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Financial Inclusion for Strengthening Climate Resilience

A Literature Review

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Contents

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1 Introduction

Shifts in rainfall, extreme temperatures, droughts, and flooding are making agricultural systems, farmers, and small- and medium-sized enterprises (SMEs) more vulnerable. Smallholder farmers and impoverished rural residents, primarily in developing countries, are particularly susceptible to these extreme climate shifts and lack the emergency relief, preventive measures, tools, and strategies necessary to cope with the effects of climate change (FAO, 2020; Harvey et al., 2018; Jawo et al., 2023; Pulleman et al., 2023; Bracken et al., 2023). In response, agricultural research and innovation efforts are focusing more on making the entire agricultural value chain resilient. Various strategies, such as *climate-smart agriculture (CSA), precision agriculture, nature-based solutions, regenerative agriculture, organic agriculture, agroecology, peasant agriculture, and sustainable agriculture*, have been employed in different value chains by various stakeholders in different contexts while addressing climate change in various ways. More evidence is required on how and where these strategies have been implemented to identify the gaps and opportunities to effectively address the real needs and struggles of farmers in a sustainable manner.

Considering the above, the FAIR Center at Tecnológico de Monterrey and the KIT Institute are conducting research on financial inclusion to strengthen climate resilience. This study will focus on the adaptation and mitigation strategies used by Mexican and other Latin American coffee farmers. This literature review will explore existing adaptation and mitigation strategies in a comprehensive manner, considering the realities of farmers, their struggles to cope with the consequences of climate change, and how financial inclusion can support them. Using a differential approach that considers the effects of social and gender dynamics, this literature review will provide a foundation for evaluating the impact of access to financial products and services on improving mitigation and adaptation practices.

The review highlights key climate-resilient strategies, challenges, and opportunities for smallholder coffee farmers. Chapter two clarifies key concepts such as climate resilience and sustainable agriculture to qualify the impact of climate change on farmers. It also explores the main barriers that farmers face when trying to respond to climate change and find sustainable solutions. Chapter three presents the most prominent mitigation and adaptation strategies used by different actors in the coffee sector and other value chains. Chapter four explores the concept of transition and the need for a just transition to achieve sustainability, with a specific focus on the crucial role of financial inclusion in supporting this transition. Finally, Chapter Five illustrates the relevant research gaps identified in the literature that could be further explored by this study or that could form the basis of other pertinent, much-needed studies that would contribute to achieving sustainable climate resilience.

2 Qualifying the Impact of Climate Change on Farmers

2.1. Clarifying Key Concepts

Before exploring the realities and struggles of farmers in finding strategies to cope with the impact of climate change, it is important to clarify key concepts. Notions such as resilience, climate resilience, vulnerability, and sustainable agriculture are defined and understood quite differently by key actors and institutions. Thus, our aim in exploring the existing literature is to identify the most appropriate definitions of these concepts to guide this review.

Resilience is an increasingly popular word in almost any climate change discussion. As an isolated concept it has its origins in environmental studies and has been defined in different ways. Crawford (Buzz) Holling defined the "resilience of an ecosystem as the measure of its ability to absorb changes and still exist", which requires stability; meaning "the ability of a system to return to its equilibrium state after a temporary disturbance" (McAslan, 2010). In the specific context of climate change, the Intergovernmental Panel on Climate Change (IPCC) defines resilience as the "...capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation" (IPCC, 2014).

Climate resilience thus derives from the abovementioned definition of resilience and refers to the capacity to prepare for, *adapt* to *absorb* and recover from the impacts of changes in climate and extreme weather (C2ES, 2025). The OCDE uses two additional terms to understand climate resilience: learn and *transform*. It defines climate resilience as "...the capacity of human and natural systems to learn, adapt, and transform in response to risks induced or exacerbated by climate variability and change" (OCDE, 2021). Furthermore, FAO considers that short and long-term climate mitigation and adaptation strategies could enhance resilience, while ensuring transparent and inclusive participation of multiple actors and stakeholders in decision-making and management processes (Alvar-Beltran et al. 2021).

Vulnerability. Resilience is closely related to vulnerability, but in opposite ways. *Vulnerability* refers to the propensity or predisposition to be adversely affected (IPCC, 2014), by different types of harm. One of the most relevant harms for agricultural producers is climate change, which affects them in different ways and levels.

Sustainable agriculture is defined as "the efficient production of safe, high quality agricultural products, in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species" (Buckwell et al., 2015). Furthermore, it should permanently meet essential conditions congruent with ecological stability, economic viability and socially fair agricultural systems (Liu, 2023). FAO considers that sustainable agriculture must fulfill the needs of present and future generations, and it identifies four pillars of food security to which it contributes: *availability, access, utilization* and *stability* – and the *dimensions of sustainability* (environmental, social and economic) (FAO, 2025).

Absorptive, adaptive and transformative capacities. To reduce vulnerability and increase resilience, people must increase certain capacities: absorptive, adaptive and transformative capacities (Béne et al, 2012). *Absorptive* is a capacity to absorb shocks and reduce risks of exposure to them and is present before shocks occur; *adaptive* capacity refers to the way societies react and adjust to new conditions, but if this capacity is exceeded, *transformative* capacity will operate towards a structural change of society. While absorptive is a capacity useful mainly before shocks, adaptive and transformative capacities are important aftershocks. This framework is also useful for understanding social and gender dynamics. As Rietveld et al., (2023) evidence, gender norms directly influence women's opportunities for developing economic resilience to climate change in food production systems.

2.2. Coping with the Impact of Climate Change: The Struggle of Farmers

As mentioned in the introduction to this document, the impact of climate change is disproportionate among the world's population, particularly affecting farmers. When examining the socioeconomic, geographical, and weather conditions of these farmers, significant differences emerge. This literature review will present evidence that smallholder farmers, especially those in developing countries and countries more susceptible to climate disasters, have more difficulty accessing financing and mechanisms that would enable them to adopt climate-resilient strategies. Among these farmers, women tend to face even greater structural challenges.

