Agency and behavior change in agri-food systems transformation: Lessons from the CGIAR Agroecology Initiative

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The CGIAR Initiative Transformational Agroecology across Food, Land, and Water Systems develops and scales agroecological innovations with small-scale farmers and other food system actors in seven low- and middle-income countries. It is one of 32 initiatives of CGIAR, a global research partnership for a food-secure future, dedicated to transforming food, land, and water systems in a climate crisis.

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INITIATIVE ON
Agroecology

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Executive Summary

Systems-level transformation is increasingly recognized as necessary to improve the sustainability, equity, and resilience of agri-food systems. The CGIAR Initiative on Agroecology uses a systems transformation approach in alignment with Gliessmann (2014) and the 13 principles of agroecology outlined by the HLPE (2019). This approach requires new understandings of actor agency and behavior change processes that enable systems change. To provide these new understandings for approaches and investments in agroecological transitions, our study presents a novel framework and lessons from past experiences in similar transitions that required changes in behavior and agency of food system actors.

The specific objectives of this study were to

1. Understand how agroecology-relevant projects, government and/or donor programs, community initiatives, and social movements (collectively referred to as "initiatives" in this report) have approached behavior change and agency of food system actors for agri-food systems transformation;

2. Identify common assumptions on behavior change and agency that underpinned the initiatives' design; and

3. Recommend adjustments to the Theories of Change, assumptions, and processes in initiative design and implementation to enhance the roles of actor agency and behavior change processes in systems change.

Methods

To address the study objectives, we drew upon initiatives that involved agroecology-relevant projects, government or donor programs, community initiatives, and social movements (henceforth called "initiatives") from five countries: Tunisia, Zimbabwe, Peru, India, and Kenya. We developed an inventory of initiatives through a review of published and gray literature, such as websites and reports. We then characterized these initiatives in terms of the type of initiative, time period of implementation, and the focal agroecological principles addressed.

To further investigate approaches to changing behavior and agency, we selected a subset of initiatives from each country as case studies based on the following criteria: engagement with multiple and diverse agroecological principles, geographical scale of reach, diverse representation of initiative type and objective, relevance or impact as reported by local experts, and some country-specific criteria. We interviewed the designers and/or implementers of these case study initiatives to collect additional data, including the perceived factors that enabled or impeded the intended behavior changes.

Olive intercropping system with cereal and legume mixtures for soil health, Kairouan, Tunisia.

📷 Z. Idoudi

We developed and applied a framework for behavior change and agency of actors in agri-food systems to synthesize across the case studies:

i. Targeted actor groups, targeted behavior changes, and intervention modalities (behavior change approaches) applied
ii. Whether and how actor diversity and power asymmetries were addressed
iii. Common assumptions made about achieving change and how these played out in practice

After identifying the key assumptions underlying the Theory of Change in each case study, we analyzed whether these assumptions were supported by the initiative results, primarily the factors reported as enablers of or impediments to change, or needed refining.

Key results

The inventory included a total of 239 past initiatives that had pursued agroecological transitions, often by addressing a range of the 13 HLPE agroecological principles. Sixty-five percent of these initiatives had begun within the last 12 years (although dates were unavailable for 25% of the initiatives) and 88% were government- or donor-supported projects or programs. Nineteen community initiatives and ten social movements were also identified.

These initiatives most often applied agroecology principles related to resilience: biodiversity (71% of the initiatives), soil health (67%), economic diversification (60%), and synergy (49%). The exception was animal health, which was among the least applied (19%) of the 13 principles. One principle related to social equity was also frequently applied (co-creation of knowledge, 44%), while other social equity principles were given lower priority: connectivity (31%), social values and diets (31%), and fairness (25%).

From the 29 case studies, food system actors whose behaviors were targeted for change included producers (farmers, fishers, pastoralists, and other food producers) as individuals and groups, other value chain actors (retailers, input sellers, and actors in postharvest activities), extension and education actors (national agricultural extension agents and researchers), communities (women and groups of natural resource users), governance actors (policymakers and donors), and food consumers.

All case studies targeted the behavior of farmers and/or other producers, most often related to on-farm activities (such as changing or diversifying the farm production portfolio, 45% of cases) or value chain engagement (such as collaborating/negotiating with value chain actors, 41% of cases). When the behavior of other actor groups was targeted, it was usually to reinforce influence on producer behavior. For example, 52% of the cases targeted the behavior of extension/education actors. Other commonly targeted behavior of non-producer actors involved improving natural resource management practices in communities (28% of cases), engaging governance system actors to encourage agroecology-friendly policies (24% of cases), and changing diets of consumers (21% of cases).

Individual behavioral factors were most targeted by case studies. Technical assistance, training, and demonstrations were the most common approaches used to shape producer knowledge, attitude, and behavior. All cases applied multiple approaches to target behavior, for instance, improving productive infrastructure in addition to providing technical assistance and training.

Facilitating actor interactions was also common. Seventy-six percent of the cases supported collaboration through producer organizations or multi-stakeholder platforms to create opportunities for collective action toward change. Designers and implementers of initiatives frequently perceived factors related to these interactions as enablers of change, such as the scope and quality of partner engagement or a codesign process that included target actors and led to buy-in. However, poor stakeholder coordination was sometimes perceived as an impediment to change, even among cases that applied approaches to address producer and stakeholder interactions.

Many of the case studies also sought to expand actors' opportunity spaces by addressing external forces influencing behavioral outcomes:

Economic drivers: Fifty-five percent of the cases sought to expand actor opportunity spaces by addressing economic drivers of behavior, through facilitating market relationships, expanding credit mechanisms, and/or strengthening value chains. Cases addressing these drivers more frequently reported that market opportunities and engagement with value chain actors and other diverse stakeholders helped to achieve intended changes. However, these cases also more frequently noted that inadequate market linkages contributed to ongoing challenges.

Resource system drivers: Fifty-two percent of the cases approached resource-related drivers of behavior beyond the level of individuals' resources, for example, by improving infrastructure related to water management, food production, storage, and processing. Many of these cases also facilitated social learning and networking, and their frequently reported enablers of change, such as wide stakeholder involvement, reflected these approaches.

Social and relational drivers: Fifty-five percent of the cases addressed these drivers using approaches such as promoting agency, entrepreneurship, and/or inclusion and equity. Forty-one percent of the cases had a specific focus on inclusion and equity for women or other marginalized groups. Cases that did not address such social and relational dynamics more often reported poor codesign and poor alignment with stakeholder needs as challenges to achieving intended outcomes.

Governance drivers: Only 38% of the cases addressed governance (including institutional and policy-related) drivers of behavior; of these, only one case reported success in achieving institutional reform. Cases that did and did not address governance drivers commonly reported institutional and policy challenges to achieving behavior change. At the same time, cases that did address governance drivers more often reported success in achieving intended outcomes through partner engagement and collaboration, market and value chain opportunities, and/or wide stakeholder involvement.

S. Freed

Lessons on assumptions behind behavior change engagements

Although the interview data provided some insights, the logic and assumptions behind the Theories of Change employed in each initiative were more often implied than directly stated. The behavior change targets, approaches, and reports of factors enabling or impeding intended changes revealed some common assumptions:

○ *Producers and their behavior are central to achieving agroecological transitions*. Furthermore, participatory and codesign approaches that involve producers throughout design and implementation improve the likelihood of achieving change targets.

○ *Multiple entry points are often necessary to achieve behavior change and agroecological transitions*. Producers are not acting in a vacuum. Their social interactions and connections with resources, economic systems, and governance systems matter. Because these interactions and connections can either enable or impede behavior change, they must be understood and addressed as needed.

○ *Social learning and collaboration can be powerful approaches to achieving change*. However, ignoring varied levels of agency and opportunity among collaborators can limit marginalized groups' participation and undermine the equity of impacts.

The findings also revealed some common assumptions in need of refinement:

○ Initial assumption: Expanding producer knowledge is essential to enable behavior change.
Refined assumption: Although essential, knowledge is rarely a sole driver of producer behavior. Coupling training with efforts to address other barriers to or enablers of change, such as norms, policies, resources, and especially economic and market opportunities, is more likely to create opportunities for sustained behavior change.

○ Initial assumption: Introduced technologies are improved, desirable, and feasible additions to producer portfolios.
Refined assumption: A technology or practice must be appropriate for the user and context. Codesign of the technology or practice is an effective way to support behavior change. The co-production process is further supported by embedding engagement within existing institutions and practices, which was a commonly cited enabling factor for behavior change.

○ Initial assumption: Training is the easiest and most direct way to achieve, sustain, and scale behavior change.
Refined assumption: Accessible training and the capacity to deliver it effectively require more planning and resources than often assumed. Training must be tailored to the recipient's needs and is most effective when integrated with local knowledge, practices, and structural subsystems. Training alone was rarely adequate to achieve or sustain behavior change as most initiatives reported additional barriers to change.

○ Initial assumption: Collaboration and behavior change readily occur when multi-stakeholder engagement takes place.
Refined assumption: Many initiatives facilitated collaboration between producers and other stakeholders. However, engagement may not be effective, equitable, or sustained if different stakeholders' power, agency, constraints, and priorities are not understood and addressed.

○ Initial assumption: Actors are homogeneous in their power to access and participate in producer and stakeholder groups.
Refined assumption: Efforts at inclusion often fail to overcome normative barriers to engagement. Transformational diversity and inclusion efforts are needed to create opportunity for sustained, equitable behavior change. Many past initiatives cited success through delivering training on equity and empowerment and supporting women's leadership.

○ Initial assumption: Resource constraints to behavior change can be overcome with one-time inputs or awareness-raising.
Refined assumption: Although behavior change may be stimulated through a one-time input or awareness-raising around available resources, it is rarely sustained. Some initiatives found success in part by addressing resource constraints, especially at the producer group or community level, while others reported that these activities fueled dependency. Sustained opportunity for behavior change requires actor buy-in and building resource and economic systems that enable continued, equitable access to resources.

Recommendations for initiative design and implementation

Transformational change requires coordinated action across actors, behavior, and the internal and external forces influencing behavior. We recommend the following steps for achieving this coordination in future initiatives aiming at agri-food systems transformation:

i. Prioritize the social equity principles of agroecology as key entry points for knowledge exchange, agency, collaboration, and behavior change.

ii. Understand the diverse actors in the agri-food system, their power dynamics, and their diverse priorities, opportunities, and constraints through thorough and properly disaggregated needs assessments.

iii. Map how structural subsystem elements impact actors' behavior and identify priority entry points for achieving behavior change.

iv. Engage diverse actors in a visioning process to prioritize and commit to the components for change and then develop a Theory of Change with clearly defined assumptions linking the steps in the change pathway and rationales for the prioritized entry points.

v. Plan and implement transformational DEI approaches to stakeholder engagement that help shift social norms and expand behavior change opportunities.

vi. Undertake careful and inclusive codesign of interventions with a diversity of actors (both within and between actor groups).

vii. Apply an adaptive management approach, making time and resources available for participants and initiative partners to jointly reflect on progress and adjust as needed.

Left: Custard apple, Anantapur, India; Right: Olives, Kef/Siliana, Tunisia. 📷 S. Freed

Introduction

Increasingly, efforts to make agri-food systems more sustainable, equitable, and supportive of human well-being aim for systems-level transformation (Woltering et al., 2019; Klerkx and Begemann, 2020; Leeuwis et al., 2021). Among the approaches to sustainable agri-food systems reform is agroecology, typically defined as a science, set of practices, and social movement oriented around the integration of ecological and social concepts into agricultural systems in support of environmental, economic, and social outcomes (Altieri, 2002; Wezel and Soldat, 2009; Gliessman, 2014). Although highly context-specific, agroecology is guided by a set of widely accepted principles (Figure 1) that prioritize resource conservation, agroecosystem resilience, and social equity (HLPE, 2019; Wezel et al., 2020).

Figure 1. HLPE principles of agroecology.

Source: *Biovision Foundation (2022).*

The CGIAR Initiative on Transformational Agroecology Across Food, Land, and Water Systems (AE-I) aims to support agri-food systems transformation in line with the High Level Panel of Experts' (HLPE) principles. AE-I aims not only for changes to on-farm practices, but to shift entire food systems into "sustainable and equitable states, involving change in norms and institutions in the public and private sector that govern how food is produced, processed, transported, sold, and consumed, as well as the relationship between consumers and other food chain actors, including producers" (CGIAR AE-I, 2021). This focus on wider food systems transformation necessitates understanding agency and behavior change at and beyond the farmer level and throughout agri-food systems, including changes that alter the decision-making environment in which actors operate. As such, achieving agroecological transformation through wide and sustained uptake of agroecological innovations requires examining behavioral drivers and their intersections for a diversity of actors across agri-food systems: at the farm and farmer scale, within communities of producers and consumers, along value chains, within supporting systems of researchers and extension agents, and among policymakers and donors.

Behavior in this context refers to actions, interactions, and practices carried out by individuals or groups, including management practices at the individual, farm, or territorial/landscape level, implementation of business models, or the interactions and processes involved in decision-making. Individual behavior in aggregate constitutes collective behavior at the community, landscape, or societal level. Collective behavior can influence individual behavior, for instance, through social pressure and norms that dictate which behavior is considered appropriate by others in society.

> " Individual behavior in aggregate constitutes collective behavior at the community, landscape, or societal level.

Understanding which actors' behavior changes are central to agroecological transition and what factors might enable such behavior change is challenging but critical to supporting agri-food systems transformation. Much research on behavior within agricultural systems focuses on technology adoption at the individual and household level and diffusion of innovations at the community and regional level, building on early adoption and diffusion theories (Rogers, 2003). These studies are often grounded in the idea of "technology transfer," whereby expert-developed innovations are distributed to and taken up among producers, who are implicitly portrayed as passive end-users of technologies. As such, emphasis is on incentive structures and knowledge dissemination that influence adoption at the farm level (Mockshell et al., 2023). Critiques of this narrow focus on adoption are increasingly common, especially when adoption is treated as a flipped switch – a binary, permanent behavioral outcome (Doss, 2006; Loevinsohn et al., 2013; Glover et al., 2016; Glover et al., 2019; Rietveld and van der Burg, 2021). Fundamentally, this approach treats behavior change as something that happens at an isolated point in time, at limited scale, and in a single direction. A systems perspective requires attention to wider, societal transitions that create conditions for behavior change (Leeuwis et al., 2021; Woltering et al., 2019). In alignment with the AE-I's approach, this perspective emphasizes the need to expand actors' agency to choose behaviors that carry them closer to an agri-food system state that provides them with opportunities to achieve their goals and aspirations.

