Funding transformation but measuring yields

Results from a review of strategic interventions to enhance climate resilience and food security in agricultural systems in low- and middle-income countries

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Executive Summary

Agricultural systems in low- and middle-income countries (LMICs) are under mounting pressure. Climate change is eroding the productive capacity that smallholder farmers depend on, while the knowledge base meant to guide a coherent policy response remains divided — one stream focuses on raising yields, another on managing climate risk. This fragmentation has created a critical blind spot: the evidence needed to pursue food security and climate resilience simultaneously has never been properly assembled. This report addresses this gap directly.

Drawing on a systematic mapping of the global research literature, this report identifies which agricultural interventions are most consistently associated with joint food security and climate resilience outcomes, where evidence is robust, where it remains thin, and how current research priorities may be distorting the way policymakers and investors make decisions.

The evidence base is growing but highly uneven. The volume of empirical work connecting agricultural interventions to both productivity and resilience has grown substantially over the past decade, reflecting a long overdue recognition that these objectives must be pursued together. Yet the literature is concentrated in ways that limit its policy relevance. Three interventions — soil conservation, improved water management, and crop diversification — account for roughly three-quarters of all studies. For these, the evidence linking practice to outcome is relatively strong.

Beyond this core, the evidence thins sharply. Agroforestry, access to climate information and extension services, improved market linkages, and post-harvest management and storage all feature far less in the literature, despite the fact that these are often the enabling conditions that determine whether short-term productivity gains translate into sustained resilience. Their underrepresentation is not a reflection of limited importance; it reflects a systematic bias in research toward interventions that are technically straightforward to measure, at the expense of the institutional and social processes — governance arrangements, functioning markets, access to actionable knowledge — that sustain agricultural systems over time.

The way resilience is measured compounds this problem. The dominant indicators in the literature are agronomic and economic: yields, soil health, income levels. Outcomes that speak more directly to food security — food access, perceived vulnerability, the capacity to absorb and recover from recurring or compounding shocks — are rarely tracked. Most studies capture resilience as a farm-level, short-term outcome rather than as a systemic attribute that persists across multiple seasons and stresses. This means the evidence base tells us a great deal about where productivity can be improved, but far less about whether those gains endure and withstand climate shocks.

Climate resilience and food security are not properties of individual practices; they are properties of systems. They depend on whether the practices in use are aligned with the markets that stabilise farmer incomes, the institutions that can manage shared resources, and the information systems that enable adaptive decision-making. Until the evidence base reflects these interdependencies, policy and investment decisions will continue to rest on partial and potentially misleading pictures of what makes food systems genuinely resilient.

Two cross-cutting implications follow. First, **policy must shift from a project logic to a systems logic**. Scaling up isolated interventions can deliver local gains but will not alter the structural conditions that make food systems fragile. Coordinating interventions across production, post-harvest, and market domains within a common institutional framework is not optional — it is the precondition for system-level resilience.

Second, **metrics must be redesigned to track long-term change**. Research and monitoring frameworks should adopt a common indicator to capture both immediate outcomes and longer-term effects — linking yields and incomes to adaptive capacity, equity, and sustained food access, etc. Harmonised indicators across contexts would make it possible to compare findings and convert them into actionable policies. Building climate-resilient and food-secure agricultural systems in LMICs will depend less on discovering new practices and more on better measuring the systemic conditions under which existing ones succeed or fail.

1. Introduction

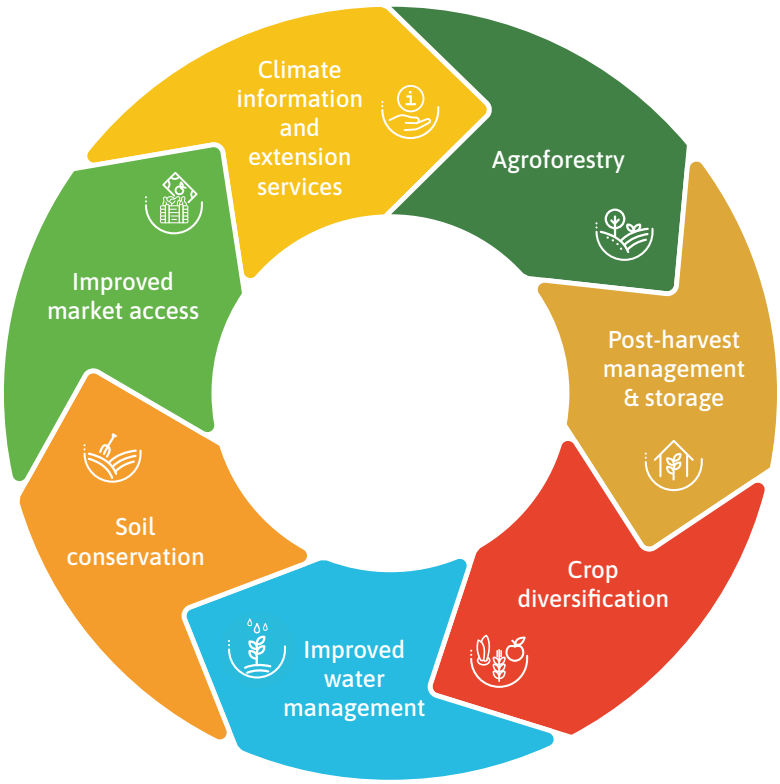
About this synthesis

Climate change is reshaping agricultural systems worldwide, but its impacts are particularly severe in low- and middle-income countries (LMICs), where agriculture underpins livelihoods and food security. Rising temperatures, erratic rainfall, and more frequent shocks are already reducing yields (Ainsworth & Long, 2021; Cheng et al., 2022), disrupting supply chains (Godde et al., 2021), increasing the prevalence of foodborne pathogens (Awad et al., 2024), reducing nutrient content of staple crops (Mason et al., 2022), and accelerating food spoilage (Misiou & Koutsoumanis, 2022). These threats compound existing vulnerabilities of rural households, many of whom depend directly on smallholder farming for income and sustenance.

Despite extensive research on food security and on climate resilience, these fields are often examined in isolation (Rosenzweig et al., 2020). This fragmentation prevents policymakers, researchers, and practitioners from identifying scalable and context-appropriate interventions that can deliver dual benefits on food security and climate resilience. Current strategies tend to emphasise short-term productivity gains or siloed outcomes, leaving major blind spots in how agricultural investments can simultaneously enhance resilience and ensure sustainable food access (Olarewaju et al., 2025).

This report addresses this gap by synthesising and mapping evidence on the intersection between agriculture, food security and climate resilience. It highlights where robust knowledge exists, where major gaps remain, and how these patterns matter for policy and donor priorities. It systematically gathers the evidence on seven widely discussed agricultural interventions (Figure 1).

Figure 1: The seven agriculture interventions with impact on both climate resilience and food security



These seven interventions were selected because the IPCC's Special Report on Climate Change and Land (SRCCL - Chapter 6) identifies them as the most common strategies promoted to help smallholder farmers adapt to climate risks while improving food security (Smith et al., 2019).

These interventions represent the main areas where empirical evidence is expected to concentrate on dual impacts. This study was intentionally scoped to identify evidence where the interventions influence both food security and climate resilience outcomes. By restricting inclusion to studies reporting dual outcomes, the analysis focused on the research that explicitly examined linkages between these two domains. This boundary reflects the practical reality that agricultural interventions are increasingly expected to deliver simultaneous gains in productivity and livelihood stability under climate stress (Lipper et al., 2014).

Because studies were included only when both outcomes were reported, the review does not represent the wider body of research on single outcomes. For example, post-harvest management and storage is rarely captured in this evidence base, not necessarily because such interventions are absent, but because related studies tend to frame outcomes primarily in terms of food security without explicitly linking to climate-resilience outcomes (Nyabako et al., 2021). As a result, they fall outside the dual-outcome boundary applied in this mapping.

Finally, it is important to note that this report **describes where research has focused, not which interventions work "best"**. In other words, **a larger evidence base means scientists have studied the intervention more, not that it produces bigger or better results**. This distinction is essential for interpreting the findings.

Definitions

The definitions of the interventions, as well as the climate resilience and food security outcomes are presented in Table 1 and 2 respectively. Each intervention has a definition, alongside a note from the IPCC's SRCCL, which illustrate how global science has described the potential dual benefits of these interventions.

Table 1: Definitions of the seven interventions and explanations of the dual benefits of each intervention based on IPCC - SRCCL Chapter 6

Interventions	Definitions	IPCC SRCCL Chapter 6 notes (summary)
Agroforestry	The intentional integration of trees and shrubs into crop and livestock systems to enhance productivity, biodiversity, and sustainability (USDA, 2019)	Integrating trees with crops/livestock increases water retention and ecosystem resilience, but total food production depends on careful tree-crop balance.
Soil conservation	Techniques and practices designed to prevent soil erosion, maintain fertility, and promote sustainable land use (FAO, 2025).	Raising soil organic matter and reducing erosion greatly stabilises yields under stress. Short-term yield trade-offs can be modest, but long-term gains matter.
Post-harvest management and storage	A series of processes applied after harvesting crops, including cleaning, sorting, drying, packaging, and storing, aimed at maintaining quality, extending shelf life, and reducing losses (El-Ramady et al., 2015).	Enhanced storage and handling buffer food supplies against shocks and slash losses, but do not directly reduce climate risks for on-farm production.

Crop diversification	The practice of cultivating a variety of crops within a single farm, with the explicit intention to improve resilience, optimise resource use, and enhance food security (FAO, 2017).	Spreading risk across multiple crops can boost climate adaptability and dietary diversity, strongly aiding food security.
Improved water management	The implementation of strategies and technologies to efficiently utilise water resources in agriculture, ensuring sustainable crop production and conservation of water (FAO, 2017).	Efficient irrigation and water harvesting reduce drought vulnerability. Large yield benefits are likely, but water availability can limit widespread impact.
Access to climate information and extension services	The provision of timely climate-related data and extension services to farmers, enabling informed decision-making and adoption of best practices (IPCC, 2022).	Effective knowledge sharing and access to information are essential enabling conditions for sustainable land management and food security. Weak institutional capacity and limited information access constrain adaptive responses.
Improved market access	Reduction of barriers for smallholder farmers to sell their products in higher-value markets, enabling better prices, more stable sales, and increased income (adopted from (Ume, 2023)).	Better connectivity can stabilise income and reduce post-harvest losses, strongly supporting food availability. Its resilience value varies by market stability.

Table 2: Definitions of the dual outcomes

Outcomes	Definitions
Food security	A condition that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2000). This definition encompasses the following dimensions, which delineate the boundaries of this study; (i) **food production** (e.g. crop yields, livestock productivity), (ii) **people's ability to obtain food** (e.g. household income, market access), (iii) **the way food is used** (e.g. dietary diversity, food consumption scores).
Climate resilience	The capacity of agricultural systems, communities, and individuals to anticipate, prepare for, respond to, and recover from the impacts of climate variability and extremes, maintaining or improving their functions in the face of stress or disturbance. Climate resilience involves adapting to climate change to ensure sustainable agricultural productivity and food security (FAO, 2015). This definition encompasses the following dimensions, which delineate the boundaries of this study: (i) **biophysical stability** (e.g. soil health, water resilience, carbon sequestration), (ii) **the stability of those conditions across seasons or years** (e.g. yield variability), (iii) **social and institutional capacity to cope with shocks** (e.g. adaptive capacity, reduced vulnerability, risk management, land restoration).

Classification of the climate resilience and food security outcomes from the literature

Every study in this evidence mapping included evidence on at least one food security outcome and one climate resilience outcome. This dual-outcome requirement is what makes this mapping distinct. It does not focus on the assessment of individual the interventions in isolation, but how they link climate resilience and food security together.

Studies report outcomes in many different ways, some present changes in yield, others in household income, soil fertility, or water-use efficiency, while still others use household food-insecurity or dietary-diversity scores. These results are too fragmented to compare or synthesise if each outcome is assessed individually. To make this evidence usable, we placed similar types of outcomes into a smaller set of standardised outcome categories (Table 3). For example, measures such as grain yield, biomass production, or crop productivity were grouped under Crop yield/productivity (Food Security Outcome Category), while indicators such as irrigation efficiency, water-use efficiency, or soil-moisture retention were classified under Water resilience (Climate Resilience Outcome Category).

Table 3: Standardised outcome categories of food security (a) and climate resilience (b)

Food Security Outcome Categories (a)	Climate Resilience Outcome Categories (b)
Crop yield / productivity	Yield stability
Household/farm income	Water resilience
Income diversification	Soil health / fertility management
Dietary diversity (HDDS, MDD)	Ecosystem services
Food consumption score (FCS)	Adaptive & coping capacity
Food insecurity scales (FIES, HFIAS)	Perceived resilience
Perceived household food security	Risk / vulnerability
Food access (economic/physical)	Hazard-specific resilience
Food supply & market availability	Land restoration / rehabilitation
Post-harvest loss & shelf-life	Energy use
Livestock productivity	Carbon sequestration

Note: The categories are independent of each other, but a study needed to report at least one outcome from both outcome categories

2. Summary of methods

An evidence mapping was conducted using systematic mapping methods to identify and collate relevant studies published since 2008. A protocol outlining the study scope, eligibility criteria, and methodology was developed and registered in protocolRxiv repository (Ozturk et al., 2025). A comprehensive, tested search strategy was designed to capture peer-reviewed literature from multiple databases. Searches were conducted in five bibliographic databases (CAB Abstracts, Web of Science Core Collection, Scopus, Agricola and Proquest Dissertations & Theses). Database searches conducted using topic-specific search strings resulted in the retrieval of 28,392 records in total.