The literature consistently highlights the significant challenges that climate change poses to smallholder farmers (US Global Leadership Coalition, 2021; Harvey et al., 2018; Jawo et al., 2023; Pulleman et al., 2023; Bracken et al., 2023). Due to limited information, resources, and technology for costly adaptation, they are in a significantly vulnerable position, making them more susceptible to shifts in coffee-growing regions, pest migration, and changing weather patterns (Jawo et al., 2023). Studies have shown that smallholder farmers tend to have low adaptive capacity due to their *high dependency on rain-fed agriculture and cultivation of marginal areas, lack of access to technical or financial support* (Harvey et al., 2018), *lack of income*

diversification, lack of knowledge of policies related to the sector, environmental laws, spatial planning and poor access to alternative technology (Rahn et al., 2014).

According to the International Coffee Organization (ICO) and the United Nations Industrial Development Organization (UNIDO), coffee farmers face mounting pressure to improve sustainability, productivity, and quality due to climate change, price volatility, aging plantations, and strict regulations. They also struggle with limited access to financing, knowledge, and resources (ICO and UNIDO, 2024). For example, Rahn et al. (2014), in their study of coffee smallholders in Nicaragua, highlight their vulnerability and the serious threats posed by climate change. The study predicts the difficulties they will encounter when adapting to extreme changes and emphasizes the necessity of innovative strategies to improve their livelihoods (Rahn et al., 2014). In a study on "Regenerative Farming Practices and Sustainable Coffee of Ethnic Minority Farmers in the Central Highlands of Vietnam," Quan et al. (2021) described how farmers were grappling with decreasing harvests due to climate change. The article discusses their reluctance to switch to organic methods due to concerns about initial costs and pest management despite recognizing the potential benefits of regenerative practices (Quan et al., 2021). Furthermore, Ruiz-Garcia (2021) observed an increase in pests and diseases in a study of Mexican coffee farmers and noted that this finding coincides with other studies focusing on coffee-growing regions of Mexico and Latin America).

2.1.1. Struggling to Access Inclusive Finance

A lack of financial support poses a constant challenge for farmers when it comes to implementing climate adaptation and mitigation strategies (Sigh et al., 2020; Ramírez et al., 2015). Green farming requires significant investments in technology, resources, and training to modify existing practices, such as transitioning to more resilient crop varieties, efficient water and soil systems, and precision agriculture tools. It also requires investments in shade tree adoption (Wienhold & Goulao, 2023; Sathyapriya et al., 2024). However, studies have shown that efforts to make financial systems and services more inclusive are limited. Although services such as grants, low-interest loans, and subsidies are available (Bracken et al., 2023), they have yet to address the actual needs of farmers and SMEs.

According to the Consultative Group on International Agricultural Research (CGIR), food systems must receive an additional $400 billion per year by 2030 — less than 0.5% of the global Gross Domestic Product (GDP) — to achieve climate mitigation and adaptation targets (Marshal et al., 2023). In this regard, the Center for Financial Inclusion indicates that, although there has been a significant increase in national and international funds to mitigate and adapt to the impacts of climate change, these funds have mainly been invested in top-down greenhouse gas emissions mitigation efforts (Miller et al., 2023). Investments in adaptation, particularly for the most vulnerable farmers, households, and MSMEs, remain insufficient (Miller, H., 2023; Buchner et al., 2021; Marshal et al., 2023).

Several initiatives and interventions aim to enhance financing for climate-related activities (Miller et al., 2023). For instance, in 2015, the International Coffee Organization (ICO) and Coffee and Climate presented a guideline document to promote the integration of the coffee sector into countries' Intended Nationally Determined Contributions (INDCs) for submission to the United Nations Framework Convention. The guide emphasizes the

importance of informing policymakers about the impacts of climate change on coffee and takes an integrated approach, acknowledging that "adaptation, productivity, and mitigation actions are not mutually exclusive" (ICO, 2015, p. 3). Another example is the work to increase the New Collective Quantified Goal (NCQG)[1] on climate finance, which was agreed upon at the UN COP29 in November 2024 at USD 300 billion annually.

2.1.2. The Differential Impact of Climate Change on Women

When considering the differential impact of climate change on smallholder farmers' livelihoods, it is clear that women are disproportionately affected. Their ability to mitigate and adapt to climate change is often disproportionate and determined by unequal gender norms, access and control of resources, and institutional inequalities (Pyburn, R., & Hallin, R., 2023; Duffy et al., 2020). The literature provides ample evidence to support this claim. Education is a clear example of this inequality; many rural women lack access to it, which restricts their productivity, earning potential, and ability to adapt to climate change (Ramirez et al., 2015). Similarly, women face challenges accessing agricultural technologies and mechanization, which leads to lower productivity in plots managed by women and in households headed by women (Pyburn et al., 2024).

Gender norms play a crucial role in the unequal position of women farmers and their limited opportunities to adopt climate resilience practices. For instance, research conducted in Honduras has shown that local gender norms primarily assign authority over agricultural production to men while assigning domestic and caregiving responsibilities predominantly to women. This gender division of labor limits women's mobility and availability of time, both of which are crucial for learning and adopting new agricultural techniques (Palacios et al., 2023; Carr & Thompson, 2014). Research in Malawi found that male farmers benefit more than female farmers from formal extension services for agroforestry. This disparity is due to differences in access to these services and the distinct sociocultural challenges women face (Duffy et al., 2020).

In recent decades, women have increasingly taken on formal roles within different value chains, including the coffee supply chain. They serve as cooperative members and leaders. However, they still face significant barriers, including limited access to essential resources such as land, agricultural inputs, information, technical assistance, and financial resources and services. As will be further explained in Chapter Four, the challenges male farmers experience when trying to access financial services are heightened for women due to discriminatory gender norms, limited access to basic resources, and overall structural inequalities. Even within financial inclusion initiatives, the specific needs and interests of women are often overlooked or disregarded. However, interesting initiatives, many of which are locally based and emerge from collective efforts, such as Village Savings and Loans and cooperatives, address women's financial concerns and provide innovative alternatives to improve financial access and mitigate the effects of climate change on women farmers (2Scale, 2022; Okello & Mwesigwa, 2022; Seidu, 2018; Hendricks et al., 2011; Lipper et al., 2022).

