SIX-STEP APPROACH
Scaling Solutions, Transforming Food Systems

A SIX-STEP APPROACH FOR SCALING LOW-EMISSION FOOD SYSTEMS: EVIDENCE AND GUIDELINES

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Alliance Bioversity & CIAT
CGIAR
SLUS Project

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ISBN: 978-958-694-256-0
E-ISBN: 978-958-694-257-7

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Citation

Amahnui GA; Sylvester JM; Vanegas-Cubillos M; Castro-Nunez A. (2024). A Six-step Approach for scaling low-emission food systems: Evidence and guidelines. International Center for Tropical Agriculture (CIAT), Cali, Colombia. 51 p.

ISBN: 978-958-694-256-0

E-ISBN: 978-958-694-257-7

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** CIAT is part of the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT).*

Design and layout: Lorena García, Consultant, Alliance of Bioversity International and CIAT.

Cover photo: CIAT/Juan Pablo Marín.

January 2025

Acknowledgements

This research was supported by the CGIAR Science Programs on **Climate Action, Policy Innovations, and Scaling for Impact (S4I).** The six steps presented in this document build on the results of CGIAR Initiatives **Mitigate+: Research for Low Emissions Food Systems and AgriLAC Resiliente.** The CGIAR Trust donors fund CGIAR Initiatives and Science Programs.

The six steps also build on the results of 18_III_106_COL_A_Sustainable productive strategies. This project was part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative based on a decision adopted by the German Bundestag.

This document includes contributions from Schiller Katharina Josefa in Chapter One; Diana Maria Gutierrez in Chapters Two and Three; Alexander Buritica, Mary Ngaiwi, and Lisset Perez in Chapter Four; Eliza Villarino in Chapter Five; Borda Carlos Andres and Alexander Buritica in Chapter Six; and Ciniro Costa Junior and Casallas Ivon Maritza in Chapter Seven.

The authors also acknowledge the editorial support provided by Olga Spellman and Glenn Hyman of the Alliance of Bioversity International and CIAT Science-Writing Service.

Silvopastoral farm in Guaviare, Colombia. CIAT/N.Palmer

Abstract

The global food system is a major contributor to climate change and is responsible for approximately one-third of all anthropogenic greenhouse gas (GHG) emissions. In many low- and middle-income countries, scaling innovations for climate-change mitigation requires identifying the right incentives, as well as navigating complex realities such as policies, regulations, and value chain-related barriers. Consequently, efforts aimed at transforming food systems to low emissions may not yet deliver the desired impacts and, in some instances, may even produce undesirable effects on other Sustainable Development Goal (SDG) outcomes. This "Six-step Approach" to scaling low-emission food systems aims to bridge this gap. It provides a structured guide for creating an enabling environment that enhances scaling innovations for low-emission food system transformation, while delivering co-benefits and minimizing trade-offs and unintended side effects on SDG outcomes. These six steps include: (1) identifying direct and underlying drivers of food system GHG emissions and GHG emission sources; (2) identifying geographical areas where government development priorities overlap with food system GHG mitigation opportunities; (3) identifying farm-level drivers of adoption of innovations; (4) implementing value chain upgrading strategies to overcome adoption barriers; (5) promoting sustainable business models and financial mechanisms to scale innovations; (6) measuring climate action benefits, SDG co-benefits, and undesired effects. In this document, we present the approach and key considerations for its use in developing an enabling environment for scaling innovations toward low-emission food systems. Furthermore, we explore each step in-depth, discussing evidence, relevant methodological approaches, and information required for each step. To illustrate the approach's application, we present a case study on scaling silvopastoral systems undertaken during the implementation of a project aimed at delivering climate-change mitigation and peacebuilding outcomes in the Colombian Amazon. The guidelines presented here emphasize the need for scaling practitioners to identify key delivery partners at the nexus between government SDG priorities (national and regional) and food system GHG mitigation opportunities, to secure political and social support for scaling low-emission food systems.

Key words

Innovation scaling, value chain, climate change mitigation, sustainable development goals, co-benefits.

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CHAPTER ONE: INTRODUCTION 1

SLUS project aims to contribute towards the reduction of land-based greenhouse gas emissions, conserving forests, restoration of degraded landscapes and improving rural livelihoods while stimulating peacebuilding in rural Colombia. CIAT/E.Villarino

1.1 Introduction

Innovations typically describe new or enhanced products, processes, services, or policy and institutional arrangements aimed at creating value (Nagji and Tuff, 2012). These innovations may be technological, like new machinery, a seed variety, or digital tools, or non-technological, such as new farm-management methods, capacity-development approaches, policy shifts, business models, or changes in gender norms (Geldes et al., 2017). Innovation in low-emission food systems includes a broad spectrum of solutions aimed at reducing greenhouse gas (GHG) emissions (Li et al., 2014). These solutions target various stages of the food value chain, from the production of farm inputs and equipment (pre-production) to the production, processing, distribution, preparation, and consumption of food commodities, as well as disposal of food waste or food waste management (Li et al., 2014). According to Zhu et al. (2023), innovation is one of the key factors driving the transformation of global food systems and accelerating the achievement of the Sustainable Development Goals (SDGs). Through the widespread adoption of these innovations, the world can significantly improve the transformation of food systems to become more sustainable (Nicolétis et al., 2019).

As of now, there is no universally accepted or standardized definition of "scaling" (Frake and Messina, 2018). Pitt and Jones (2016) define scaling as the process of spreading an innovation across different boundaries to reach a larger audience. In a more recent definition, Woltering et al. (2019) provide a broader meaning of scaling: "from reaching many (adoption) to a process aimed at achieving sustainable systems-change at scale." Within the context of food systems, scaling involves reaching more or larger consumers, producers, or a range of actors within the food value chain (Pitt and Jones, 2016), as well as supporting shifts towards favorable (policy) environments for innovations, to achieve sustainable systems at scale (Woltering et al., 2019). Moore et al. (2015) identified three types of scaling: **scaling out**, **scaling up**, and **scaling deep**. Scaling out results in impacting greater numbers, replication, and dissemination, increasing the number of people or communities impacted. Scaling up results in impacting laws and policy, driving institutional change in terms of policy, rules, and law, while scaling deep involves creating transformative impacts at the cultural level, fostering shifts in values, beliefs, and the nature of relationships.

Scaling innovations is affected by various conditions, factors, and interactions that either enable or hinder

Cattle in the Colombian Eastern Plains. CIAT/N.Palmer widespread adoption and successful implementation of innovative solutions (Sartas et al., 2020). These conditions – collectively referred to as the "enabling environment" – encompass the array of socioeconomic, institutional, policy, cultural, and technological factors that dynamically shape the context within which scaling efforts unfold. Understanding the enabling environment is crucial for identifying barriers, leveraging opportunities, and designing strategies that effectively promote the dissemination and uptake of innovations at scale (Elechi et al., 2022). Research into understanding enabling environments, therefore, provides critical insights needed for developing conducive contexts that enhance the likelihood of successful innovation scaling (Minh et al., 2021).

Numerous scaling tools and frameworks have been developed in the context of agricultural research for development to analyze bottlenecks and opportunities for scaling innovations, and to develop strategies for achieving inclusive and equitable impact at scale (Martinez-Baron et al., 2024). Notable tools include the Scaling Scan (Jacobs et al., 2018), Scaling Readiness (Sartas et al., 2020), GenderUp (McGuire et al., 2024), and the Agricultural Scalability Assessment Toolkit (ASAT) (Kohl and Foy, 2018), among others. The Scaling Scan is a useful tool for understanding the multiple dimensions of scaling and the significant roles non-technical factors play in scaling, identifying bottlenecks for scaling and finding openings to tackle these bottlenecks, and developing realistic scaling ambitions jointly with stakeholders (Jacobs et al., 2018). Scaling Readiness offers methods, best practices, and resources for enhancing the team's ability to scale innovation, comprehensively grasp innovations, and pinpoint obstacles and possibilities for scaling innovations in a particular setting (Sartas et al., 2020). GenderUp is an approach centered on dialogue that aids project and research teams in responsibly and inclusively scaling agricultural innovations (McGuire et al., 2024). Lastly, ASAT is intended to offer a qualitative assessment of an innovation's capacity for scalability (Kohl and Foy, 2018). Despite the availability of these tools, guidelines for generating the information needed for developing an enabling environment for scaling innovations that reduce emissions, while delivering SDG co-benefits, are still lacking.

The Six-step Approach presented in this paper aims to fill this gap. The approach emphasizes the importance of working with delivery partners at the nexus between food-system GHG mitigation and government SDG priorities (national and regional) to secure political and social support for scaling low-emission food-system innovations from local to regional levels. In the following subsection (1.2), we present the relevance of the **Six-step Approach** in the context of global efforts to mitigate climate change in the food-system sector. We then present key considerations for using this approach to generate the information needed for developing an enabling environment for scaling innovations toward low-emission food systems and SDG co-benefits. We also provide a detailed overview of each step, reviewing evidence, relevant methodological approaches, and information needed at each step.

To illustrate the application of this approach, we present a case study on scaling silvopastoral systems (SPS) undertaken as part of the project titled "Implementing sustainable agricultural and livestock systems for simultaneous targeting of forest conservation for climate change mitigation (REDD+) and peacebuilding in Colombia (SLUS)," aimed at promoting sustainable agricultural and livestock production systems in Colombia and delivering climate-change mitigation and peacebuilding outcomes in the Colombian Amazon. The SLUS project was a collaborative effort by the International Center for Tropical Agriculture (CIAT), the Leibniz Center for Agricultural Landscape Research (ZALF), the Center for Research in Sustainable Agricultural Production Systems (CIPAV) and the Thünen Institute in Germany. The project's goals were to reduce emissions from land use, conserve forests, restore degraded landscapes, and improve rural livelihoods, while contributing to peacebuilding in the region (Morales Munoz et al., 2023).

A key focus was on scaling practices related to cacao agroforestry and silvopastoral livestock (SPS) – considered as innovative practices in the context of the project area – to create low-emission food systems and achieve sustainable development co-benefits. The case study presented here (and more fully in section 2.5) is focused on SPS – a form of livestock agroforestry where forage plants, such as grasses and creeping legumes, are integrated with shrubs and trees, which are used for animal feed and other complementary purposes (Murgueitio and Ibrahim, 2001). These systems are part of a broader strategy for conserving biodiversity and providing ecosystem services at the landscape scale, while reducing the negative impacts of production activities on the environment (Solarte et al., 2023).

1.2 The relevance of the Six-step Approach in the context of global climate-change mitigation efforts

The need to transform food systems into low-emission production systems has become a pivotal theme in global climate discussions, focusing on addressing key challenges in sustainable development (Elechi et al., 2022). The global food system plays a significant role in driving climate change, accounting for approximately one-third of total human-generated GHG emissions (Costa Jr et al., 2022; Crippa et al., 2021; Theurl et al., 2020). In 2015 alone, food systems emitted 18 gigatons of CO_2 equivalent, representing about 34% of all anthropogenic GHGs (Crippa et al., 2021). Despite this significant impact, countries' pledges to mitigate climate change through instruments such as the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement (2016) fall short and do not necessarily consider food-system emissions (Bliuc et al., 2015). This is in part due to countries' concerns regarding the impact of interventions on key development priorities such as food and nutrition security (Vågsholm et al., 2020).