In an effort to develop a systems perspective on agency and behavior change that could guide AE-I activities, the initiative team sought to learn from past successes and failures in achieving behavior change and improving the agency of marginalized actors during agroecological transitions. Our research questions were the following:

○ Which agroecological principles were the foci of past initiatives?
○ Which actors and behaviors were targeted and what were the associated intervention modalities that past initiatives applied?
○ How did past initiatives grapple with actor diversity and power?
○ What did the approaches to and targets of behavior change, along with the factors reported as having enabled or impeded behavior change, reveal about past initiatives' assumptions?
○ Were there common assumptions across initiatives and, if so, how did they play out in practice?
○ Do any assumptions need revision in light of the reported enabling and impeding factors and a systems perspective on behavior change?

The tools we used to investigate these questions included a framework to identify and analyze elements of agency and behavior change at the levels of individuals and food systems, an inventory of agroecologically relevant initiatives in five focal countries, and a subset of initiatives from each country for which in-depth research was conducted on their approaches to, achievements of, and challenges in motivating and sustaining behavior change.

A conceptual framework on agency and behavior change in the transformation of agri-food systems (ACT)

To build a relevant conceptual framework for a systems perspective of agency and behavior change in agri-food systems, we adopt a widely accepted systems framework as a foundation: Ostrom's socio-ecological systems (SES) framework (McGinnis and Ostrom, 2014). We then bring in elements relevant to agri-food system actors from agricultural innovation systems research and relevant concepts from social and behavior change science. This includes concepts from the behavior change wheel (Michie et al., 2011), which usefully integrates internal and external behavioral drivers but does not adequately address behavior as a systems-level process.

Our conceptual thinking begins with recognition that diverse actors interact within a system. In line with the SES framework, we adopt the concept of action situations, in which actors interact and make individual and collective choices among available options in light of expected benefits and costs of potential behavior (McGinnis and Ostrom, 2014). Producers are often the actors who interact most directly with agroecosystems, making their behavioral outcomes especially important to agroecological transformation. However, their behavior is influenced by interactions with agro-dealers, processors, aggregators, distributors, extension agents, consumers, researchers, and government representatives.

Farmers discussing their vision for an agroecological transition in their local food system.

Each actor has a unique and dynamic makeup in terms of knowledge, cognition, needs-based motivations, aspirations, biases, self-efficacy, attitudes and beliefs, and other internal resources that we term *individual behavioral factors*. They also experience differences in power, agency, and opportunity – largely linked to external forces – that shape their ability to choose and implement desired behavior (Avelino and Wittmayer, 2016).

> ❝ Resource subsystems here refer to the range of biotic and abiotic resources relevant to agri-food system functions, including soil, water, ecosystem, biodiversity, climatic conditions, and human-constructed infrastructure.

In this framework, we characterize the external forces shaping actors' interactions in the action situation and individual agency, opportunity, and behavior as four structural elements: governance, economic, resource, and social and relational subsystems. In doing so, we acknowledge their crucial roles in agri-food systems as well as the possibility of altering these subsystems and their roles as external forces (e.g., as supporting or hindering forces) on individual and collective agency and behavior change. *Resource subsystems* here refer to the range of biotic and abiotic resources relevant to agri-food system functions, including soil, water, ecosystem, biodiversity, climatic conditions, and human-constructed infrastructure. *Economic subsystems* refer to market conditions that actors encounter for inputs and outputs, financial services, and overall economic development. *Governance subsystems* refer to the entities that coordinate societal processes and actors' behavior, including public, private, and civil sector institutions,
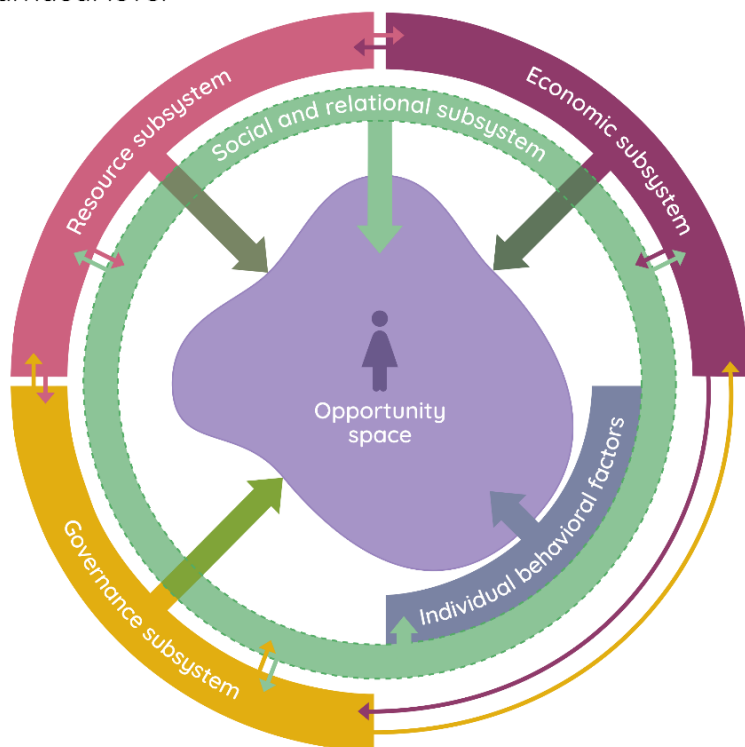
organizations, and services as well as formal systems of rules. *Social and relational subsystems* refer to social norms, network structures, socially constructed identities (both individual and collective), and resulting collective attitudes, roles, and relationships. Social and relational dynamics operate at multiple levels and thus permeate most aspects of the wider agri-food system, including the way actors experience the other three subsystems. For example, network structures and injunctive norms at the systems level govern how actors relate to one another within social systems (such as households and communities) and therefore actor relations, actions, and interactions in the action situation. Network structures and injunctive norms also influence actor interactions with markets, financial and policy systems, property rights systems, natural resource systems, infrastructure, and other structures (see also notes of Figure 2A). At the individual level, actors might internalize social norms to direct their motivations and behavior.

We adopt the concept of an *opportunity space* to describe the range of behavioral options available to and preferred by individuals (Rietveld et al., 2020). The options in an actor's opportunity space depend on the intersection of individual behavioral factors with external forces (i.e., the governance, economic, resource, and social and relational subsystems). We emphasize the importance of the social and relational subsystem in this context as it mediates the relationship between actors and the economic, governance, and resource subsystems, and therefore heavily impacts actors' opportunity spaces (Figure 2B). Opportunity spaces thus reflect the "baggage" of motivations and other internal factors, power, agency, and resource access that actors bring into an action situation where decisions related to behavior are made. Within the action situation, synergies between actors' individual opportunity spaces can create *collective* opportunity spaces that determine the range of possible behavioral outcomes (both individual and collective) and resulting feedback to the different subsystems.

Finally, we conceptualize an initiative's entry points to influence agency and behavior change through this framework. First, we propose that any of the framework elements can serve as entry points; this was part of the rationale for including these elements. Second, we recognize three levels at which an initiative could target an entry point: (1) at the level of individuals through their opportunity space, (2) at a collective level through the action situation, or (3) at an enabling environment level through the structural elements. For example, an initiative that chooses resources as an entry point could employ them by targeting individual resource access, collective resource access and management, the resource subsystem, or a combination of the three levels.

Figure 2. A conceptual framework on agency and behavior change for transforming agri-food systems (ACT), adapted from the SES framework (McGinnis and Ostrom, 2014). (A). Structural subsystem elements and individual behavioral factors shape actors' unique opportunity spaces, particularly by expanding or constraining their resources, power, and agency. (B). Actors' interactions in action situations are influenced by their opportunity spaces and by structural subsystem elements, leading to individual and collective behavioral outcomes.

A. Individual level

B. Collective level

Actors:
The range of diverse actors involved anywhere in the agri-food system.

Resource Subsystem:
The range of resources relevant to agri-food system functions, including ecosystem components and human-constructed infrastructure.

Economic Subsystem:
Markets, financial services, and overall economic development.

Governance Subsystem:
The entities and formal rules coordinating societal processes, including public, private, and civil sector institutions, organizations, and services.
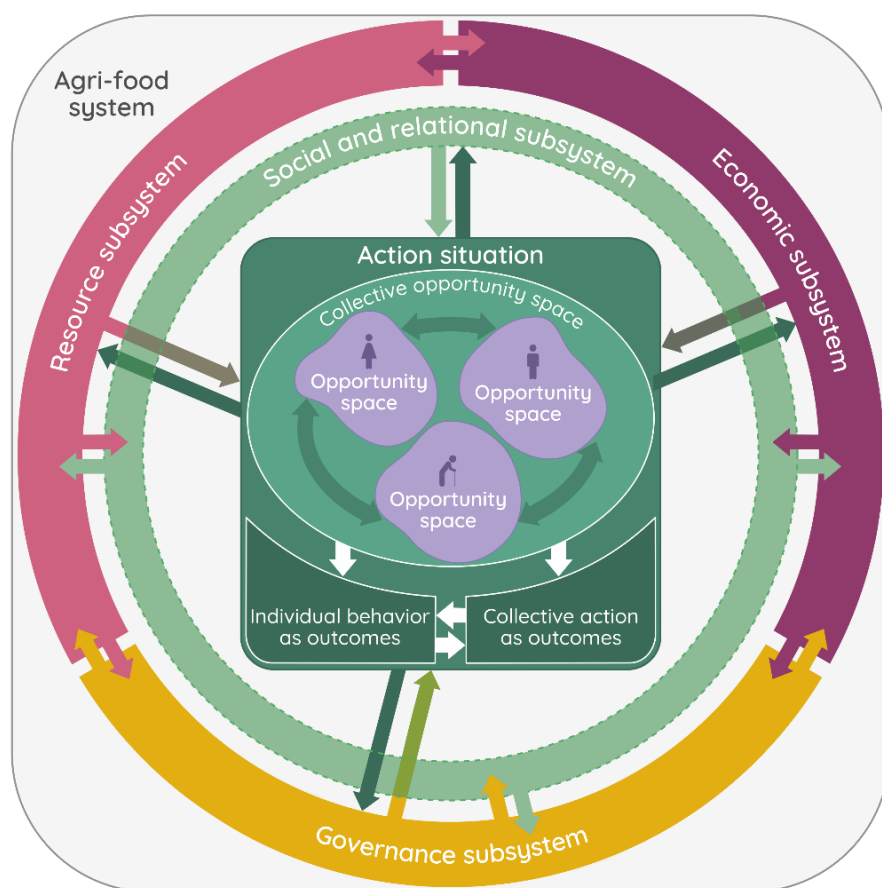
Social and Relational Subsystem:
Social norms, network structures, socially constructed identities (both individual and collective), and resulting collective attitudes, roles, and relationships.

Individual Behavioral Factors:
An individual's internal resources of knowledge, cognition, need-based motivations, aspirations, etc.

Opportunity Space:
The range of behavioral options available to and preferred by individuals or groups depending on their behavioral factors, connections to subsystems, power, and agency.

Action Situation:
A specific set of interactions among actors which results in individual and collective behavioral outcomes.

Methods

For this study, we leveraged innovation history analysis to examine and reflect on past innovations, allowing us to draw lessons about behavior change in agri-food systems transformation and propose paths forward (Douthwaite and Ashby, 2005; Klerkx et al., 2012). We focused on five countries participating in the CGIAR Agroecology Initiative: India, Kenya, Peru, Tunisia, and Zimbabwe. These countries have varied experiences and histories in implementing agroecological transitions, which allowed us to apply the ACT framework across diverse contexts. In each country, a subset of regions was targeted for AE-I activities; therefore, we focused the study on the experience of the agroecological transitions (at both national and subnational levels) most relevant to these regions.

Study sites

In India, AE-I activities are being implemented in two states: Andhra Pradesh, specifically in Anantapur District, and Madhya Pradesh, in Mandla District. Both districts predominantly have red and black soil. Anantapur, situated in a dryland region, faces frequent droughts and receives an average annual rainfall of 552 mm, significantly lower than the national average of 1,160 mm. Historically, Anantapur had diverse crop systems in its rainfed areas before a shift toward groundnut monocropping began in the early 1980s. This shift decreased reliance on millets and pulses for household consumption while depleting the soil's biomass. Nevertheless, mixed farming practices have emerged in the region, alongside initiatives promoting climate resilience through the cultivation of millets, agrobiodiversity, and agroecology. The major crops grown in Anantapur are groundnut, pulses, cotton, and rice (MoA&FW, 2022). Mandla District, where the major crops are rice, wheat, and pulses, struggles with soil erosion across the landscape and especially in ridge areas. Mandla experiences good rainfall but its topography and soil type do not retain water for extended periods, resulting in water scarcity during the summer. More than 60% of the district is covered by forests, which provide habitat for wildlife and constitute a major resource for the locals (Data from Land Use Statistics Information System, 2020-21).

AE-I activities in Kenya are implemented in two counties: Kiambu (central Kenya) and Makueni (central-eastern Kenya). Agriculture based on bimodal rainfall is the primary economic activity in both counties, with food and cash crops produced in Kiambu (sometimes with irrigation, especially among larger farmers) and more subsistence production in Makueni, with the exception of more commercialized livestock and fruit production (Mwangangi et al., 2012; Kiambu County Government, 2013). Both counties have a range of soil types and agroecological zones: Kiambu has Upper Highland, Lower Highland, Upper Midland, and Lower Midland Zones (Kiambu County Government, 2013), whereas Makueni has Upper Zone (primarily Kilungu and Mbooni), Middle Zone (Wote area), and Lower Zone (Kibwezi areas) (MoALF, 2016). Maize, green grams, pigeon peas, and sorghum dominate in Makueni (County Government of Makueni, 2013), although farmers also produce pawpaw, oranges, mangoes, and other fruits. Livestock in Makueni include dairy cattle, beef cattle, sheep, goats, donkeys, poultry, and pigs (County Government of Makueni, 2013). In Kiambu, the main food crops are maize, beans, Irish potatoes, bananas, and vegetables, alongside horticultural crops (Kiambu County Government, 2021). Coffee and tea are grown in the county's highlands as cash crops, while cows, poultry, and pigs are kept as livestock.