[1] ¨The New Collective Quantified Goal (NCQG) is a key element of the Paris Agreement, designed to set a new financial target to support developing countries in their climate actions post-2025. ¨ In Climate Action (2024) The NCQG: What is it and why does it matter? https://www.weforum.org/stories/2024/07/new-collective-quantified-goal-what-is-it-and-why-does-it-matter/

It is crucial to recognize the vulnerabilities that women experience, which are intensified by climate change, in order to understand how productive and reproductive tasks evolve and how natural resources are utilized and managed (Suárez et al., 2019). This recognition also provides opportunities for targeted, gender-transformative interventions (Rietveld et al., 2023). These types of approaches could promote gender equality in various spheres of influence. The growing presence of women in the formal agricultural sector highlights the necessity of addressing economic opportunities as well as the sociocultural and political factors contributing to gender inequality.

The literature clearly shows that smallholder farmers are highly vulnerable and face enormous challenges in implementing climate-resilient practices. Many face similar challenges, but socioeconomic and geographical conditions pose different barriers to diverse groups. Therefore, tailored strategies that comprehensively and holistically respond to these specific realities are needed.

3 Adaptation and Mitigation Strategies for the Impact of Climate Change

In light of the profound impact of climate change on agricultural systems, it is essential to acknowledge the various approaches developed to address these challenges. Although agriculture is highly vulnerable to climate change, it also plays a pivotal role in finding solutions. This dual role is evident in the adoption of various climate-resilient strategies, such as regenerative agriculture, which aim to minimize negative environmental externalities while enhancing ecosystem services (Schreefel et al., 2020). This chapter explores adaptation and mitigation strategies implemented under various approaches, employed by farmers, or recommended by the literature.

A broader perspective on climate adaptation and mitigation underscores the importance of biodiversity conservation, reduced chemical inputs, improved soil quality, and strengthened farmer livelihoods (Pulleman et al., 2023). The existing literature further underscores the need for diversification and the careful, context-specific implementation of these practices (Jawo et al., 2023; Lipper et al., 2022; Pulleman et al., 2023). This integrated approach is reflected in Rahn et al. (2014) when addressing the mitigation potential of climate change in coffee production. Rahn et al. (2014) present a methodological framework for assessing "triple benefits" (see Figure 1), which illustrates the interconnected nature of climate change adaptation, mitigation, and improvements to the livelihoods of smallholders.

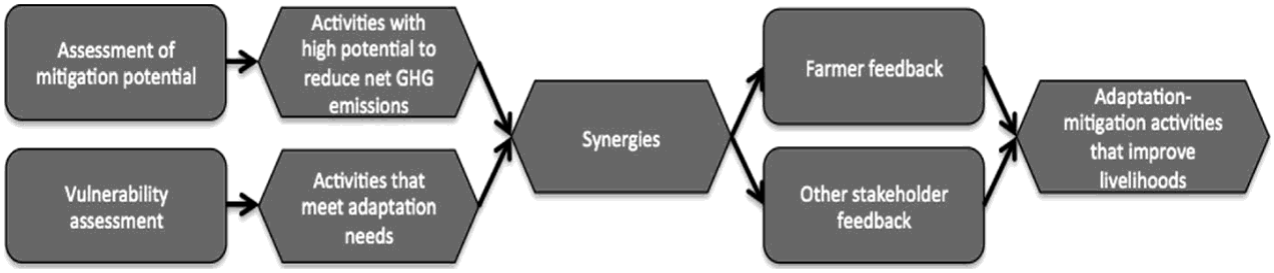

Fig. 1 *Methodological framework for assessing "triple benefits"* (climate change adaptation, mitigation, and livelihood improvement) for coffee farmers in Nicaragua in Rahn et al. (2014).

This framework illustrates the need, emphasized by scholars such as Eakin et al. (2012) and Hidayat (2024), to strengthen adaptive capacities at the individual level for personal benefit and at the community and landscape levels to enhance resilience in coffee-growing regions. Their research shows that this can be achieved by promoting farm-level diversification and community-level investment in collective action and organizational capacity.

Recent strategies, such as climate-smart agriculture, precision agriculture, nature-based solutions, and regenerative agriculture, build on previous efforts, including organic agriculture, agroecology, peasant agriculture, and sustainable agriculture. Table 1 below provides definitions of these strategies and their advocates.

Strategy	Definition	Proponents / participants
Climate Smart Agriculture (CSA)	A set of agricultural practices and technologies which simultaneously boost productivity, enhance resilience, and reduce GHG emissions (https://www.worldbank.org/en/topic/climate-smart-agriculture, 2024)	Firms: Yara, CropLife, Organizations: World Bank, FAO, AGRA, Earth.org,
Precision Agriculture	The science of improving crop yields and assisting management decisions using high technology sensor and analysis tools (Sigh et al, 2020)	Firms: Agtech and innovation firms for agriculture GOV: USDA, European Parliament
Nature-based Solutions	Nature-based Solutions involve working with nature, as part of nature, to address societal challenges, supporting human well-being and biodiversity locally (https://www.naturebasedsolutionsinitiative.org, 2024).	Firms: Oil and gas companies NGO: WWF, Aga Khan Foundation, AGWA, GIZ, SEI
Regenerative Agriculture	RA has at its core the intention to improve the health of soil or to restore highly degraded soil, which symbiotically enhances the quality of water, vegetation, and land-productivity (Rhodes, 2017).	Firms: Nestle, Pepsico, Archer-Daniels, Unilever, Walmart, Cargill NGO/donor: Renature, NRDC, Ellen McArthur, CBF

Table 1. Source: Taken from literature review of the concept note for the Study to be conducted by the FAIR Center Tecnologico de Monterrey and KIT Institute on Financial Inclusion and Climate resilience (2024). (Concept author's own elaboration from various sources including webpages of institutions).

These strategies aim to contribute to climate change resilience among agricultural producers by mitigating causes or adapting to consequences, as defined. As the above table shows, these strategies have different proponents and address climate change challenges in different ways.

As stated in the study's concept note, which is aimed at being conducted by the FAIR Center, the Tecnológico de Monterrey, and the KIT Institute, Regenerative Agriculture (RA) has been gaining popularity among several agro-industries. These firms are committed to sustainability and reducing greenhouse gases (GHGs), with the goal of becoming zero-emissions companies in the future. For example, Nestlé aims to eliminate direct and indirect emissions (including those in its value chains) by 2050. Unilever plans to achieve net-zero emissions by 2039. PepsiCo aims to source 100% of its agricultural products using regenerative practices by 2030. Cargill aims to expand regenerative practices to 10 million acres and 10 million producers by 2030. Walmart is committed to protecting, managing, and restoring 50 million acres by 2030. Starbucks is also committed to reducing carbon emissions by 50% by 2030, with regenerative agriculture being one of the strategies (FAIR Center, et al., Study Concept Note, 2024).