Evidence suggests that, in contexts where the sustainable development co-benefits of climate-change mitigation have been demonstrated, funding and greater political and social support were attracted (Castro-Nunez et al., 2017). Furthermore, low-emission food systems have the potential to deliver SDG co-benefits beyond reducing carbon emissions, including enhancing food and nutrition security, conserving biodiversity (Khatri-Chhetri et al., 2022), restoring degraded land (Smith et al., 2022), and fostering peacebuilding efforts (Castro-Nunez et al., 2017). However, if well-planned transitions are not in place, innovations for food-system transformation can also result in unintended negative consequences such as exacerbating social inequalities or harming biodiversity or soil health, which can ultimately impede the achievement of true sustainability (Herrero et al., 2021). This underscores the opportunities emerging from identifying and scaling innovations that can deliver on both mitigation outcomes and the SDGs (Niles et al., 2018).

Scaling low-emission innovations in the Global South countries requires navigating complex development challenges, including fragile contexts, weak institutional and regulatory frameworks, reduced government presence, and reduced access to finance. As a result, initiatives aimed at reducing food-system emissions may not yet achieve the desired outcomes and, in some cases, might even negatively impact other SDGs (Merrey et al., 2023).

1.3 The purpose of the Six-step Approach and mechanisms for generating the enabling environment for scaling innovations

The Six-step Approach (Figure 1) – developed to complement existing scaling tools in the literature – serves as a guideline for creating an enabling environment to scale innovations that achieve both GHG emission reductions and sustainable development co-benefits within the food system. Recognizing that transforming the food system requires significant and purposeful changes to reduce GHG emissions and meet other SDGs (Elechi et al., 2022), this approach provides policymakers, researchers, and practitioners with essential insights for fostering such an environment. The structured guide outlined in this paper helps implementers scale innovations for a low-emission food system, while providing co-benefits and minimizing potential negative or unanticipated side-effects on SDG outcomes. The steps and their importance are as follows:

Step 1:

Identifying direct and underlying drivers of food system GHG emissions and their sources. This step is about examining areas of GHG emissions to identify where the highest mitigation potential exists. This is essential for designing effective mitigation strategies and achieving meaningful climate action.

Step 2:

Understanding government development priorities. This step aims to identify thematic and geographical areas where development priorities overlap with food-system GHG-mitigation opportunities. By focusing mitigation interventions on regions where development and mitigation priorities overlap, scaling efforts can gain stronger political support. This step also involves analyzing/reviewing governance models and identifying key delivery partners. Understanding community-based governance models is vital for fostering cooperation among various stakeholders, optimizing synergies, identifying institutional drivers of food-system GHG emissions, and reducing socio-ecological conflicts. While climate mitigation may not be a top national priority in many contexts, demonstrating the sustainable development co-benefits of such interventions can attract greater funding, and political and social backing.

Step 3:

Assessing farm-level potential for innovation adoption. This step aims to help scaling stakeholders understand the factors that influence farmers' adoption behavior, enabling them to design effective incentives.

Step 4:

Developing value-chain upgrading strategies to overcome adoption barriers. This step focuses on understanding the obstacles within the value chain that hinder the adoption of sustainable practices and crafting strategies to effectively address these challenges.

Step 5:

Designing inclusive business models and financial mechanisms to scale innovations. The inclusive business models and financial mechanisms developed will facilitate the scaling of innovations for food-system transformation. It operates under the assumption that the costs associated with adopting innovations for low-emission food systems may not always be outweighed by immediate economic benefits.

Step 6:

Measuring climate action and developing co-benefits. This step involves assessing how much emission reduction can be achieved by the innovation and identifying other SDG co-benefits generated. The term "co-benefits" in this context refers to achieving multiple objectives or interests simultaneously as a result of a policy intervention, private-sector investment, or a combination of both (World Bank, 2021). This step also ensures that negative effects arising from these interventions are identified early, allowing stakeholders to adjust strategies to maintain sustainability.

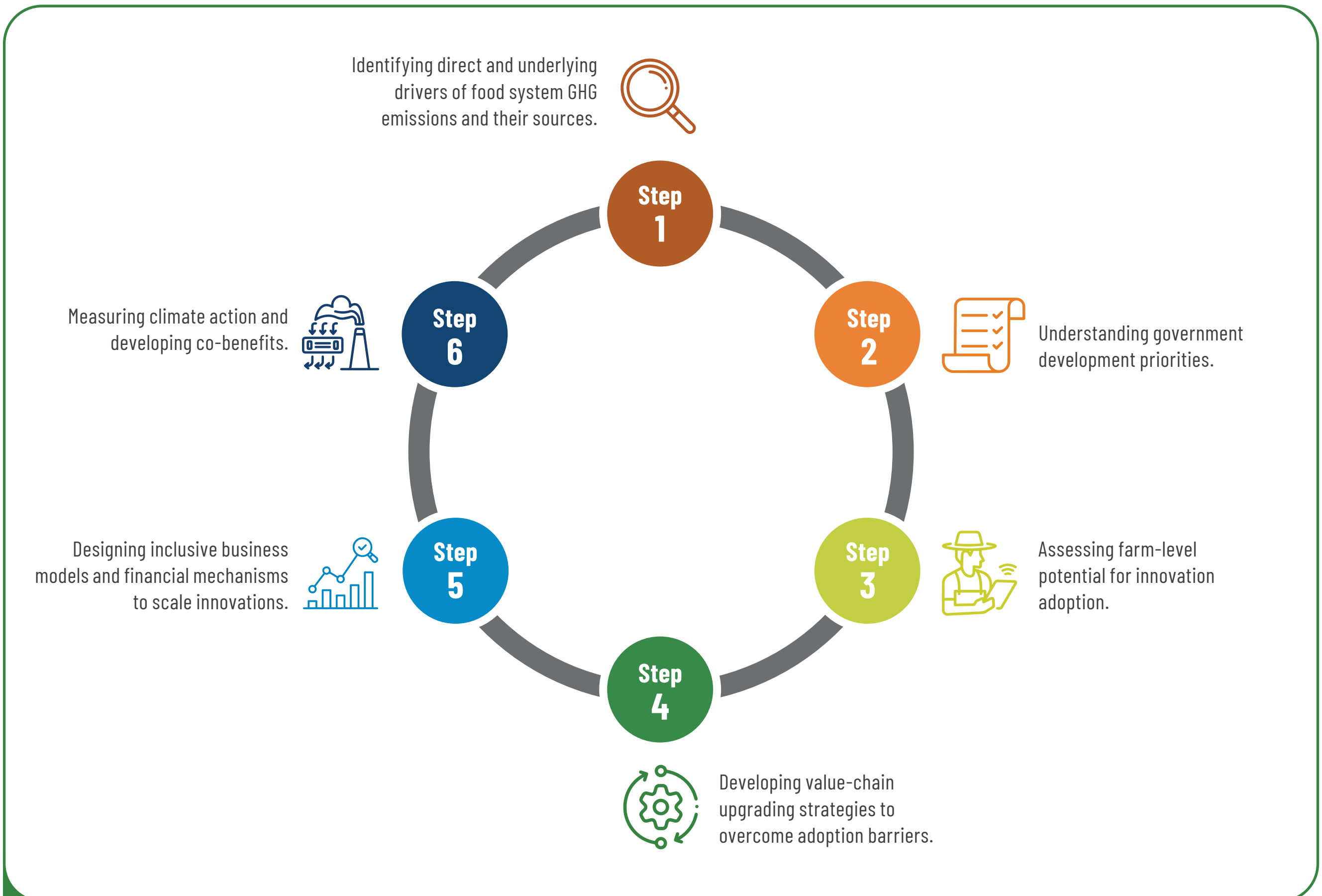

Figure 1 The Six-step Approach for generating the enabling environment for scaling innovations for low-emission food systems. Adapted from Bonatti et al. (2021).

Users of the Six-step Approach presented here should bear in mind the following important considerations:

- The steps are not prescriptive. The scaling process may or may not require some of the proposed steps depending on the characteristics of the innovation or innovation packages, as well as the available information about the enabling environment.
- It is not a scaling tool, but it is designed to complement other scaling tools by providing guidelines for generating the conditions that will enable the core innovation(s), such as value chain upgrading strategies and business models, to thrive.
- The approach should be applied to innovations whose high potential for impact at scale is well supported by evidence from field research – conducted under existing conditions in the target context – and whose scaling has been limited by bottlenecks in the enabling environment. Ideally, the targeted innovations are already in use on a small or sparse scale. In this case, this approach is useful for informing stakeholders about complementary non-technological requirements needed for scaling these innovations.
- The approach provides valuable insights and information needed for developing a scaling strategy, but it is not a substitute for the strategy itself. While the approach helps identify key factors, barriers, and opportunities for scaling innovations, practitioners will still need to formulate a comprehensive scaling strategy based on these insights. Thus, the Six-step Approach complements and informs the scaling strategy, but it does not replace the need for creating a detailed and actionable scaling plan.
- It is not intended to monitor innovation scaling; however, it can support the monitoring of climate action and development co-benefits derived from scaling.
- Although the approach is developed and presented in the context of food systems, it can be adjusted and applied to scaling a broad range of innovations or innovation packages across different sectors.

In the process of scaling innovations, it is essential to gather evidence, apply suitable methodological approaches, and collect relevant information at each step to ensure success. The following chapters will present this information in alignment with the steps outlined in the Six-step Approach.

The pilot laboratory in La Montañita seeks to enable local people and producers to benefit from their food resources and reduce greenhouse gas emissions. Facultad de Estudios Ambientales y Rurales, Pontificia Universidad Javeriana, Colombia.

CHAPTER TWO: IDENTIFIYING GHG EMISSION SOURCES AND THEIR DIRECT AND UNDERLYING DRIVERS

2

Planting of potato demonstration plot with zero and minimum tillage on Mr. Bernardino Carbajal's land in Mushit, Chugay, La Libertad, Peru. CIP/J.Rinza

2.1 Introduction

Identifying greenhouse gas (GHG) emission sources and their underlying drivers is essential for designing targeted mitigation strategies and achieving meaningful climate action. Step 1 of this scaling framework equips stakeholders with the tools to locate key emission sources and understand their drivers, enabling a focus on areas with the highest mitigation potential. By analyzing the direct and underlying drivers of food system GHG emissions, stakeholders can effectively tailor solutions (Gao et al., 2018), identify opportunities for intervention (Lamb et al., 2021), and measure the impact of their actions (MacLeod et al., 2015).

2.2 Food-system emission source

Understanding the sources and drivers of GHG emissions in the food system is essential for identifying emission hotspots and corresponding activities that can be effectively targeted by innovation interventions. The food system can be broken down into four key sectors – land-based (encompassing Agriculture, Forestry and Other Land Use-AFOLU), energy, industry (industrial processes and product use-IPPU), and waste sectors – that serve as broad emission sources, each contributing to the total emissions footprint of food production, distribution, and consumption (Tubiello et al., 2021; Crippa et al., 2021; Cerutti et al., 2023). Within these sectors, emissions are categorized into different food-system stages, and specific activities within these stages act as direct drivers of GHG emissions (Figure 2) (Tubiello et al., 2021).

