours that are deeply ingrained in an organisation's DNA. A key principle that leaders need to apply to change organisational culture is ensuring diversity and inclusivity in the leadership team. For example, in the context of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), bringing regional and gender diversity to the leadership team was a key element of success. A 'service from science' ethos – wherein the thinking shifts from an egocentric feeling of entitlement to support to one that centres the value science provides to others and when the support received depends on the perceived benefits provided to others – is key to culture change. This is evident in all three case studies that focused on fostering such an ethos. The organisational culture also needs to encourage creativity, entrepreneurship, and independence while also ensuring accountability, leading to a results-driven culture, and not a compliance culture.

Box 18.2

Seeds of Change: Case Studies of Effective and Authentic Leadership in Practice in AR4D Organisations

18.2.1 Sustainable Agriculture Flagship in the Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Around the year 2000, CSIRO – Australia's national science agency – underwent a transformation captured in the book 'Icon in Crisis: The Reinvention of CSIRO' (Sandland & Thompson, 2012). The transformation included the development of sectoral flagships including the sustainable agriculture flagship, which proved successful as a cohort of leaders was empowered to 'look outside' the organisation, secure resources, and ensure its scientific offerings were impactful and meeting expectations. Time and resources were committed to national and international thought leadership, contributing to, and sometimes leading, the dialogues and pursuing an 'open door' approach to others contributing. Staff members were embedded in key paths to impact in the relevant policy domains, such as, statutory advisory committees for carbon farming. Internally, explicit incentivisation of working together in multidisciplinary teams and a zero-tolerance approach to internal silo-building among senior leadership were key features. A soft and flexible approach to internal financial performance targets was taken, to encourage senior leaders to share business opportunities and/or pass them on to other groups where appropriate. Another key feature was a diverse set of external advisors who were supportive of the effort and could 'open doors' but also provide frank, fearless advice and critique.

18.2.2 The International Centre for Tropical Agriculture (CIAT) in a Changing CGIAR

CIAT is one of the founding centres of the CGIAR, formerly the Consultative Group on International Agricultural Research. When new leadership was put into place in 2008, challenges faced included achieving financial stability, building greater resilience within the organisation, and positioning the organisation at the leading edge of change. CIAT's approach to embracing change, including in the wider CGIAR system, proved successful. Looking out for opportunities combined with a culture of risk-taking was helpful. Raising resources both through wider CGIAR efforts and strengthening the fundraising capacity, combined with partnerships and communications were other success factors.

A particularly important partnering strategy was to re-engage with the Global South and particularly CIAT's host country, Colombia. This added an entirely new dimension to CIAT's work based on deep partnerships with public organisations, civil society, and the private sector in developing countries, as well as complementing the expansion of presence in Asia and Africa. A flat management structure combined with

Continued

Box 18.2 (cont.)

competitive hiring helped to build a systems approach to research, with an impact-oriented vision. In fact, 'Science For Impact' was the slogan of CIAT in the 2010s.

18.2.3 The Experience of CCAFS

CCAFS was the first attempt by the CGIAR system to systematically address climate change and move away from a fragmented research agenda towards a programmatic, mission-oriented approach that emphasised achieving societal outcomes. During its decade-long operations, CCAFS's approach to leadership involved hiring science leaders for their abilities in coordination, business development, and outcome orientation. This was done both thematically as well as geographically, resulting in a matrix leadership. Thereafter, efforts focused on 'thought leadership' activities underpinned by 'looking out' for major opportunities. Over the life of CCAFS, there is evidence of continued efforts to 'stay different' from a typical CGIAR program. Examples include the level of flexibility accorded to staff, including in their location, host institution, disciplinary background, etc., with the common focus being on outcomes, all of which were found to be effective (Haman & Hertzum, 2019). This approach also allowed CCAFS to add new dimensions to the typical CGIAR research program such as climate services, participatory visioning with policymakers, climate finance with the mainstream financial community, and climate security with the peace and conflict community. Emphasis was placed on national, regional, and global policy, institutional pathways to impact, and ensuring diversity and inclusion within the leadership team. This fostered creativity, entrepreneurship, independence, and accountability to develop a high-performing culture. This culture focused on the delivery of outcomes as the key measure of success, which drove a cultural change towards impact pathways, partnerships, targeted capacity strengthening, and creative communications.