A random subset of 1,800 studies was manually screened comparing their eligibility based on the information available in the title and abstracts to the eligibility criteria. This screening was used to train a machine learning (ML) model to assist with the prioritisation of studies and reduced the number of total studies from 20,434 to 5,805 relevant records. In deviation from the protocol and standard systematic mapping methods, only a subset of 273 articles (5%) (identified as the most relevant by the ML model), were screened at full text. As the focus was on research trends, this approach gives a low-resolution picture of the evidence base but should be representative of the broader trends.

After full text screening, 150 studies were included for data extraction. A further 22 studies were excluded during data extraction leaving 127 studies for data analysis. Data on publication year, location, timeframe, agroecological zone, study scale (i.e. plot, household, community, or national), agricultural interventions, and food security and climate resilience outcomes was extracted following the data extraction template in the protocol (Ozturk et al., 2025). The findings of the 127 studies were synthesised narratively with visualisations to show evidence clusters and knowledge gaps.



3. Overall findings across the seven interventions and standardised outcomes

Links between food security and climate resilience are framed mainly through stable production, higher yields, and farm income.

Most studies focus on household or community scale, with little attention to higher-level effects such as markets, governance, or regional spillovers.

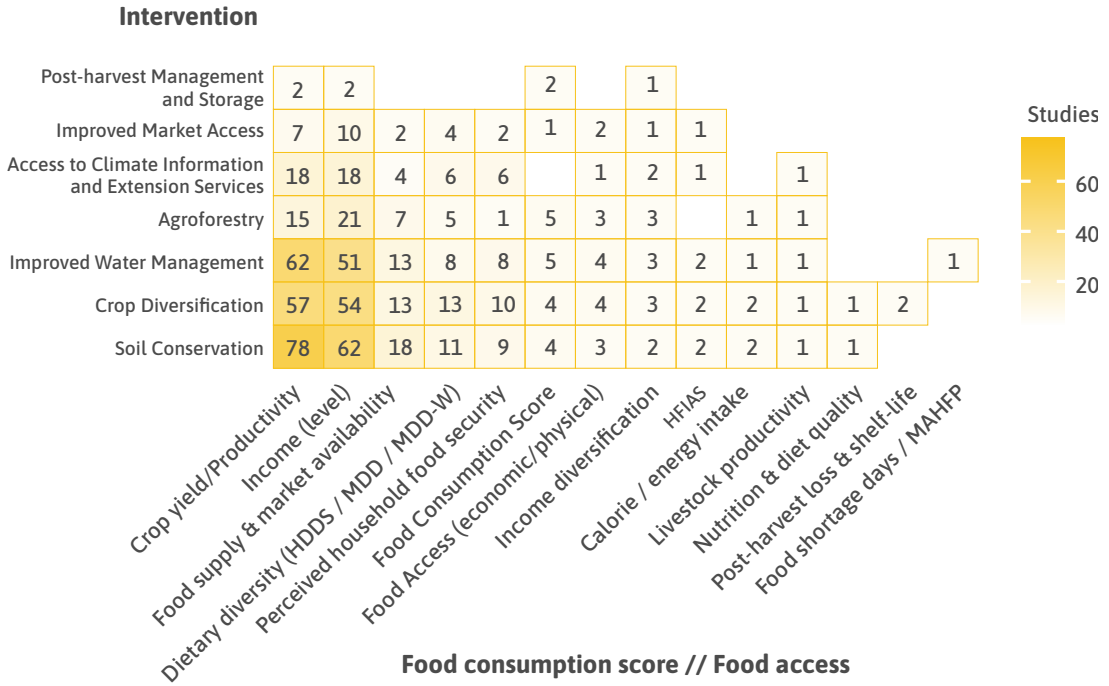
This section synthesises the subset of evidence linking the seven agricultural interventions to standardised food security and climate resilience outcomes. It shows how research is distributed across interventions and outcome categories, revealing where evidence is concentrated and where gaps remain.

Figures 2a and 2b illustrate the evidence between food security and climate resilience outcomes. On the food security side, studies are dominated by yield and income indicators, while dietary, access, and perception-based measures remain thin. On the climate resilience side, soil health and yield stability dominate, with fewer studies addressing water resilience, risk reduction, or adaptive capacity. The patterns in the heatmaps show that research is concentrated on agronomic and economic dimensions, while broader social, dietary, and systemic aspects of food security and climate resilience are comparatively underexplored.

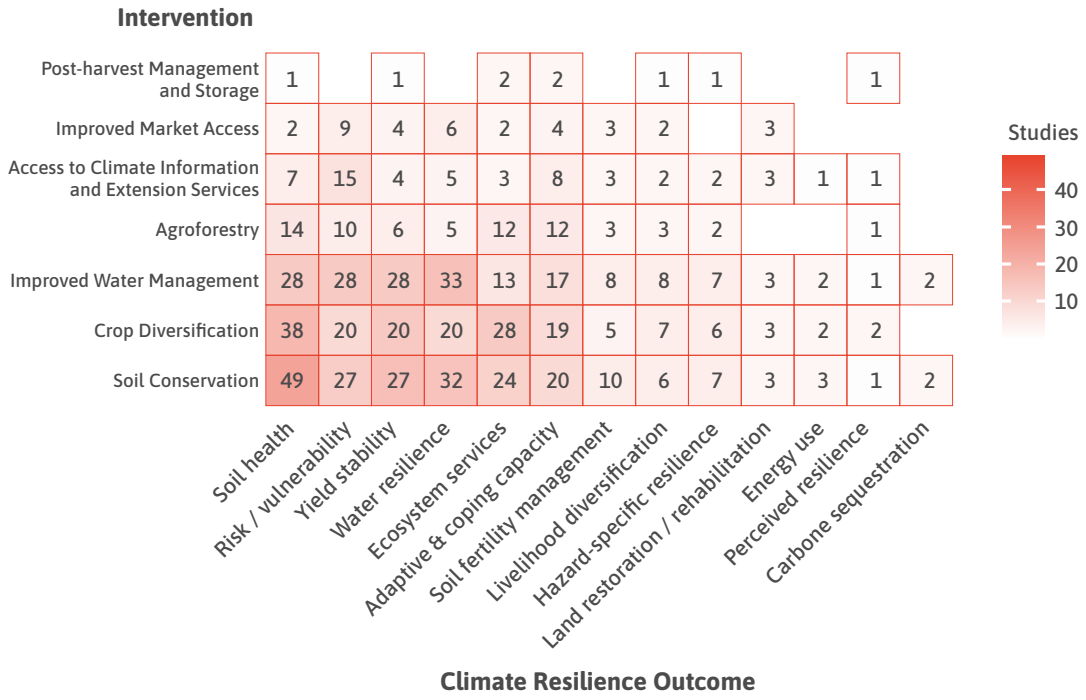
Practices such as soil conservation and water management are easier to measure and fit within short project cycles, while enabling measures like market access, information services, or post-harvest management require longer timeframes and involve social or institutional processes that are harder to quantify. As a result, research clusters around agronomic outcomes, leaving the enabling dimensions under studied.

Figure 2: Number of studies by intervention (a) food security and (b) climate resilience outcomes

(a) Number of studies by interventions vs food security outcomes



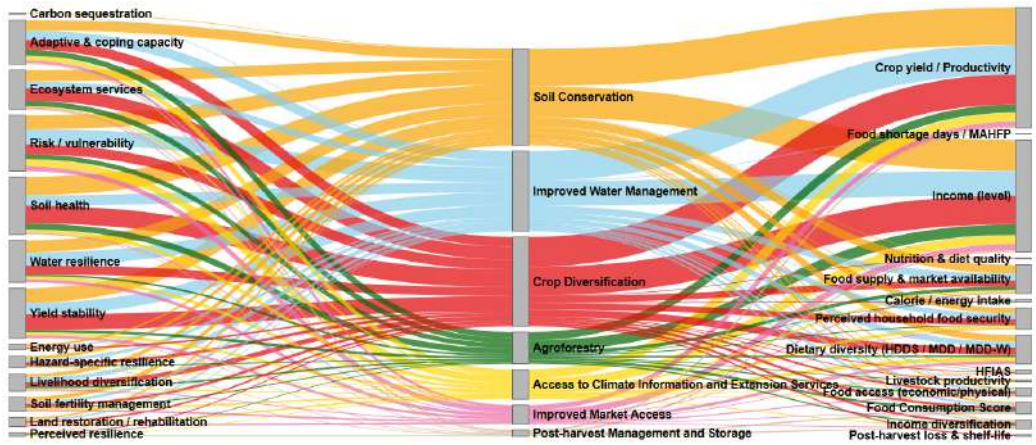
(b) Number of studies by interventions vs climate resilience outcomes



Note: The heatmap displays the volume of studies connecting each intervention (rows) with standardised climate resilience and food security outcome categories (columns). The colour gradient (light to dark represents the relative density of evidence as darker cells indicate more studies. Numbers inside the cells are the exact counts of studies coded for that intervention and outcome pair.

Figure 3 illustrates how these relationships play out between interventions and outcomes. The flows mirror the imbalance seen in the heatmaps. Most flows connect soil health, yield stability, crop yield, and income, while links to dietary diversity, post-harvest loss, food access, or adaptive capacity are far thinner. This suggests that the literature on the seven interventions with dual outcomes remains concentrated on agronomic and economic performance, while broader food access, utilisation, and systemic resilience dimensions remain underexplored.

Figure 3: Standardised outcome connections for the interventions



Note: The diagram shows how climate resilience outcomes (left) are linked to food security outcomes (right) through different interventions (centre). Flow thickness reflects the number of studies connecting a given pair of outcomes as wider flows indicate more evidence. Detailed categories were used where a study specified nutrition or diet quality outcome (e.g. MDD). Interactive Sankey Diagram

Assessment of each intervention against the standardised outcomes

This subsection reviews each intervention, outlining the climate resilience and food security outcomes it is linked to, noting where more evidence exists and where it is limited.

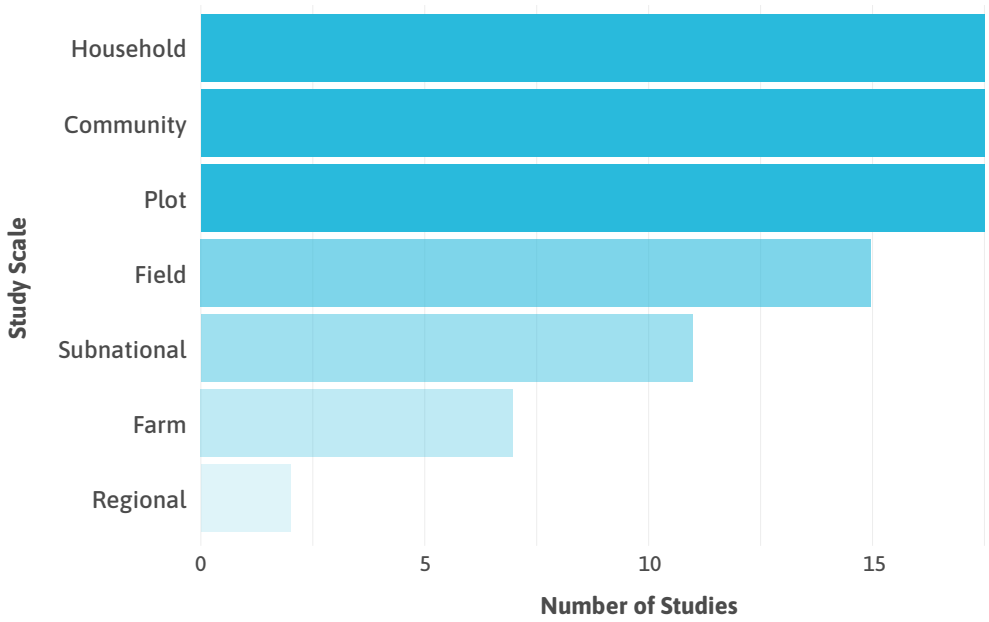
1 Soil conservation

Soil conservation appears most frequently in the evidence base, forming the largest body of research linking food security and climate resilience outcomes (Figures 2a–b). The large volume of studies reflects how widely soil management practices have been tested across LMIC contexts and how central they are to both productivity and resilience agendas.

The distribution of study scales (Figure 4) indicates that most analyses were conducted at the household, plot, or field level, reflecting how soil conservation outcomes are shaped by context-specific factors such as topography and rainfall.

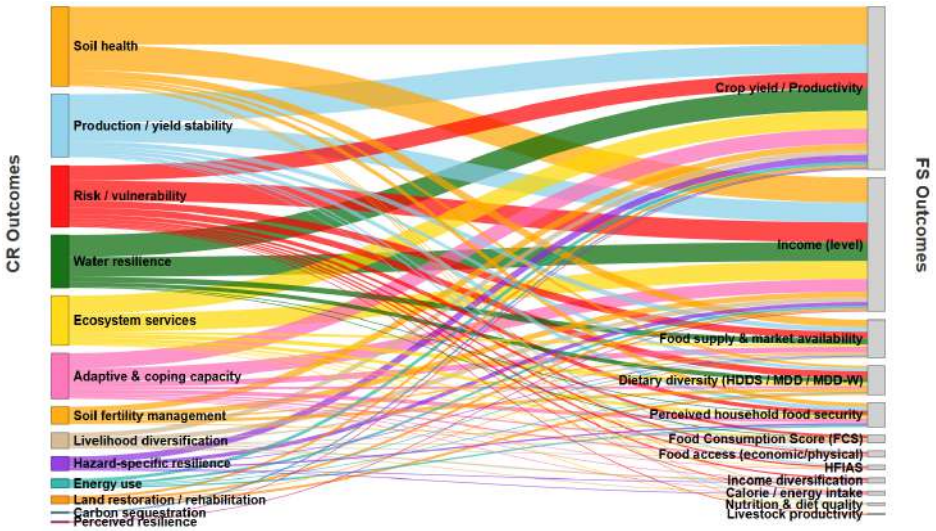
Soil conservation has the largest and most detailed body of research among the interventions, with studies frequently linking soil health, yield stability, and income primarily through agronomic pathways.