NGHGI Sector		Activity	GHG Emitted: CH_4	N_2O	CO_2	FAO		
AFOLU	LULUCF	Forest Conversion to Other Land Uses and Burning Biomass	•	•	•	LAND USE CHANGE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	LULUCF	Peat Fires	•		•	LAND USE CHANGE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	LULUCF	Drained Organic Soils	•		•	LAND USE CHANGE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Burning - Crop residues	•	•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Burning - Savanna	•	•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Crop Residues		•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Drained Organic Soils		•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Enteric Fermentation	•			FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Manure Management	•	•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Manure Applied to Soils		•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Manure Left on Pasture		•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Rice Cultivation	•			FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
AFOLU	AGRICULTURE	Synthetic Fertilizers		•		FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
ENERGY AND IPPU		On-farm Energy Use	•	•	•	FARM GATE	AGRICULTURAL LAND	FOOD SYSTEM
ENERGY AND IPPU		Food Transport	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
ENERGY AND IPPU		Processing	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
ENERGY AND IPPU		Packaging	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
ENERGY AND IPPU		Refrigeration	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
ENERGY AND IPPU		Retail	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
ENERGY AND IPPU		Cooking	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
ENERGY AND IPPU		Fertilizer manufacturing and other pre-production	•	•	•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
WASTE		Solid Food Waste	•			PRE- AND POST-PRODUCTION		FOOD SYSTEM
WASTE		Incineration			•	PRE- AND POST-PRODUCTION		FOOD SYSTEM
WASTE		Industrial Wastewater	•	•		PRE- AND POST-PRODUCTION		FOOD SYSTEM
WASTE		Domestic Wastewater	•	•		PRE- AND POST-PRODUCTION		FOOD SYSTEM

Figure 2 Sources of Food systems GHG emissions (Adapted from Tubiello et al. 2021).
Legend: **AFOLU**=Agriculture, Forestry and Other Land Use; **FAO**=Food and Agriculture Organization of the United Nations; **IPPU**=Industrial Processes and Product Use; **LULUCF**=Land use, land-use change, and forestry; **NGHGI**=National Greenhouse Gas Inventory.

Elvia Ruiz in her farm in Puerto Rico Village, Caquetá department. CIAT/J.Urrea

Direct drivers can be considered the immediate actions at the local level that trigger GHG emissions in the food system. The largest contributor to emissions is the land-based sector, responsible for approximately 61% of total food-system emissions (Cerutti et al. 2023). This sector accounts for activities related to land use and land-use change (LULUC) and agricultural production.

LULUC includes activities such as deforestation for agricultural expansion, conversion of grasslands to croplands, and draining of wetlands for agriculture. These processes release carbon stored in vegetation and soils, contributing substantially to global CO_2 emissions. The removal of natural vegetation not only releases stored carbon, but also reduces the land's capacity to sequester future carbon, creating a long-term emissions source (Schmitz et al., 2012). For example, tropical deforestation for cattle ranching and soy production in the Amazon and Southeast Asia is a major contributor to global emissions from land-use change (Henders et al., 2015).

The production stage involves activities related to crop cultivation and livestock production that account for an estimated 44% of food-system emissions (Cerutti et al. 2023). Enteric fermentation from ruminant livestock together with manure management and the use of synthetic fertilizers release substantial amounts of methane (CH_4) and nitrous oxide (N_2O), respectively (Borhan et al., 2012). Additionally, crop residue burning and rice cultivation under flooded conditions are important sources of methane emissions (Tariq et al., 2018).

The agricultural production emissions profile can vary significantly depending on the type of farming practices, livestock systems, and crop types employed (Yue et al., 2017). Additionally, emission sources and drivers vary geographically; for instance, tropical regions may see higher emissions from deforestation, while regions with intensive livestock farming may have elevated CH_4 emissions. Identifying which sectors and activities are the largest emitters in each context is essential for tailoring interventions that effectively reduce food-system GHG emissions.

Potato harvest from the conservation agriculture trials using cereal and leguminous cover crops in the villages of Pishauli and Pampa del Condor, Chugay, La Libertad, Peru. CIP/W.Pradel

2.3 Underlying drivers of food system GHG emissions

While direct drivers of GHG emissions, such as agricultural practices and land use changes, are more evident, the underlying drivers represent the broader forces that shape the food system, its activities, and its outcomes. Adapting the Geist and Lambin (2002) framework for deforestation to the context of food-system GHG emissions, we can categorize these underlying drivers into economic, technological, cultural, sociopolitical, institutional, and demographic factors. Understanding these drivers is essential for identifying the root causes of emissions and for developing durable and robust intervention strategies.

Economic factors such as income level, market demand, global trade, and investment flows play a pivotal role in shaping food-system emissions. For instance, rising incomes in middle-income countries are often associated with increased consumption of resource-intensive foods like meat and dairy, leading to higher emissions from livestock production. Global trade dynamics also contribute significantly, as demand for export-oriented commodities like palm oil, soy, and beef drives deforestation and land-use change in tropical regions. Conversely, trade restrictions on deforestation-risk commodities can impact access to export markets and influence production and land-use dynamics. Foreign direct investments in agricultural development can exacerbate these trends by promoting large-scale land acquisitions and intensive farming practices that increase emissions (Sylvester et al., 2024).

Demographic factors, such as population growth, urbanization, and migration patterns, also shape food-system dynamics. Rapid urbanization, particularly in developing countries, is linked to shifts in dietary patterns toward more processed and animal-based foods, which increases the demand for high-emission products (Caradus et al., 2024). As urban populations grow, consumption patterns evolve, with a marked trend towards higher per capita emissions due to increased demand for resource-intensive food products (Chang et al., 2023).

Institutional and policy drivers significantly influence food-system emissions through regulations and incentives. Agricultural subsidies, trade policies, and land-use regulations can either support sustainable practices or perpetuate high-emission activities. For example, subsidies for synthetic fertilizers and water-intensive crops may encourage unsustainable agricultural practices, while weak enforcement of land-use regulations can result in uncontrolled deforestation. International climate agreements and trade pacts set the rules for production, trade, and environmental protection, thereby shaping the global food-system's trajectory.

Technological drivers include technologies that enhance agricultural productivity, such as high-yield crop varieties and precision farming techniques, which can potentially reduce the need for land expansion and lower emissions per food unit produced. Conversely, emission-intensive technologies, such as synthetic fertilizers and mechanized farming, can increase emissions if not managed sustainably (Sims and Kienzle, 2017).

Lastly, cultural and sociopolitical drivers, including dietary preferences, consumer behavior, and political priorities, shape the demand for food products and influence the regulatory environment. Cultural norms that favor meat- and animal-based diets contribute to high emissions from livestock production, while sociopolitical factors such as public policies and industry lobbying can reinforce these high-emission dietary patterns or, conversely, promote more sustainable consumption choices such as plant-based dietary options.

2.4 GHG emissions data and sources

Data on GHG emissions across the food system provide insights into the stages and sectors with the highest emissions footprint, helping to pinpoint innovations that can provide significant emission reductions. Key data related to the direct drivers of food-system GHG emissions include farming practices, production systems, land use dynamics, energy use, transportation data, waste generation, emission factors, and emission inventories (Cerutti et al., 2023). Data on underlying drivers include: economic data (such as GDP per capita, income distribution, and consumer expenditure patterns, which help illustrate the economic factors that drive food production, consumption, and waste, influencing GHG emissions); policy and land-use data (e.g., land-use policy and tenure systems); population data (e.g., growth rates, urbanization rates, migration patterns); trade data (e.g., exports, imports, investment flows); and consumer behavior (e.g., dietary shifts, public awareness) (Geist et al., 2002).

The sources of these data include the national statistics offices, data repositories from international organizations such as the World Bank and the Food and Agriculture Organization of the United Nations (FAO), research institutes, environmental agencies, remote sensing technologies, industry and government reports, key informant and expert interviews and surveys, and literature reviews.

To understand the dynamics of emission sources and identify their associated drivers, this data can be analyzed using several qualitative (e.g., expert consultations) and quantitative (e.g., regression, machine learning, process simulation) methods. For instance, Sylvester et al. (2024) employed a machine learning approach to analyze the underlying food-system drivers of deforestation. Using FAO and World Bank data, they found that foreign direct investments and urbanization were significant drivers of global and regional deforestation. Similarly, Bai et al. (2018), highlighted increased demand, government support, and technological improvements as the main drivers of livestock expansion in China; while Jiang et al. (2022), using regression analysis, highlighted drought and anthropogenic disturbances such as agricultural mismanagement and resource exploitation, as key drivers of land degradation in Central Asia.

These studies' findings underscore specific demand- and supply-side factors that can be addressed to reduce emissions from these sources through targeted interventions such as promoting sustainable diets, reducing the consumption of forest-risk commodities, and promoting the sustainable management and intensification of production systems.

Targeting emission hotspots requires a nuanced understanding of the geographical and sectoral variations in emission sources. For example, interventions in Latin America may focus on curbing deforestation for cattle ranching, while in Southeast Asia, reducing emissions from rice cultivation could be a priority. This contextual approach ensures that scaling efforts align with local and regional realities, ultimately enhancing their impact on emissions reduction.

Training for cocoa farmers in Caquetá. CIAT/E.Ramírez

2.5 Case study: Identifying GHG emission sources and underlying drivers to inform the scaling of silvopastoral systems in the Colombian Amazon

2.5.1 The Colombian context

Colombia is one of the most biodiverse countries in the world, and is also heavily forested, with vast areas of tropical forests. However, since the signing of the 2016 peace agreement, which ended a 50-year armed conflict between the Colombian government and the Revolutionary Armed Forces of Colombia, deforestation has increased at alarming rates. While offering opportunities for peace and development, the post-conflict period has also provided new challenges in forest conservation (Vanegas-Cubillos et al., 2022). The SLUS project, with its focus on forest conservation as a means of climate-change mitigation, prioritized understanding these dynamics to effectively target interventions (https://allbiociat.org/4bFBQUf).

2.5.2 Assessment of GHG-emission drivers

The assessment of emission sources and drivers was conducted in alignment with the SLUS project objectives, which focused on forest conservation and sustainable land use as mitigation interventions. To identify areas with high mitigation potential, data on above-ground woody biomass (AGB) were used to reflect areas with high carbon stocks that are indicative of high forest cover. This variable provides useful information for prioritizing areas for emissions reduction through forest conservation. Next, data on deforestation rates were used to identify areas experiencing high carbon loss, which served as a proxy for GHG emissions from land-use change. These two variables allowed identifying areas where SLUS interventions could reduce emissions from deforestation while conserving standing forests. Data on AGB were derived from a raster file provided by the Colombian Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) for 2010, and total and mean AGB carbon stocks were calculated at the municipal level in Colombia. Mean annual deforestation rates from 2005 to 2017 were also calculated at the municipal level using raster data from IDEAM (Castro-Nunez et al., 2017).

2.5.3 Assessment of underlying drivers

Analyzing the underlying drivers of deforestation was crucial for understanding the root causes of the emissions that the interventions would aim to address. Insights into the dynamics driving forest-cover changes in Colombia were gained first through a preliminary literature review. This was followed by an analysis (Ganzenmüller et al., 2022) and systematic literature review (Vanegas-Cubillos et al., 2022), which confirmed that post-conflict dynamics driving coca and livestock expansion continue to be predominant deforestation drivers in Colombia.