18.3 Guidance to Operationalise the Principles and Achieve This New Vision for Leadership

The principles below have been derived from case studies (Box 18.2) as well as from the leadership literature and can be applied in a changing agricultural research and development arena, characterised by an increasing focus on food-system transformation. Table 18.1 provides guidance on how these principles can be applied in AR4D organisations to catalyse food-system transformation. These principles must be complemented with efforts to lead collectively, both internally and externally, helping collective wisdom emerge over time by bringing new ways of thinking, acting, and being. Nurturing strong, trusting partnerships (Chapter 16) can help such collective leadership build a shared understanding of complex

Table 18.1. *Operationalising principles for effective and authentic leadership in AR4D leaders to develop the new vision*

Principle	Guidance to apply in a changing arena for agricultural research and development
Looking out	Focus on next users and partners, by recruiting leaders who serve as knowledge brokers and who focus on external partners and their knowledge needs. Shift from 'Publish or Perish' to 'Partner or Perish' and focus on addressing societal needs through research efforts. Rethink publishing not as an objective in itself but an essential tool to achieve concrete outcomes, ensuring it is rigorously reviewed, clearly communicated, and experimented/applied.
Getting different	Develop a unique selling proposition that is distinct but complementary to others in the arena, with a clear vision and mission to achieve impact.
Focused experimentation	Focus on delivering the mission of the organisation while also ensuring room to tap into emerging opportunities. Push for and showcase a profound change in the appreciation and response to failures and embed it in the organisational culture.
Diversity and inclusion	Ensure diversity in, gender, nationalities, values, and perspectives on the leadership team.
Service from science ethos	Recruit staff who share the 'service from science' ethos to ensure mission orientation in the organisation's efforts.
Creativity, independence, and accountability	Help people identify their own strengths and develop leadership skills, while giving them the freedom to take their own steps.

problems, and enable collaborating organisations to jointly develop solutions that are sometimes not evident to them individually. Collective leadership also means recognising the great diversity of organisational cultures and developing an ability to connect with them productively. However, such efforts require a deep culture change based on trust and an emphasis on listening to others to create self-sustaining change. For example, the culture should shift the conversation around failure in efforts beyond first-order causes and individual/organisational blame, to enable in-depth collective learning (Chapter 14).

Delivering these principles requires systems leaders. We have identified the characteristics of such leaders based on the seminal work of Senge et al. (2015) on systems leadership and the wider leadership literature, and embedded them in the three 'openings' identified by Scharmer and Kaufer (2013), while adapting them to the changing AR4D context (Figure 18.1).