While all the proponents declare that Regenerative Agriculture (RA) is necessary for reducing emissions and restoring soil, the strategies and their benefits are less clear in social terms. Proponents cannot guarantee that these changes will improve the social, gender, or economic conditions of agricultural producers. This indicates an uneven commitment to sustainability, prioritizing economic and environmental dimensions over social and gender dimensions. Here, we emphasize the potential of regenerative agriculture practices in addressing the impacts of climate change. However, RA is still in the early stages of exploration, and it is predominantly framed as an outcome rather than a deliberate intervention. The primary focus is on enhancing farmer resilience (Pyburn et al., 2024).

3.1. Mitigation Strategies

In this section, we highlight the most relevant climate change mitigation strategies identified in the literature review and deployed in value chains. We focus on mitigation as defined by the IPCC as the *set of actions or activities aimed at limiting greenhouse gas (GHG) emissions* (IPCC, 2022). Agricultural practices have been recognized as playing a dual role in relation to climate change because specific methods can generate significant emissions of methane and nitrous oxide. In other words, agriculture causes negative externalities. Thus, approaches such as regenerative agriculture and agroforestry, including strategies like improving soil health, reducing emissions from livestock, implementing direct seeding techniques, and incorporating cover crops, emerge as key strategies for making agriculture part of the solution to climate change (Bracken et al., 2023).

The table below includes some of the most significant mitigation practices identified in the literature (Bracken et al., 2023; FAO, 2008; ICO, 2015; Mukherji et al., 2024; OECD, 2021; Rahn et al., 2014).

Mitigation Practices
Afforestation and reforestation
Soil conservation & management
Wastewater treatment
Use of organic fertilizers
Improved livestock management
Agroforestry – shade trees
Use different crop varieties

Table 2. Mitigation Practices Identified in the Literature Review.

Through this literature review, we identified several mitigation strategies that are closely linked to climate change adaptation, food security, and renewable resource production (see 3.1.2, "Synergies between Mitigation and Adaptation Strategies"). Mitigation strategies are often framed within a broader, multidimensional approach to climate resilience in this context, enhancing communities' capacity to cope with and recover from climate impacts (Mehriar, S., 2022). The Food and Agriculture Organization of the United Nations (FAO) reinforces this perspective, emphasizing that mitigation in the natural resources sector should target livestock, forestry, rangeland, agriculture, and fisheries. Key strategies include *reducing deforestation and degradation, promoting afforestation and reforestation, enhancing forest management for carbon storage, and increasing carbon stocks in wood products*, as well as supporting fuel substitution (FAO, 2008).

The literature shows that most efforts to address climate change impacts focus on agroforestry and climate-smart agricultural practices. One prominent strategy that smallholder coffee farmers use is to incorporate shade trees into coffee production. This approach has several positive outcomes: shade trees reduce warming conditions in coffee gardens and enhance the soil's physical, chemical, and biological properties (Wienhold & Goulao, 2023; Tschora & Cherubini, 2020). Other mitigation responses include carbon sink enhancement and fossil fuel offsetting (Djufry et al., 2022). To ensure the sustainability of coffee agroforestry farming systems, smallholder farmers should also diversify their sources of livelihood. This will help them avoid becoming overly reliant on coffee as their primary source of income (see the section on Adaptation Strategies for a more in-depth discussion of income diversification).

Since most coffee is produced by smallholder farmers, organizations such as cooperatives and unions have become essential in promoting climate-smart agricultural (CSA) practices and mitigation strategies (Kishaija et al., 2025). Research from Ethiopia indicates that cooperatives encourage their members to adopt CSA practices. Furthermore, these cooperatives benefit the larger community by offering services such as access to information, extension services, and marketing support to non-members (Kahsay & Endalew, 2025). Similarly, research in Peru and Guatemala shows that, while certain strategies may be infeasible for individual smallholders, cooperatives have experience with organization, management, and knowledge distribution. This experience is valuable in partnerships with government agencies or NGOs (Shapiro-Garza et al., 2020).

It is also important to note that the gender dynamic significantly impacts the specific climate change mitigation practices adopted in most coffee farming communities (Kishaija et al., 2025), as women have taken on formal roles as coffee producers and cooperative members. However, they continue to have less access to productive resources, such as land, information, credit, and technical assistance (Bilfield et al., 2020b).

3.1.1 Barriers to Implement Mitigation Strategies

Many mitigation strategies have been and are currently being implemented in different value chains (FAO, 2008; Mukherji et al., 2024; Rahn et al., 2014; Adaptation Committee, 2020). However, these strategies face significant constraints. From the literature, we identified the most relevant barriers to implementing mitigation strategies:

- *High implementation costs* are a relevant constraint, as underscored by Sathyapriya et al. (2024). Mitigation strategies like conservation agriculture and agroforestry require significant upfront investments, posing a barrier for smallholder farmers lacking financial resources.
- *Inadequate policy support* is another significant challenge. The lack of supportive policies and government incentives discourages farmers from adopting sustainable agricultural practices. Clear guidelines and incentives are often absent (Qi & Terton, 2022).
- *Knowledge and awareness gaps*: Many farmers are unaware of the benefits of mitigation strategies or how to implement them. This hinders the adoption of practices that reduce greenhouse gas emissions (ICO & UNIDO, 2024; Rahn et al., 2014).
- *Technological constraints* further limit farmers' ability to implement these strategies because advanced technologies, such as precision agriculture tools, are expensive and not widely available to smallholder farmers (Pyburn et al., 2024; Harvey et al., 2018).
- *Social resistance to change* also plays a role. Cultural attachment to traditional farming practices can slow the adoption of new strategies. Farmers often resist changing methods passed down through generations (Suarez et al., 2019).
- The *absence of market incentives*, such as carbon credit schemes, hinders farmers' financial motivation to adopt sustainable practices. Meanwhile, coffee industry actors need improved connections, expertise, and networks to access new markets. They also need education on selling by-products, particularly smallholders and cooperatives (Sathyapriya et al., 2024).