In Peru, the AE-I study area was the department of Ucayali, with activities targeting the province of Padre Abad and the districts of Yarinacocha, Nueva Requena, Campo Verde, Manantay, and Pucallpa in the province of Coronel Portillo. This region of the Amazon boasts a high diversity of flora and fauna and and is home to four protected areas. However, it faces severe deforestation due to encroachment of oil palm, cocoa, coffee, rice, coca leaf, plantain, papaya, and pastureland (MINAM, 2016; MINAM 2021; MIDAGRI, 2022). Besides agriculture and livestock, fishing and mining are important economic activities in the region (MIDAGRI, 2022; MIDAGRI, 2021). Child malnutrition, child mortality, and illiteracy rates remain high, and the area has a large population of people identifying as native or indigenous (INEI, 2022).

In Tunisia, AE-I activities focused on the governorates of Siliana and Kef. The agriculture and fishing sector contributes more than 10% to Tunisia's GDP and accounts for 16% of national employment (WFP, 2018). However, agricultural systems face challenges related to the arid climate and the uncontrolled exploitation of soil and water resources (ONAGRI, 2016). Soil degradation and erosion pose a clear threat to the country's arable land, with an estimated potential loss of up to 50% by 2050 (UNFCCC, 2014). Climate change also exacerbates these problems (Giannakopoulos et al., 2009), with expected decreases in orchard areas and the potential decline of cereal production (Gafrej, 2016). Apart from the plains focused on intensive, often irrigated cereal production, these two northwestern mountainous regions are mainly characterized by integrated low-input cereal-livestock systems and are strongly threatened by the abovementioned soil degradation and erosion problems.

Preparing a natural farming fertilizer, West Godavari, India.

📷 S. Freed

In Zimbabwe, AE-I activities are organized in Murehwa District of Mashonaland East Province and in Mbire District of Mashonaland Central Province. Agriculture based on a unimodal rainfall pattern is a critical livelihood strategy for 70% of Zimbabwe's population, but productivity in most regions remains low (FAO, 2020). Cropping systems in AE-I target regions are largely centered around maize, the primary staple crop, but groundnut, cowpea, sweet potato, sunflower, sorghum, millet, tobacco, cotton, and various vegetables are also cultivated (FAO, 2006). Mixed crop-livestock production is very common in Zimbabwe, including in the target regions, and most households own livestock (FAO, 2022). Many Zimbabwean landscapes, notably Mbire, boast high levels of biodiversity and an abundance of wildlife, including megafauna that enable wildlife tourism but contribute to human-wildlife conflict and heightened tensions between agro-pastoralists and conservation efforts (Baudron et al., 2022). Climate change is motivating on- and off-farm adaptation (Asare-Nuamah et al., 2022), including shifts away from maize and cotton, especially in Mbire District (Baudron et al., 2022).

Data collection

Past initiative inventory compilation
AE-I team members based in the countries conducted desk reviews to document past initiatives focused on or related to agroecology, following standardized guidance. In Peru and Zimbabwe, interactions with members of the AE-I

Agroecological Living Landscapes (ALLs) were also used to generate lists of important past initiatives in AE-I target regions. The ALLs in the initiative target countries are diverse groups composed of members and researchers who work together (with support from other agri-food system actors) to design and test innovative practices, develop the business appeal of preferred options, and support behavior changes toward agroecological transition. The Kenya country team was able to leverage *databases from the Intersectoral Forum on Agro-Biodiversity and Agroecology* to produce their inventory.

The country research teams also conducted Google searches (both Google Scholar and general web searches in locally relevant languages) for initiatives related to agroecology and other context-relevant terms in each country (Table 1). Variation across countries in the level of engagement in agroecological transitions meant that the search criteria for some countries were customized or narrowed (spatially and temporally) in order to successfully learn from initiatives relevant to the ALL's agroecological transition. In Kenya, for instance, the huge number of past initiatives documented in the Intersectoral Forum on Agro-Biodiversity and Agroecology database led the team to impose tighter inclusion criteria, focusing on AE-I target regions over a ten-year period and only those initiatives touching on integrated natural farming, circular economy, *and* social justice principles.

Table 1. Inventory development criteria by country.

Country	Search terms	Timeframe	Other criteria
India	Agroecology projects, natural farming/organic farming projects in [each state], programs on climate resilience, conservation agriculture	1980 to present	At least four agroecological principles targeted
Kenya	Makueni, Kiambu, agroecological practices, agroforestry, permaculture, regenerative agriculture, organic agriculture, integrated pest management, climate-smart agriculture, sustainable farming systems	2012–2022	- Implemented in the ALL locations (Makueni or Kiambu) - Touched on integrated natural farming, circular economy, and social justice principles
Peru	Agroecological projects, climate-smart agriculture, sustainable agriculture, environmentally friendly agriculture, sustainable rural development movements, programs, and initiatives	1980–2022	
Tunisia	Agroecology, conservation agriculture, Tunisia, projects, etc.	1999 to present	
Zimbabwe	Agroecology, agroforestry, conservation agriculture, sustainable agriculture, regenerative agriculture, organic agriculture, integrated farming systems, diversified farming systems, livestock integration, agrobiodiversity	2002–present	

For each initiative identified, we followed standardized guidance in classifying the type of initiative (social movement, project, program, community initiative, etc.), funding and implementing institutions, geographic area of intervention, implementation period, and, if possible, activities performed. We then identified which agroecological principles (HLPE, 2019; Wezel et al., 2020) an initiative addressed. Documentation typically depended on websites, blogs, available reports, and (occasionally) peer-reviewed literature or key informants. Information on some initiatives was too limited to include them in the final inventories.

The findings of these analyses are specific to the initiatives studied and cannot be considered definitive for any country's agroecological history or for agroecological transitions in general. This is partly due to limitations on data availability: more recent initiatives are more likely to have been recalled by participants and/or documented online, while externally funded projects and programs are also potentially more likely to have been documented online than community-based initiatives. Additionally, the digitalization of project histories appears more common in some countries (notably Kenya due to its available database) than in others (Tunisia, Zimbabwe). Because some of the initial inventory analysis (notably the assignment of agroecological principles) was handled by separate country teams, there was also some variability in the criteria used for these. Tunisia found that most initiatives touched on at least ten principles, the highest of all countries, and about double the average number of principles that Kenya identified.

Case studies

In each country, the initial review of past initiatives enabled purposeful selection of five to eight interventions for in-depth review. Selection criteria, following standardized guidance, were the following:

○ Engagement with many and diverse agroecological principles (i.e., focusing on not only resource-conserving agronomic practices but also social and economic outcomes)

○ Scale of reach (i.e., regional or landscape-scale initiatives, especially in AE-I target regions, were prioritized over village-level activities and initiatives outside target AE-I regions)

○ Diversity (in terms of agroecological practices, principles, and farming systems targeted, as well as the type of initiative [project, social movement, community initiative])

○ Relevance/impact as reported by local stakeholders

In Kenya and Peru, where inventories were largest, we selected case study initiatives that specifically targeted ALL regions, prioritized initiatives with the most principles covered, and sought to include initiatives implemented by local organizations rather than only larger organizations. For Peru, we focused on initiatives that included native communities and also sought to include one initiative with a large number of beneficiaries (more than 20,000). In Tunisia, we sought a diversity of case studies specifically in reference

to different intervention modalities (i.e., on-farm R&D and demonstration, sensitization and capacity building, value chain structuring, multi-stakeholder dialogue, and financial support).

After case study selection, the country teams organized key informant interviews with one or more individuals knowledgable about and/or involved in the implementation of the selected initiatives. These were often representatives of implementing organizations or government agencies, project field agents, and, on occasion, participating producers. We used a standardized semi-structured interview protocol across countries and cases to gather details about each initiative, including the Theory of Change and the motives or interests of the actors involved in developing it, the behavior changes targeted, the activities introduced to achieve the intended behavioral changes, assumptions made about how behavior change would occur, diversity and social inclusion efforts, and factors perceived to have enabled or impeded the intended behavioral changes and the diversity and inclusion efforts.

Analysis

We compiled the country inventories of past initiatives and used descriptive statistics to analyze patterns and trends in the agroecological principles targeted, the types of initiatives, and the years they were active. Country teams and a cross-country researcher jointly analyzed the literature and interview data from the in-depth case studies. In many cases, interview data were paired with gray literature (often project proposals and reports) to triangulate answers to research questions. To synthesize the data across countries and initiatives, we systematically coded past initiative characteristics.

Drawing on established typologies of behavior change techniques (Abraham and Michie, 2008; Kok et al., 2016), the ACT framework, and the themes that emerged from the case study data, we coded the promoted behavior changes, the actor groups whose behavior was targeted, and the intervention modalities (i.e., approaches to bring about behavior change). We organized the intervention modality codes into a typology common to agri-food system initiatives (Table A3). When assumptions were not clearly stated, we relied on the targeted behavior and intervention approaches to re-construct the links between the intervention and intended behavior change (i.e., we reconstructed the steps within the Theory of Change) and the underlying logic that would make up the assumptions. We then identified the most common links and assumptions among the cases. Finally, we used inductive analysis to categorize the initiative assumptions and the factors enabling and/or impeding behavior change by elements of the ACT framework. For the analysis of factors enabling or impeding behavior change, we relied on the 28 cases that reported these data (i.e., one case provided no report and was excluded from this portion of the analysis).

To assess past initiatives' engagement with issues of diversity, equity, and inclusion (DEI) across gender and other lines, we used a coding system based on existing gender equity continuums (UNFPA, UNICEF, and UN Women, 2020). DEI engagement ranged from diversity-blind, in which no clear acknowledgment of differences between actors on the basis of identity was acknowledged, to transformational, in which initiatives sought to transform social relations to the benefit of marginalized groups. Three interim categories were identified: diversity-aware, in which differences were acknowledged and reported on; diversity-responsive, in which initiatives proactively responded to target actors' differences; and diversity-intentional, in which marginalized groups were explicitly targeted for initiative benefits (Figure 3).

Figure 3. Diversity, equity, and inclusion considerations in initiatives ranged from diversity-blind to transformational.

Diversity-blind	Diversity-aware	Diversity-responsive	Diversity-intentional	Transformational
The initiative did not appear to acknowledge differences in actors' needs, constraints, or priorities.	Differences in actors' needs, constraints, or priorities were acknowledged. The participation of women and marginalized groups in the initiative was monitored and reported.	The initiative sought to level the playing field for women and marginalized groups, in recognition that their participation in the initiative was not or would not be equal. Examples included targeted, separate, or personalized training and outreach, alongside DEI monitoring and reporting.	The initiative deliberately aimed to benefit women and marginalized groups over other groups. Examples included prioritizing women's groups or persons with disabilities for training, equipment distributions, or economic activities, alongside DEI monitoring and reporting.	The initiative dedicated time and funds to identifying and reforming structural barriers to the participation and benefit of women and marginalized groups, especially social and relational structures. Examples included gender-transformative training around norms, increasing women's leadership, or expanding access to credit or education for marginalized groups, alongside DEI monitoring/reporting and deliberate efforts toward equitable participation.

Results

Overview of inventories and case studies

The inventory generation process yielded 239 past initiatives related to agroecology across the five countries, with a disproportionate number in Kenya because of the available database of past projects (Table 2). From these, 29 case studies were selected for in-depth review. Not all cases reported on factors that enabled or impeded behavior change, or engagement of marginalized groups. The number of reporting cases is indicated in the relevant subsections.

**Table 2. Past initiatives captured in country inventories.**

Country	Initiatives	Case studies
India	39	5
Kenya	103	5
Peru	45	5
Tunisia	26	8
Zimbabwe	26	6
Total	239	29

Although inventories sought to capture a range of past agroecology-related initiatives, projects and programs were much more frequently documented (88% of all initiatives) than community initiatives (8%) or social movements (4%). Although dates of implementation were not available for 24% of the initiatives, 65% of the initiatives had started in the last 12 years (Annex A1), which might reflect bias in recall and digitalization of initiative records as much as (or more than) it reflects the popularity of agroecology-related topics.

Agroecological principles addressed

The thematic focus of past initiatives, captured in the agroecological principles addressed, provides insight into the scope of past initiatives. Overall, the agroecological principles most commonly addressed by the initiatives in the inventory were biodiversity (71% of documented initiatives), soil health (67%), economic diversification (60%), and knowledge co-creation (44%; Figure 4). The least commonly addressed principles were animal health (19%), fairness (25%), connectivity (31%), and social values and diets (31%). The relative popularity of the principles over time, based on when the initiatives started, does not show meaningful patterns.

Figure 4. Percentage of initiatives addressing each agroecological principle.
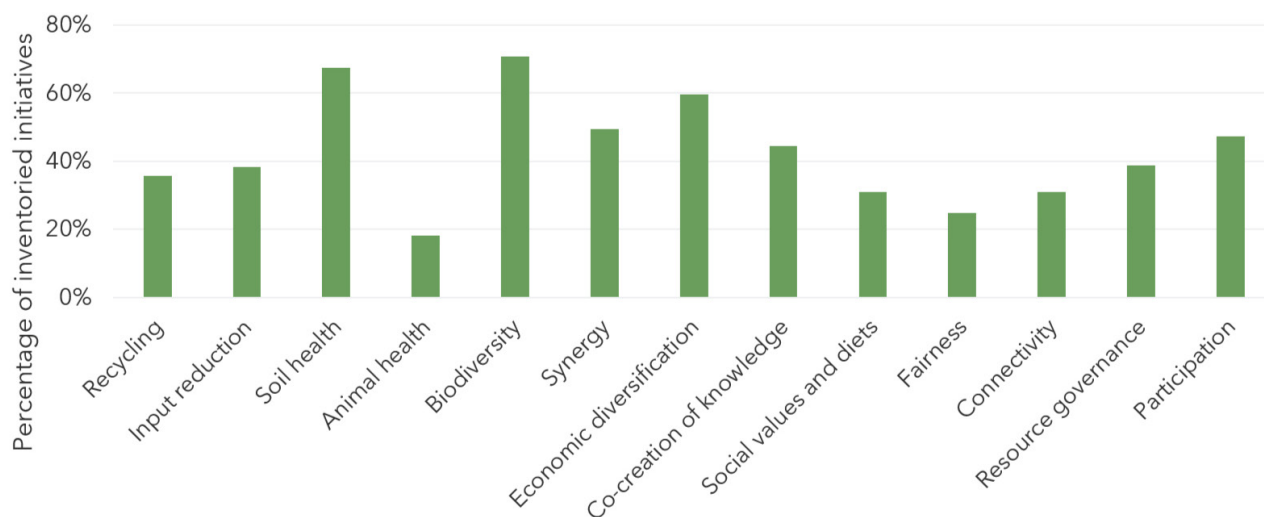
We also identified the thematic foci of the initiatives based on the thematic organization of the 13 principles presented in Figure 1: resource efficiency (principles of recycling, input reduction), resilience (principles of soil health, animal health, biodiversity, synergy, economic diversification), and social equity (principles of knowledge co-creation, social values and diets, fairness, connectivity, resource governance, participation). Past initiatives addressed a median of three of the five resilience principles and 98% of the initiatives addressed at least one. Resource efficiency and social equity principles were less often addressed. For resource efficiency, past initiatives addressed a median of zero of the two principles, but 46% addressed at least one. For social equity, past initiatives addressed a median of two of the six principles and 92% addressed at least one.