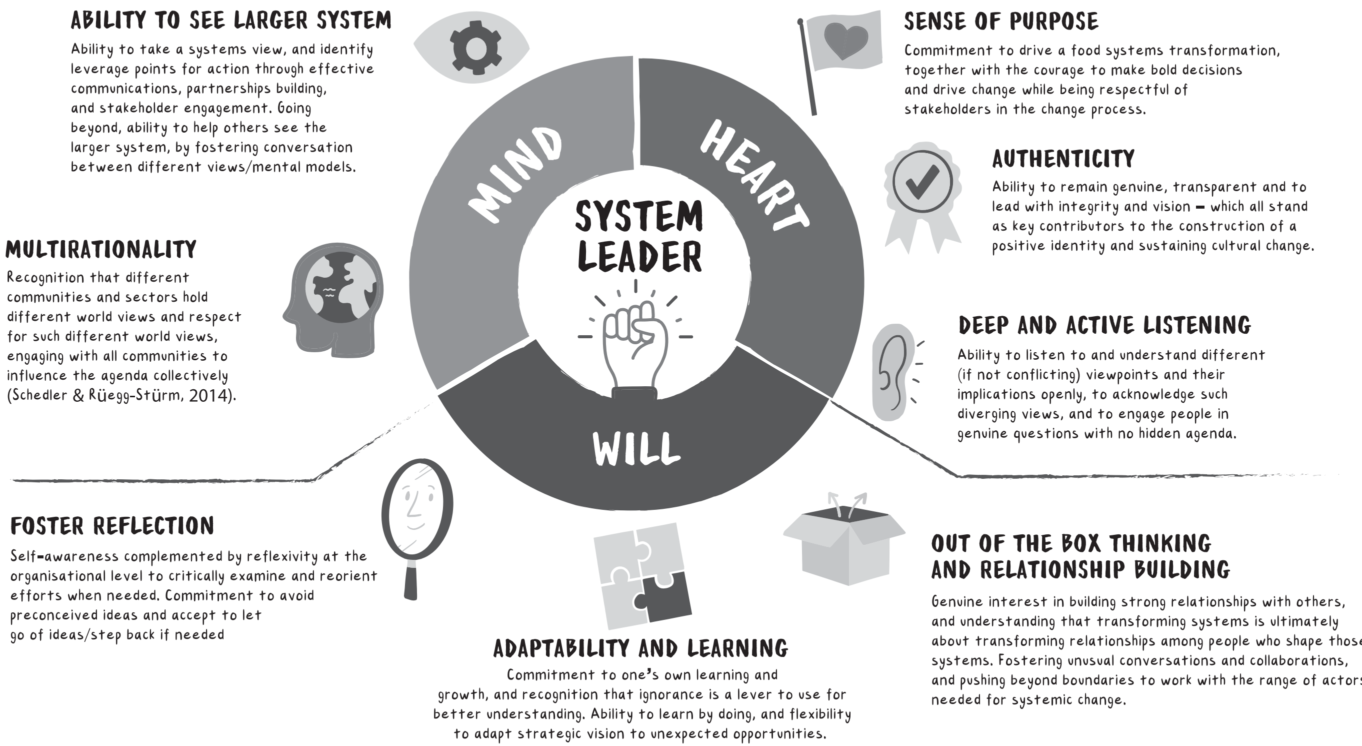

Figure 18.1 Characteristics of systems leaders in the AR4D context

18.4 Way Forward

We believe that the leadership lessons from the experiences and the literature discussed in this chapter will continue to be relevant as agricultural research for development evolves into food-system research and innovation. Skilful and adaptive leadership in the face of change will continue to be critical and should combine the characteristics of systems leaders, with the principles required to transform strategy and culture. AR4D organisations will face continuing challenges, but we feel these lessons distilled here will remain relevant in the face of the inevitable changes to come. Such efforts in AR4D organisations also need complementing with efforts within the university system, as sources of disciplinary excellence and the pathway to nurturing future capabilities.

To successfully contribute to the transformation of food systems, AR4D organisations must create a culture that embraces ongoing change and thrives on real partnerships. Without fostering such a culture change, such organisations risk neglecting short-term societal demands, losing relevance in the medium term, and jeopardising their very own existence in the long term.

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19

Create, Reorient, Phase Out

The Way Forward for Food-System Transformation through Research and Innovation

LEANNE ZEPPENFELDT AND DHANUSH DINESH

Highlights

- Research and innovation have a unique value proposition in the context of food-system transformation; creating, reorienting, and phasing out aspects of our current research systems can realise their potential.
- We can *phase out* research institutions, mental models, and incentives that are siloed and that promote top-down silver-bullet thinking.
- We can *reorient* agricultural research for development to food-system research wherein performance is measured based on benefits to users and the ability to scale rapidly.
- We can *create* spaces and matching incentives to catalyse action, imagine shared futures among stakeholders, and support intergenerational allyship and learning.

19.1 Rethinking Food Systems, Research, and Innovation: Key Takeaways

Multiple social, systemic, and structural factors threaten our current food systems. Climate change is pushing us to transform these systems, not only to mitigate its impact but also to ensure food and nutrition security and pursue other ecological, social, political, and economic benefits. As Chapters 1–3 have highlighted, research and innovation can enable that transformation in four action areas: (1) rerouting food systems along novel trajectories, (2) addressing nascent socio-cultural issues and thereby reducing risks, (3) responding to new environmental challenges, thereby lowering emissions, and (4) realigning enablers of change such as policies, regulation, finance, and innovation. Research and innovation can generate necessary knowledge and practical applications to support these actions (Chapter 3) but doing so will entail rethinking our research systems in the context of food-system transformation.