3.1.2 Synergies Between Mitigation and Adaptation Strategies

It is important to note that mitigation strategies cannot be fully understood without considering adaptation strategies. Several activities demonstrate the synergies between the two, including **afforestation of degraded areas, boundary tree planting, enhanced soil conservation practices, and diversification strategies** (Rahn et al., 2014). Traditionally, adaptation and mitigation policies have been addressed separately due to their distinct objectives and stakeholders (OECD, 2021). However, activities such as forest restoration can contribute to both carbon sequestration and risk reduction. Identifying these opportunities is crucial for enhancing climate resilience and promoting effective policy integration (Adaptation Committee, 2020; IPCC, 2014). The table

below, informed by a literature review, shows how specific climate actions contribute to adaptation and mitigation efforts.

Climate Action/ Strategy	Mitigation Benefit	Adaptation Benefit	Productivity Benefit
Use of crop varieties with higher drought and pest resistance. **Sustainable land management practices (efficient nitrogen use and soil management)**	GHG emissions savings from reduced energy consumption for irrigation and improved soil quality	Increased resilience to drought and floods	Improved soil fertility and crop yields
Agroforestry (shade trees)	Carbon sequestration	Enhanced soil health and moisture retention	Better microclimate for coffee growth
Soil management	Carbon stocks in soil can be maintained and increased (ICO, 2015, p. 4)	Loss of topsoil can be reduced in severe rain or drought events; moisture can be maintained in soil (ICO, 2015, p. 4)	Enhanced soil health and fertility
Conservation agriculture (practices that improve soil health and moisture retention)	Reduction of GHG emissions	Increased resilience to climate variability	Enhanced crop productivity
Better planting practices (higher density, quicker development of productivity)	Higher planting density and quicker development reduce potential pressure on land (ICO, 2015, p. 3)	Stronger seedlings are better prepared to survive climatic events (ICO, 2015, p. 3)	Faster yield production and improved land use efficiency
Improved livestock management to reduce methane emissions and enhance pasture quality	Lower methane emissions	More resilient agricultural systems	Improved pasture quality for livestock
Good agricultural practices (shade, soil, and water management, as promoted by FNC, Embrapa, and Rainforest Alliance)	Reduction of emissions through sustainable land use	Increased resilience to climate stressors	Enhanced productivity through better growing conditions

Table 2. Synergies Between Climate Actions, Adaptation, Mitigation, and Productivity (ICO & Coffee & Climate, 2015, adapted with information from FAO, 2008; Rahn et al., 2014; IPCC, 2014; ICO, 2015; Adaptation Committee, 2020; OECD, 2021; Qi & Terton, 2022; Bracken et al., 2023; Mukherji et al., 2024)

The significance of mitigation strategies can only be fully understood in relation to adaptation. However, the literature on this synergy is limited (IPCC, 2014; Imelda, 2024; Hidayat, 2024; Qi & Terton, 2022). While many studies emphasize the importance of linking mitigation and adaptation effectively to achieve integrated and synergistic climate action, a comprehensive framework for identifying and assessing these synergies and trade-offs is lacking (Qi & Terton, 2022). Thus, it is essential to recognize that adaptation, resilience, and mitigation are interconnected yet distinct. Adaptation enables communities to adjust to climate change; however, some

measures may inadvertently reduce resilience by limiting future options. Mitigation, on the other hand, plays a fundamental role in addressing the root causes of climate change. A balanced, integrated approach combining proactive adaptation, resilience building, and mitigation ensures long-term, sustainable responses (Mehriar, S., 2022). With this in mind, we will now examine the identified adaptation strategies while accounting for their potential synergies with mitigation.

3.2. Adaptation Strategies

This section examines the adaptation strategies that farmers have adopted in different value chains, particularly in the coffee sector, in response to climate change. A literature review reveals various strategies and the challenges and barriers to their effective implementation. Before exploring these strategies in detail, it is important to define adaptation in the context of addressing climate change.

According to the United Nations Framework Convention on Climate Change (UNFCCC), adaptation refers to "adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects." It involves changes in processes, practices, and structures to minimize potential damage or take advantage of opportunities associated with climate change" (UNFCCC, n.d.). In this regard, adaptation is framed as specific actions, usually related to resilience. This concept is highlighted in Sustainable Development Goal (SDG) 13, which includes the target of "strengthening resilience and adaptive capacity to climate-related hazards and natural disasters in all countries" (UNFCCC, n.d.).

Several adaptation strategies can be found in the literature. Morrison (2024) provides a list of eleven adaptation strategies that farmers are implementing in the face of climate change. These are:

1. *Diversification of Crops and Livestock*
2. *Precision Agriculture and Technology (e.g., GPS-guided tractors and drones)*
3. *Sustainable Farming Practices (e.g., conservation tillage, crop rotation and cover cropping)*
4. *Water Management and Irrigation Efficiency (e.g., Drip irrigation, rainwater harvesting and soil moisture sensors)*
5. *Maximizing Existing Agricultural Land*
6. *Climate-Resilient Crop Varieties*
7. *Knowledge Sharing and Adaptation Networks*
8. *Weather Forecasting and Early Warning Signs*
9. *Resilient Infrastructure and Farm Design*
10. *Education and Training*
11. *Government Policies and Support*

This list captures what is found in literature worldwide. For instance, studies from South Asia (e.g., Nepal and India) identify the following as key adaptation strategies for farmers: access to financial resources and risk transfer, diversification and spatial adaptation, climate-smart agriculture, pooling of resources, social action, traditional and local knowledge, food and water storage, and crop calendars and land holidays (Rijal et al., 2021; Bahinipati, 2021). Other strategies include using drought-tolerant crops and burning charcoal in Kenya

(Mburo, B.K., et al., 2015), while in southern Benin, farmers enhance resilience through crop diversification, agroforestry, and perennial plantations (Fadina & Barjolle, 2018). In Latin America and the Caribbean, common adaptation measures include crop and livestock integration, efficient irrigation water management, climate monitoring and prediction, and biotechnology (Sánchez & Reyes, 2015; Lee et al., 2014). In Bolivia, small-scale farmers adapt by diversifying crops, managing plots across different zones, adjusting planting times, integrating livestock, and using traditional food preservation methods, such as freeze-drying potatoes and oca (Pérez et al., 2010). In Brazil, balanced animal feed (Burney et al., 2014) and climate-smart sustainable agricultural practices, such as green manure, crop association, and crop rotation, have been employed in various value chains (Blaser et al., 2018; Jat et al., 2016).