There were variations between countries in terms of agroecological principles targeted (Annex A2), which likely results in part from variation in analysis methods between country teams. However, the patterns point to potentially meaningful variation in priorities between agroecosystems, regional donors, and implementing organizations. Soil and input-related principles were disproportionately targeted in Tunisia, Zimbabwe, and India, where soil quality concerns are often high and conservation agriculture has been heavily promoted. India also saw heavy focus on organic and natural farming, the latter involving the use of indigenous natural inputs and adoption of multiple-cropping techniques. Peru's greatest focus was on participation, biodiversity, and connectivity, reflective of the large number of projects touching on agroforestry, community efforts to reduce deforestation, household nutrition, farmer well-being, and market linkages. Kenyan initiatives focused most on biodiversity, synergy, and economic diversification, perhaps in part due to the use of the Intersectoral Forum on Agro-Biodiversity and Agroecology's database of past initiatives.

Targeted behavior changes

From the in-depth case studies, we identified seven actor groups targeted for behavior change (Figure 5A): producers (farmers, fishers, and pastoralists), consumers, producer groups (such as a farmers' association), communities, value chain actors, extension and education actors, and governance system actors (typically policymakers). All 29 case studies targeted producer behavior and most targeted at least one other actor group in addition.

In terms of the specific behavior changes that the initiatives promoted, producers were encouraged to adopt new practices, to change or diversify their production portfolio, to stop or decrease harmful practices such as deforestation, or to collaborate or negotiate with other actors along the value chain (Figure 5B).
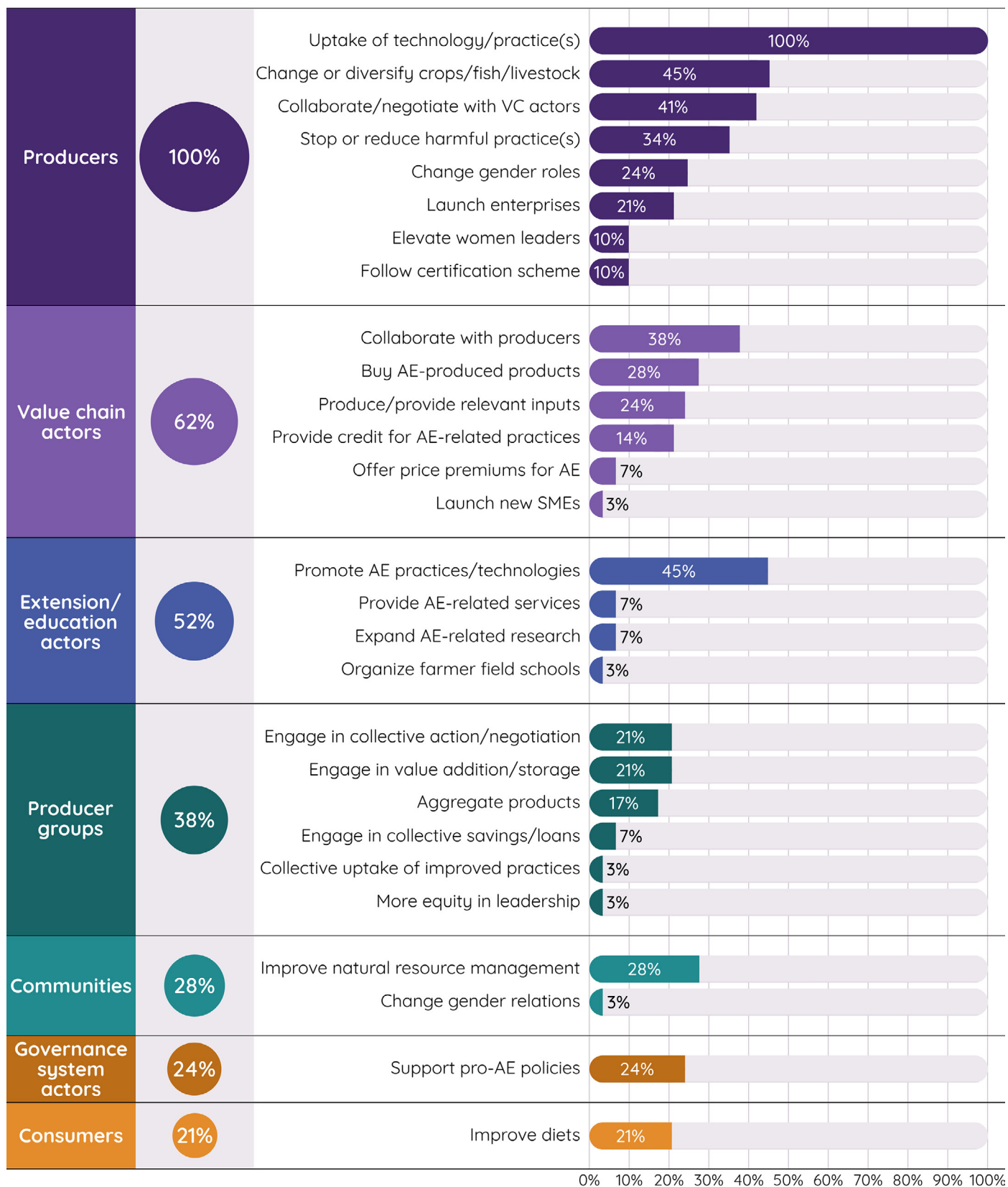
Most cases that targeted value chain actors' behavior (62% of cases) intended to stimulate collaboration and engagement between private-sector actors and producers, especially to strengthen markets for agroecological products or to build market linkages between producers and other value chain actors. However, three cases reported that private-sector actors were not engaged enough in planning and/or implementation or that they withdrew after the initiative ended, leaving market linkages underdeveloped. Regarding the behavior of extension/education system actors (targeted by 52% of cases), initiatives focused on changing behavior primarily to improve delivery of agroecology-related knowledge to producers. The mode of intervention was almost exclusively through training and capacity building of extension agents.

In 38% of the cases, producer groups were encouraged to engage in collective action, product aggregation, and collective marketing or to collectively take up processing and storage practices that enabled value addition. A focus on wider behavior change at the consumer, community, and governance system level was less common: 28% of the initiatives addressed community behavior, with attention to improved management of shared resources, or, in a few cases, women's empowerment. Only 24% of the initiatives campaigned for governance system actors to support or enable agroecology-relevant policies or governance structures at one or more levels. Consumer behavior was least frequently addressed, with only 21% of the initiatives deliberately promoting improved or diversified diets.

Figure 5. (A). Frequency at which agri-food system actors were targeted for behavior change by initiatives. (B). The associated behavior changes promoted for each actor group in the sample of case study initiatives. Percentages are based on the total reports from all case studies (29 total). Each initiative typically targeted multiple actor groups and behaviors.

A. Targeted agri-food system actors

B. Behaviors promoted in case study initiatives

Producers — 100%

Behavior	%
Uptake of technology/practice(s)	100%
Change or diversify crops/fish/livestock	45%
Collaborate/negotiate with VC actors	41%
Stop or reduce harmful practice(s)	34%
Change gender roles	24%
Launch enterprises	21%
Elevate women leaders	10%
Follow certification scheme	10%

Value chain actors — 62%

Behavior	%
Collaborate with producers	38%
Buy AE-produced products	28%
Produce/provide relevant inputs	24%
Provide credit for AE-related practices	14%
Offer price premiums for AE	7%
Launch new SMEs	3%

Extension/education actors — 52%

Behavior	%
Promote AE practices/technologies	45%
Provide AE-related services	7%
Expand AE-related research	7%
Organize farmer field schools	3%

Producer groups — 38%

Behavior	%
Engage in collective action/negotiation	21%
Engage in value addition/storage	21%
Aggregate products	17%
Engage in collective savings/loans	7%
Collective uptake of improved practices	3%
More equity in leadership	3%

Communities — 28%

Behavior	%
Improve natural resource management	28%
Change gender relations	3%

Governance system actors — 24%

Behavior	%
Support pro-AE policies	24%

Consumers — 21%

Behavior	%
Improve diets	21%

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

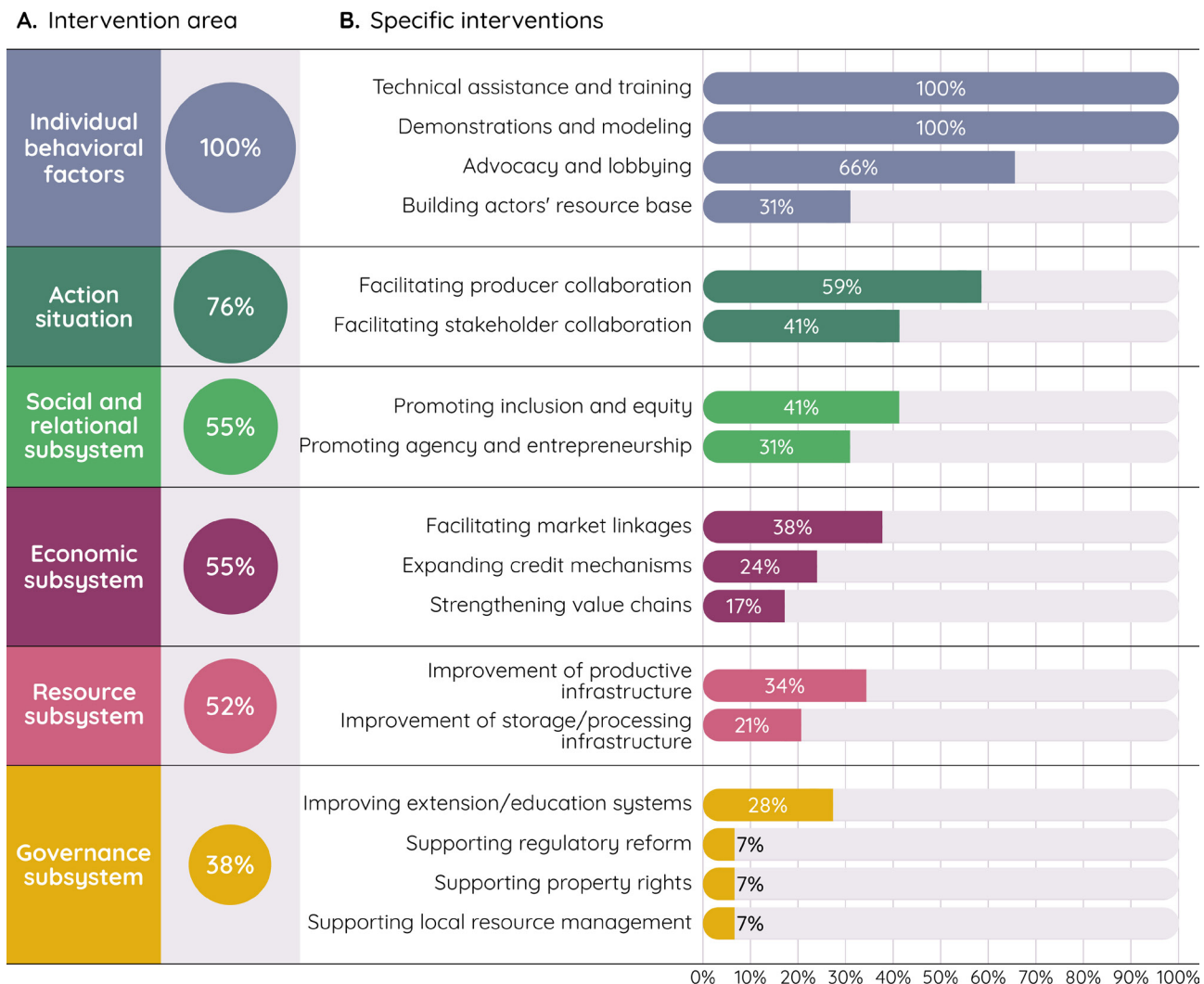## Approaches to behavior change (intervention modalities)

We found 18 intervention modalities in the in-depth cases. We link the types of interventions to the ACT framework elements (Annex A3 and Figure 6). All cases addressed individual behavioral factors through technical assistance, training, demonstrations, and modeling. Most employed additional approaches related to advocacy and lobbying (66%) and/or individual resource-building (31%). Cases that strengthened actor interactions in the action situation focused on producer organizations or multi-stakeholder platforms for social learning and collaboration.

Most cases sought to create a more enabling environment for behavior change by expanding actors' opportunity spaces. To achieve this, they typically addressed micro- and meso-scale aspects of the four subsystems. For instance, many cases addressed economic subsystems by improving economic opportunities or decreasing economic barriers through new credit mechanisms, market-building, or value chain development. Interventions touching on the governance subsystem were least frequent and included support for regulatory change, changes to property rights systems, changes in resource management systems, or improvements

to extension and education systems. Initiatives addressing the resource subsystem contributed to expanding public or collective infrastructure related to production or processing. At least half of the initiatives touched on micro- or meso-scale elements of the social and relational subsystem, with interventions supporting gender equality, empowerment, and agency-building (including through entrepreneurship training and promotion of women's groups) within target communities.