Chapters 4–14 have sketched out eleven actions – the 'what' – that will lead to urgent transformation within the four action areas, and *how* these actions can be realised. The *rerouting* of food systems will require innovative financial mechanisms that can empower actors to pursue change, complemented by a robust pipeline of bankable projects, mechanisms to aggregate such projects, and efforts to matchmake investors and projects. If they are attentive to gender and age differences, integrated policies that combine safety nets with incentives for climate-smart practices will also enable a shift in markets and production systems. *De-risking* our food systems in the face of climate change calls for a climate security agenda combined with early warning and action mechanisms that are backed by finance for safety nets. Specifically for farmers, information and communication technologies and climate data can mitigate risks, so creating options for access and connection to these resources will be vital. *Reducing* emissions, through climate-friendly diets and fighting food loss and waste, entails large-scale behavioural change. Market innovations, like more sustainable meat alternatives and demand-driven planning and supply chain coordination, can facilitate that change if policies actively promote them. All these actions depend on a *realignment* of the enablers of change in our systems, structures, and society, to ensure that our policies, institutions, and innovations foster and finance transformation.

Chapters 15–18 have highlighted how outcome-orientated research and innovation can support the eleven actions through (1) transformational theories of change, (2) strategic partnerships, (3) working across horizontal and vertical scales, and (4) transformative leadership. The use of theories of change to guide research, engagement, and capacity development activities helps steer research programmes beyond outputs to impact. In addition, theories of change, combined with adaptive management, can help identify key leverage points and strategic partnerships. Diverse, flexible, multi-scale partnerships, in turn, can move research from generating knowledge to driving societal changes. By propelling action on multiple scales, partnerships are also essential to successful scaling. Transformative leadership characterised by a strong mission orientation, embodied in both organisations and individuals, can pioneer these approaches to realise the potential of research and innovation to catalyse transformation.

19.2 It Is Time: Create, Reorient, and Phase Out

All the chapters in this book highlight how a food-system transformation could be realised. Taken together, they express one overarching message: transforming food systems not only means changing *what* is done, but also changing *how* things are done. Research can act as an important driver of that change. As it stands,

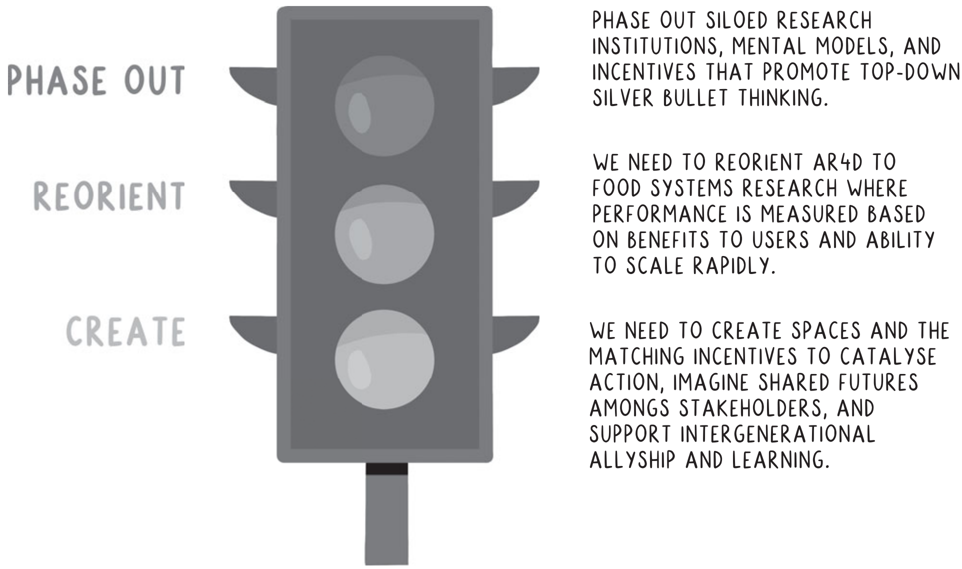

Figure 19.1 Create, reorient, phase out: The way forward for food-system transformation through research and innovation

however, our research and innovation systems are too much intertwined with our current food system and not the force for change that is needed. To fulfil the transformational potential of research and innovation, we can reflect on which aspects of our research and innovation systems need to be *phased out*, which ones we can *reorient* for transformational purposes, and what is missing and should be *created* (Figure 19.1). Building on the insights of this book, it is time to do as follows.