Figure 4: Distribution of study scales for soil conservation



Note: The bar chart shows how many studies were conducted at each scale, from plot and field to household, community, subnational, national, and regional levels. The length of the bars represents the number of studies. Plot: Smallest unit such as experimental plots within a field, Field: A full farmer's field. Farm: Whole-farm level in which management decisions across crops/animals taken on one farm, may include multiple plots and fields. Household: Survey or case study data collected at household level. Community: Data collected at village or group level, often aggregating multiple households. Subnational: Larger administrative unit below national. Regional: Multi-country or transboundary studies.

Figure 5: Standardised outcome connections for soil conservation



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of soil conservation. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. *Interactive Sankey Diagram*

Most studies measure biophysical and economic results in the short-term only. Few assess whether these gains translate into improved dietary diversity, household food access, or longer-term livelihood security. For example, in Ethiopia's Blue Nile highlands, Teklu et al. (2022) examined households' adoption of soil- and water-conservation practices together with indicators like the Food Consumption Score and a Livelihood Vulnerability Index. This study is one of the few that report soil conservation practices together with household food security and livelihood indicators.

In summary, soil conservation has the most extensive evidence base among the interventions reviewed, with studies primarily reporting outcomes such as yield stability and income. Yet to inform system-level planning, evidence must extend beyond farm productivity to learn whether short-term outcomes translate into long-term resilience. Integrating soil management into broader monitoring frameworks that track longer term impacts would enable researchers to evaluate its full contribution to climate resilient, food secure agricultural systems.

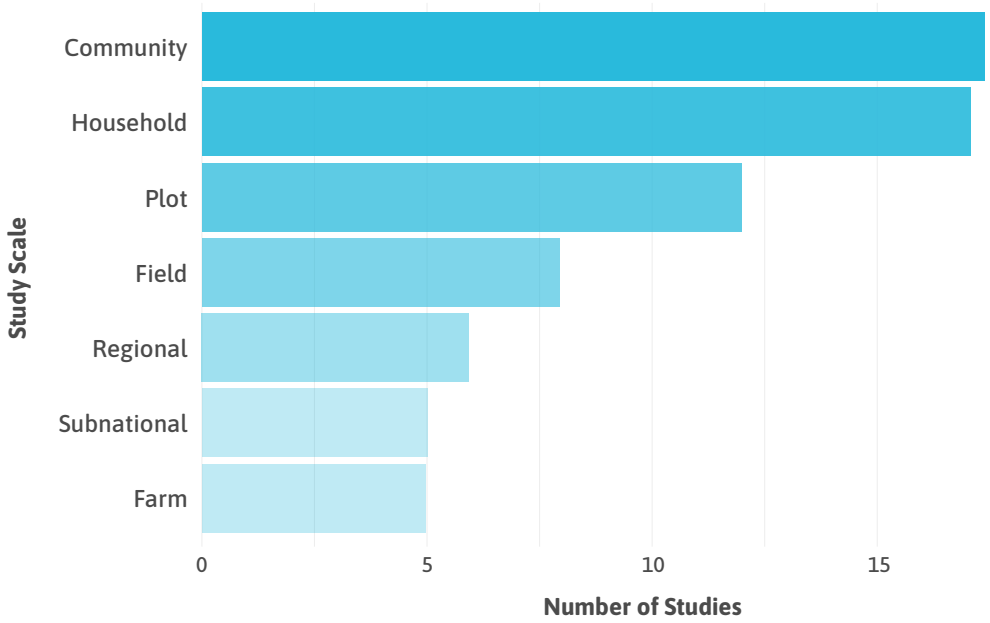
2 Improved water management

Improved water management appears as the second most frequently studied intervention in the evidence base, reflecting the central research interest in water's role in sustaining productivity and resilience across LMICs.

The analysis identifies a dense cluster of studies examining how water management relates to both food security and climate resilience outcomes. The distribution of study scales (Figure 6) shows that most studies were conducted at the community and household levels, with smaller groups at the plot and field scales. This reflects the situation that water management often depends on collective resources and local rules such as community irrigation systems, rainwater harvesting schemes, or watershed restoration projects where outcomes are shaped by local governance.

Studies on improved water management primarily examine irrigation efficiency and yield reliability, with limited attention to system-wide aspects such as watershed trade-offs.

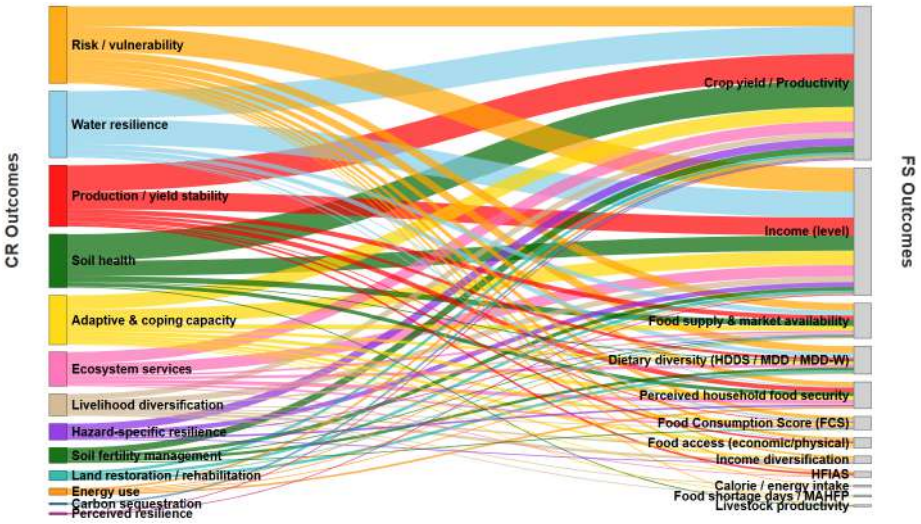
Figure 6: Distribution of study scales for improved water management



Note: The bar chart shows how many studies were conducted at each scale, from plot and field to household, community, subnational, national, and regional levels. The length of the bars represents the number of studies. Plot: Smallest unit such as experimental plots within a field, Field: A full farmer's field. Farm: Whole-farm level in which management decisions across crops/animals taken on one farm, may include multiple plots and fields. Household: Survey or case study data collected at household level. Community: Data collected at village or group level, often aggregating multiple households. Subnational: Larger administrative unit below national. Regional: Multi-country or transboundary studies.

Studies on improved water management most often report combinations of water resilience, soil health, yield stability, crop yield, and household income (Figure 7). However, these associations do not indicate the direction or strength of effects, only the co-reporting of outcomes within the same studies.

Figure 7: Standardised outcome connections for improved water management



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of improved water management. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. *Interactive Sankey Diagram*

The results indicate that the current body of work assesses water management primarily through efficiency and reliability of crop production under climatic stress. Only a small number of studies examine system-wide impacts, such as watershed level trade-offs or long-term implications for water availability. Broader outcomes such as equity in water access, adaptive capacity, or dietary and livelihood effects are rarely measured. This narrow framing leaves potential co-benefits, such as carbon storage or flood mitigation, largely understudied.

Measuring improvement in water management is focused on biophysical outcomes. Future studies need to expand beyond efficiency measures, and include how collective water management, governance, and equitable access influence resilience across communities. Without this wider view, how localised improvements in water use connect to long-term, system-level water security and food-system resilience remains unclear.

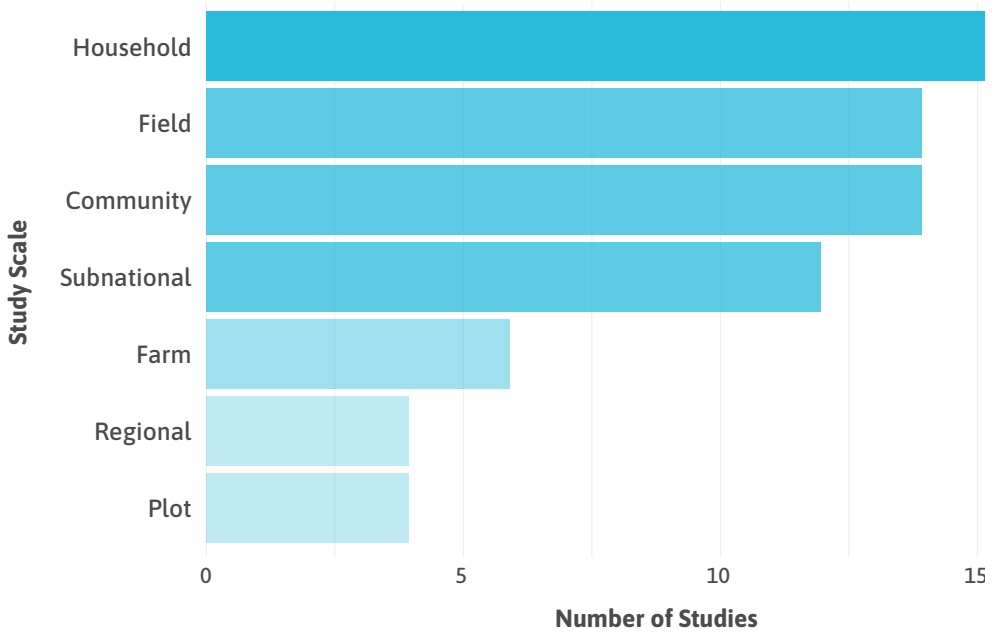
3 Crop diversification

Crop diversification is the third most frequently studied intervention overall but represents the second-largest concentration of studies in the heatmaps after soil conservation, giving it a larger "footprint" than improved water management (Figures 2a - b). This indicates a substantial body of research examining diversification both as an agronomic practice and as a resilience strategy across LMICs.

The distribution of study scales (Figure 8) indicates that most crop diversification studies were conducted at the household level, with larger numbers also at field, community, and subnational scales. This shows that research on diversification spans both farm-level management and broader livelihood contexts.

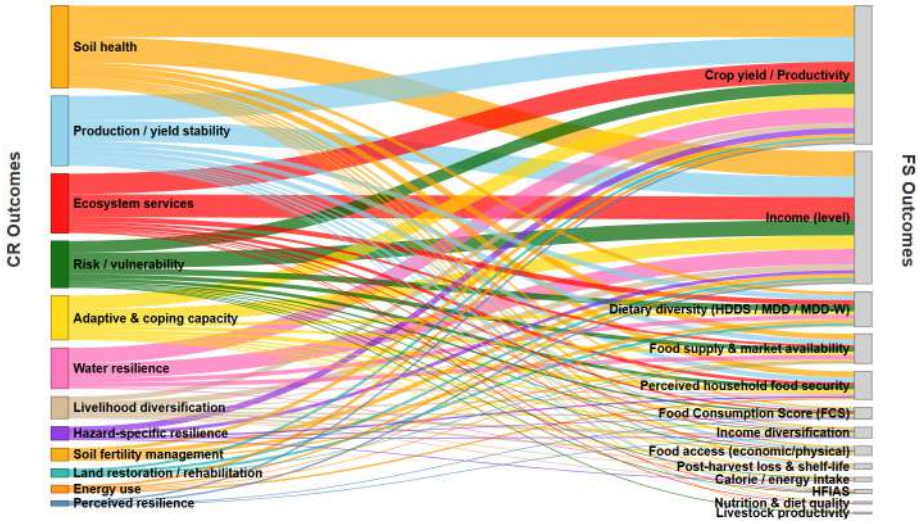
Crop diversification is studied across multiple scales from field to subnational levels, yet most evaluations still focus on biophysical and economic outcomes, showing that its potential as a broader livelihood and resilience strategy remains underexplored.

Figure 8: Distribution of study scales for crop diversification



Note: The bar chart shows how many studies were conducted at different scales, from plot and field to household, community, subnational, national, and regional levels. The length of the bars represents the number of studies. Plot: Smallest unit such as experimental plots within a field, Field: A full farmer's field. Farm: Whole-farm level in which management decisions across crops/animals taken on one farm, may include multiple plots and fields. Household: Survey or case study data collected at household level. Community: Data collected at village or group level, often aggregating multiple households. Subnational: Larger administrative unit below national. Regional: Multi-country or transboundary studies.

Figure 9: Standardised outcome connections for crop diversification



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of crop diversification. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. *Interactive Sankey Diagram*

Studies on crop diversification most often report yield stability and income outcomes together, reflecting where evidence is concentrated. Adaptive capacity, dietary diversity, and household food security, are less often assessed outcomes. While many recognise its broader potential as a livelihood and resilience strategy, most measure only agronomic and economic dimensions. For instance, work in Zimbabwe reported associations between integrating legumes and drought-tolerant sorghum into maize systems and improved yield stability under variable climatic conditions (Rurinda et al., 2014). Fewer studies examine how diversification relates to dietary quality, food access, or long-term livelihood security such as those describing household food availability and nutritional outcomes in diversified dryland systems in Kenya (Mwango'mbe et al., 2013) or perceived improvements in dietary diversity and income through value addition and animal fattening in Burkina Faso (Ayantunde et al., 2020).