On average, the cases applied six intervention modalities in tandem, and all but one case targeted drivers other than just Individual behavioral factors. As such, almost all initiatives sought to pull multiple behavior change levers at once and expand actors' opportunity spaces. Through these efforts, initiatives touched on, on average, three to four elements of the conceptual framework, including individual behavioral factors. Although individual behavioral factors and actor interactions were a heavy focus among the case studies, only about half addressed economic, social and relational, and resource subsystems as an element of the behavior change process (Figure 6A). Governance subsystem changes were even less commonly included. On average, initiatives targeted two of the four structural subsystems.

Figure 6. (A). Intervention areas of the conceptual framework targeted. (B). Specific intervention modalities employed to generate behavior changes in case study initiatives.

A. Intervention area

Intervention area	%
Individual behavioral factors	100%
Action situation	76%
Social and relational subsystem	55%
Economic subsystem	55%
Resource subsystem	52%
Governance subsystem	38%

B. Specific interventions

| Intervention	%
Technical assistance and training	100%
Demonstrations and modeling	100%
Advocacy and lobbying	66%
Building actors' resource base	31%
Facilitating producer collaboration	59%
Facilitating stakeholder collaboration	41%
Promoting inclusion and equity	41%
Promoting agency and entrepreneurship	31%
Facilitating market linkages	38%
Expanding credit mechanisms	24%
Strengthening value chains	17%
Improvement of productive infrastructure	34%
Improvement of storage/processing infrastructure	21%
Improving extension/education systems	28%
Supporting regulatory reform	7%
Supporting property rights	7%
Supporting local resource management	7%

Engagement with actor agency, diversity, and power

In terms of the attention given to diversity, equity, and inclusion, the largest number of cases appeared "responsive" to diversity concerns (38%), meaning that they made some effort to level the playing field for participants from marginalized groups but did not seek to address social and relational norms (Figure 7). Generally, this involved tailoring training programs and outreach to women, youth, people with disabilities, or tribal groups. One case, for instance, initially set quotas around participation in their training programs. When the engagement of marginalized groups proved challenging, they tailored their training approaches (topics, training times and places) to the interests, needs, and constraints of these groups. Although some initiatives aimed at inclusion from the start, others evidently adapted their approach in response to unequal participation rates.

Seventeen percent of the cases appeared completely blind to diversity concerns and 10% were only minimally aware of them. The latter collected data on the participation of women and marginalized groups but seemingly took no steps to better reach them. "Counting women" through participation in training programs was the core indicator of success in most of these initiatives' DEI efforts. In one diversity-aware initiative, it was explicitly acknowledged that marginalized groups' unique challenges were not adequately addressed because of inadequate needs assessment.

A few cases (14%) intentionally targeted women and marginalized groups as beneficiaries over other groups. Often, these initiatives targeted women's producer groups for training or prioritized women and youth entrepreneurial activities, for instance, through engagement in organic input production and coffee seedlings, fruit trees, and/or other tree nurseries. One case specifically sought to support indigenous communities' land rights. However, two other cases instrumentalized women by targeting them, but not other family members, for nutrition training as a means to improve household nutrition and food security. These cases illustrate that diversity-responsive and diversity-intentional initiatives can reinforce rather than transform household roles and inequalities, in addition to potentially causing backlash if men feel excluded or unacknowledged (Bonatti et al., 2019; Vercillo, 2020).

Twenty-one percent of the cases employed transformational approaches. These deliberately sought to reform social and relational dynamics in order to improve the standing and agency of women and marginalized groups, for instance, by elevating women leaders. One case introduced leadership schools for women, while another aimed to increase women's representation in local governance structures. Some initiatives provided training aimed at equalizing household labor burdens and decision-making. One other case aimed to shift household gender relations through training that encouraged men's engagement in household labor, advocated against gender-based violence, and promoted "positive masculinity."

Figure 7. Classification of case study initiatives according to engagement with diversity, equity, and inclusion. The percentage of case studies in each category (from a total of 29) is indicated.
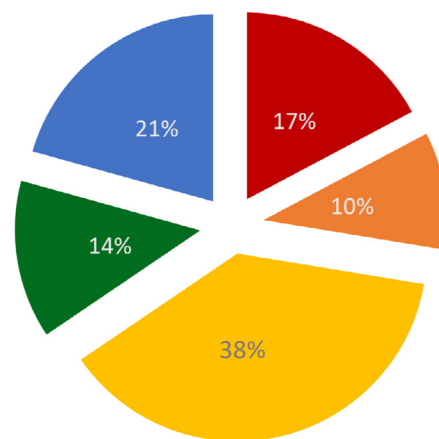
■ Blind ■ Aware ■ Responsive ■ Intentional ■ Transformational

Nineteen of the 29 cases reported on indicators of success or enabling factors specifically linked to engaging marginalized groups, and only 15 cases reported on impeding factors. The enabling factors most frequently reported related to deliberately building the capacity of marginalized groups to make and act on decisions (13/19 cases). This was common in transformational, diversity-intentional, and diversity-responsive cases and entirely absent in diversity-aware and diversity-blind cases. Conducting a needs assessment or tailoring technologies to marginalized groups was also reported to contribute to initiative DEI efforts (7/19 cases), particularly in diversity-intentional and diversity-responsive cases. Training on equity and empowerment (6/19 cases) was primarily reported as a DEI-enabling factor in transformational and diversity-intentional cases, while support for women's leadership (4/19 cases) was a feature almost exclusively of transformational cases.
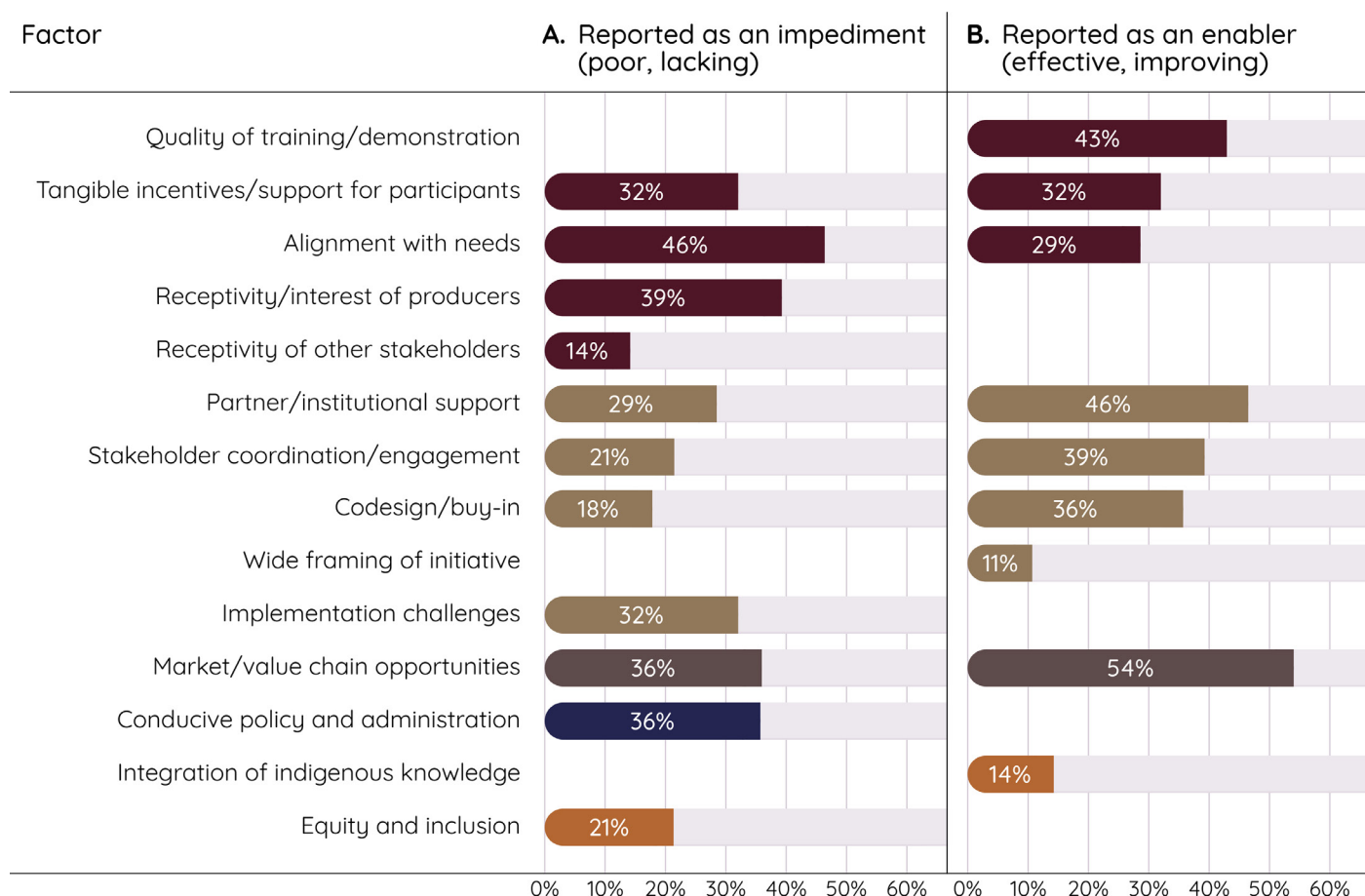
One frequently reported impediment to achieving DEI aims was the persistence of social norms limiting equal participation (10/15 cases), such as those underlying unequal household labor burdens, stigma, or norms around engagement in public spaces. This impeding factor was identified in all of the transformational cases, indicating the challenge of overcoming this persistent impediment. One transformational case that dealt with women's leadership also reported a policy barrier. Although the participation of women in coffee cooperatives increased during the initiative, most women were prevented from joining the board of directors because of a policy requiring that board members supply at least 1,000 kg of coffee to the cooperative, whereas women often had limited access to land and also ownership of coffee production. This was one of many issues in the board leadership, as the appointments were reported to be quite political and often followed unethical practices. Access to and control over land and other resources was acknowledged as a challenge in about half of the cases (7/15) reporting on DEI impediments.

Factors perceived to enable or impede behavior change

Twenty-eight of the 29 cases reported on factors perceived to enable or impede behavior change. The factors most commonly reported to have enabled behavior change in initiatives were the productive engagement and fruitful collaboration between initiative partners, high-quality training and demonstrations, support for market and value chain linkages, engagement of a wide range of stakeholders, codesign with target actors leading to high buy-in, and alignment between promoted behavior and actors' needs and constraints (Figure 8). The factors most reported to have impeded behavior change mirrored enabling factors in many cases: the poor suitability of introduced practices or technologies, farmer disinterest in or resistance to behavior change, limited market opportunities, and challenges related to policies and institutional bureaucracy.

Figure 8. Frequently reported factors perceived to (A) impede or (B) enable initiatives' intended behavior changes (multiple responses permitted).

Factor	A. Reported as an impediment (poor, lacking)	B. Reported as an enabler (effective, improving)
Quality of training/demonstration		43%
Tangible incentives/support for participants	32%	32%
Alignment with needs	46%	29%
Receptivity/interest of producers	39%	
Receptivity of other stakeholders	14%	
Partner/institutional support	29%	46%
Stakeholder coordination/engagement	21%	39%
Codesign/buy-in	18%	36%
Wide framing of initiative		11%
Implementation challenges	32%	
Market/value chain opportunities	36%	54%
Conducive policy and administration	36%	
Integration of indigenous knowledge		14%
Equity and inclusion	21%	

Relationships between framework elements and enablers of and impediments to behavior change

Many initiatives reported poor alignment with producers' and other actors' needs and constraints, unreceptivity of producers, and unreceptivity of other stakeholders (in 46%, 39%, and 14% of the cases reporting on enabling and impeding factors, respectively). These reflect inadequate attention to individual behavioral factors and/or external factors shaping behavior, for example, the labor and input demands of some promoted practices. These reports also indicate flaws in the initiatives' assumptions and Theories of Change, for example, preparing inadequately for drought or other climate events, or assuming homogeneous needs across different types of farmers. Reports of tangible incentives/support as enablers (32% of reporting cases) or the lack of tangible incentives/support as impediments (32%) affirm the importance of understanding actors' needs and motivations. However, incentives/support do not always need to be tangible to expand actors' opportunities for change, as indicated by the reports of quality of training as an enabler of change (43%).

Reports of effective or limited codesign processes (36% and 18%), effective partner engagement and support for the initiative (46%), and effective or poor stakeholder coordination and engagement (39% and 21%) indicate the importance of facilitating an inclusive and stimulating action situation to achieve intended changes. For instance, one case found wide acceptance of the aims to decrease deforestation through agroforestry and silvopastoral systems because farmers and ranchers were involved in initiative codesign. Similarly, another case adapted its approach based on farmers' experiences. In response to participant feedback that wildlife was undermining the initiative's target

agricultural practices, the initiative began to promote non-violent mitigation of human-wildlife conflict. This contributed to heightened community engagement and satisfaction in the initiative. Such cases illustrate how an initiative's role in facilitating participation and interactions in the action situation can build on motivations, widen opportunities, and strengthen buy-in. In contrast, another case reported low interest in promoted vaccination and artificial insemination technologies and attributed this to a lack of codesign; these technologies were not compatible with existing practices and some of the value chains targeted in the initiative were not local priorities. Reports of implementation challenges (e.g., insufficient on-site resources for training, unexpected climate variability, competing objectives of other initiatives) as an impediment to change (32%) and a wide framing of the initiative as an enabler of change (11%) indicate the importance of ensuring proper planning of an initiative and its own role within the action situation.

Market and value chain linkages were often reported as key drivers of change, both as impediments (36%) and enablers (54%). This reflects the importance of the economic subsystem in achieving and sustaining intended behavior change. Improved access to product markets, input supply chains, value chain development, and increased farm-gate prices were all cited as value chain and market-based enablers of change. Low profit margins and insufficient market opportunities were frequently reported market-based impediments to change. Sometimes, market and/or value chain linkages played both an impeding and enabling role within the same initiative. For example, one case reported limited market access for products while access to inputs improved. In another case, market intelligence and engagement improved among farmers, but perverse

incentives prevented a decrease in pesticide use. In yet another case, small-scale farmers experienced market benefits while market demand was too low to attract large-scale farmers, thus preventing change in the latter's behavior. Finally, some cases experienced tangible but ultimately short-lived benefits. For example, one case developed markets for forage stover and seed that facilitated increased income for smallholders, but the markets collapsed after the initiative closed despite efforts to establish partnerships and negotiate contracts to sustain market linkages.