Activities on a silvopastoral farm in Guaviare, Colombia. CIAT/N.Palmer

CHAPTER THREE: UNDERSTANDING GOVERNMENT PRIORITIES TO IDENTIFY AREAS WHERE DEVELOPMENT PRIORITIES OVERLAP WITH FOOD-SYSTEM GHG-MITIGATION OPPORTUNITIES

3

There are three types of cocoa in Colombia: criollo, forastero and hybrid or trinitario.
Criollo cocoa is the finest, characterized by its pleasant flavor and exquisite aroma. CIAT/J.Marín

3.1 Introduction

Scaling innovations for achieving low-emission food systems is more viable and effective when aligned with other prevailing concerns and priorities, such as government development goals and the SDGs outcomes (Heinrichs, 2013). This involves strategically targeting specific areas in the food-system sector and the value chain, as well as the geographic region, for applying scaling innovations that will transform the food systems and contribute to development priorities. This selection should ensure that scaling efforts simultaneously contribute to government development and food-system GHG mitigation priorities (Castro-Nunez et al., 2017). By doing so, this will improve the enabling policy environment for scaling the target innovation. To achieve this objective, the second step of this guideline recommends that scaling efforts include the following key activities (Figure 3).

Figure 3 Key steps and activities for understanding where government development priorities overlap, to identify food-system GHG-mitigation opportunities.

3.2 Understanding government development priorities

Governments prioritize public policies according to specific development targets. These targets may be driven by internal political agreements, the emulation of countries that are succeeding in achieving their environmental targets, or a broad international consensus on best practices, among others (Castañeda et al., 2018). By understanding public development priorities at national and subnational levels, lead scaling organizations can be aware of the sectors, programs, value chains, and geographic areas that are of high interest to the government. Methods for identifying these priorities include but are not limited to: reviewing policy documents, government strategic plans, and budget allocations; assessing national commitments to international agreements; monitoring media coverage of government activities, declarations, and announcements; conducting interviews with government stakeholders and key leaders; and performing discourse analysis of governmental speeches.

3.3 Prioritizing regions to scale innovations

Stakeholders can prioritize intervention areas using information obtained on government development priorities and the direct and underlying drivers of GHG emissions. The scaling of the target innovation can contribute simultaneously to national development goals and reduction of food system emissions. This alignment in government priorities can provide several advantages such as policy support, resource allocation, and greater impact (Karim and Ray, 2022).

Geospatial analysis can identify areas with the highest potential for reducing GHG emissions and contributing to government development goals – prioritizing regions for intervention (Castro-Nunez et al., 2017). The prioritization effort uses data on GHG emissions alongside its drivers, as well as data on indicators of government development priorities. The methodological approach for analyzing these linkages includes correlation analysis and local indicators of spatial association (LISA) (Ganzenmüller & Castro-Nuñez, 2019; Castro-Nunez et al., 2020). In the context of the Six-step Approach, the correlation analysis is applied to draw links between drivers of GHG emissions (mitigation opportunities) and government development goals. Anselin's (1995) LISA analysis identifies and assesses the degree of spatial clustering or spatial autocorrelation within a dataset at a local level. In the context of the Six-step Approach, LISA identifies hotspots where GHG mitigation opportunities overlap with government development priorities. However, once regions have been identified, government representatives and other stakeholders use a scoring tool containing a set of prioritization criteria to prioritize and select the regions to scale the innovation. The approval and support of the government and other stakeholders will ensure the political and institutional environment for scaling innovation in the selected region.

3.4 Understanding local governance models

After prioritizing where to scale innovations to achieve the highest impact related to food system transformation and government SDGs, the next important task is to analyze and assess local governance models. According to Kettl (2015), governance refers to "a category of social facts, specifically, the processes of interaction and decision-making among the actors involved in a collective problem that led to the creation, reinforcement, or reproduction of social norms and institutions." Understanding community-based governance models provides insights into resolving socio-ecological conflicts, particularly those related to the access, use, and management of natural resources (Eufemia et al., 2023). Participatory community engagement in a wide-ranging evaluation of existing governance issues is key to build trust, to facilitate inter-sectorial dialogue, and to engage different stakeholders (and their interests).

In scaling for food system transformation, understanding community-based governance models is vital for fostering cooperation among various stakeholders, optimizing synergies, identifying institutional drivers of food system GHG emissions, and reducing socio-ecological conflicts. In a recent study, Eufemia et al. (2023) analyzed governance models through a literature review of environmental and local governance mechanisms and institutions. They conducted surveys and expert workshops, with participants chosen based on expertise in social, economic, political, and environmental issues within the area. This study was conducted in the frame of the SLUS project and aimed to facilitate the selection of sustainable land use systems (SLUS) tailored to specific and unique socio-economic and environmental contexts. The broader effort sought to improve livelihoods while stimulating peacebuilding in rural conflict-affected settings in Colombia.

3.5 Prioritizing innovations to scale

Various tools and approaches have been employed for prioritizing food system innovations. These include simulation modeling (Shirsath et al., 2017; Rosegrant et al., 2014), mathematical optimization methods (Holzkämper et al., 2015; Borgomeo et al., 2016), cost-benefit analysis (Kumar et al., 2018), economic surplus models (Stevanović et al., 2016; Shiferaw et al., 2008), econometric techniques (Schlenker et al., 2006), meta-analysis and systematic reviews (Lamanna et al., 2015), spatial analysis with GIS and remote sensing (Notenbaert et al., 2017), and integrated assessment modeling (Rosegrant et al., 2017; Weindl et al., 2015). While these tools and approaches offer several advantages, such as incorporating multiple variables and providing a structured framework for decision-making, we strongly recommend using participatory methods involving local stakeholders when prioritizing innovations. Involving local actors in the scaling process facilitates a deeper understanding of the realities in the field (Thornton et al., 2018). A participatory approach can serve to identify innovations that are already being implemented in the region, efforts that have the potential to positively impact GHG emission mitigation and the prioritized development goal, if adjusted for achieving these objectives.

Many development specialists support the use of participatory methods (Kumar et al., 2018; Mwongera et al., 2017; Khatri-Chhetri et al., 2017). For instance, Kumar et al. (2018) employed a multi-stakeholder participatory prioritization of climate-smart agricultural practices and an ex-ante impact assessment to determine the necessary investments and potential benefits of prioritized climate-smart agricultural practices at a local level. The top-ranking practices identified during the participatory workshops were analyzed for their potential impact on productivity and economic return on investment.

Similarly, Mwongera et al. (2017) used the Climate-Smart Agriculture Rapid Appraisal (CSA-RA) to prioritize innovations for scaling. CSA-RA is a mixed-method approach that combines participatory bottom-up, qualitative, and quantitative tools to assess local contexts' heterogeneity and prioritize context-specific CSA options. This tool evaluates innovations based on their suitability to biophysical, climatic, socio-cultural, economic, and technological characteristics at the household, farm, community, and regional levels.

Khatri-Chhetri et al. (2019) applied a comparable framework using a participatory approach with stakeholders to prioritize agri-food system innovations based on their ability to increase farm productivity and income, build resilience to climate change, and reduce agricultural emissions. Scaling practitioners should explore these participatory frameworks for selecting innovations for scaling in this stage of the guideline.

Professionals of the CGIAR initiative Mitigate+ developed a comprehensive scoring system to assess the potential of scaling different innovations for GHG emissions reduction (Amahnui et al., 2023). They established a framework to assess the scalability of innovations targeting low-emission development. This framework utilizes a multi-criteria scoring approach, allowing stakeholders to evaluate each innovation across several key dimensions, including institutional, social, and biophysical contexts; barriers to adoption; market potential; costs; financial opportunities for scaling; and the environmental, social, and economic co-benefits and trade-offs. Stakeholders participated in a two-day workshop, applying these criteria to generate scores that indicate each innovation's potential for broader implementation and impact.

3.6 Case Study: Understanding development priorities to identify where government priorities overlap with food system GHG mitigation opportunities during the scaling of silvopastoral systems

3.6.1 Overlapping government priorities with areas of high carbon storage

To understand areas where climate change mitigation opportunities overlap with government development priorities, an analysis was performed using data on AGB carbon and forest areas from IDEAM (2018), armed actions from *Universidad de los Andes* (2018), and victims of armed actions from *Red Nacional de Información Colombia* (2019). The effort prioritized the SDG on conflict reduction in alignment with the Colombian government's focus on promoting peacebuilding after the signing of the peace agreement. The analysis covered 1,121 municipalities in Colombia and employed visualization techniques and descriptive statistics. Local indicators of spatial association (LISA) analysis was performed using GeoDa software (University of Chicago, 2018), while all other computations were conducted with ArcGIS (ESRI, 2016) and R (R Core Team, 2018). Ganzenmüller and Castro-Nunez (2019) presented a full report of this methodology and how it was applied. These analyses provided valuable insights to political partners on the potential areas for intervention. Subsequently, in a workshop using a scoring matrix, stakeholders prioritized interventions areas that aligned with government concerns.

3.6.2 Assessing governance models

In the SLUS project, the various stakeholders assessed governance models through workshops designed to gather data on governance frameworks, drivers of conflict, deforestation, and land use dynamics in Caquetá and Cesar, where SPS were implemented. Various stakeholders were invited to participate, including local government representatives, NGOs, farmers' associations, academia, and private companies. The researchers employed the World Café methodology, a conversational process that fosters trust-building, constructive dialogue, and collaborative learning (Löhr et al., 2020). Participants discussed topics such as governance, conflict analysis, sustainable land use, deforestation in Caquetá and Cesar, and land restitution. This activity was instrumental in fostering cooperation among diverse stakeholders, optimizing synergies, identifying institutional drivers of food system GHG emissions, and reducing socio-ecological conflicts.

3.6.3 Prioritizing innovations to scale

To determine which combination of SPS practices (the innovations) to prioritize, stakeholders conducted a comprehensive review of promising SPS practices in each region, considering factors like productivity, climate change mitigation, biodiversity protection, and soil conservation. The review led to a prioritization process to identify the most suitable SPS practices for developing productive models. The selection focused on models that best fit each region and evaluated aspects such as GHG emissions mitigation, peace building contributions, integration into value chains, adoption potential, conservation and restoration, productivity and economic efficiency, adaptation and resilience capacity, and water resource protection. Stakeholders from the regions where the project was carried out defined the criteria, their weighting, and evaluation methods through a participatory process.

CHAPTER FOUR: ASSESSING THE FARM-LEVEL POTENTIAL FOR THE ADOPTION OF INNOVATIONS

4

Cattle on Las Juntas farm - Lácteos La Arboleda, Montañita, Caquetá. CIAT/J.Urrea

4.1 Relevance and approaches for conducting adoption studies

Rogers (1962) defines innovation adoption as the "the mental process an individual goes through from first learning about an innovation to its final adoption." Final adoption at the individual farmer's level is defined as the extent to which a new technology is utilized in the long term once the farmer has fully understood the technology and its potential. The adoption of food system innovations is an action driven by the intention to continue using it as long as it provides advantages over alternative practices (Kaine et al., 2009). In scaling agri-food system innovations, farm-level adoption is crucial because individual households, rather than firms, are usually the key decision-makers. These households ultimately determine the success and widespread implementation of new practices and innovations within the agricultural landscape. In addition to their critical role in determining the success and widespread adoption of agricultural innovations, farmers are also vital for the following reasons:

Key Drivers of Agricultural Sustainability: Farmers help translate innovations into tangible benefits, such as better yields or reduced input use, thereby contributing to long-term sustainability. As such, the adoption of sustainable innovations is crucial (Rosário et al., 2022).