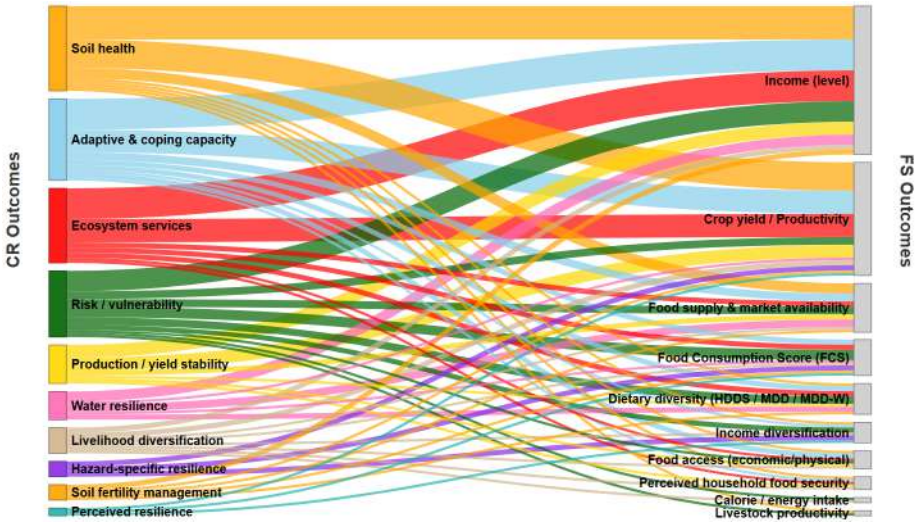
4 Agroforestry

Agroforestry emerges as one of the smaller evidence clusters in the mapping (Figures 2a – 2b), despite being repeatedly highlighted as a cornerstone strategy in global climate adaptation and food security debates (FAO, 2024; IPCC, 2023). The evidence captured here shows that agroforestry is being studied, but at a far lower volume than soil conservation, crop diversification, or improved water management with respect to dual outcomes.

Although agroforestry features prominently in global policy debates, relatively few studies measure both climate-resilience and food-security outcomes together, leaving its dual-outcome evidence base limited.

The agroforestry studies that met inclusion criteria link agroforestry to both climate resilience and food security outcomes. Agroforestry is most frequently associated with soil health, adaptive and coping capacity, and ecosystem services on the climate resilience side, and crop yield and income on the food security side (Figure 10). Dietary diversity, food access, and food supply are much less consistently reported together with climate resilience outcomes.

Figure 10: Standardised outcome connections for agroforestry



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of agroforestry. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. Interactive Sankey Diagram

The findings indicate that agroforestry publications report on a limited number of standardised outcomes. Most likely this stems from the requirement that the included studies needed to measure both climate resilience and food security dimensions simultaneously. This narrows the evidence base and excludes studies that evaluated outcomes only on single domain. However, even within single domain outcomes, the evidence base is relatively scarce. A recent systematic review on impacts of agroforestry interventions on agricultural productivity, ecosystem services, and human well-being found only 11 studies with experimental or quasi-experimental evaluation methods (Castle et al., 2021). Ten of those studies were on human well-being and six on agricultural productivity.

In summary, agroforestry has strong conceptual appeal, but current evidence falls short of what is needed to inform large-scale policy or investment decisions. Strengthening the evidence will require systematically tracking how biophysical changes translate into tangible food and livelihood outcomes over time, allowing decision-makers to assess not only whether agroforestry works, but for whom and under what conditions.

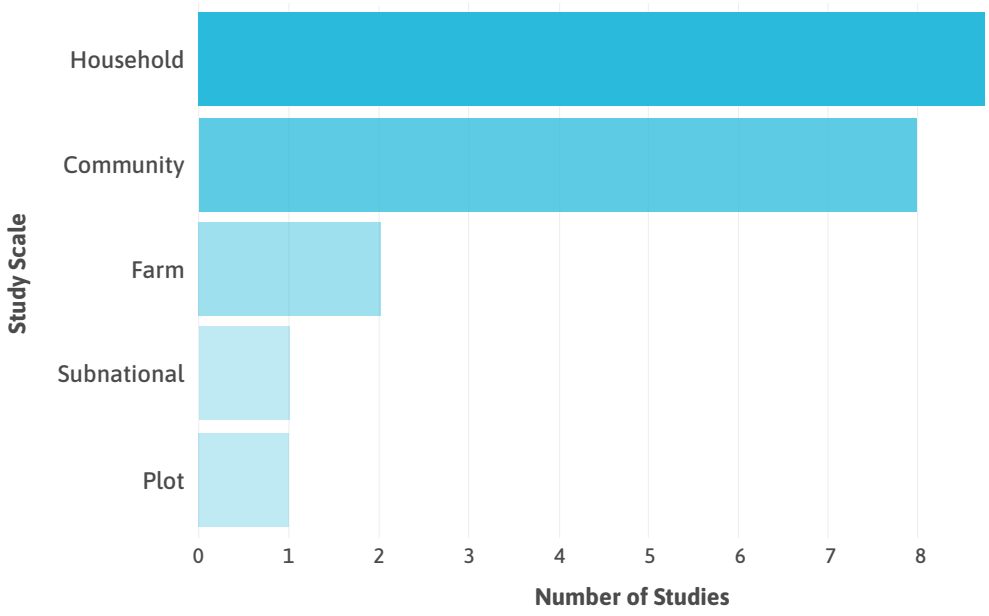
5 Access to climate information and extension services

Access to climate information and extension services forms a larger evidence cluster than anticipated, considering it is often treated as an enabling or secondary intervention rather than a direct driver of food security or resilience outcomes (Smith et al., 2019). The mapping shows a moderate but notable body of studies that explicitly measure climate resilience and food security effects (Figures 2a–2b).

Most studies are conducted at the household and community levels, with only a few at farm, plot, or subnational scales (Figure 11). This is expected as climate information and extension services are designed to engage directly with people through advisory delivery, training, or participatory platforms, so household and community level outcomes are the most relevant data points (Harvey et al., 2019; Tall et al., 2014). The relative absence of higher-scale studies reflects implementation practice rather than a design gap.

Access to climate information and extension services are covered by more studies than anticipated, often capturing perception-based and adaptive capacity outcomes.

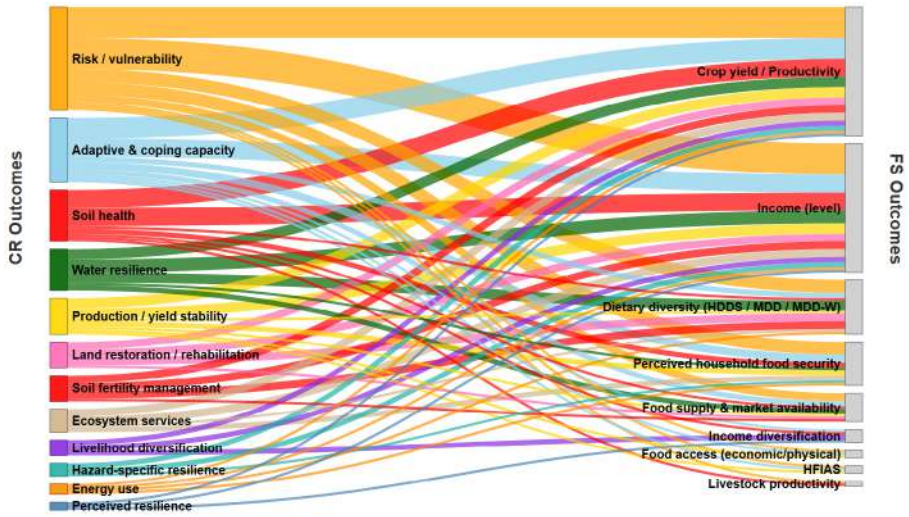
Figure 11: Distribution of study scales for access to climate information and extension services



Note: The bar chart shows how many studies were conducted at each scale, from plot and field to household, community, subnational, national, and regional levels. The length of the bars represents the number of studies. Plot: Smallest unit such as experimental plots within a field. Farm: Whole-farm level in which management decisions across crops/animals taken on one farm, may include multiple plots and fields. Household: Survey or case study data collected at household level. Community: Data collected at village or group level, often aggregating multiple households. Subnational: Larger administrative unit below national. National: Whole country level study.

Studies on access to climate information and extension services most frequently report relationships with adaptive capacity, risk reduction, income, and yield outcomes (Figure 12). Thinner flows connect these resilience outcomes to dietary diversity, food access, and household food security (HFIAS), indicating that while the literature often links information and advisory services to farmers' management capacity and productivity, their connections to broader household food and nutrition conditions are less commonly assessed.

Figure 12: Standardised outcome connections for access to climate information and extension services



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of access to climate information and extension services. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. Interactive Sankey Diagram

Access to climate information and extension services is one of the few interventions where resilience is empirically measured through decision-making and coping strategies rather than through biophysical stability alone. This outcome profile shows that while the overall evidence base is modest, studies in this area capture resilience in ways that resonate with policy debates.

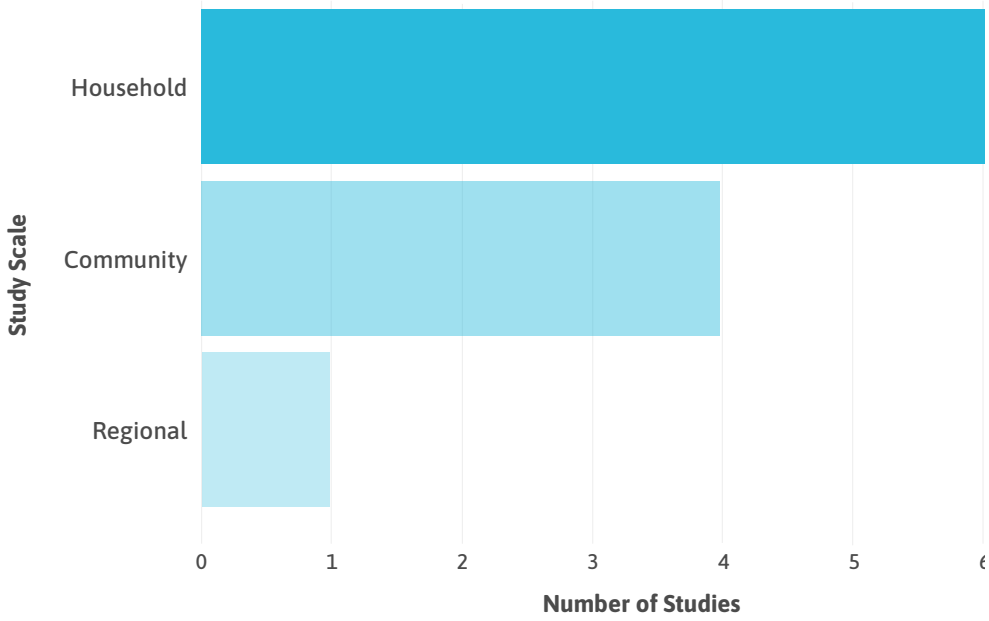
The most frequently reported outcome pairings in studies on climate information and extension services link risk or vulnerability indicators with income or productivity measures. In practice, this reflects that studies often report these sets of outcomes together rather than linking them to food security or longer-term livelihood indicators. Since these sets of indicators are seldom combined in the same studies, it remains unclear whether capacity to respond is associated with improvements in food security or livelihood stability.

6 Improved market access

Improved market access remains among the least studied interventions in the mapping (Figures 2a–2b). Evidence is confined to a small number of recent studies that are mainly at household and community scales with little data at higher levels (Figure 13). Most appeared after 2018, showing that this area of research is still emerging.

Improved market access is among the least examined interventions linking food security and climate resilience, with most existing studies reporting income-related outcomes and few connecting them to household-level food-security or resilience indicators.

Figure 13: Distribution of study scales for improved market access

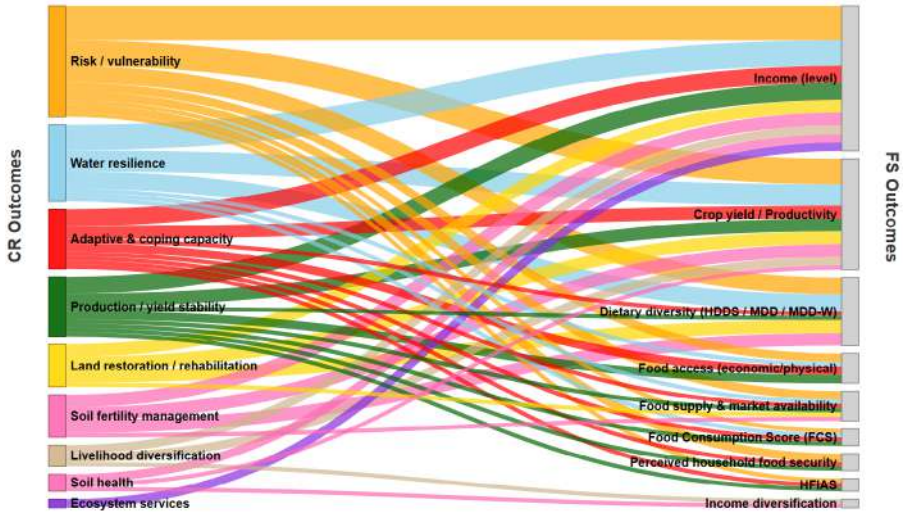


Note: The bar chart shows how many studies were conducted at each scale, from plot and field to household, community, subnational, national, and regional levels. The length of the bars represents the number of studies. Household: Survey or case study data collected at household level. Community: Data collected at village or group level, often aggregating multiple households. Community: Data collected at village or group level, often aggregating multiple households. Regional: Multi-country or transboundary studies.

The studies on improved market access form a small but diverse evidence cluster dominated by economic outcomes (Figure 14). Most report associations between market access variables and farm or household income, with some including yield or production indicators, while smaller sets of studies link income to food security indicators such as food supply, dietary diversity, or household food security measures (HFIAS, FCS). These patterns indicate that the literature captures several dual-outcome combinations, but the emphasis remains on short-term economic effects, with fewer studies examining how market access relates to wider food security or resilience dimensions.

The limited evidence contrasts with the prominence of market access in donor and policy agendas, where it is often highlighted as essential to food system transformation (FAO, 2022; World Bank, 2025). This gap in the evidence base is significant because unlike biophysical interventions, improvements in market access are arguably less context dependent, since functioning markets and value chains are pre-requisites for the sustainability and scalability of almost any other adaptation measure. For soil, water, or diversification gains to translate into durable resilience and food security, farmers must be able to sell surpluses, smooth consumption, and access inputs through markets (Ume, 2023).