Challenges related to policies and institutional bureaucracy were among the most frequently reported impeding factors (36%). At the same time, the governance subsystem was the least frequently targeted framework element in the case studies. Only one case reported success in achieving institutional reforms: the inclusion of agroecology in national agricultural policies and reforms to extension systems. Policies emerged as a barrier to success in many other cases. Reports from three cases noted that existing policies ran counter to the initiative goals (e.g., promoting conservation agriculture, regulating GMOs, and promoting organic agriculture and seed sovereignty) and therefore undermined behavior change.

Reports of a lack of equity and inclusion as an impediment and the integration of indigenous knowledge as an enabler (21% and 14% of reporting cases, respectively) indicated the importance of equity and inclusion, both within the action situation and more broadly in the social and relational subsystem. The previously mentioned factors of stakeholder resistance, stakeholder coordination and engagement, and codesign/buy-in also indicate the importance of equity and inclusion. For instance, in two cases, the promotion of women leaders, gender-transformational training, and

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new business and credit opportunities increased women's participation in value chains (from 22% to 40% in one of the cases) and their engagement as cooperative leaders. In another case, women were recognized as change champions within their communities and were given opportunities to lead and drive the initiative forward. Their active participation and leadership not only expanded their opportunity spaces but also brought about positive social and economic changes within the community, helped ensure that initiative activities were aligned with the specific needs and aspirations of the community, and contributed to more meaningful and sustainable outcomes. A fourth case found success in pairing the recovery of indigenous practices with training in new agroecological practices and creation of new markets.

Assumptions underlying past initiatives

Few key informants or initiative documents explicitly described the assumptions underlying the initiatives. However, implicit assumptions became more apparent when examining the initiatives' selections of intervention modalities and actors to target for behavior change. The factors perceived to enable or impede behavior change provided insight into whether these assumptions held true. We identified a total of 18 assumptions that were embedded in the case study initiatives and were associated with the ACT framework elements. We grouped them by frequency as most common (MCA), common (CA), and least common (LCA) assumptions.

Most common assumptions (MCAs)

MCA-1	Producers and their behaviors are central to achieving agroecological transitions
MCA-2	Expanding producer knowledge is essential to enabling behavior change
MCA-3	Introduced technologies are improved, desirable, and feasible additions to producer portfolios
MCA-4	Trainings are the easiest and most direct way to achieve, sustain, and scale behavior change
MCA-5	Multiple entry points (beyond producer knowledge) are necessary to achieve behavior change and agroecological transitions
MCA-6	Social learning and collaboration can be powerful approaches to achieve behavior change
MCA-7	Collaboration and behavior change readily occur when multi-stakeholder engagement takes place

Common assumptions (CAs)

CA-1	Transfer of agroecological knowledge to producers readily occurs from extension agents and others
CA-2	Extension and education actors will continue agroecological technical assistance and training after an initiative ends and can thereby sustain and expand behavior change among producers
CA-3	Actors are homogeneous in their power to access and participate in producer and stakeholder groups
CA-4	Increased access to inputs and market opportunities for products can sustain behavior change
CA-5	Improving existing infrastructure and ensuring collective access to and management of resources can facilitate behavior change at scale
CA-6	Constraints in power and agency can impede actors' behavior change, particularly for marginalized groups
CA-7	Policies and institutions are beyond the scope of change possible through initiatives

Least common assumptions (LCAs)

LCA-1	Increasing women's leadership roles in decision-making processes can ensure their interests are represented and that solutions meet their needs, thereby paving the way for behavior change at more equal rates by gender
LCA-2	Increasing producers' active and effective engagement in economic activities along the value chain can lead to greater monetary gains and sustained behavior change incentives
LCA-3	The influence of policies and institutions on behaviors must be addressed to enable behavior change at scale and over the long term
LCA-4	Individuals' resource access constraints to behavior change can be overcome with one-time input distributions or awareness raising

Assumptions around individual behavioral factors

All case studies addressed producers' behavior, first and foremost by targeting individual behavioral factors, and specifically knowledge. This underscored two widely held assumptions: producer behavior plays a crucial role in agri-food systems transformation (MCA-1) and targeting producers' individual behavioral factors, especially knowledge, is essential to achieve behavior change (MCA-2). However, reports of producer disinterest and disengagement as impeding factors indicate that increased knowledge may not be sufficient to enable producer behavior change and that the assumed desirability and/or feasibility of introduced technologies may be overestimated (MCA-3).

In some cases, initiatives aimed to change producer behavior indirectly via the behavior of other actors. One case, for example, strengthened the capacity of local educational institutions and universities around agroecological farming practices, in addition to providing direct outreach to producers. Initiatives that aimed to build capacity and change attitudes within extension and agricultural education systems assumed that training was the most feasible way to achieve intended behavior change (MCA-4). The use of extension and agricultural education systems relied on two additional assumptions: that knowledge about agroecology would trickle down from extension agents and others to producers (CA-1) and that extension and education actors would continue agroecological technical assistance and training beyond the immediate lifespan of the initiative, thereby sustaining and expanding behavior change among producers (CA-2). However, among the cases that engaged extension service actors, reports of partner engagement/ collaboration and quality of training as enabling factors were surprisingly low (22% and 11% of cases, respectively). Most cases (73%) that engaged extension service actors reported that poor suitability of the interventions and/or farmer resistance impeded behavior change. Various reasons were cited, such as inaccessible training for certain farmers (such as the illiterate, women, and/or disabled), deficiencies in the training or organization (such as overly technical or poor staff availability or coordination), and inappropriate technologies (too labor intensive, too technically and/or logistically challenging, wrong commodity to reach women's groups). In addition, a large majority of cases (73%) engaging extension service actors identified other impediments to change, such as market linkage problems, consumption preferences that contradicted the commodities promoted in the training, challenges in securing land tenure, and subsidies or inputs as either a prerequisite for or deterrent from changing practices.

" All case studies addressed producers' behavior.

Assumptions around the action situation

All but one of the cases layered additional interventions on top of training and demonstrations. In these initiatives, the implicit (and sometimes explicit) assumption was that producer awareness and knowledge would be necessary *but not sufficient* to change behavior and transform agri-food systems (MCA-5). These "add-on" intervention modalities typically addressed actor interactions or structural subsystems, and, in doing so, carried their own assumptions.

The most common intervention modality *not* addressing individual behavioral factors involved strengthening interactions between agri-food system actors, thereby targeting the action situation (in 76% of cases). These interventions generally sought to facilitate social learning and collaboration by building or strengthening producer organizations or multi-stakeholder platforms. These activities point to the assumed importance of social learning, resource sharing, collective action and bargaining among producers, as well as expanded interactions between producers and other value chain actors in facilitating sustained behavior change (MCA-6). These efforts appeared to contribute to success: when comparing cases that targeted value chain actor behavior to those that did not, the former more often identified market and/or value chain opportunities as enabling factors (11/17 vs. 4/11). Similarly, cases with reports of wide stakeholder involvement as an enabling factor targeted more actor groups on average (4 vis-à-vis 2.8). In one case, the exclusion of key stakeholders (in this case, relevant private-sector actors) from planning and implementation processes was perceived to undermine the initiative's success. In contrast, another case was perceived as having achieved intended changes in part due to its focus on establishing relationships and trust between farmers, the private sector, and government actors involved in target value chains. However, this case also reported a failure to fully realize the intended market and profitability changes to benefit farmers, which was perceived as potentially due to intermediary involvement in the market, suggesting that intervention focused on the action situation alone may not be adequate to enable economic changes.

" These interventions generally sought to facilitate social learning and collaboration by building or strengthening producer organizations or multi-stakeholder platforms.

Cases that facilitated actor interactions often carried implicit assumptions that these actors shared enough interests to collaborate and that the engagement of multiple actors could lead to behavior change (MCA-7). However, poor stakeholder coordination emerged as an impeding factor in some of these cases (27%). Respondents from one case noted that they were uncertain that farmer platforms had continued to function after the initiative's close, and there were reports that a crucial farmer-buyer linkage collapsed after the close of a second initiative. It was also sometimes unclear whether multi-stakeholder interactions extended beyond annual meetings. For the 64% of cases addressing actor interactions that did not use diversity-intentional or transformational DEI approaches, the implied assumption was that actors held equal power to access and participate in producer and stakeholder groups (CA-3). This was contrasted by the factors most reported as impeding DEI efforts: norms and other cultural factors that limited equitable participation in initiative activities (10 of the 14 cases reporting specifically on DEI failures), indicating that power and equity issues were widespread.

Assumptions about economic subsystems
More than half of the case study initiatives (55%) targeted the economic subsystem, for instance, by establishing certification schemes or credit mechanisms, building farmers' linkages to markets, or expanding value chain activities beyond production. These interventions operated under relatively clear but generally implicit assumptions that increased access to inputs and market opportunities for agroecological products would help ensure the sustainability of behavior changes (CA-4). A key informant involved in one case highlighted the importance of a wider systems mindset, reporting that "large-scale application of technologies and innovations, in a whole value chain approach, would accelerate the development of agricultural value chains, to rapidly increase food and nutrition security, as well as incomes for all players (producers, processors, marketers), and consequently contribute significantly to inclusive agricultural and economic development." A second case built special markets for native communities' agroecological products by promoting participatory guarantee systems, which involved actors from the production chain for the certification. A third case created strong incentives for uptake of natural farming practices by establishing value addition processing centers, certification systems, and direct sales platforms with fixed guaranteed prices. In contrast, a fourth case provided free inputs as the key behavioral incentive for producers but did not establish conditions for large-scale behavior change or create lasting economic incentives for uptake of promoted practices. When comparing initiatives that did and did not address the economic subsystem, the former more often reported enabling factors linked to market and value chain opportunities (11/15 vs. 4/13) and less often reported poor codesign (1/15 vs. 4/13) and resistance from non-producer stakeholders (0/15 vs. 4/13). However, cases addressing the economic subsystem also more often reported inadequate market linkages (7/15 vs. 3/13) and poor stakeholder coordination (5/15 vs. 1/13) as key impeding factors.

Assumptions about resource subsystems

Just above half of the cases (52%) also sought to upgrade resources and/or infrastructure at a collective level, for example, to lower barriers to behavior change by building postharvest processing and storage facilities or water management infrastructure. In one case, equipment contributions to producer cooperatives were seen to generate support for the initiative and greater interest in the promoted practices. The implicit assumptions behind these efforts were that improving existing infrastructure and ensuring collective access to and management of resources could facilitate behavior change at scale (CA-5). These efforts may have targeted shared infrastructure out of necessity (drilling boreholes or building milk storage facilities for individual farmers is impractical in most cases), but these activities might also echo MCA-6 on the power of social learning and collaboration to achieve behavior change. Many of these cases implemented approaches to social learning and networking and their reported enabling factors, such as wide stakeholder involvement (47% of cases that addressed collective resources), often reflected these approaches.

Assumptions about social and relational subsystems

Cases that sought to influence social dynamics and empower actor groups within the action situation, and thereby addressed aspects of the social and relational subsystem, were fairly common (55%). These interventions implicitly or explicitly assumed actors' constrained power and agency to be a barrier to behavior change (CA-6), often prioritizing inclusion of and benefits for marginalized groups (41%) and making efforts to elevate their social standing within the household and community. In four initiatives, efforts were made to elevate women leaders under the assumption that women's increased leadership in decision-making processes would ensure that their interests were represented and that solutions met their needs, thereby paving the way for behavior change at more equal rates (LCA-1). Some initiatives (31%) focused on empowering producers by building skills related to entrepreneurship and marketing, under the assumption that producers' more active and effective engagement in economic activities along the value chain would lead to greater monetary gains and sustained behavior change incentives (LCA-2). When comparing cases that did and did not address the social and relational subsystem, the latter were more likely to report poor codesign (1/15 vs. 4/13 cases) and poor alignment with stakeholder needs (5/15 vs. 8/13 cases) as impeding factors.

Assumptions about governance subsystems

In general, intervention approaches that supported governance subsystem reforms were relatively uncommon (38% of cases). These intervention modalities carried an implicit assumption that institutional and governance subsystems influenced existing behavior and must therefore be changed if behavior was to be changed at scale and over the long term (LCA-3). Several key informants identified institutional barriers (unsupportive policies or weak institutional support systems) as impeding factors, but, as these were rarely addressed directly by initiatives, they were often implicitly assumed to be beyond the initiatives' scope of change (CA-7). Cases that addressed governance subsystems, when compared to those that did not, were more likely to report enabling factors related to partner engagement and collaboration (8/11 vs. 5/17) and wide stakeholder involvement (6/11 vs. 5/17). These initiatives were also more likely to have reported most of the impeding factors, including policy challenges (7/11 vs. 3/17) and weak support institutions (6/11 vs. 2/17). As with the focus on economic subsystems, this might indicate that policy and governance issues, like market engagements, are important to address but can be particularly challenging to resolve.

Assumptions around external forces in the opportunity space

Relatively uncommon (31% of cases) were approaches that shifted individuals' opportunity space through material support to overcome resource constraints. One case, for example, built livestock sheds for farmers, and another case distributed inputs, pumps, and solar dryers. However, such initiatives did not always engage in wider enabling conditions such as value chain development. The implicit assumption was that one-time distributions would be adequate to enable behavior change or that raising awareness of existing resources would lead producers to independently access inputs and equipment (LCA-4). In some cases, building actors' resource base was also a means to generate interest and goodwill. In one case, input provision was identified as the key driver of uptake of basin planting among participants. Key informants expressed some concern, however, that producers were motivated only to practice basin planting at the minimum level required to secure free inputs. This concern indicated that the intervention modality was not adequate to instigate sustained behavior change at scale.

Discussion: Lessons learned to guide future agri-food systems transformation

From this innovation history analysis of past agroecology-related initiatives, we can draw numerous lessons about pathways for agri-food systems transformation. This includes attention to not only individual behavioral factors, but to the diversity of actors, their agency and relative power in action situations, as well as structural subsystems that influence opportunity spaces and behavior change at scale.