Farmers as Innovators: In many cases, farmers themselves drive innovation by adapting technologies to their specific contexts, experimenting with new methods, and sharing knowledge within their communities. Their practical experience enhances the adaptability and scaling potential of innovations (Senyolo et al., 2018).

Influence on Adoption Success: Farmers' decision-making power plays a significant role in whether agricultural innovations take hold, spread, and generate positive outcomes (Rosário et al., 2022).

Understanding farmer behavior is key to identifying both barriers and opportunities for scaling food system innovations (Herrero et al., 2021). Farmers are not only the end-users of agricultural innovations but also active agents in shaping and spreading these innovations. Their engagement ensures that innovations are both technically and socially feasible, making them indispensable stakeholders in agricultural development.

In addition to the crucial role of farmers in adopting food system innovations, farm-level adoption is equally important due to the significant contribution of food production to greenhouse gas (GHG) emissions in countries of the Global South. For example, in tropical regions like the Amazon Basin, tropical deforestation – largely driven by agricultural expansion – accounts for approximately 6–17% of global carbon emissions (Nambiar, 2021). Furthermore, on-farm activities such as the use of chemical inputs like fertilizers and pesticides contribute substantially to GHG emissions (Boakes et al., 2024). As a result, the farm gate presents the greatest opportunity for emissions reduction in the Global South (Amahnui et al., 2025). This potential is particularly high because many farmers in these regions are smallholders who may not yet be utilizing the most efficient or sustainable practices.

Deforestation in the Orinoquia region, Colombia. CIAT/J.Marín

The theory of agricultural innovation adoption is a comprehensive concept that explains why some farmers embrace new innovations while others do not. Previous studies on this topic have explained farmers' innovation adoption in three primary paradigms: the adopter perception paradigm, the diffusion-innovation paradigm, and the economic constraint paradigm (Alemayehu et al., 2024; Adesina and Zinnah, 1993; Prager and Posthumus, 2010).

The adopter-perception paradigm suggests that the adoption process starts when farmers recognize a need for innovation. This recognition is influenced by personal factors such as values, education, and experience, as well as the physical characteristics of their land. Farmers' preferences for specific innovation traits play a crucial role in their adoption decisions (Adesina and Zinnah, 1993). The process involves rational decision-making, influenced by their perceptions of the technology's suitability and its delivery, alongside cultural, contextual, and individual factors (Adesina and Zinnah, 1993; Prager and Posthumus, 2010). For example, Marra et al. (2003) identified ease of use as one of the key factors influencing the adoption of conservation practices. The adopter-perception paradigm expands the concept of utility to encompass a broader range of considerations (Ruzzante et al., 2021).

The innovation-diffusion paradigm describes how agricultural innovations are adopted over time through the spread of communication, information, and knowledge (Prager and Posthumus, 2010). This paradigm holds that access to information is vital for shaping adoption decisions. The paradigm outlines a five-stage cognitive process for adoption: recognizing the technology, perceiving its benefits, deciding to use it, implementing it, and confirming its effectiveness. For instance, Bandiera and Rasul (2006) illustrate that farmers' decisions to adopt new innovations are often shaped by the social networks to which they belong.

Finally, the economic constraint paradigm argues that farmers aim to maximize profit, with resource distribution being a critical factor influencing adoption behavior. This paradigm emphasizes the importance of the impact of economic considerations at the individual level on shaping adoption decisions.

Farm-level adoption studies are typically conducted to identify factors influencing the adoption of agri-food system innovations through various paradigms. However, the factors influencing farmers' innovation adoption behavior depend on the nature of the innovation and the context in which it is scaled. Data on farm-level adoption, particularly socio-economic data, are mostly collected through surveys and analyzed using econometric models that incorporate variables from these paradigms (Alemayehu et al., 2024; Castro et al., 2024; Teklu et al., 2023; Ngaiwi et al., 2023). A more detailed example of data collection and analysis methods used in farm-level adoption studies is provided in our case study. Given the importance of these studies, scaling practitioners should conduct farm-level adoption studies to understand the factors driving farmers' adoption behavior. Insights gained from these studies will help set incentives to overcome farm-level barriers to adoption.

4.2 Case Study: Assessing the farm-level potential for the adoption of silvopastoral systems

Prior to the implementation of silvopastoral systems, a survey was conducted among smallholder livestock producers across four municipalities in the Caquetá department (Castro et al., 2024). The survey primarily targeted household heads or, when unavailable, the individual responsible for agricultural activities. It gathered extensive socioeconomic data, technical information, and economic indicators of livestock farming, paddock details, and the reasons and conditions influencing SPS adoption. Using this data, an econometric multinomial logit model was developed to identify the factors determining SPS adoption, with the paddock serving as the unit of analysis. This model incorporated various socio-economic variables, assessing farm characteristics, household head attributes, and paddock features, offering insights into the drivers of SPS adoption. Finally, a descriptive analysis explored the relationship between each variable and the likelihood of belonging to different SPS adoption categories. The results of the study were used to propose a financial mechanism that would integrate technical assistance, a key factor identified as crucial in the adoption study. The outcomes of the adoption study provided valuable input for a workshop that was organized to design the scaling strategy.

Workshop Agronomic practices to mitigate climate change in potato-cereal-legume based systems: Regenerative agriculture and its potential scaling up in the Northern Andes of Peru, January 2024, Huamachuco, La Libertad, Peru. CIP/W.Pradel

CHAPTER FIVE: DEVELOPING VALUE CHAIN UPGRADING STRATEGIES TO OVERCOME ADOPTION BARRIERS

5

Cocoa agroforestry system CIAT/J.Marín

5.1 Relevance and approaches for conducting value chain upgrading strategies

Step 4 identifies and analyzes the specific obstacles within the value chain that prevent the widespread adoption of food system innovations. By understanding these barriers – whether they are related to economic constraints, lack of awareness, technological limitations, or policy gaps – we can develop targeted strategies to overcome them. This process involves engaging with stakeholders across the value chain, from producers to consumers, to gather insights and assess the underlying issues that hinder progress. In Step 4, stakeholders craft solutions that ensure that innovations can be implemented at scale.

A value chain encompasses the entire spectrum of activities needed to take a product or service from its initial conception, through various production stages (which involve both physical transformation and the input of diverse producer services), to its delivery to end customers, and ultimately to its final disposal after use (Hellin and Meijer, 2006). The value chain concept offers a means to examine the actors, structures, and dynamics within value chains. It emphasizes the roles of chain actors, the connections between them, the distribution of value-addition along the chain, and opportunities for upgrading. Value chain actors involved in the transaction of a food product as it moves through the chain include input suppliers (e.g., seed suppliers), farmers, traders, processors, transporters, wholesalers, retailers, and final consumers.

Reardon and Timmer (2007) have thoroughly documented the role of innovations in improving food value chains, markets, and market structure. However, numerous socio-economic and environmental challenges in food value chains remain unresolved, hindering the full potential of innovations to transform food value chains towards sustainability (Bhat and Jõudu, 2019). Socio-economic issues primarily affect local populations and consumers. Challenges may affect household income, food price fluctuations, gender inequality, and health concerns, among others. Other significant challenges include food shortages, pre- and post-harvest losses, imbalances between supply and demand, insufficient land holdings, rising prices, consumer demand for safe and quality foods, nutritional security, access to market information for farmers, exposure to global opportunities for free trade or technology transfer, outdated information and intelligence, and disorganized and inadequate market infrastructure and supply chains (Bhat and Jõudu, 2019). These issues negatively impact value chain efficiency in many contexts. For instance, Kaur and Watson (2024) showed how inadequate post-harvest infrastructure in developing countries leads to food losses ranging from 20–50%, creating a significant barrier to value chain efficiency. Besides the above challenges, environmental problems can also affect value chain efficiency (Li et al., 2014). These problems include: climate change; unsustainable land, water, and energy use practices; waste disposal both on and off the farm; industrial food waste; and food waste at the consumer level.

Value chain analysis enables researchers to address dynamic linkages and identify issues within value chains, rather than focusing on static, isolated components (Kaplinsky and Morris, 2014). This approach involves a shift from tackling individual issues within the value chain to examining and responding to systems holistically (Kaplinsky and Morris, 2014). Understanding the relationships and dynamics among actors of agri-food value chains requires investigating attitudes and circumstances from the perspectives of all stakeholders (Leat and Revoredo-Giha, 2008). This understanding enables researchers to identify bottlenecks within the value chain and possible actions that can lead to improvement in the efficiency of the flow of a commodity within and off the chain (Lundy et al., 2014).

The LINK Methodology (Lundy et al., 2014) remains a credible approach for value chain analysis for understanding and identifying bottlenecks within the value chain. The LINK Methodology is a toolkit for building inclusive commercial relationships that link rural producers with modern markets. This methodology comprises four tools: the value chain map, the business model canvas, the New Business Model principles, and the prototype cycle. These tools form a basic toolkit that can be used to implement innovations from inception to completion, creating a recurring action cycle that fosters development and benefits for small producers. The LINK Methodology has proven effective in diverse settings, such as enhancing market access for small-scale potato farmers in the Andean region, successfully addressing value chain challenges (Devaux et al., 2018). Through the LINK methodology, value chain mapping can be used to identify value chain bottlenecks for scaling innovations.

5.2 Value chain mapping

The primary objectives of creating a value chain map are: to clarify the relationships and connections among various stakeholders; to understand the flow of products, services, information, and payments; to improve communication among all involved parties; and to identify key entry points or leverage opportunities to enhance the overall efficiency and effectiveness of the value chain. By the end of a value chain mapping exercise, the researcher gains a clear visualization of the various roles and connections among the participants within the chain. This process highlights sources of innovation and potential areas for improvement. It also provides a macro-level understanding of the situation and context, traces the flow of products and information, identifies key actors and functional stages, and reveals blockages, bottlenecks, and disruptions within the market system. Multi-stakeholder participants – from all sectors and stages of the value chain, ensuring a comprehensive representation of perspectives, from production to commercialization – conduct the value chain mapping exercise in workshops. The value chain mapping process consists of three key subtasks: mapping the core processes, identifying partners and networks, and analyzing external influences (Figure 4).