Figure 14: Standardised outcome connections for access to improved market access



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of improved market access. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. *Interactive Sankey Diagram*

7 Post-harvest management and storage

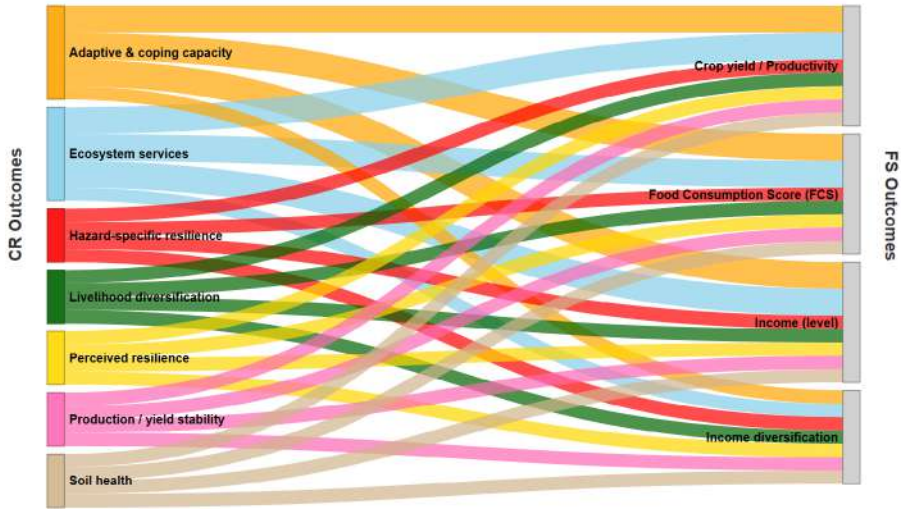
Post-harvest management and storage is the least represented intervention in the evidence base with only two studies captured in the analysed subset. The near absence of studies reflects a real gap in the peer-reviewed literature. This is important given how often it is described as a pillar of food security strategies in global policy debates and donor priorities (Stathers et al., 2020; WWF, 2017).

Post-harvest management and storage is linked to seven climate resilience and four food security categories (Figure 15). With just two studies represented, these connections should be interpreted as indicative rather than conclusive. They show that post-harvest management and storage has been examined in relation to a very narrow subset of potential pathways, reinforcing how little is known about its wider food security and resilience functions. This gap likely reflects the design of primary studies. Most studies assess post-harvest and storage interventions through a single-outcome lens typically focusing only on loss reduction or food supply without also evaluating resilience impacts.

Potentially, post-harvest management and storage could play an important role in adaptation systems by sustaining and extending the benefits of other interventions. Reliable storage and reduced post-harvest losses are essential for converting short-term productivity gains from soil, water, or diversification measures into lasting food security and climate resilience outcomes. The lack of dual-outcome studies makes this gap particularly significant, as a strategy widely emphasised in global policy remains largely untested in the empirical evidence base.

Post-harvest management and storage is severely underrepresented in the evidence base, despite being widely emphasised in policy debates as essential for reducing losses and sustaining food security and resilience gains.

Figure 15: Standardised outcome connections for post-harvest management and storage



Note: The diagram shows how food security outcomes (blue) are linked to climate resilience outcomes (green) in studies of post-harvest management and storage. Flow thickness reflects the number of studies connecting a given pair of outcomes, with wider flows indicating stronger evidence. Interactive Sankey Diagram

4. Where does the evidence come from?

This section describes how the evidence is distributed over time, geography, and intervention type. All the results are based on the sub-sample and hence, give only a low-resolution picture of the evidence base. However, they should be representative of the general trends.

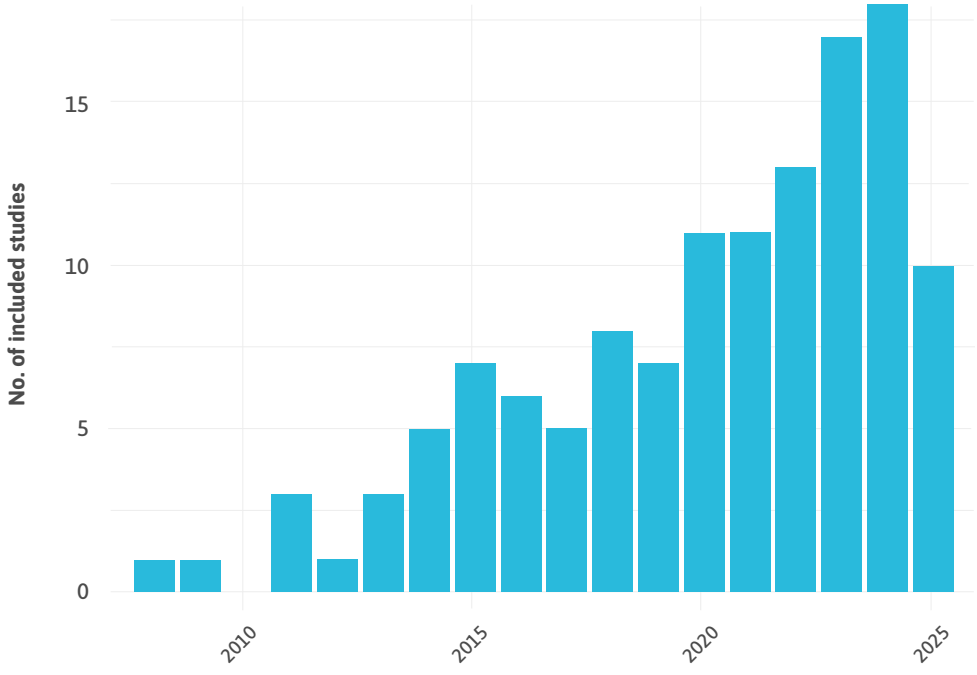
The number of studies has risen over time, indicating growing research attention to measuring both food security and climate resilience simultaneously.

Most studies are located in tropical semi-arid and arid zones, showing a focus on dryland and drought-prone systems. South Asia, particularly India, dominates the geographic distribution, followed by notable clusters in East and West Africa.

Evidence accumulation over time

Aligning with general trends in production of research outputs over time, there is increase in the number of studies over the years (Figure 16). This reflects a growing recognition of the importance of agricultural interventions in addressing food security and climate resilience together.

Figure 16: Evidence accumulation over time



Note: The figure shows the number of studies published per year in the subset of the evidence base. Bars represent publication counts.

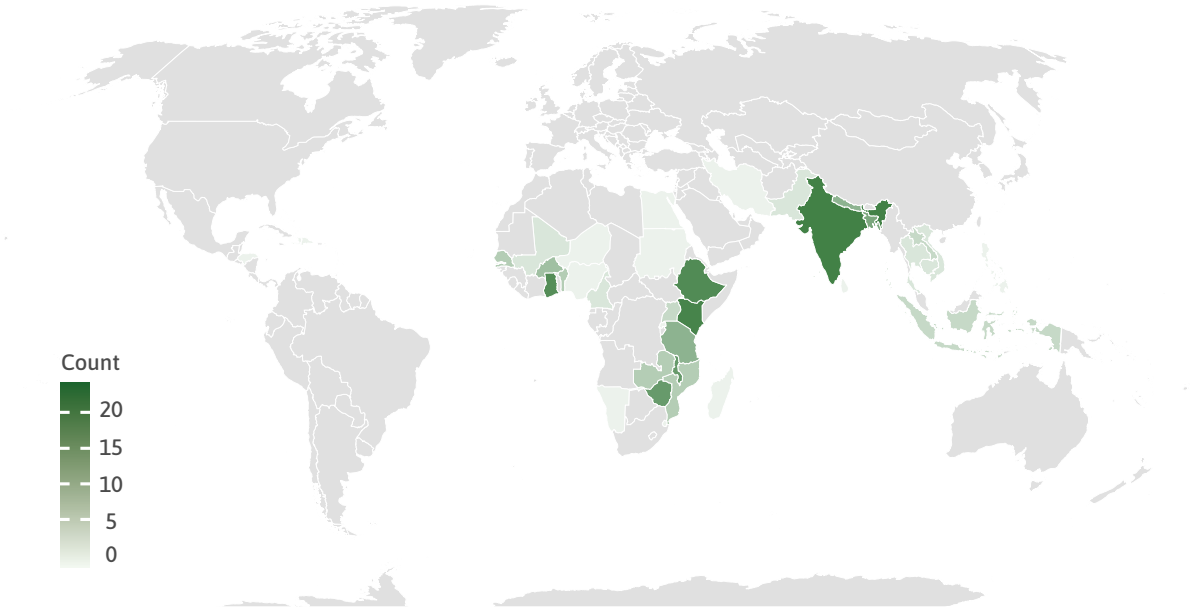
Geographical distribution of the evidence

The distribution of studies was strongly concentrated within particular geographic hotspots. South Asia, particularly India, accounted for the largest number of studies, with additional contributions from Bangladesh and Nepal, together representing 21% of the subsampled evidence base. This was followed by a notable cluster in East Africa, especially in Kenya, Ethiopia, Zimbabwe and Malawi, which collectively accounted for 32% of the total. West Africa was less represented although Ghana emerged as a notable centre of research activity contributing around 7% of studies. In Southeast Asia, studies were more evenly dispersed across multiple countries but remained moderate in numbers, contributing to 10% of the evidence base in total (Figure 17). Fewer studies were conducted in South America, with a handful of Central American countries represented (1% in total).

Some regional patterns in the evidence base are due the review's focus on low- and lower-middle-income countries. This excludes studies conducted in Europe, North America, and Australia as well as many countries in South America, and North and Central Asia. In addition, restricting the review to English-language publications excluded research published in Spanish, Portuguese, French and many other languages. Because of this, it is likely that some research is missing from the results, for example, from Latin America and parts of West and Central Africa. However, within English-language publications the distribution of studies remains uneven, with certain regions receiving far greater research attention than others (Figure 17).

The regional imbalances in research coverage have important implications for policy. Concentrating evidence in a few geographic hotspots may distort understanding of how agricultural interventions perform under different climatic, socio-economic, and institutional contexts. Regions with limited evidence risk being underrepresented in global assessments and funding priorities, constraining the development of context-appropriate strategies for strengthening food security and climate resilience. Expanding research efforts in under-studied areas is therefore essential to ensure that future policy recommendations are inclusive, representative, and globally relevant.

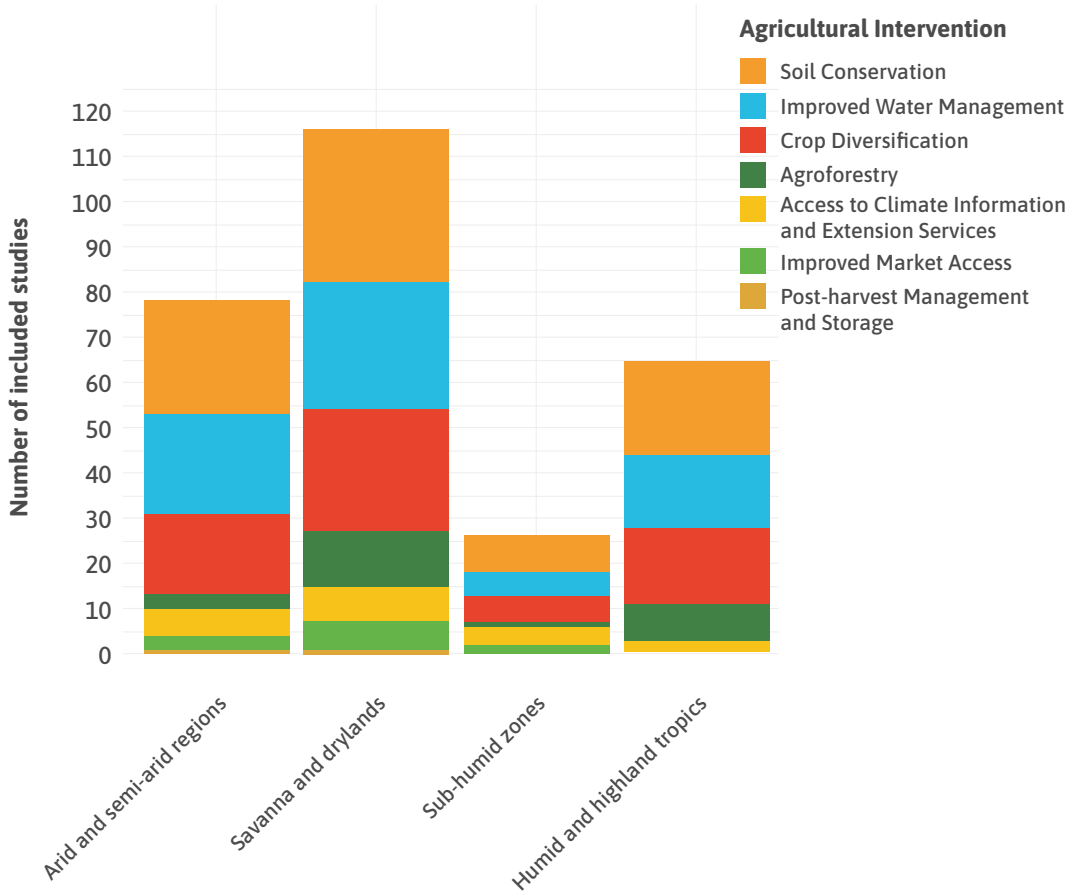
Figure 17: Number of studies per country



Note: Multi-country studies are counted once for each country included. The darker shading indicates a higher concentration of studies. Grey countries are currently classified as upper-middle or high income; income status at the time of each study may have differed.