Behavior change targets and intervention modalities

Through this analysis, we noted two key gaps in the behavior change efforts of past initiatives: (1) a lack of attention to agency and behavior change among actors other than producers and (2) a failure to adequately address structural subsystems. We discuss these gaps and our recommendations to address them in future initiatives.

Attention to non-producer actors

Each initiative, in its own way, sought to expand producers' opportunity spaces, primarily by increasing their knowledge and skills, building market opportunities, or decreasing resource constraints. Although actor interactions were often a focus of initiatives' intervention modalities (76% of all cases) through the facilitation of producer collaboration or cross-stakeholder collaboration, in most cases these interventions were used as a means to change producers' behavior (for example, through engagement of extension service actors). Behavior change outcomes for other actors were rarely a priority in the initiatives' approaches to agroecological transformation.

The ACT framework emphasizes that interactions between diverse actors shape outcomes for individuals and the collective agri-food system. Engagement with diverse actors within the agri-food system reflects an understanding that interactions between actors' diverse interests contribute to individual and collective behavioral outcomes. The cases often reported on engagement of a wide range of stakeholders, such as private-sector actors, public institutions providing support services, and local governing bodies. Engagement could be further improved with greater involvement of community, governance, and consumer actors. However, challenges with stakeholder coordination and/or resistance to change were noted in some cases, indicating that understanding stakeholder needs and facilitating coordination are areas for further improvement.

Furthermore, ensuring that market-based incentives outlive the initiative requires understanding the economic needs and constraints of multiple actor groups along the value chain. The short-lived market linkages reported in some cases indicate that buyers' needs were likely not fully met or sustained. In future work, the needs and constraints of non-producer actors could be more thoroughly assessed and addressed.

Attention to subsystem elements

Most initiatives engaged with one or more subsystem elements with the intention to expand opportunity spaces or facilitate interactions in action situations. However, economic, resource, and social and relational subsystems were each addressed by only about half of the cases, and governance subsystems were addressed even less frequently. This points to failure at the initiative design phase to incorporate a systems or enabling environment approach that creates *opportunity* for behavior change. Indeed, many initiatives attributed failure in achieving behavior change to unaddressed subsystem elements in the ACT framework, including limited market opportunities, unsupportive policies, and norms governing social and relational dynamics that prevented actors' equitable engagement. Market and value chain linkage elements, among the most frequently reported enabling or impeding factors, were found to highly influence initiative achievements and lasting outcomes.

At the same time, addressing structural subsystems did not guarantee success. In many cases, initiatives touching on structural subsystems typically aimed to widen producers' opportunity spaces, for instance, by providing equipment, inputs, or market linkages, or increasing their power and agency. However, few initiatives addressed these subsystem elements with attention to other actors in the agri-food system; the focus was typically only on *producers*' access to resource-related infrastructure, markets, and bargaining power. Additionally, many initiatives that targeted subsystem elements still reported challenges related to them. In some cases, attention to the wider context might have uncovered additional challenges, whereas, in others, subsystems might have been resistant to change. The nature and design of initiatives might also add to the challenges for addressing structural subsystems. First, the tools an initiative has at its disposal to address subsystem elements are arguably less developed, less tested, and far less familiar than the tools for the more commonly addressed elements such as producer knowledge. Second, initiatives might hesitate to take on structural subsystem issues, even when they are important, because of their slow pace of change and the common requirement to demonstrate initiative progress on short time scales.

Seed fair, Murehwa Zimbabwe. 📷 CGIAR initiative on Agroecology

Recommendations for behavior change targets and approaches

We recommend three actions to better engage non-producer actors and address subsystem elements in future initiatives: (1) conducting needs assessments with a range of food system actors, (2) using transformational DEI approaches, and (3) meaningfully engaging diverse actors in knowledge co-creation and initiative codesign.

Needs assessments could better detect subsystem influences on specific behavior and thereby support initiatives in the design phase to address subsystem drivers of behavior. By conducting the needs assessment with participants that represent the diversity of food system actors (to include the diversity of roles in the food system as well as the diversity of demographics and intersectionality), a more inclusive DEI approach with attention to power asymmetries can also be developed.

Transformational DEI approaches could improve engagement of the diverse range of food system actors by addressing cultural and relational norms that influence the intended agency and behavior changes. These approaches could also ensure more inclusive action on the identified needs and constraints from the needs assessment.

Finally, engagement of the diverse actors in knowledge co-creation and initiative codesign could more effectively address the range of behavioral drivers and the variation in their influence on different actors. This would include acknowledging the vast and diverse knowledge already held among the various actors and making use of this knowledge alongside the generation of new knowledge from participatory methods. Embedding interventions within existing community practices and social structures (a crucial part of codesign and knowledge co-production) was reported as a factor that enabled change in many cases. For instance, although producer training was employed across the cases, key informants for several initiatives noted that training-of-trainers approaches and leveraging of respected lead farmers or community leaders for outreach contributed to initiative success. Additionally, for several initiatives, the integration of "new" practices with indigenous knowledge and practices also contributed to increased interest and behavior change among producers. A suggested approach for the codesign process would be participatory visioning and Theory of Change development (in the AE-I, this was conducted as a vision-to-action exercise). Key steps in this approach include the agreement from diverse system

actor on a systems transformation vision, assessing system dynamics and identifying needs for agency and behavioral change across different actors, and reflecting on entry points for improving agency and changing target behaviors.

Refining assumptions in reference to factors perceived to enable or impede change

Drawing on the enabling and impeding factors reported by past initiatives, we propose refinements to some of the assumptions embedded in the initiatives' intervention targets and approaches.

MCA-2: Expanding producer knowledge is essential to enable behavior change. Assumptions about the importance of producers' individual behavioral factors run deep in the world of agricultural innovations. Although a crucial element of behavior change, farmer knowledge is rarely a sole driver of behavior, and the case studies examined here illustrate that extension and training alone are usually inadequate to change producer behavior. Past initiatives have found success by coupling knowledge-focused interventions with efforts to address other barriers to or enablers of change, such as norms, policies, and resources, and especially economic and market opportunities. Engagements with market and policy issues were correlated with enabling factors in those areas but also appeared difficult to fully resolve.

MCA-3: Introduced technologies are improved, desirable, and feasible additions to producer portfolios. The cases examined here revealed that often overconfidence existed in how well an introduced technology suited producer needs and desires; misalignment of technologies with producer needs was the most frequently reported impeding factor. Participatory and inclusive co-innovation processes with diverse stakeholders are critical to ensuring that technologies are appropriate.

MCA-4: Training is the easiest and most direct way to achieve, sustain, and scale behavior change CA-1: transfer of agroecological knowledge to producers readily occurs from extension agents and others, and CA-2: extension and education actors will continue agroecological technical assistance and training after an initiative ends and can thereby sustain and expand behavior change among producers. Assuming that improved knowledge is in particular cases a critical behavioral driver, accessible training and the capacity to deliver it effectively requires more planning and resources than often assumed. This must be tailored to the needs of the group or individual receiving the training and was reported to be most effective when integrated with local knowledge, practices, and structural subsystems. Training alone was rarely adequate to achieve or sustain behavior change; initiatives often must also address other barriers to or enablers of change, such as markets, norms, policies, and resources.

MCA-7: Collaboration and behavior change readily occur when multi-stakeholder engagement takes place. Many initiatives facilitated collaboration between producers and wider stakeholders, and this was often cited as an enabling factor. However, continued challenges in stakeholder coordination and social inclusion indicate that creating space for stakeholder engagement does not mean that these engagements are productive, inclusive, or sustainable. The reports of equity and inclusion, partner and institutional support, stakeholder coordination and engagement, and codesign and/or buy-in as influential factors in achieving intended outcomes demonstrate the emphasis needed on understanding and addressing power and agency, as well as differences in needs and motivations, in multi-stakeholder engagements. This can improve the quality of interactions and create shared ownership over transformation processes.

CA-3: Actors are homogeneous in their power to access and participate in producer and stakeholder groups. Efforts at inclusion often failed to overcome normative barriers to engagement, while some gender- and diversity-intentional initiatives reinforced existing inequalities. Because actor engagement in producer and multi-stakeholder groups, and their access to knowledge, shared infrastructure, or resources introduced by initiatives, is mediated by social norms, transformational DEI efforts are necessary to ensure that engagements create opportunity for equitable and long-term behavior change.

LCA-4: Resource constraints to behavior change can be overcome with one-time inputs or awareness raising. Although behavior change might be stimulated through a one-time input or awareness-raising around available resources, it is rarely sustained. If actors responded to such one-time interventions, it points at the need to adjust structural subsystems in a way that provides continuous incentives or permanently eases resource constraints. Many of the cases that strengthened collective resources and infrastructure found that social learning and collaboration reinforced achievement of the intended behavior changes. Sustained subsidies, long-term market opportunities, and/or inclusive value chain development are also likely to create better conditions for long-term behavior change than one-time resource distributions.

These refined assumptions underscore the importance of building a comprehensive Theory of Change grounded in a thorough understanding of the agri-food system context: what a shared vision for a just and sustainable agri-food system looks like in that context, the actor groups involved and their relative power and agency, which behavior must change to achieve the vision, the internal and external influences on the behavior, and the assumptions and logic that underlie each step in the change pathway. Use of the ACT framework presented in Figure 1 can support this approach to developing the Theory of Change.

Conclusions

This synthesis revealed how transformational change hinges on not only the motivations, needs, and opportunities of actors, but also on the structural subsystems and action situation in which they interact. Working with producers alone may be a comfortable, but insufficient, approach to effect change, especially in cases where structural subsystems impose serious constraints. Facilitating interactions among actors and supporting them to develop adapted solutions suited to their diverse needs and capacities can be a challenging but powerful approach, especially when it is done with an understanding of differential needs across actors and with emphasis on expanding opportunities for marginalized groups. Our study findings point to important lessons and approaches for future initiatives aiming at agri-food systems transformation.

> **"Working with producers alone may be a comfortable, but insufficient, approach to effect change, especially in cases where structural subsystems impose serious constraints.**

Increase focus on the agroecological principles related to social equity, which drive outcomes related to resilience and resource efficiency. These also constitute key entry points for knowledge exchange, agency, collaboration, and behavior change.

Conduct a thorough and properly disaggregated needs assessment that includes the diverse range of actors in the agri-food system, their power dynamics, and their diverse priorities and constraints. Engaging these actors in initiative design helps ensure that their needs and priorities are met while exploring the role of subsystem elements in behavior change processes.

Map how structural subsystem elements impact actors' behavior to identify the range of resource, economic, governance, and social and relational entry points for behavior change. This should be possible once a thorough and differentiated needs assessment has been conducted. Once actions are proposed, it is also important to map how diverse actors might experience the proposed structural subsystem changes to ensure that new barriers are not created, especially within economic and governance subsystems.

Develop a vision and Theory of Change with clearly defined assumptions linking steps in the change pathway and rationales for the prioritized entry points. The disaggregated needs assessment and mapping of structural subsystem elements can enable more balanced attention to internal and external behavioral drivers and can provide the necessary background for a vision and Theory of Change that are co-created by the diverse agri-food system actors. The co-created vision considers potentially diverging interests and needs of the actors, explores opportunities for alignment, and converges on priorities for which diverse actors can take ownership and commit to making a change. Clearly defined assumptions and rationales in the Theory of Change can enable monitoring, reflection/learning, and adjustment, both during the initiative and as lessons to apply in future initiatives.

Include in the Theory of Change transformational DEI approaches to stakeholder engagement that help shift social norms, as these are key factors limiting power and agency, and therefore behavior change opportunities. Examples from the cases such as training and elevating women leaders, empowering producers in interactions with other value chain actors, and improving gender relations within households and on farms can provide guidance for future efforts. Other important steps to further the state of the art in this area include developing and testing additional approaches to addressing agency and power asymmetries, researching the mechanisms behind norm shifts through transformational DEI approaches, and conducting monitoring and evaluation on the influence of these approaches on system change.

Undertake careful and inclusive codesign of interventions and innovations with a diversity of actors (both within and between actor groups). This maximizes the appeal of technologies and allows for the identification of DEI constraints that warrant attention. In the process, prioritize engagement with women, youth, poorer and landless farmers, smallholder groups, disabled and other groups, and community initiatives that might struggle to engage with major initiatives.

Apply an adaptive management approach, making time and resources available for participants to reflect on progress and adjust approaches as needed. Responding to the complexity of behavior change processes in agri-food systems requires embracing iterative planning, implementation, and reflection.

Within the Agroecology Initiative, country teams are working to integrate these learnings into in-country activities, particularly in stakeholder engagement and codesign processes. In Tunisia, "knowledge hubs" are planned to connect smallholders to research and development actors, value chain actors, and state entities. These aim to overcome key identified impeding factors, including the slow

Community members present their forest management activities, Mandla, India. ⃝ S. Freed

implementation of activities and disengagement of farmers, unstable commercial relations, and the excessive number of value chain intermediaries. Peru's team is developing activities in a bottom-up scaling approach, considering the needs of farmers and other stakeholders to identify leverage points for behavior change. These changes are mainly aimed at strengthening key institutions for the agroecological transition (for example, platforms that have been working on the participatory guarantee system) and also at supporting the construction of a public management instrument that promotes biodiversity products. Dedicated studies of youth experiences are also planned in several countries to generate insights into the unique opportunity spaces and behavioral drivers of youth in agri-food systems. This research will help unpack the power and agency dynamics that diverse producers experience and areas for reform in social and relational systems. Country teams are also exploring novel connections with economic subsystems; the Peru team analyzed cocoa cooperative models and explored how they could strengthen relationships and trust between producers and their organizations through technical assistance and other services and inputs provided by the cooperative. They are further exploring financing schemes based on the natural capital that cocoa producers have on their farms, such as secondary forests and agroforestry systems, to support forest conservation and agroforestry-based cocoa production.

As we further explore agency and behavior as outcomes of interactions within these complex agri-food systems, we find new and more diverse opportunities for engagement. Through the recommended steps above, initiatives aimed at agri-food systems transformation can structure pathways in which actors' behavior change, in line with community visions, is possible.