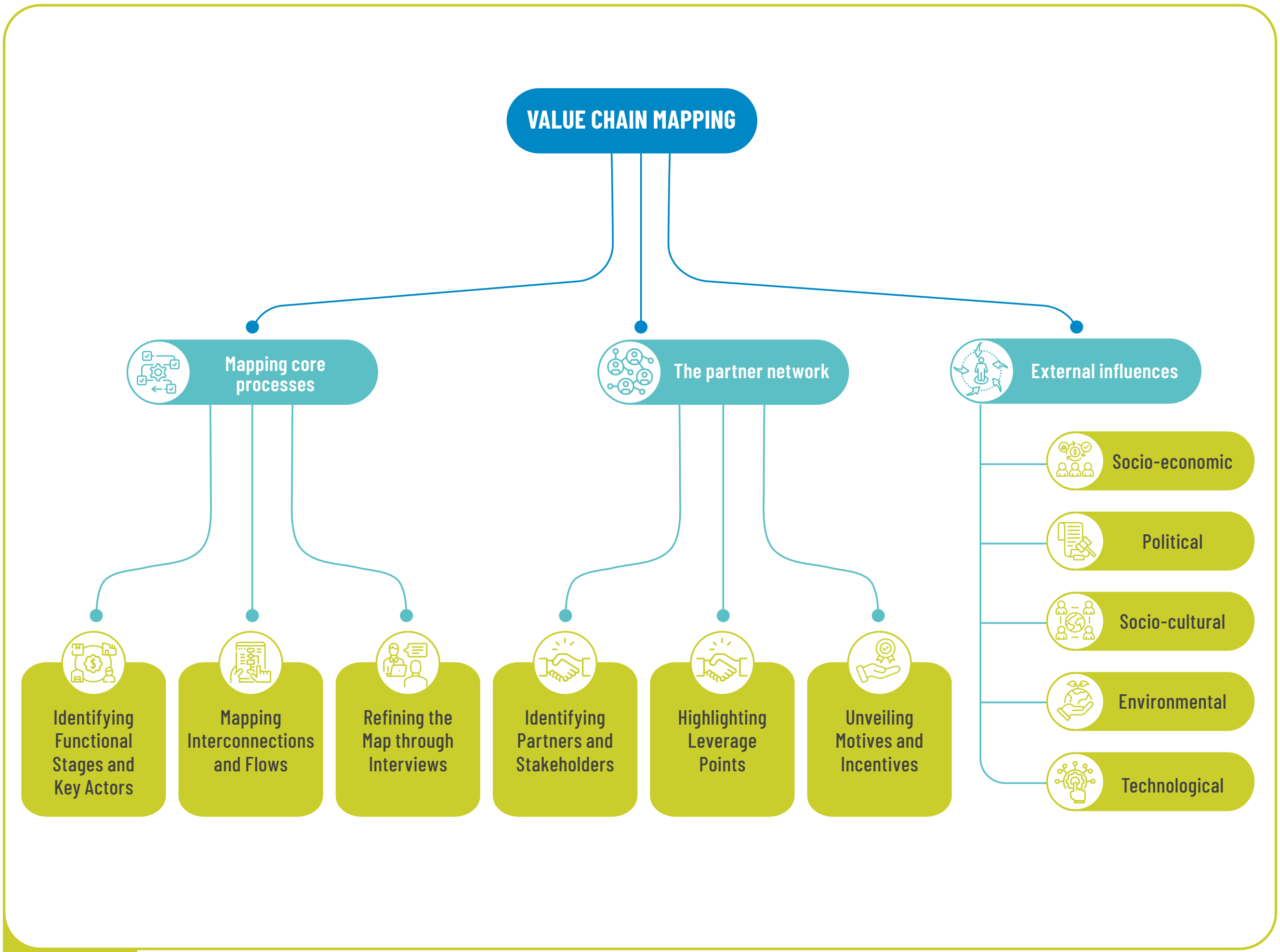

Figure 4 Value Chain Mapping.

5.2.1 Mapping core processes

The purpose of this exercise is to gain insight into how different business links work together as an integrated system. A visual representation of the value chain helps to understand the system's dynamics and can highlight key actors involved, the boundaries of the system, and the inter-relationships and functional roles within it. It also traces the flow of goods, services, payments, and information along the chain, pinpointing linkage points, gaps, or blockages between actors. The mapping of core processes involves four essential steps.

Identifying functional stages and key actors in the value chain: This process involves organizing the value chain into functional stages, from start to finish. During this process, the key actors at each stage of the value chain are identified, along with their respective roles.

Mapping interconnections and flows: In this stage, it's crucial to ask the actors to define their connections in terms of product flow, payments, communication, and knowledge exchange. Stakeholders should also consider that non-sequential connections, such as those between producers and traders, may exist. These relationships are then visualized on the value chain map by drawing connecting lines between the actors.

Refining the map through interviews: Once the basic structure of the value chain is established and participants have a general understanding of how the different stages are interconnected, more detailed information can be added. Stakeholders interview key actors within the value chain to gather further insights.

5.2.2 The partner network

Partners refer to external actors or organizations, whether public or private, that play a crucial role in the effective functioning of the value chain, even though they are not directly involved in its core stages. These partners are essential for ensuring the value chain operates smoothly, often by providing critical business support services at key stages such as production, post-harvest, and marketing. Primary information about partner networks is usually gathered from value chain actors during workshops, with additional insights obtained through market surveys. The process of mapping the partner network can be broken down into three stages:

Identification of partners and stakeholders: This involves asking questions such as: Who supports the business at each link of the market chain? How do they support the chain? What services do they offer? Are there any services missing, and who could provide them? Who are the allies, neutral parties, or obstructionists in the process?

Highlighting leverage points: To identify leverage points, researchers may consider the following questions: What are the domains of influence, interests, strengths, and relative power of each stakeholder to either support or hinder change? How is each stakeholder's power being utilized? Are key relationships within the system functioning effectively?

Unveiling motives and incentives: The final stage involves uncovering the motives and incentives of the stakeholders. Questions to consider include: What are the capacities and resources of each stakeholder? What incentives could drive the change process? What options or strategies could maximize incentives and facilitate change? Are there additional partners needed to address existing challenges?

Potato harvest from the conservation agriculture trials using cereal and leguminous cover crops in the villages of Pishauli and Pampa del Condor, Chugay, La Libertad, Peru, May 2024. CIP/W.Pradel

5.2.3 External Influences

Value chains are part of broader socioeconomic systems and institutions within a country. These institutions can be formal, such as laws and regulations, or informal, like cultural practices. They operate at various levels. These larger systems can either facilitate, restrict, or remain neutral towards the development of the value chain. Stakeholders should evaluate how both formal and informal institutions affect the participation of marginalized groups, including the poor, women, ethnic minorities, and other often-excluded members of society. To gather this information, it's important to consider five external forces – economic, political, socio-cultural, environmental, and technological. After presenting these forces, participants should be asked some key questions related to each area. Those forces most relevant to their specific context are selected. The sources of information at this stage are like those used in partner network mapping. The following are key questions for each specific area:

Socio-economic: What macroeconomic forces impact the performance of the value chain? What microeconomic factors influence the value chain's effectiveness? How do socioeconomic conditions affect the value chain's success?

Political: How do laws, regulations, standards, or taxes affect the value chain and the selected market? In what ways do private sector standards and business practices influence the value chain and the selected market? What other policies impact the value chain?

Socio-cultural: What are the cultural, religious, demographic, educational, and ethnic characteristics of the value chain's actors and partners? How do values, beliefs, attitudes, and lifestyles influence consumer preferences, business practices, and producer organizations?

Environmental: How do climate change and variability affect the value chain? How does the value chain interact with key environmental functions (e.g., water access, soil health)? Do environmental conditions support or hinder the chain's development?

Technological: Is technology accessible to value chain actors and their partners? Is the adoption of technology desired or feasible? How do the costs and availability of technology impact the value chain? Is technology developed locally for the value chain, or is it sourced externally?

By effectively conducting a value chain mapping exercise using the outlined stages, researchers can pinpoint bottlenecks and barriers within the chain that hinder the scaling of an innovation. This process not only helps in identifying these obstacles but also in developing targeted upgrading strategies to overcome them, thereby facilitating the smooth expansion and adoption of the innovation across the value chain. The insights gained from this exercise ensure that the innovation can be scaled inclusively, leading to greater impact and sustainability within the system.

5.3 Case study: Developing value chain upgrading strategies to overcome adoption barriers for scaling silvopastoral systems

The identification of barriers and bottlenecks in scaling SPS was conducted using the LINK methodology outlined by Lundy et al. (2014). This process involved three key activities: understanding the current state of the livestock value chain, value chain mapping, and identifying bottlenecks with stakeholders. To assess the state of the value chain, aspects such as the structure, key actors, regional characteristics, environmental factors, relationships between actors, and competitiveness levels were considered. Data were sourced from official departmental databases, sector reports, development plans, competitiveness policies, and statistics from organizations like the Departmental Committee of Caquetá Livestock Farmers, the Ministry of Agriculture and Rural Development, and the Colombian Livestock Federation (Fedegan).

A detailed value chain mapping was then performed, focusing on key actors, their processes, relationships, and information flows. Guiding questions included who the products were sold to, pricing, quality requirements, buyer-producer relationships, and the current regional environment.

The information was reviewed and validated through multi-stakeholder workshops, which aimed to update and map the value chain, identify market opportunities and competitive advantages, and pinpoint strengths, weaknesses, bottlenecks, and barriers. The workshops involved experts from various fields. Strategies for value chain upgrading were proposed.

Potato harvest from the conservation agriculture trials using cereal and leguminous cover crops in the villages of Pishauli and Pampa del Condor, Chugay, La Libertad, Peru, May 2024. CIP/W.Pradel

CHAPTER SIX: ASSESSING FINANCIAL MECHANISMS AND DESIGNING SUSTAINABLE BUSINESS MODELS TO SCALE INNOVATIONS

6

Planting of potato demonstration plot with zero and minimum tillage on Mr. Bernardino Carbajal's land in Mushit, Chugay, La Libertad, Peru. CIP/J.Rinza

6.1 Assessing financial instruments for scaling innovations

A range of actors across the food value chain, including smallholder farmers and agribusinesses, require capital to adopt innovations that will help them transition to sustainable practices. For instance, approximately 270 million smallholders globally need around USD 188 billion each year to meet essential agricultural needs, such as purchasing inputs or investing in new innovations (Apampa et al., 2021). Finance, therefore, plays a crucial role in any scaling strategy for food system transformation (Wattel et al., 2024).

According to Wattel et al. (2024), finance is a "relevant direct source of funds for climate investments." To scale low-emission innovations effectively, a diverse mix of financial resources from public, private, international, and domestic sources must be mobilized. These funds cover a substantial share of the costs involved in scaling innovations (Minh et al., 2021; Rosenstock et al., 2020). Also, the funds have the potential to generate additional revenue streams for farmers and agribusinesses, thereby encouraging investments in climate-relevant measures (Wattel et al., 2024).

Wattel et al. (2024) identified four types of financial instruments that can facilitate the scaling of innovations for food system transformation: private financial instruments, private incentives, public policy instruments, and blended finance. Private financial instruments refer to financial products and services such as loans, equity investments, insurance, guarantees, and bonds offered by the private sector on a commercial basis. These are reimbursable and typically incur interest costs. Some instruments are suitable for smallholder farmers, while others are designed for large-scale farmers. Private incentives consist of various types of incentives provided by private sector actors to encourage the production of more sustainable products. Examples include carbon credits, price premiums for sustainable and climate-friendly products, and interest discounts on climate-related investments. Public policy instruments encompass a wide range of policies, including those related to trading, forestry, farming, land use, environment, nutrition, dietary guidelines, agricultural trade, corporate responsibility, and the financial sector. These policies can have a positive impact on the scaling of innovations. Blended finance typically involves a combination of private and public partners who share investment risks according to their objectives and capacity to bear risk. At this stage of the framework, we recommend that lead scaling organizations identify financial instruments that can effectively support their sustainable business models for food system transformation.