19.2.1 Phase Out

The path to food-system transformation requires moving away from a one-sided focus on growth as the hallmark of development. In the context of agricultural research for development (AR4D), this shift entails phasing out mental models that ignore the social, political, and ecological challenges that climate change brings. In addition, the food-system perspective also demands sensors throughout the system to grasp the complex dynamics at play. Yet too much research focuses on aggregating results to the highest level, looking for and promoting silver bullets, and obscuring insights into complex dynamics at lower levels. Along the same lines, siloed research institutions, where disciplines and academic buzzwords can limit innovative thinking and practical relevance, are not fit-for-purpose any more and could be phased out. On the governance side, the time of purely voluntary commitments to transformation has passed: we do not have enough time left to transform our food systems using only soft incentives. Research can create the evidence base needed to design and justify policies and strong incentive structures that push unwilling actors into action.

19.2.2 Reorient

When reoriented, other aspects of current research and innovation systems can actively support food-system transformation. Research can produce high-quality, timely evidence that will enable us to navigate the uncertainties and options that beset the pathways of transformation. Academic dialogues, institutions, and funding can open up and explicitly use transdisciplinary methods to address the many causes of our food system crisis. In addition, the reorientation of performance measurement in research will shape both the research agenda and the evidence base. Moving away from a definition of 'success' that favours the supply side and towards performance indicators that incorporate user perspectives and truly allow for innovative research will promote the uptake and scaling of innovations. As such, scaling strategies that are currently top-down and disconnected from research processes can be redirected so that scaling is part and parcel of innovation trajectories from the onset. Overall, AR4D must be reoriented as food systems research for development to deliver the needed systems change.

19.2.3 Create

Our research and innovation systems are still missing spaces that bring together the wide variety of actors from our food systems to catalyse necessary transformation. These spaces will support the creation of shared visions of transformational goals. Hence, in the face of climate change, we need platforms that facilitate dialogues among sectors and among the wider range of stakeholder groups that are linked to food-system transformation, such as farmers and consumers, across different generations. Promoting intergenerational allyship can preserve valuable lessons from past traditions, experiences, and failures. Research can build on these visions to guide agendas that are people-centred and demand-driven, while contributing the evidence base that is needed to realise them. We must not stop at dialogue, however, but ensure that action emerges from these shared visions. Partnerships among research, policy, and private-sector organisations will play a central role in translating evidence into large-scale action throughout our food systems. Action will require the creation of incentive and funding mechanisms that value research based on its functionality for end users.

19.3 Way Forward

Research and innovation have a unique value proposition in the context of food-system transformation: they can inspire, enable, and assess transformative action through knowledge creation and evidence. Harnessing this potential can promote transformed food systems that sustainably manage current and future resources and stresses and bring about a world in which all people, including future generations, are well-nourished and food secure. This book provides an agenda for the transformation of food systems and supporting research and innovation systems, building on insights from twelve years of the CGIAR Research Program on Climate Change, Agriculture and Food Security, a prominent effort in AR4D to respond to climate change challenges. Transformation will require big, bold investments from both public and private actors to finance fundamental changes in our food systems (Chapter 2). At the same time, it will be crucial to ensure there is continuous and rapid multidimensional and multi-level feedback through transdisciplinary metrics and measurements, to secure directed transformation that maximises benefits and minimises trade-offs (Chapter 1).

In some cases, this transition to transformational food systems research and innovation will involve phasing out, reorienting, or creating entire institutions and initiatives. In other cases, some parts of the same institution or initiative may need to be phased out, others reoriented, and new parts created. Identifying each of these parts requires critical, humble self-reflection about how research and innovation systems are currently hindering the transformation of our food systems and what must change to enable transformational research. Reluctance from incumbent actors to do so will end up stranding assets so they do not address the necessity of transformation. Moving forward, urgent priorities include fostering transdisciplinary and multi-level research-action relationships and creating spaces for shared learning, targets, metrics, and failure. In this process of phasing out, reorientation, and creation, leadership from organisations and individuals can fulfil the potential and responsibility of our research and innovation systems in realising the food-system transformation we need.

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