This literature review identified shade-tree cultivation, income and product diversification, and soil and water conservation practices as the most common adaptation measures in the coffee and cocoa sectors. Considering the FAIR Center's study focus, we will elaborate on these three strategies below.

Shade-Tree Production

Among coffee farmers, the most commonly reported strategy was transitioning to shade coffee production. This practice offers several advantages, including reducing extreme temperatures and evaporation and providing natural wind barriers through shade trees (ICO, 2015). Shade-grown coffee is a traditional agroforestry system in which coffee plants are cultivated alongside various shade trees, including fruit, timber, and leguminous species. By mimicking the layered structure of natural forests, this system strikes a balance between ecological sustainability and economic viability (FAO, 2020). Shade coffee production has multiple benefits, including distributing harvests and income throughout the year and enhancing food and economic security. This efficient system reduces the use of fertilizers and biocides, increases pest resistance, and extends the productive lifespan of coffee plants. Additionally, it adapts well to steep slopes, requires less labor, and has strong commercial potential in emerging eco-friendly markets (WOCAT, 2019).

Several resources have highlighted that shade management practices enhance biodiversity, improve soil quality, and support farmers' livelihoods and economic viability (Quan et al., 2021). Tscharntke et al. (2011) emphasize that sustainable agroforestry management requires conserving or creating a diverse layer of multipurpose shade trees that can be pruned rather than removed when crops mature, which is particularly important for cocoa cultivation. Incentives from payment-for-ecosystem services and certification schemes encourage farmers to maintain high to medium levels of shade tree cover. It is important to note, however, that other studies in Ghana on shade tree management have shown that shade systems can affect cocoa yields differently depending on the region (Abdulai et al., 2018). Medium shade systems increased yields in the dry and mid regions but decreased them in the wet region. Therefore, shade recommendations for cocoa should be adapted to the specific climatic conditions of each region.

Preventing erosion is crucial for coffee farms, especially on steep slopes, where heavy rainfall can cause topsoil loss and landslides (Pulleman et al., 2023). Eroded soils lose their ability to effectively retain water and nutrients, resulting in environmental and economic consequences. Some studies conducted in Mexico have also highlighted the importance of local knowledge in successful adaptation, considering management through traditional techniques and cultural elements while using fifty multipurpose species for coffee shade (Ruiz-

García, 2021). Shade-grown coffee is a clear example of how local knowledge and cultural practices can promote more resilient systems. However, strategies for managing shade trees must also consider the carbon sequestration potential of cocoa agroforests in West Africa, which, as Blaser et al. (2018) point out, is heavily influenced by land use prior to their establishment. For instance, integrating shade trees into annual or degraded systems is likely to lead to an increase in below- and aboveground carbon stocks.

3.1.1 Income and Product Diversification

Another common technology adaptation strategy implemented at the farm level is income and product diversification (Jawo et al., 2023). In the context of Mexico and Guatemala, diversification refers to both changes in coffee varieties and in crop mix (Eakin et al., 2006). Enhanced crop varieties can endure higher temperatures, resist pests and diseases, and adapt more effectively to increased shade in agroforestry systems (Van de Vossen et al., 2015, as cited in Rahn et al., 2014). Smallholders diversify their land use strategies in direct response to environmental pressures and insufficient support. This shift often involves moving away from coffee cultivation toward more feasible options, such as sugarcane, pasture, or urban development (Eakin et al., 2009).

Economic adaptation in agriculture focuses on enhancing farmers' resilience by diversifying livelihoods, reducing consumption, and establishing agricultural insurance and inclusive financial systems to manage climate risks. These adjustments are driven by reduced household income due to climate vulnerabilities and vary based on farmers' abilities and financial situations (Hidayat, 2024). Within regenerative agriculture, diversification plays a key role in empowering farmers to improve their income, food security, and resilience against economic and environmental challenges. This approach emphasizes gradually implementing carefully tailored practices that suit individual circumstances (Pulleman et al., 2023). As a key adaptation strategy, crop diversification is often recommended and considered a practice that should be adopted immediately. However, many policies fail to effectively support or plan for farmers' diversification efforts, particularly in low-altitude regions that are becoming increasingly unsuitable for coffee cultivation (IDH, 2019).

3.1.2 Soil and Water Conservation Practices

Soil and water conservation practices were identified as key strategies employed by farmers. In regenerative agriculture, the focus is on soil conservation to regenerate the land and provide a variety of services, including provisioning, regulation, and support. The goal is to improve environmental, social, and economic outcomes of sustainable food production (Schreefel et al., 2020). Research in southern Mexico shows that shade trees can positively impact coffee crops by affecting the overall water balance. Despite consuming water, the data suggest that shade trees' water usage does not threaten the water needed for coffee cultivation in high-shade systems. Furthermore, shade trees promote water retention by reducing evaporative demand from soil evaporation and coffee plant transpiration (Lin, 2010).

Amfo et al. (2021) examined the soil and water conservation practices used by cocoa farmers in Ghana to adapt to climate change. These practices included applying organic fertilizers, mulching, planting leguminous crops, retaining trees, and planting shade trees on cocoa farms. Mango et al. (2017) found that the adoption of soil and water conservation practices in the Chinyana Triangle in southern Africa is influenced by various factors,

including the age and education level of the household head, the agricultural advice received, membership in farmer groups, the amount of land owned, and the land-to-person ratio within the household.

3.1.3 The Relevance of a Differential Approach

Based on the idea that adaptation is not one-size-fits-all, research on the various adaptation strategies used by farmers in a given sector must consider the impact of traditional knowledge, gender roles, and the socio-economic context of their communities (Suárez et al., 2019). When examining the adaptation options available to farmers, it is crucial to adopt a comprehensive approach that recognizes the need for programs and policies tailored to the local context (Bilfield et al., 2020a). This approach would facilitate the allocation of resources better suited to fostering meaningful and sustainable changes in farmers' livelihoods. We emphasize the importance of adopting a differential approach that considers the diverse perspectives of all stakeholders from the beginning of a research process, particularly marginalized voices. Prioritizing the input of producers, their families, and field staff can help inform the development of more relevant and responsive interventions. These interventions, especially those related to regenerative agriculture (Pyburn et al., 2024), would better address the specific needs and challenges of the involved communities, ensuring they effectively and sustainably foster long-term resilient changes.