Savannas and drylands emerged as the most frequently studied agroecological zones (contributing 41% of the total evidence base), followed by arid and semi-arid regions (27%), and humid and highland tropics (23%) (Figure 18). In comparison, sub-humid zones were less represented (9%). Although the difference in study numbers between these drier systems (left side of Figure 18) and more humid zones (right side of Figure 18) is not substantial, this pattern indicates a somewhat greater research focus on dryland and drought-prone farming systems, where climate variability and resource constraints are particularly pronounced. However, the distribution of intervention types was relatively consistent across agroecological zones, suggesting that comparable agricultural strategies are being explored irrespective of climatic context (Figure 18).

Figure 18: Agricultural interventions across different agroecological zones



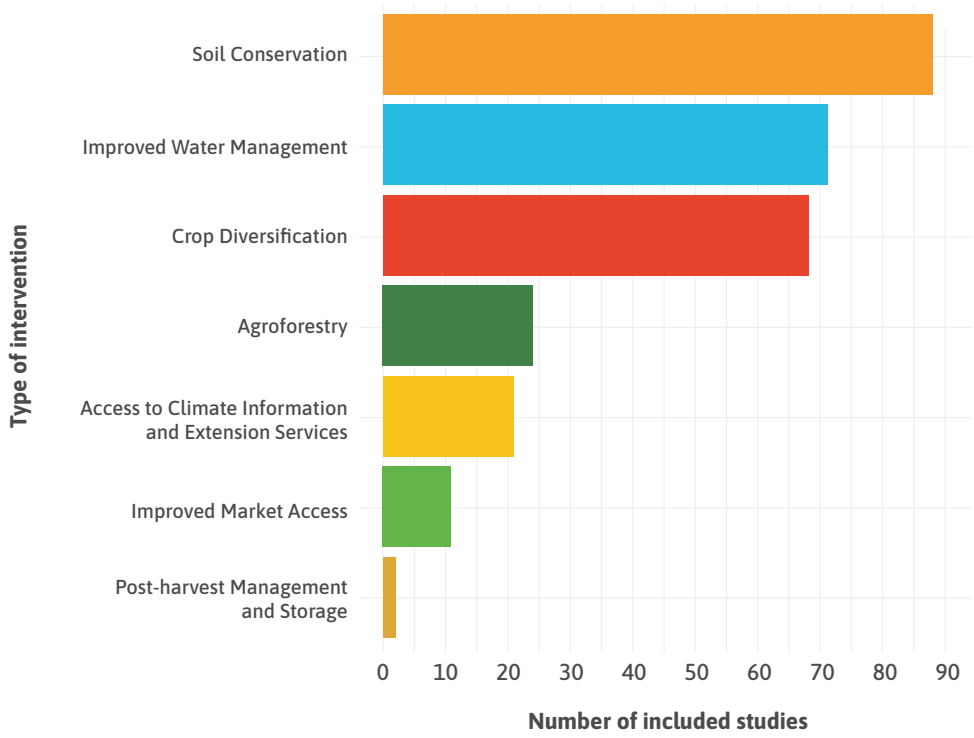
Note: The stacked bars show the number of studies for each intervention across agroecological zones, arranged from more arid (left) to more humid (right).

Distribution of evidence across intervention types

The distribution of studies across the selected interventions is uneven (Figure 19). On-farm interventions, such as soil conservation (31%), improved water management (25%) and crop diversification (24%) are supported by a substantial number of studies, reflecting long-standing priorities in both research and development programmes. In contrast, enabling interventions such as improved market access (4%), post-harvest management and storage (1%) and access to climate information and extension services (7%) remain under-researched despite their prominence in policy agendas (Acevedo et al., 2020).

The uneven distribution reflects a higher complexity in studying enabling interventions due to the need of longer timeframes and thus greater funding, and the need for broader institutional or market-level engagement beyond individual farms. In comparison, on-farm interventions are often more straightforward to implement, monitor, and evaluate at the farm level. This imbalance matters because it may limit understanding of how institutional, informational, and market-based interventions contribute to long-term resilience and food security. A larger evidence base for these broader interventions is essential to inform policies that address structural barriers and support sustainable transformation across agricultural systems, rather than focusing solely on farm-level practices.

Figure 19: Frequency of reported interventions in the evidence base

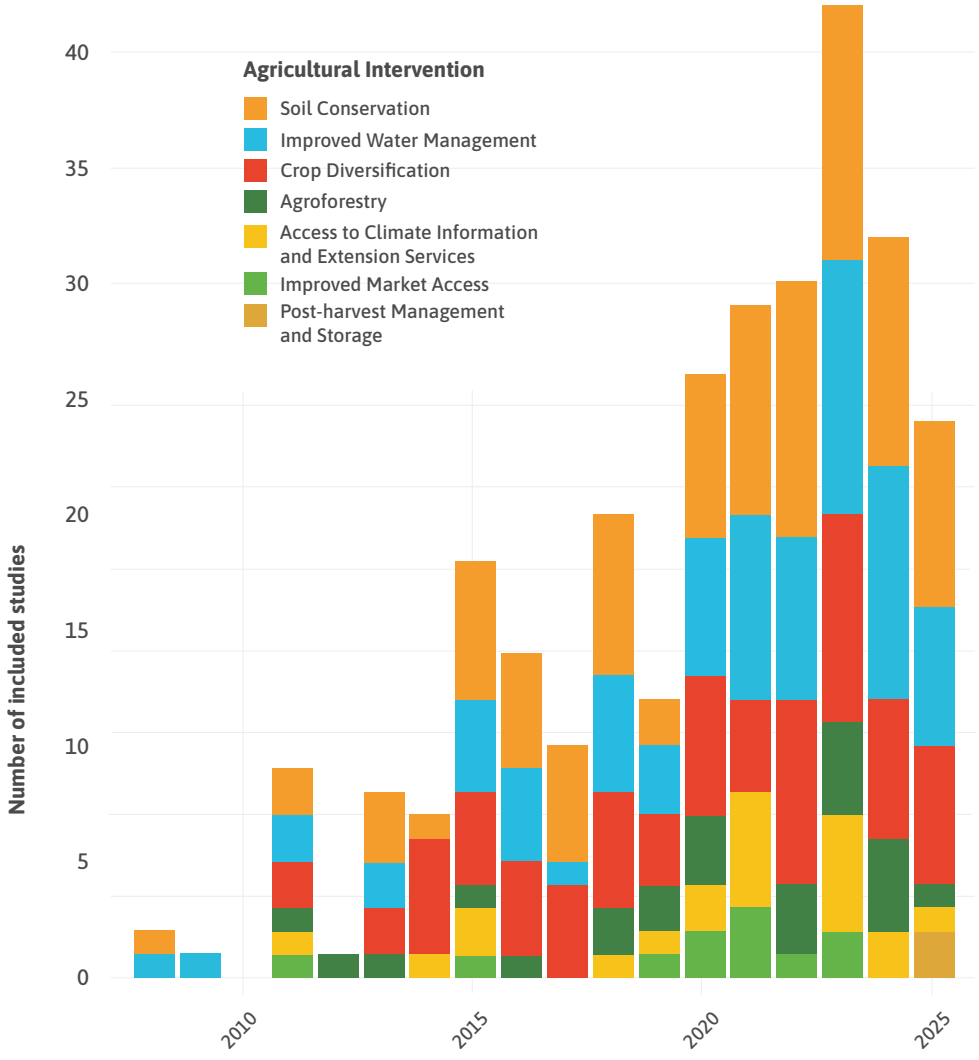


Note: The bars represent how often each agricultural intervention appears across all studies

Temporal and spatial distribution of evidence

The dominance of studies linked to on-farm interventions is seen across different publication years (Figure 20). Soil conservation, improved water management, and crop diversification consistently account for the largest share of studies. In contrast, improved market access and post-harvest management and storage are supported by very few studies overall, with no clear indication of increasing research activity over time.

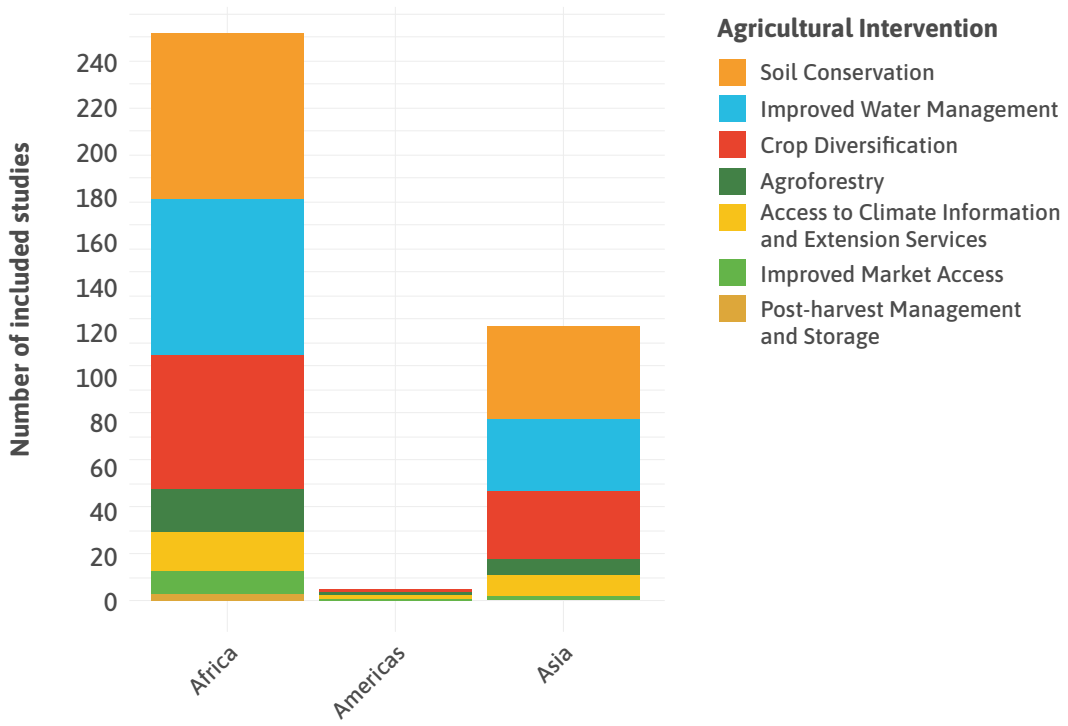
Figure 20: Agricultural interventions studied over time



Note: The stacked bars show the number of studies by intervention across publication years.

Geographically, the evidence base shows a similar imbalance (Figure 21). Africa and Asia are the most represented continents, with research strongly emphasising on-farm interventions, while enabling interventions remain comparatively underexplored. In the Americas, although the overall evidence base is smaller, it is more evenly distributed across intervention types. Notably, access to climate information and extension services dominates the limited evidence from a few South American countries.

Figure 21: Agricultural interventions per continent





5. Applying this evidence synthesis to enhance the design of future studies

This synthesis is intended as a decision-support resource for aligning future research portfolios and funding decisions with evidence gaps. It shows where integrated evidence already exists and where gaps remain. The discussion below outlines why targeted investment in new studies, indicator design, and harmonised measurement over longer time periods would generate the greatest learning returns.

Pathways towards sustainable systems

Sustainable agriculture and food (agrifood) systems use practices that regenerate natural resources rather than degrade them, they are socially just and accessible, and support the development of local communities and economies (Robinson, 2024). **Transitioning toward such systems requires rethinking how food is produced, processed, distributed, and consumed**, shifting away from extractive models to ones that integrate environmental sustainability with human well-being.

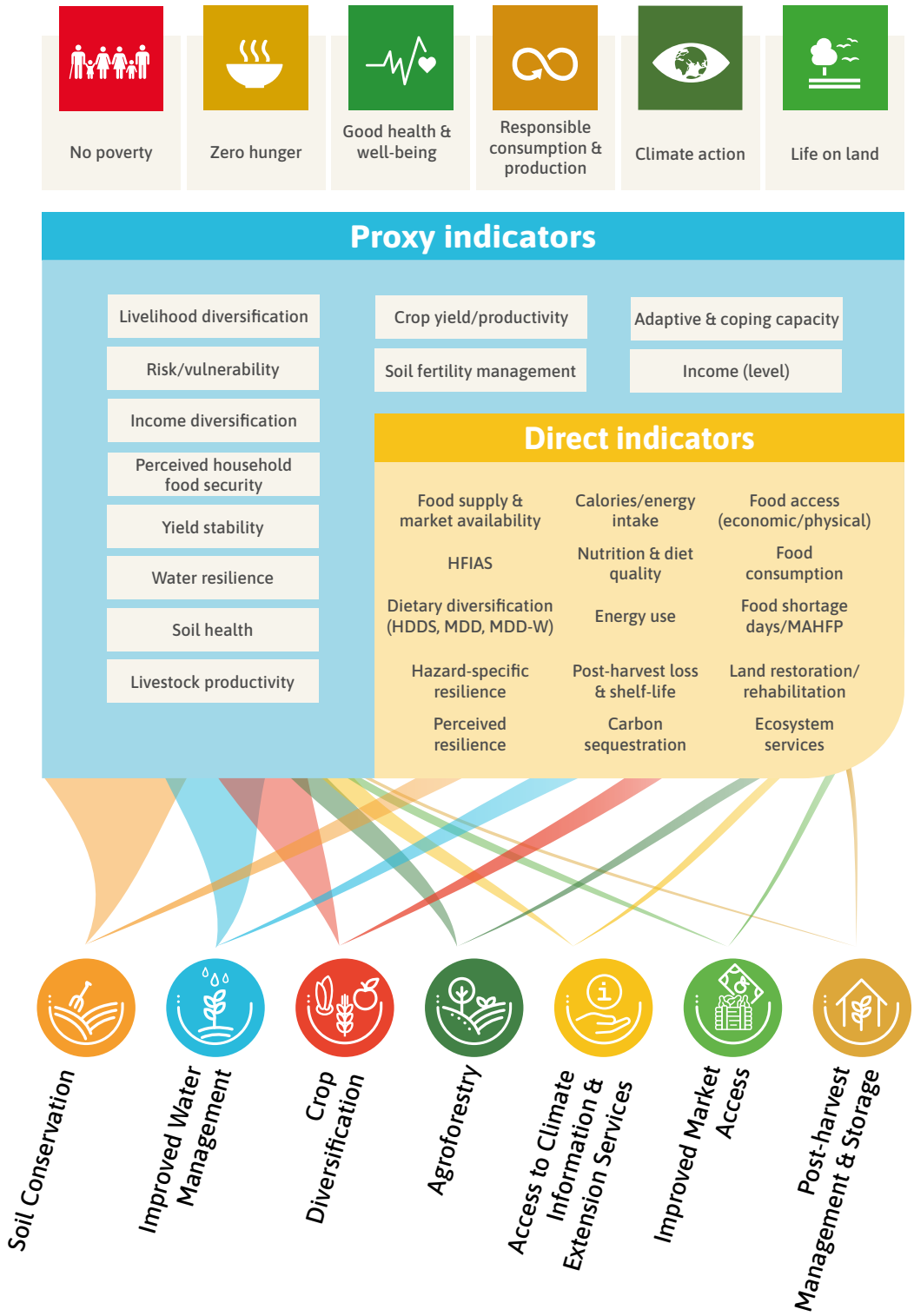
1. Measuring long-term change

The evidence shows that most research has focused on production. How food is produced is a key component of sustainability, and much effort has been devoted to implementing and studying sustainable practices. However, much of the existing research remains concentrated on short-term outcomes such as income, yield, and productivity. Although these outcomes are important, they provide limited insight into whether current practices lead to longer-term climate-resilient and food-secure households and communities (Figure 22).