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Annex A: Supplemental tables and figures

Annex A1. Number of documented initiatives that were reviewed by years across country inventories.
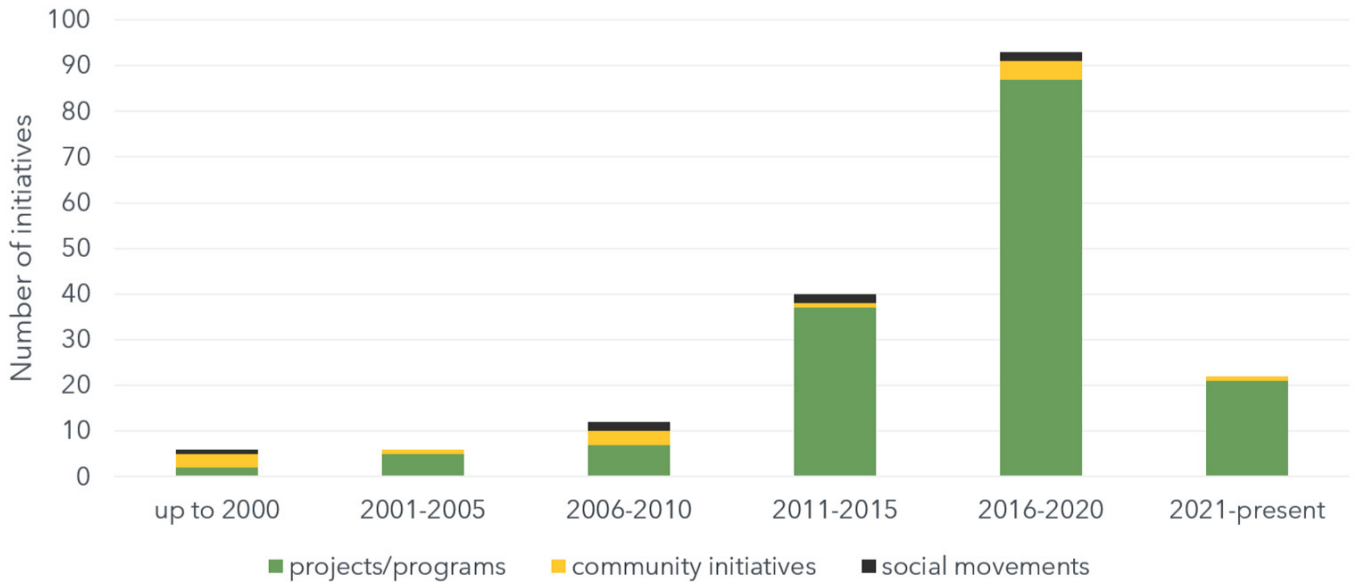
Annex A2. Percentage of initiatives targeting each principle, by country.
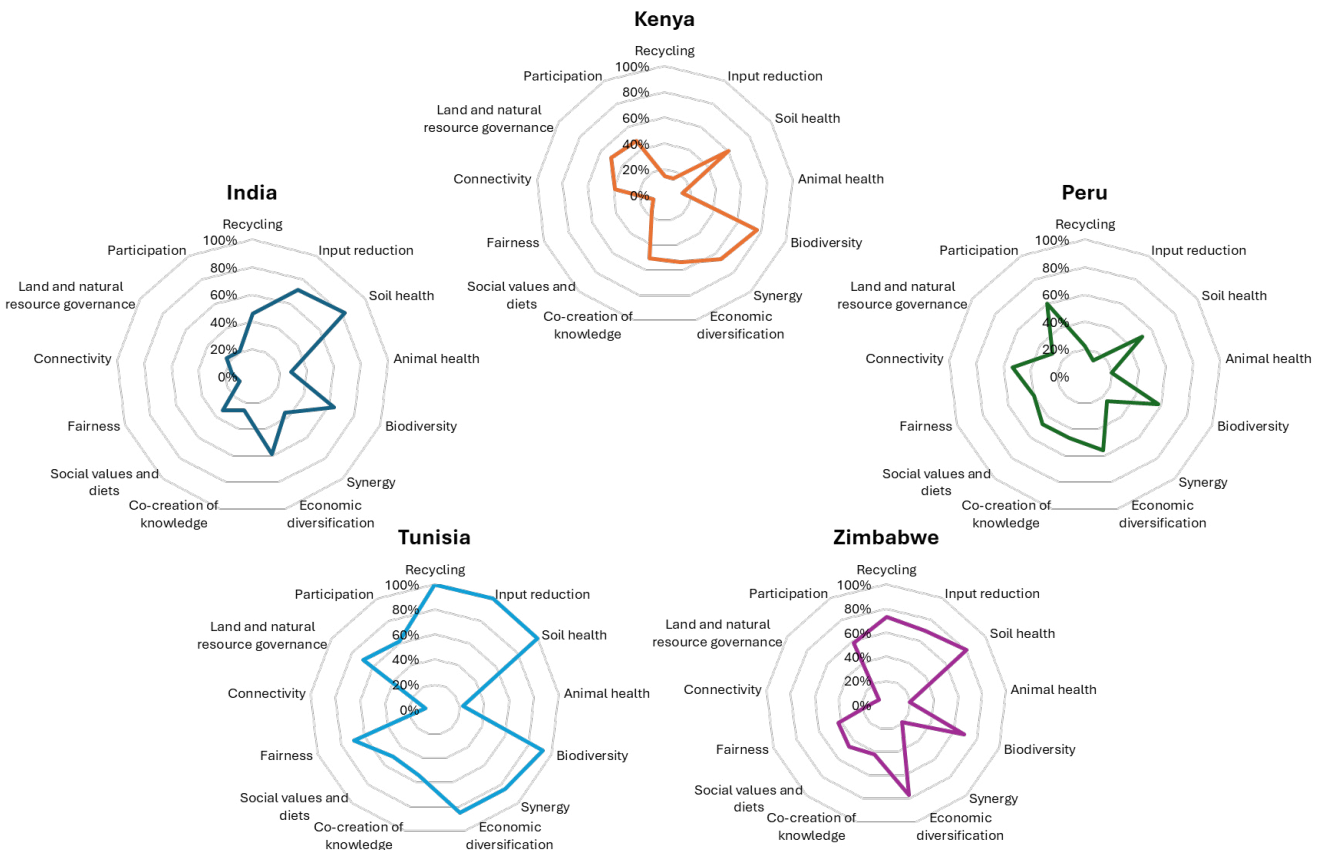
Annex A3. A typology of behavior change intervention modalities for agri-food systems. Modalities are categorized according to which aspects of the conceptual framework on behavior change they target. For each intervention modality, we identified the target actor(s), target behavior(s), and the related (and often implicit) behavioral driver(s) that the case study initiatives targeted.

Framework element	Key intervention modalities	Case studies' target actor(s)	Case studies' target behavior(s)	Case studies' target behavioral driver(s)
Individual behavioral factors	Advocacy, lobbying, awareness campaigns	Producers, consumers, general public	Adoption of improved farming/consumption practices	Knowledge and attitude
	Technical assistance (including extension) and training	Producers, consumers	Adoption of improved farming/consumption practices	Knowledge, skills, attitude
	Demonstrations and modeling via lead farmers, trials, demo plots	Producers	Adoption of improved practices	(Experiential) knowledge, skills
	Building individuals actors' resources to enable behavior change (e.g., input and equipment provision, subsidies)	Producers	Adoption of improved practices	Resource constraints
Action situation	Building/strengthening producer organizations for social learning and collaboration	Producers, producer groups	Collaboration, innovation, knowledge-sharing	Social network structures/ institutions
	Building/strengthening multi-stakeholder platforms for collaboration	Various actors	Collaboration, innovation, knowledge-sharing	Social network structures/ institutions
Resource subsystem	Expanding public/collective infrastructure related to production	Producers, producer groups	Improved production practices	Infrastructural constraints in resource system
	Building capacity for postharvest storage/processing	Producers, producer groups	Improved processing practices	Infrastructural constraints in resource system
Social and relational subsystem	Promoting inclusion and equity (e.g., gender equality training, promoting women leaders or women's groups)	Producers, producer groups, households, communities	Marginalized groups exerting greater control over decisions	Power and agency
	Empowering producers to act in their self-interest (e.g., entrepreneurship and market training)	Producers, producer groups	Producers exerting greater control over decisions	Power and agency
Economic subsystem	Fostering market linkages between producers and value chain actors (including certification schemes)	Buyers, middlemen, producers	Buy/market agroecological goods	Market opportunities/ economic incentives
	Expanding available credit mechanisms (including VSLAs)	Lenders, buyers, producer groups	Offer new or simplified credit access	Financial resource constraints
	Value chain development (e.g., SME support)	Middlemen, processors, producers	Establish or expand SMEs along value chain	Market opportunities/ economic incentives
Governance subsystem	Supporting regulatory reform	Policymakers	Support pro-agroecology policy	Regulatory environment
	Supporting strengthening of property rights (e.g., land)	Policymakers	Recognize/strengthen property rights	Regulatory environment/ resource control
	Strengthening agricultural education and extension systems	Extension staff	Integrate agroecology into extension	Knowledge and skills
	Building/supporting local resource management systems	Producers, communities, governance actors	Community management of resources	Power and agency/ resource control

Annex B: Summary of case studies

Timeframe	Goals and objectives
1992–present	To demonstrate to the general public the way to combine sustainable agriculture and forest conservation.
2007–2012	To promote the integration of soil health perspectives in farmers' decision-making processes through on-farm experimentations of crop rotations and biomass management practices.
2008	To promote organic farming practices, crop diversification, native crop rescuing, and improving soil management practices. Create market channels and access for produce.
2008–present	To bolster sustainable farming practices and promote the use of bio-inputs as well as the financial stability of communities by diversifying income opportunities through integrated farming system methods, bio-resource centers, and horticulture crops. Conducting village-level assessments to quantify the impact of interventions and sharing information with local government stakeholders to ensure alignment for a sustainable transition.
2009–2015	To contribute to the achievement of the MDGs through the development of a commercially viable and market-oriented biogas sector and dissemination of 8,000 domestic biogas plants.
2010–2019	To integrate and intensify smallholder crop-livestock systems' production through conservation agriculture practices and help smallholder enterprises participate in markets by improving links between value chain actors.
2012–2023	To improve the livelihoods of tea farmers through crop diversification and create awareness of different food crops and innovations for household food security.
2013–2016	To support the sustainable development of local value chains, integrating aspects of sustainable development into training, extension, and accompanying measures for small-scale farmers and contributing to the elaboration of a national strategy for sustainable development.
2013–2022	To improve the income of cocoa-producing families and reduce deforestation through environmentally friendly agroforestry systems, supported via the provision of appropriate technology, technical assistance, and farmer capacity building.
2014–2016	To promote organic production systems by improving the technical capacity of producers and encouraging the commercialization of products in organic markets certified under a guarantee participatory system.
2014–2021	To improve income and food security of small-scale coffee farmers.
2014–present	To promote agroecological transformation by establishing community nutrition gardens. To increase dietary diversity among women and children, sensitizing both men and women to the importance of nutrition promoting resilience, self-sufficiency, and improved well-being for all members of the community.
2015–2021	To increase agricultural growth, resilience of people and systems, and nutrition status of people through large-scale application of technologies and institutional development with conducive policies.
2015–2023	To conserve and restore soil and landscape health through collective action with activities such as watershed planning, lantana eradication, commons restoration, etc.
2015–present	To promote a business-oriented mindset among small-scale farmers and support the development of more sustainable, profitable (dairy and potato) value chains.
2016–2020	To build resilience to climate change and slow desertification through uptake of sustainable agricultural practices, supported by ICT services, training, field days, and the provision of market information and loans for entrepreneurial activities.
2016–2022	To build resilience and disaster risk management capacity and thereby protect development gains and achieve improved well-being outcomes through improved agricultural practices, livelihood diversification, policy dialogues, information exchange, market linkages, and VSLAs.
2018–2022	To design and pilot integrated crop-livestock management solutions based on conservation agriculture principles and strengthen interactions between producers, experts, and researchers to improve agricultural production and limit its environmental impacts.
2018–present	To promote safe food production through agroecological farming, effective information sharing, knowledge management and public understanding of GMOs, sustainable natural resource management, influencing policies for interest of smallholder farmers, consumers, and the public, and campaigns against toxic agricultural inputs.
2018–present	To reduce deforestation caused by cacao, palm, coffee, and cattle ranching by implementing silvopastoral and agroforestry systems sund sustainable crop management practices, improving access of farmers to special markets, encouraging landscape restoration, and promoting sustainable livelihood diversification.
2018–present	To integrate AE codesign and co-evaluation activities into a broader territorial planning process to enhance dialogue between farmers, agricultural services, and researchers and promote innovative practices based on crop rotation, intercropping, limited tillage, and improved biomass management.

Timeframe	Goals and objectives
2018-present	To promote an integrated landscape approach to managing wildlife resources, climate change threats, and ecosystem services in forests, protected areas, and surrounding community lands via decreasing poaching and other wildlife crimes and promoting sustainable resource management and sustainable livelihoods.
2019-present	To achieve nationwide household food self-sufficiency and climate resilience through select conservation agriculture practices (basin planting, decreased soil disturbance, and mulching).
2019-present	To protect and rehabilitate soils and improve food security through (1) financial and technical support of field-based initiatives and (2) advocacy and capacity strengthening at the central and regional levels.
2020-2023	To support soil conservation and improved nutrition by promoting conservation agriculture, horticultural gardens, small grain and legume production, and linking farmers with markets to sell produce.
2020-present	To support food system actors' shift toward more resilient production, marketing, and consumption practices and services through the setting up of financial and credit mechanisms.
2021-present	To increase horticultural production and product quality through conservation agriculture practices, promote judicious and safe chemical use, and train smallholders in marketing skills.
2022-present	To promote organic production systems and revitalize the environment while empowering communities through resilient and eco-friendly practices, and prioritize uplifting local economies and enhancing the well-being of individuals and families. This encompasses implementing agroforestry practices to enhance biodiversity and soil health, establishing community-led organic farming cooperatives for collective empowerment, and providing education and training on sustainable farming methods to build capacity and expertise, and collaborate with local governments to develop policies supportive of organic agriculture.
2022-present	To raise awareness about the importance of healthy eating through crop diversification, native crop rescuing, improving soil management practices, food handling, and food cooking.