3.1.4 Challenges to Implement Adaptation Strategies

The barriers that farmers face in implementing adaptation strategies are as varied and sometimes context-specific as the strategies themselves. Insufficient funding, inadequate technological expertise, limited institutional capacity, and a lack of understanding of climate change issues are some of the major constraints to adaptation strategies (Jones & Boyd, 2011; Masud et al., 2017; Gifford et al., 2011). Several studies in sub-Saharan Africa list institutional factors, access to credit, a lack of information, and the irregularity of extension services as key challenges for farmers adapting to climate change (Adégnandjou Mahouna, 2018). In Southeast Asia, studies include sociodemographic factors, physical capital, assistance, information, and social factors as the most significant factors affecting farmers' adaptation strategies toward climate change (Nor Diana et al., 2022).

For coffee-growing farmers, weak household adaptive capacity is a key factor constraining the implementation of adaptation strategies. As demonstrated by research in the Chiapas region of Mexico, smallholder farmers can generally cope with short-term challenges, but they struggle to adapt to the future. The limited and unstable resources available to them support only short-term subsistence, which prevents long-term adaptation planning and implementation (Ruiz Meza, 2015). Thus, the lack of resources and the unstable nature of their environment hinder their ability to implement sustainable changes. Socioeconomic factors, such as household wealth, education levels, landholding sizes, and access to agricultural services, also influence farmers' ability to adapt. Similarly, Eakin et al. (2006) emphasize that these factors play a critical role in shaping farmers' capacity to adapt; wealthier, better-resourced households are more likely to successfully implement adaptive strategies.

Furthermore, research on coffee farmers in Chiapas indicates that successful adaptation necessitates strengthening not only the adaptive capacities of individual households, but also the resilience of the broader community and landscape (Eakin et al., 2012). A collective approach is essential because focusing solely on

individual households is often insufficient. Farmers face many challenges, such as limited access to financing, technical support, and services. Many rely on informal financial sources, which restricts their ability to invest in long-term adaptation strategies. Additionally, low trust in farm associations, labor shortages, and reluctance to adopt new farming practices exacerbate these difficulties (Eakin et al., 2009). These barriers underscore the necessity of comprehensive solutions that bolster both individual and community resilience, providing farmers with better access to the support they need to implement sustainable adaptations.

3.1.5 Differential Adaptation Needs

While the literature emphasizes the challenges that smallholder farmers face due to climate change and their limited ability to adapt, it is equally important to highlight the significance of hearing their perspectives directly to understand their unique requirements. This is essential for developing contextually relevant adaptation strategies.

Studies such as Harvey et al. (2018) have shown that coffee farmers identified the need for fertilizer and agrochemical provisions, technical support, training, better coffee prices, marketing strategies, and access to financing. Similarly, other studies disaggregate this data by gender to determine whether strategies, barriers, and needs differ between men and women (Suárez et al., 2019). In this context, women's needs include financial literacy training and accessible information channels, which would enable them to play an active role in decision-making and access formal credit. Supportive networks and programs tailored to rural needs, along with flexible options and childcare support, would help women overcome unique challenges and fully engage in economic opportunities (Ramirez et al., 2015).

3.1.6 The Adaptation Process

The United Nations Framework Convention on Climate Change (UNFCCC) provides a useful framework for understanding the role of different actors in the policy cycle regarding adaptation (UNFCCC, n.d.). This framework helps identify the phases in which strategies and technologies can be applied to address climate change and enhance climate resilience. A detailed breakdown of the phases that comprise the adaptation process enables us to identify stages requiring more targeted interventions to strengthen resilience. In other words, the adaptation process cycle (see Figure 2) allows us to identify areas in need of support. The UNFCCC emphasizes that the framework is designed to evaluate progress toward the global adaptation goal and to assess efforts to mitigate the impacts, risks, and vulnerabilities of climate change and strengthen adaptation actions and support.

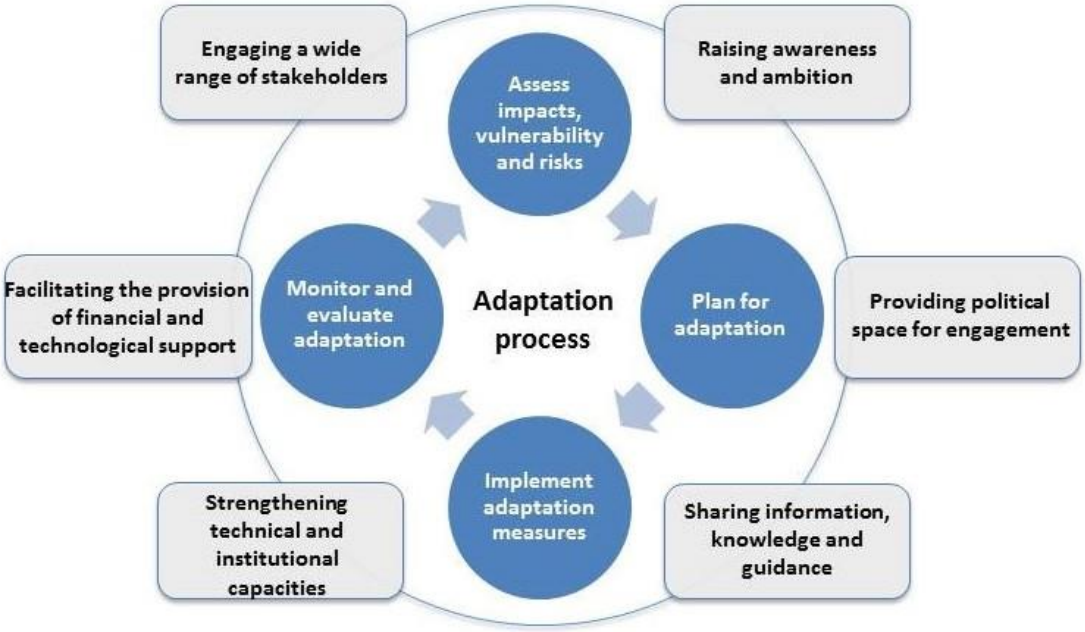

Figure 2. The Adaptation Policy Cycle (UNFCCC, n.d.)