Evaluations should give greater weight to **indicators that enable assessment of longer-term effects**, including measures such as dietary diversity, food consumption scores, land restoration, and water resilience, to capture lasting rather than temporary gains. Applying such indicators would help determine which practices are effective for scaling up and which contextual or design factors shape their success. Furthermore, **assessing climate resilience and food security outcomes together** is essential for identifying interventions that deliver mutual benefits. Traditionally, research and development have focused on one dimensional outcomes, often examined in isolation from other parts of the system. Identifying interventions that contribute jointly to resilience and food security requires studies that measure indicators of both domains together and in comparable ways, so their relationships and combined effects can be assessed across contexts.



Figure 22: Flow diagram illustrating the distribution of direct and proxy indicators measured per intervention in the evidence base



Note: Proxy indicators represent enabling conditions or processes that indirectly support progress towards sustainable development goals (SDGs), while direct indicators measure tangible outcomes linked to SDG targets. SDGs included here are those most closely linked to food security and climate resilience.

2. Focusing on hindering and enabling pathways

One of the assumed impacts of agrifood systems' transition is that households will become more resilient in the face of shocks and stresses that climate change poses. Based on the evidence **little attention has so far been given to measure actual resilience to the direct and indirect impacts of climate change in combination with food security. Instead, research has focused on adaptive capacity and vulnerability. Focusing on adaptive capacity risks ignoring negative coping strategies** that can be detrimental for overall resilience and people's well-being (Béné & Haque, 2022). Negative coping strategies mean dealing with shocks and stressors in a way that might bring relief in the immediate term but worsen the situation in a medium to long term. Examples of negative coping strategies range from overcropping and overuse of resources to withdrawing children from school to work on a farm and the sale of productive assets such as livestock and land for short-term food (Boansi et al., 2023; Saran et al., 2024).

In addition to effective production practices, **processing and distribution play a key role in system-level transitions** (Figure 22). Market-led pathway has been identified as one of the four pathways to impactful transitions alongside institutional change, innovation capacity and social capital (Maru et al., 2018). Much of the focus of agricultural development funding has been on innovations related to production, and market-led pathway has received less attention as the evidence shows. The apparent hierarchy among interventions partly reflects how climate impacts manifest: production losses from droughts or floods are immediate and highly visible, whereas post-harvest challenges are less visible. As a result, research attention gravitates toward on-farm responses even though systemic resilience also depends on downstream components such as storage, processing, and market access.

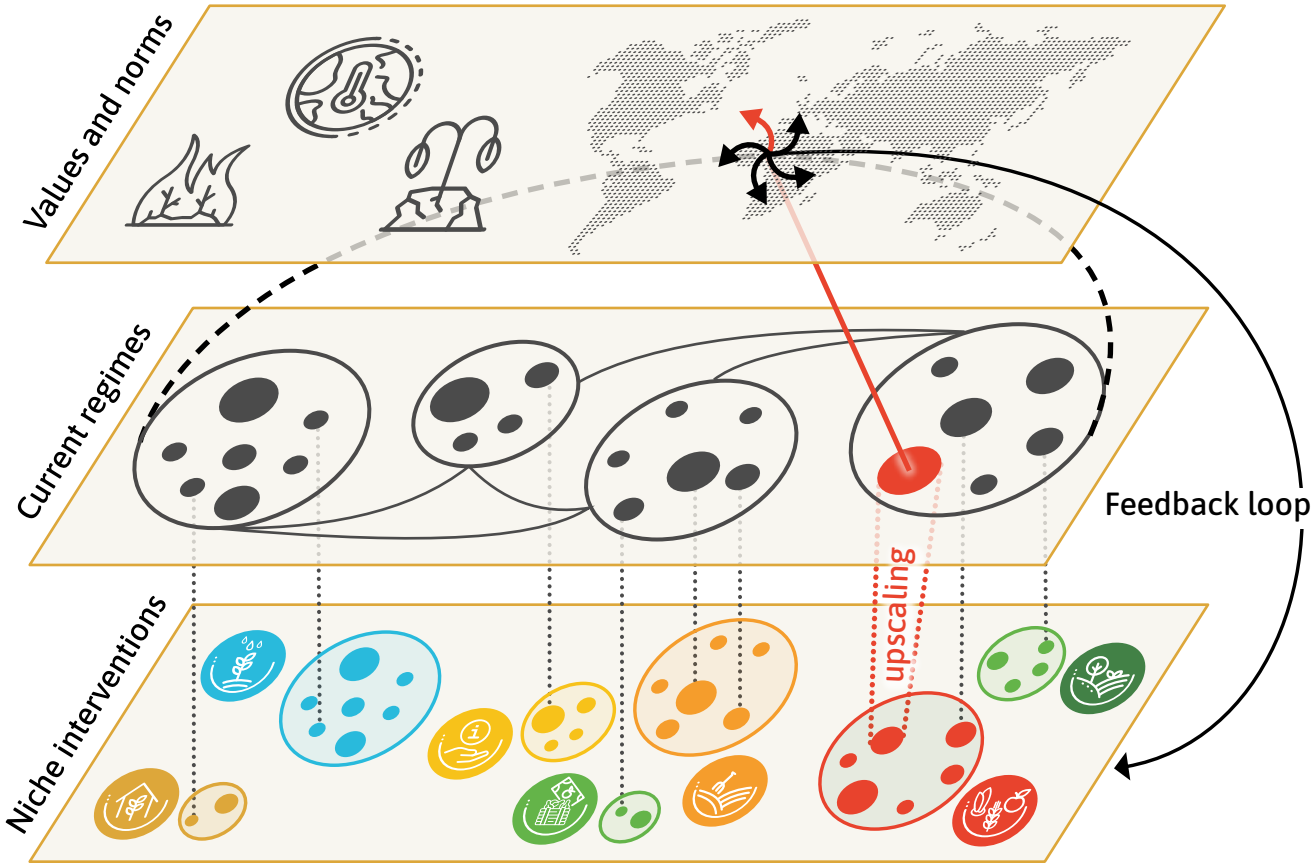
The dominance of on-farm evidence is also a structural artifact of how research and development programmes are designed. Short funding cycles and narrow performance indicators privilege interventions that deliver immediate, measurable results. "Long-maturity" interventions such as agroforestry, improved market access, or access to information systems rarely fit this model, leaving major blind spots in understanding how these mechanisms sustain resilience over time.

System-level change will not happen by focusing on production alone as current agrifood systems have multiple self-reinforcing mechanisms, i.e. system lock-ins, to keep the system in its current state while impeding adaptation to new challenges (Gaillard et al., 2025). However, climate change is changing environmental conditions and the need for system-level adaptation is urgent. Therefore, more attention needs to be paid on markets and value chains as a whole to avoid forcing farmers into conventional productivity systems and instead letting them benefit from innovative practices (Meynard et al., 2017).

In practice this can be achieved by designing bundled innovations that address all parts of value chain as well as institutional constraints. This coordinated approach to develop and implement multiple, different innovations in a holistic manner ensures that upscaling of innovations can happen. For example, a coupled intervention could include all the following to address the system as a whole: implementing agroecological practices on the field, providing advisory services to farmers on agroecological practices, working on pesticide regulations to enable the use of biopesticides, and working on market requirements, e.g. on acceptance of imperfect looking fruits and vegetables. Designing coupled innovations makes it also possible to address power imbalances between different actors to ensure that impact pathways have equity in their core. Leaving responsibility to markets is unlikely to result in transition and proactive policy interventions are needed to achieve desirable results (De Schutter, 2017).



Figure 23: Simplified presentation of system-level transitions



Note: The niche intervention level is where innovations happen are tested. These can break into current regimes through successful upscaling either through incremental adaptation or system disruption. At the highest level, norms and values embedded in cultural patterns, macroeconomics and -politics influence current systems and innovative landscape. Changes in the current regime occur through interacting processes within and between these levels through feedback loops, for example, when cultural values change in a society some interventions become more desirable and others less. Adapted from (Geels & Schot, 2007)

3. Embracing transdisciplinary learning

Finally, agrifood system transitions have a knowledge component. The findings show a moderate body of evidence on household and communities' access to extension services. Empowering farmers with information (what exists and/or can be done) and skills (how to do it) is half the picture. As important are the other knowledge components of why (what are the drivers behind an action) and when (timing of action) (Loconto, 2016). **Accruing knowledge can also mean unlearning previous habits and practices and placing more emphasis on previously undervalued knowledge systems** (Pant, 2016). For example, valuing Indigenous knowledge and production systems over monoculture-based incumbent production regimes can help to adapt to the challenges climate change poses both for environment and livelihoods.

Challenges in measuring progress towards sustainable systems

1. Mismatch between policy and research

The mapping highlights **a persistent gap between what research measures and what policy frameworks require**. Most studies stop at farm or household level outcomes such as yields and income (immediate benefits). Very few studies track what happens beyond the farm gate, for example, whether yield stability translates into improved food access, reduced climate risk, or sustained resilience (long-term benefits) (Figure 22). Yet national adaptation plans (NAPs), nationally determined contributions (NDCs), and donor frameworks need evidence that scales, ideally showing whether local interventions aggregate into systemic resilience and food security. **Bridging this gap is the main condition for aligning science with the policy**.

The call for broader-scale evidence does not imply expanding field, plot or project size. It refers instead to improving the comparability and aggregation of results across existing studies. Achieving this requires consistent use of indicators and metrics that allow findings from different contexts to be linked and synthesised. **Harmonised measurement is the key to generating policy-relevant evidence at scale**.

2. Disconnect in investment and evaluation

The current distribution of evidence also suggests a structural mismatch between investment intent and evaluation practice. Donors have increasingly directed funds toward interventions designed to transform systems such as improved market access, access to climate information and extension, and institutional strengthening yet most monitoring frameworks still capture short-term production metrics. **In effect, the system is funding transformation but measuring yields**. This disconnect obscures the real value of those investments and perpetuates the impression of "lack of evidence." To demonstrate impact credibly, funding programmes must pair systemic interventions with research designs and indicators capable of tracking long-term, multi-scale outcomes in both climate resilience and food security.

The disconnect is not hypothetical. A recent European study concluded that no simple relationship exists between farm-level diversity and national-level diversity, meaning policies designed and monitored at higher administrative levels risk misestimating resilience potential if they rely only on local or "snapshot" evidence (Machefer et al., 2024). The same danger applies in LMIC contexts because **without multi-scale evidence, policies risk being based on misleading farm-level data**.