Event for women on native seeds organized by tree sisters. 📷 J. Mosquera

6.2 Designing sustainable business models

Sustainable business models are recognized as a promising strategy for enhancing the success of scaling innovations (Boons and Lüdeke-Freund, 2013). Companies, governments, and development agencies employ these models to promote (i) smallholder participation in value chains, (ii) initiatives to catalyze and de-risk large-scale investments, and (iii) products and services that target the poor and vulnerable (Pels and Sheth, 2017). By examining business models that support the scaling of innovations, organizations can identify the best strategies to achieve their scaling ambitions. This is especially pertinent for innovations targeting food systems transformation, where potential adopters are primarily motivated by factors such as productivity, profits, and food security, rather than GHG mitigation (Appleyard and Chesbrough, 2017).

The fifth step of the Six-step Approach concerns developing inclusive business models for the product or innovation. The LINK methodology described by Lundy et al. (2014) recommends four steps for developing inclusive business models for scaling innovations (Figure 5).

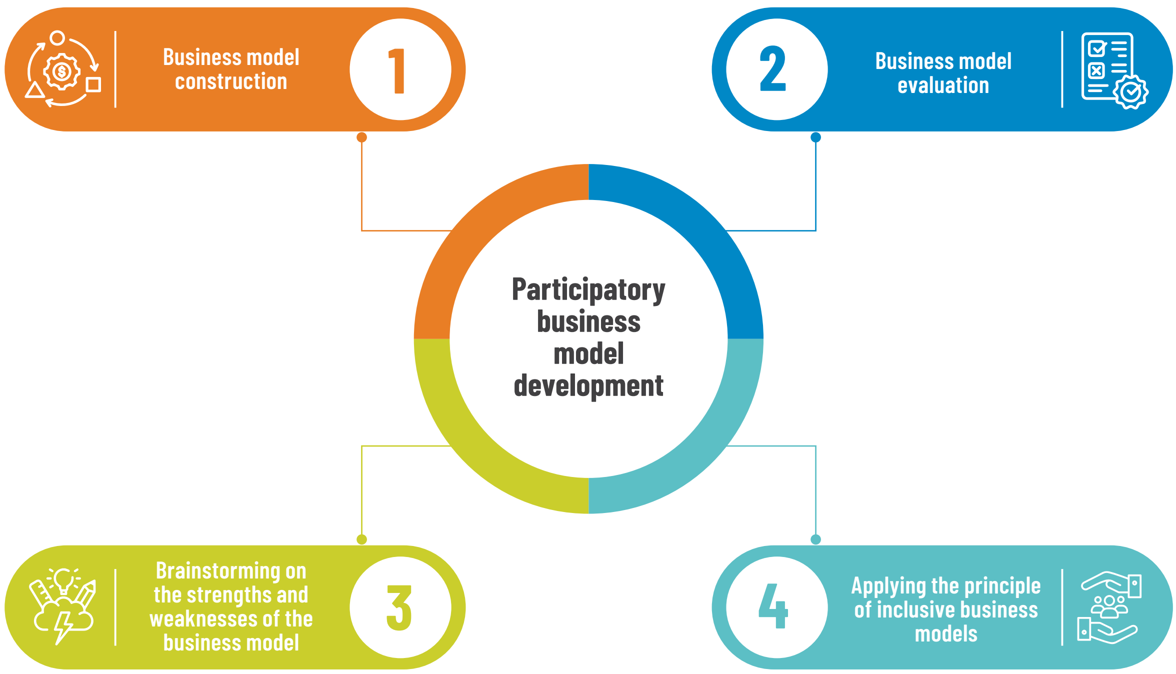

Figure 5 Steps for developing business models.

Inclusive business models should facilitate the connection of a group of producers with buyers through innovations, ensuring mutual benefits (Lundy et al., 2014). In inclusive businesses, farmers gain access to markets, knowledge, technology, and income, while buyers obtain essential products at a competitive cost, often with higher quality. These business models support economic and social development by linking actors in a coherent and traceable manner, adapting to a market limited by supply (Lundy et al., 2014).

6.2.1 Business model construction

Through a workshop, relevant stakeholders construct participatory business models of the value chain. The workshop identifies and selects the key business model that works for the value chain, indicates areas for innovation or improvement, and identifies ways to promote enhanced marketing, social inclusion, and poverty reduction within the product value chain (Lundy et al., 2014).

According to Lundy et al. (2014), the process of constructing a business model begins with an explanation and introduction of the business model template concept. The template describes each of the nine blocks in detail (Table 1). Next, key guiding questions are used to expand upon the information needed for each block, forming the essential components of the business model (Table 1).

Table 1. Business model template (Adapted from Osterwalder and Pigneur, 2010).

Key Partners

- Who are the primary direct and indirect partners?
- What essential resources do you acquire from your partners?
- How would you assess the quality of the resources obtained from your partners?

Key Activities

- What primary activities are linked to production, process, and product sales?
- What primary activities are linked to logistics management?

Key Resources

- What essential resources are needed to create and maintain the value proposition?
- Are there any resources missing that are necessary for the efficient operation of the business?

Value Proposition

- What type of product do you sell to each customer?
- What are the tangible characteristics of the product?
- What are the intangible characteristics of the product?
- What makes your product different?

Customer Relationship

- How often do you communicate with each customer?
- What communication method is employed with each customer?
- What information is communicated to each customer?
- Is the customer relationship positive, negative, or neutral?

Channels

- What mode of transportation is utilized to deliver the product to the customer?
- Who is responsible for covering the transport costs and what the delivery terms?
- How long does transportation take?
- How is the product stored?

Customer Segments

- Who are your customers?
- What does each customer need?
- Where is each customer?

Cost Structure

- What are the most critical costs associated with the business model?
- Which costs remain constant?
- Which costs fluctuate?
- What portion of your costs is supported by external sources?

Income Sources

- What is the total sales value per customer (e.g., monthly, annually)?
- What is the total sales value per product category?
- What is the profit margin per customer?
- What payment method does each customer utilize?
- Additional revenue: What sources of income, besides product sales, do you have?

After explaining each block, stakeholders should identify where value is obtained. This requires analyzing each block using the key questions indicated in Table 1. During this activity, keep the discussion focused and concise. Various ideas may arise in response to the key questions, and these should be noted down and incorporated into the template.

6.2.2 Business model evaluation

To evaluate the overall performance of the business model, a comparison must be made between the sources of revenue and the cost structure.

Additionally, it is also important to analyze the following key aspects:

Gross profit margin: This metric reflects a business's health by indicating how much the organization earns for every dollar of sales. A higher percentage indicates greater profits or funds available for expenses. *Gross profit margin (%) = gross profit/revenue x 100*

Breakeven point: This is the production quantity at which income equals costs, meaning the company neither earns nor loses money. This metric is crucial as it indicates when the company will start generating profits.

6.2.3 Brainstorming on the strengths and weaknesses of the business model

In this activity, the initial group needs to be divided into smaller subgroups, with each one brainstorming the strengths and weaknesses of the business model. The evaluation should be conducted for each of the nine blocks, highlighting weaknesses and strengths using positive and negative indicators. After this is done, participants identify the weaknesses and strengths arising from the business model template developed. They should also specify the cause or driver of these effects. Once all participants in the subgroup have contributed, the session is concluded. The last activity is to assemble all the participants together for a plenary session to discuss the results and conclusions reached.

Tropical Dry Forest Deforestation. K.Argote

6.2.4 Principles of inclusive business models

The principles serve as a guide to establishing the most inclusive and enduring commercial relationships, identifying areas for improvement in corporate businesses to promote the sustainable involvement of small producers. These principles should guide the key considerations when developing a business model to connect small-scale producers with contemporary markets. According to Lundy et al. (2014), the six principles that should be considered when designing inclusive models in the food value chain include effective market linkages, chain-wide collaboration, fair and transparent governance, equitable access to services, inclusive innovation, and measurement of outcomes.

6.3 Case Study: Developing business models for scaling silvopastoral systems

Business models for scaling SPS during the project were developed through participatory workshops with stakeholders in the dairy value chains, following the approach suggested by Lundy et al. (2014). Before these workshops, existing business models within the value chain were evaluated to assess their strengths, weaknesses, and potential for entrepreneurship development. The main objective of these workshops were to evaluate current businesses within the value chain, to identify a key business model that could connect a group of producers through innovations, to build relationships with buyers, and to achieve mutual benefits.

The construction of the business models began with an introduction to the business model template outlined by Osterwalder and Pigneur (2010). The nine blocks – key partners, key activities, key resources, value proposition, customer relationships, channels, customer segments, cost structure, and revenue streams – were explained in detail to participants. Each block was then analyzed using key questions prescribed by Lundy et al. (2014). Insights from the participatory discussions were used to populate the nine blocks. The potential performance of the business model was evaluated to ensure a balance between income sources and cost structure, aiming for long-term sustainability.

Participants were divided into small groups to brainstorm each block, identifying weaknesses and strengths. After this, the vision for the business model was developed, emphasizing the inclusion of small producers. Once the business model was constructed, participants evaluated how well it aligned with business model principles to ensure inclusiveness. These principles included collaboration between actors, effective market linkages, transparent governance, equitable access to services, inclusive innovation, and measurable results.

Measurement of gas emissions in cocoa agroforestry crops in Cesar, Colombia. CIAT/V.Yomayuza

CHAPTER SEVEN: MEASURING CLIMATE ACTION, SUSTAINABLE DEVELOPMENT CO-BENEFITS AND UNINTENDED NEGATIVE EFFECTS

7

Cacao has been a symbol of abundance since pre-Columbian civilizations. CIAT/J.Marín

7.1 Explanation and guideline

Any climate action project that seeks GHG emissions reductions or carbon sequestration must accurately calculate those reductions over time using scientifically rigorous methods. Measurement is needed to identify emission trends, evaluate the impacts of mitigation actions, and determine where to focus GHG emissions reduction efforts (Tiepolo et al., 2002). In addition to reducing GHG emissions, scaling innovations for low-emission food systems can yield non-climate benefits (co-benefits). When scaling such innovations, adopting a co-benefits approach can provide a cohesive framework to incentivize stakeholders to collaborate on ambitious policies that achieve both climate mitigation and non-climate goals. Similarly, understanding the adverse side effects that counter other development objectives is crucial to recognizing and minimizing trade-offs that could impact the delivery of the SDGs (Cohen et al., 2021). Step six of this approach emphasizes measuring the impacts of scaling on GHG emissions reduction, sustainable development co-benefits, and any unintended consequences on other development goals (Figure 6).