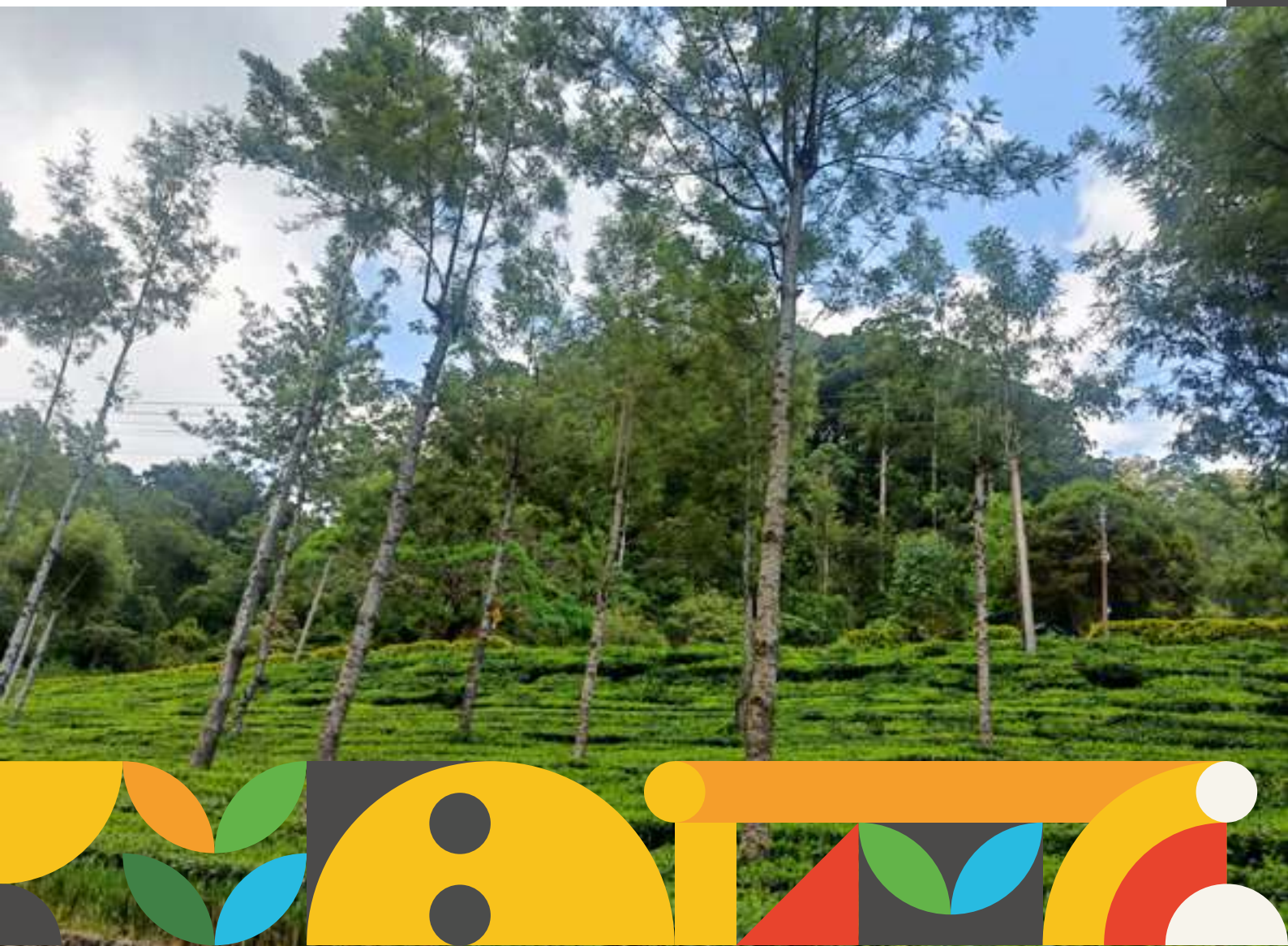
3. Need for standardised indicators

Policymakers and donors also need more than anecdotes of "farmers tried this and yields went up". In the "Green Revolution" era, such snapshot results could drive policy because immediate production gains were seen as enough. Today, that is no longer the case. We are already facing significant increase in flash-floods, wild-fires, and crop failures (IPCC, 2023). We cannot afford a patchwork evidence base stitched together from results of inconsistent studies. **We need re-designed primary studies. Even short-term projects can generate policy-relevant data if they embed a small, harmonised sets of food security and climate resilience indicators**.

The use of standardised and harmonised indicators in agriculture has been emphasised by initiatives such as CGIAR's Standing Panel on Impact Assessment (SPIA) and FAO's minimum indicator sets for agricultural interventions (FAO, 2021; SPIA, 2020). This study shows that the current evidence base is still highly fragmented. Most interventions are assessed only at farm or household scale. This makes it nearly impossible to aggregate findings or assess systemic impacts. **Without a harmonised approach, where standardised indicators are used in a way that allows results to be scaled to higher levels, building a policy framework that meets current and future needs will not be achievable**.

The following steps provide a pathway to standardised and harmonised indicators:

1. Engage with institutions, such as FAO and CGIAR, to discuss existing indicators and potential processes to build a harmonised set.
2. Seek funding for a collaborative process to work on the indicators.
3. Establish a collaborative network of researchers, practitioners and other stakeholders to identify the key indicators.
4. Present the indicators to research, practice and policy communities and seek feedback.
5. Finalise the set of indicators.
6. Once indicators are agreed on, seek commitments from donors and research funders to use the indicators to ensure they are actively embedded in research funding calls and projects implementing development or research activities.



7. Conclusion

Overall synthesis of the evidence base

This synthesis demonstrates that while research on agricultural interventions linking climate resilience and food security in low- and middle-income countries has grown substantially over the past decade, it remains biased toward a narrow subset of interventions and outcomes. The strongest evidence clusters centre on soil conservation, improved water management, and crop diversification, which together account for the majority of studies that report both climate resilience and food security outcomes. These interventions are consistently associated with improved yields, greater income stability, and enhanced biophysical conditions such as soil health and water availability, signalling that they can support both productivity and some elements of resilience under climate stress.

By contrast, the evidence thins once attention moves to enabling, value chain interventions such as improved market access, post-harvest management and storage, and access to climate information and extension services. These interventions appear far less frequently in the dual-outcome literature, even though they play decisive roles in shaping whether production gains translate into income stability and sustained food security and resilience over time.

The resulting evidence landscape is therefore not only incomplete but structurally skewed: it overrepresents what is visible and easily measured at the farm level, while underrepresenting the institutional, market, and information systems that underpin long-term agrifood system.

Conceptual blind spots: how climate resilience and food security are framed

The imbalance in the evidence base is not purely empirical; it reflects research preferences on how resilience and food security are defined and measured in practice.

Most studies operationalise climate resilience through short-term performance metrics such as yield stability under stress, improved soil properties, or reduced variability in production, often over relatively short time horizons and at the plot or household scale. These indicators capture important aspects of biophysical and economic robustness, but they stop short of assessing if these ongoing practices will sustain livelihoods and food security as climate risks intensify.

Food security is also commonly reduced to production and income proxies, with limited attention to food access, dietary diversity, intra-household allocation, or seasonal dynamics of food shortage. As a result, productivity gains are frequently assumed to imply better food security, even when there is limited empirical evidence that increased output or income is translating into consistently improved diets or reduced vulnerability. Similarly, many studies focus on adaptive capacity and reduced vulnerability as proxies for resilience but rarely measure realised resilience—that is, how households, communities, or systems actually fare during and after climate-related shocks. Negative coping strategies such as distress sales of assets, increased labour burdens, or education sacrifices for children are seldom tracked, despite their central importance for long-term resilience and equity.

This conceptual narrowing has two main consequences.

- First, encourages an emphasis on interventions that can show quick, measurable changes in yields or income within typical project timeframes, reinforcing the dominance of production-focused studies.
- Second, it conceals the ways in which interventions may produce trade-offs across scales or time—for example, when short-term gains in productivity are achieved at the expense of resource depletion. These trade-offs therefore are likely to remain largely overlooked by policy makers.

Interventions in context: from single practices to pathways

The evidence suggests that agricultural practices rarely operate in isolation; their impacts depend on the broader systems in which they are embedded. Soil conservation, improved water management, and crop diversification yield the most positive dual outcomes where they are supported by enabling conditions such as secure land tenure, access to inputs, affordable credit and extension services. Where such enabling conditions are weak, the same practices can produce modest and uneven benefits and can exacerbate inequalities by favouring better-resourced farmers.

The literature, however, seldom examines intervention "pathways" explicitly. Few studies compare different combinations or sequences of interventions (for example, soil conservation plus market access, or water management plus climate information services) or analyse how their interactions shape resilience and food security outcomes across farm, community, and market levels. Similarly, there is limited empirical work on how interventions influence, or are constrained by value chain characteristics such as the price of fuel and agriculture inputs, power relations between farmers and offtakes and the ability of farmers cooperatives to negotiate farmgate prices

This gap points to the need for a shift from evaluating discrete technologies and practices to understanding portfolios of interventions and the pathways through which they transform systems. Effective transition pathways will likely combine:

- Production-level measures (such as soil and water management, crop diversification, agroforestry) that reduce exposure and sensitivity to climate hazards;
- Post-harvest, storage, and processing interventions that buffer supplies, reduce losses, and stabilise availability;
- Market and policy interventions that stabilise prices and incomes, and improve food security across vulnerable groups;
- Information, extension, and innovation systems that build adaptive capacity across the food value chain.

However, because most of the current evidence focuses on the first set of measures, with relatively little attention to the latter three, our understanding of which pathways are most effective—and for whom—remains limited.

Measurement priorities: building a more useful evidence base

A central finding of this synthesis is that improving what is measured may be more transformative than adding more studies that track the same narrow set of indicators. Research and monitoring efforts need to rebalance toward indicators that reflect the multidimensional nature of food security and climate resilience and that can capture changes over longer periods.

For food security, this means greater use of indicators such as dietary diversity, food consumption scores, seasonality of food access, and measures of affordability and stability of nutritious diets, rather than relying primarily on production or income as proxies. For climate resilience, it implies incorporating metrics of biophysical stability (e.g. land restoration, water resilience, carbon sequestration), stability of yields and incomes across seasons and years, and social and institutional capacity to anticipate, absorb, and recover from shocks. This should include explicit tracking of coping strategies and the distribution of benefits and risks across gender, age, and socio-economic groups.

Some of these coping strategies involve significant trade-offs, and understanding their resulting impacts is useful. For example, during prolonged droughts, farmers may switch from cultivating water-intensive crops such as rice to more drought-resistant crops like millet or cassava. While this reduces climate risk and protects livelihoods, it can lower farm incomes in the short term and reduce dietary diversity if local diets shift heavily toward one staple. (With rice, poor households tend to better combine it with several food groups but when there is a shift to cheaper, drought tolerant staples, these tend to dominate diets. Dietary diversity scores then fall even if total calories are maintained). By anticipating such outcomes, decision makers can design climate resilience strategies that safeguard against negative impacts on nutrition and equity. In addition, more evidence on these indicators may also trigger extremely useful meta-analyses on which combination of enabling conditions might consistently deliver on both climate resilience and food security.

Implications for research funders

For research funders, the synthesis points to three strategic priorities.

First, rebalance portfolios to address neglected but structurally important interventions. This includes agroforestry, post-harvest management and storage, market access, and access to climate information and extension services. Portfolios should also prioritise research on how these interventions interact with production practices in delivering on resilience and food security.

Second, support longer-term, systems-oriented research. Many resilience and food security benefits, especially for interventions such as agroforestry or institutional reforms, materialise over years rather than project cycles. Funding mechanisms that allow for multi-year follow-up, repeated measurements, and the study of interventions across multiple scales (farm, landscape, value chain, and policy) are essential for dealing the increase climate shocks.

Third, invest in synthesis, comparative analysis, and open data. As evidence accumulates, its usefulness depends on the ability to aggregate and compare across studies. Supporting high-quality evidence repositories, common taxonomies and regular evidence-mapping exercises can help ensure that new research fills genuine gaps rather than reproducing existing biases.

Implications for policymakers and donors

For policymakers and donors, the findings underscore that building climate-resilient and food-secure agrifood systems will require shifting from project-level, technology-centric approaches to systemic, pathway-oriented strategies. Four implications stand out:

First, interventions should be designed and financed as 'stacked' packages rather than isolated projects. Scaling soil and water conservation or crop diversification without simultaneous investments in transport, storage, and extension services, risks generating pockets of productivity that are not matched by predicable access to off takers.

Second, policies must explicitly address the institutional determinants of resilience and food security. This includes land tenure security, accountable local institutions, input and output value chains, and social protection systems that reduce the need for negative coping strategies during shocks. Without such foundations, even technically sound interventions may entrench inequalities or shift risks onto already vulnerable groups.

Third, monitoring and evaluation systems used by governments and donors should be aligned with the multidimensional metrics discussed above. If success continues to be defined primarily by short-term yield or income gains, actors will have little incentive to design or support interventions that prioritise long-term resilience, equity, and nutritional outcomes. Incorporating indicators of dietary quality, resilience to shocks, and distributional impacts into results frameworks can help reorient programmes toward more holistic objectives.

Fourth, donors should reprioritise funding to support "long-maturity" interventions and systemic change. This may involve for example, blended finance that reduce risks for private investment in storage and cold chains. This may also call for multi-phase programmes that support institutional reforms and outcome-driven capacity building.

Looking ahead: from more interventions to better-informed systems

Taken together, the findings of this synthesis suggest that the frontier challenge for climate-resilient and food security is less about discovering entirely new practices and more about understanding how to configure existing ones within supportive systems. The key questions now are: which combinations of interventions, under which enabling conditions, deliver sustained improvements in both resilience and food security; how benefits and risks are distributed; and what institutional arrangements allow these gains to be scaled without exacerbating inequalities or ecological degradation.

Answering these questions will require deliberate investment in underexplored interventions, better and more harmonised measurement of outcomes, and a shift in how success is defined and rewarded in both research and development programming.

If research funders, policymakers, and practitioners align around a more systemic and long-term perspective, the growing body of evidence can move from documenting isolated successes to guiding coherent strategies that stabilise food systems and livelihoods under accelerating climate change. Doing so will be central not only to achieving climate resilience and food security targets but also to advancing broader goals of equity, health, and sustainable development.



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HESAT2030

Ending Hunger Sustainably, Nutritiously, and Equitably

Hesat2030 is supported by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Gates Foundation, and builds on the findings of Ceres2030 – Sustainable solutions to end hunger, jointly published in 2020 with Nature Research.

Ceres2030 provided a high impact roadmap for donors to effectively end hunger and double the incomes and productivity of small-scale producers while protecting the climate. Hesat2030 expands the focus of Ceres2030 to show the donor community the value of integrating climate- and nutrition-sensitive interventions across the agriculture and food (agrifood) system—from production to markets to consumption—and bundling components, as a better pathway to contributing to ending hunger and all forms of malnutrition, and protecting the climate.

Hesat2030 partners are Centre for Agriculture and Bioscience International (CABI), Food and Agriculture Organisation of the UN (FAO), International Food Policy Research Institute (IFPRI), and the Shamba Centre for Food and Climate. Funding support comes from Geman Federal Ministry of Economic Cooperation and Development (BMZ) and the Gates Foundation.

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