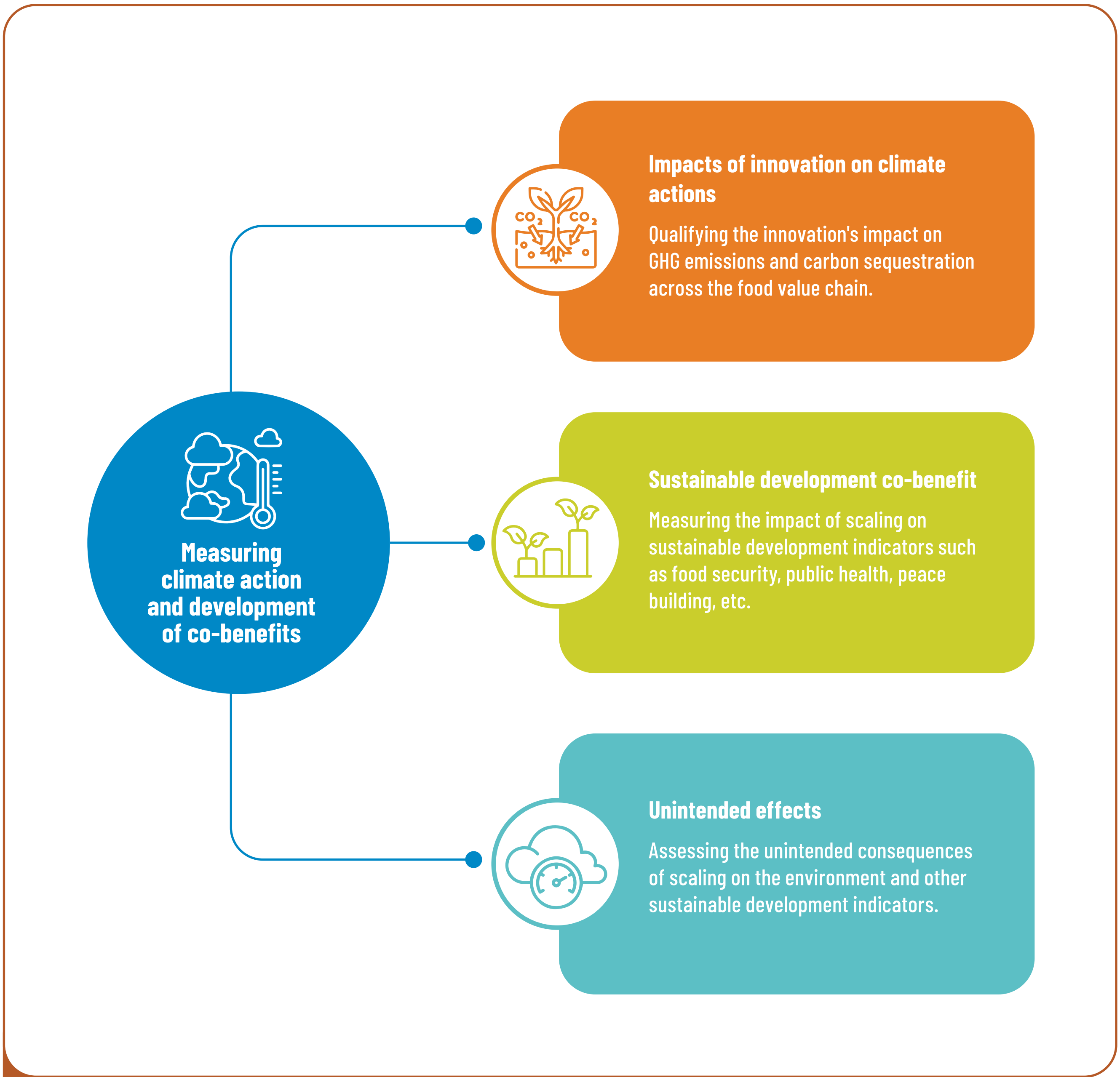

Figure 6 Measuring climate action and development co-benefits.

7.1.1 Measuring the impacts of innovations on climate action

To effectively quantify the impacts of innovations on food system's GHG emission reduction, the monitoring, reporting, and verification (MRV) method (Singh et al., 2016) is often used. MRV involves the following key steps and procedures (Singh et al., 2016):

Measure or monitor (M): This step focuses on collecting data and information related to emissions, mitigation actions, and support. It includes the direct physical measurement of GHG emissions, estimating emissions or reductions using activity data and emission factors, and gathering details on support for climate change mitigation efforts.

Report (R): The collected data is then organized into inventories and other standardized formats, making it easily accessible to a broad audience. This step ensures transparency and facilitates the public disclosure of critical information.

Verify (V): The reported information is periodically reviewed, analyzed, or independently assessed to ensure its completeness and reliability. Verification is essential for maintaining accuracy, adhering to established procedures, and providing valuable insights for continuous improvement.

This methodical approach ensures that all aspects of emissions, mitigation actions, and support are accurately measured, reported, and verified, contributing to effective and transparent climate change management.

Aside from GHG emission measurement, carbon inventories are also carried out during this stage to estimate the differences between the with- and without-project carbon pools. Carbon inventory and monitoring plans are designed to quantify the changes in key carbon pools in and around the project area. Examples of project-level carbon inventory guidelines are provided by Winrock (Walker et al., 2012) and CIFOR (Hairiah et al., 2001), among many others.

7.1.2 Measuring sustainable development co-benefits

The concept of "co-benefits" involves achieving multiple goals or positive outcomes simultaneously through policy measures, private sector investments, or a combination of both. In the context of climate change mitigation, co-beneficial strategies are those that address climate objectives while also promoting improvements in areas such as economic growth, air quality, public health, and resource efficiency among others (UNFCCC, 2015). This aligns with the notion of "Sustainable Development Benefits," which highlights the importance of supporting outcomes that contribute to sustainable development goals, as emphasized by the United Nations Framework Convention on Climate Change (UNFCCC, 2015). Currently, multiple frameworks and tools have been used for identifying linkages between mitigation actions and sustainable development.

Nationally Appropriate Mitigation Actions (NAMAs) Sustainable Development Evaluation Tool: This spreadsheet-based tool, developed by South Pole and MDG Carbon (2014), is specifically designed to support Nationally Appropriate Mitigation Actions (NAMAs). It guides users through a high-level evaluation of the sustainable development impacts of proposed NAMAs, uniquely aligning with the Sustainable Development Goals (SDGs). The tool offers substantial structure for identifying indicators across various co-benefits, supporting both pre- and post-assessment stages. While it provides recommended categories, the final selection of specific indicators is adaptable to each country's priorities (Olsen et al., 2015).

Development Impact Assessment (DIA) Visualization Tool: The DIA tool is a decision-support tool designed to present the impacts, costs, and co-benefits of mitigation strategies on a single page, offering a clear visualization of the potential outcomes (Cameron et al., 2014). It incorporates both quantitative and qualitative data, enabling comprehensive discussions about the advantages of various mitigation options. With the DIA tool, mitigation costs can be detailed numerically and co-benefits represented visually with symbols indicating effects as neutral, negative, minor, positive, or highly positive.

The Real Value of Robust Climate Action: This tool is tailored to measure co-benefits of an action that can be more easily quantified and monetized, such as biodiversity, improvements in the balance of payments, job creation, livelihoods, and health impacts. It can be applied across various sectors, offering a structured approach and clear process guidance for monetizing these impacts (Olsen et al., 2015).

7.1.3 Measuring unintended negative effects

Scaling innovations for low-emission food systems, while essential for climate mitigation, can sometimes lead to unintended negative effects if not carefully managed. In developing countries, for example, low-emission food systems can be especially impacted in areas affected by land-use changes, with agricultural expansion leading to deforestation (Bowen et al., 2011). Scaling efforts may involve land investments projects that alter natural resource access, potentially sparking conflicts of property rights especially in settings where institutional frameworks are weak (Adger et al., 2014).

Also, the adoption of advanced agricultural technologies designed to reduce greenhouse gas emissions might require substantial upfront investment, which can strain the financial capacity of smallholder farmers and increase inequity in rural communities (Zougmoré et al., 2021). Mirumachi et al. (2020) reported that most interventions targeting low emissions do not automatically lead to poverty reduction. According to these authors, such interventions may offer little to no benefit to disadvantaged groups and could even negatively impact different societal groups. Therefore, in scaling innovations for low-emission food systems, project advocates should carefully assess and mitigate any unintended negative consequences to reduce potential adverse impacts. This approach ensures that development efforts remain truly sustainable and inclusive.

Training for cocoa farmers in Caquetá. CIAT/E.Ramírez

7.2 Case Study: Measuring climate action and sustainable development co-benefits associated with scaling silvopastoral systems

Following the scaling of SPS in Colombia, studies were conducted to assess the innovation's impacts on climate action and SDG co-benefits. The climate action aspect focused on GHG emission reductions, specifically CH_4 and N_2O, while the SDG co-benefits examined the innovation's impacts on biodiversity (birdlife and vegetation), soils, and water footprint. Additionally, potential deforestation leakage resulting from SPS scaling are being investigated (Castro-Nunez et al., 2021).

Measuring GHG emissions is vital for understanding and managing climate change impacts. The project categorized emissions into primary and secondary sources. Primary GHG emissions occurred within the farm gate, including CH_4 emissions from enteric fermentation in various animal groups. CH_4 and N_2O emissions also came from both manures deposited in the field and managed manure. These emissions were measured using the static flux chamber method, with calculations based on the IPCC (2019) guidelines under the Tier 2 approach. Secondary emissions encompassed CO_2, CH_4, and N_2O emissions from the transportation and manufacturing of inputs used in the production system, fuel and gas combustion, and electrical energy usage. These emissions and their intensity were estimated using life cycle analysis methodology as outlined by Thomassen et al. (2008).

Bird diversity monitoring was conducted using the fixed radius point counting method (50-meter radius for a 30-minute period) as described by Reynolds et al. (1980). Additionally, woody species composition and vegetation structure were evaluated in a 1000 m^2 plot in each study site. Water footprint estimates were also calculated following Romero et al. (2016), using functional units of analysis such as kilograms of milk corrected for fat and protein (Thomassen and Boer, 2005) and kilograms of live meat produced. Additionally, deforestation leakage linked to SPS scaling is currently being assessed through proximity and counterfactual analysis of forest loss, applying methodologies like those used by Ford et al. (2020).

Process for making organic fertilizer. CIAT/E.Ramírez

Conclusion

The Six-step Approach outlined in this study offers a practical guide for policymakers, researchers, and practitioners to navigate the challenges associated with developing an enabling environment for scaling innovations toward low-emission food systems, ensuring that these efforts not only reduce greenhouse gas emissions but also align with sustainable development goals (SDGs). By applying the Six-step Approach, low-emission development can contribute to the broader effort of transforming food systems to become more sustainable and resilient, providing a blueprint for achieving significant climate mitigation impacts while minimizing negative spillovers on other SDG outcomes. The case study on scaling intensive silvopastoral systems in Colombia further illustrates the practical application of this approach, demonstrating its potential to deliver both environmental and socio-economic benefits in real-world settings. The case studies in this paper demonstrate the critical role of a structured approach in creating an enabling environment for scaling innovations toward low-emission food systems, particularly in the complex contexts of low- and middle-income countries. The findings highlight the importance of understanding the direct and underlying drivers of food system emissions, aligning interventions with government development priorities, and fostering cooperation among stakeholders through effective governance models. The framework also emphasizes the need for developing inclusive business models and financial mechanisms that support the widespread adoption of these innovations. In conclusion, the Six-step Approach offers a valuable framework for scaling innovations that can lead to a low-emission food system transformation, providing a pathway for achieving climate goals while supporting sustainable development in diverse and challenging contexts.

During the technical tours of the SLUS project, producers received training on harvest and post-harvest processes. CIAT/E.Ramírez

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