The stages of the adaptation process are shown in the UNFCCC's adaptation policy cycle. The UNFCCC emphasizes the contributions of various stakeholders to this process. The graph provides an opportunity to delve deeper into the role of financial services in the adaptation strategy cycle. This is important because creating financial assistance programs can help smallholders access essential resources to adopt sustainable practices. These programs could take the form of grants, low-interest loans, or subsidies tailored to support climate-resilient agricultural methods (Bracken et al., 2023). However, the barriers preventing farmers from implementing adaptation strategies also hinder their access to financial support for adopting sustainable, climate-responsive technologies. This topic will be elaborated on further in Chapter Four.

4 Transitioning Towards Sustainability

The literature has provided evidence of the compelling challenge of ensuring the sustainability of strategies and approaches used to address climate change impacts. Such sustainability requires transitioning to effective, efficient, and durable solutions. The call for this transition to be a just transition that "leaves no one behind" is gaining momentum in the global discussion on climate change. This approach recognizes the systemic impact of external factors on achieving the desired change (UNDP, 2022; AWB, 2021; SEI, 2023). Many of the adaptation and mitigation strategies implemented in recent decades have contributed to this transition (Singh et al., 2023; WB, 2024; NbSI, 2024). However, based on the literature, these strategies cannot yet be considered fully sustainable due to various factors, including the need to acknowledge and address the synergies between the strategies, the ineffective integration of differential approaches to climate change impacts, the failure to recognize the importance of relations between different value chains for sustainability, and the barriers and

limited opportunities farmers face in accessing and implementing these strategies. One such limited opportunity is access to inclusive financial mechanisms, which can be a determining factor in whether farmers choose to work in green agriculture (Rubiano-Lizarazo & Astudillo, 2022; Volz et al., 2020). In this chapter, we will explore financial inclusion as a key to transitioning toward sustainability.

4.1 The Role of Financial Inclusion in the Transition to Sustainability.

According to International Fund for Agricultural Development (IFAD), "many of the barriers to adaptation in the small-scale agricultural sector are commercial in nature," including a lack of agribusiness development, risky and unpredictable financial returns, and investment risks (Lipper et al., 2022). However, the percentage of climate funds aimed at small-scale farmers is insignificant compared to their actual needs and vulnerabilities. Despite producing one-third of the world's food, small-scale producers in developing countries receive only 0.8% of total global climate finance (Marshall et al., 2023). Additionally, a study by Chirac et al. (2020) indicates that approximately 31% of financing for individual small-scale producers is allocated to adaptation in agriculture and rural development (Chirac et al., 2020, in Lipper et al., 2022). According to the CGIAR, adaptation financing receives less than 10% of total climate investments, indicating that climate finance heavily favors mitigation (Buchner, Naran, Padmanabhi et al., 2021, in Marshall, 2023).

Access to financial mechanisms and services, such as credit, insurance, savings, and investment products, can enable farmers to improve productivity, mitigate risks, and adopt sustainable practices that benefit adaptation and mitigation (Rahn et al., 2014). However, they must be offered inclusively, ensuring they are appropriate, available, and affordable and respond to the different needs of farmers (Mukherji et al., 2024). The Inclusive Green Finance (IGF) approach, supported by institutions such as the Center for Financial Inclusion and the Alliance for Financial Inclusion, addresses this issue by aiming to promote economic growth in a clean, resilient, and sustainable manner (Miller et al., 2023; AFI, 2024). This approach informs the focus of this literature review, which explores financial inclusion as a driving factor in the transition towards sustainability.

4.1.1 Financial Inclusion and Sustainable Agriculture Practices

Strategies such as community-supported agriculture (CSA), precision agriculture, and regenerative agriculture involve practices that increase productivity and sustainably enhance resilience to climate change while reducing emissions. Access to financial resources, such as **grants, low-interest loans**, and **subsidies**, is essential for adopting these strategies' techniques, such as agroforestry, conservation tillage, and soil health improvement (Bracken et al., 2023). For example, Alliance Biodiversity and CIAT, in their article on the link between economic balance and regenerative agriculture, indicate that financial innovations such as impact **investment funds**, **green bonds**, and **carbon credits** provide farmers with capital to support this shift. **Crowdfunding** and **community support models** also offer direct funding, fostering a dedicated customer base and reducing economic barriers. These options help sustain practices that are both economically viable and environmentally beneficial (Alliance Biodiversity, CIAT, & CGIAR, 2024).

For financial services to have a real impact on the transition toward sustainability, they must address the specific needs of their beneficiaries in context. For instance, a 2023 study by Rubiano-Lizarazo & Astudillo (2022) on the financial needs and preferences of coffee farmers' households in Colombia shows that not all financial services are useful in rural areas. Services such as **savings** and **insurance** are known to be **more effective than microcredit**. The study states that small, accessible savings products encourage positive savings practices and will prompt farmers to stop relying on risky and ineffective informal financial services (Rubiano-Lizarazo & Astudillo, 2022). Furthermore, the study revealed that two factors were instrumental in shaping these preferences at the household level: (1) using savings and credit for short-term needs due to their flexibility and liquidity and (2) trusting financial service providers based on access to information and consumer protection mechanisms (Rubiano-Lizarazo & Astudillo, 2022). These factors demonstrate a strong interest in reducing risk through flexibility and trust in financial institutions, which are key barriers to accessing these services. This topic will be discussed in the next section.

Access to inclusive finance offers other advantages, such as *diversification and risk management*. Financial products such as **microloans** and **insurance** can help farmers diversify their livelihoods. For example, access to credit allows smallholder farmers to transition from growing traditional crops to growing more sustainable and profitable ones (Rubiano-Lizarazo & Astudillo, 2022). Income diversification reduces the exposure of sensitive economic activities to climate and improves long-term economic prospects, contributing to risk management. Financial products are also fundamental to accessing specialty markets, which increases family income (Rahn et al., 2014).

Finally, *digital financial services* such as **mobile banking, revolving credit**, and **collective savings** have significantly expanded financial inclusion. These services "can help bridge the divide between large-scale investments and small loans, and are key to scaling up sustainable agri-food sector practices." Bundling digital financial services with other offerings, such as inputs, training, and advisement, can minimize costs and maximize accessibility for vulnerable groups, including women, youth, and the poor (Marshal et al., CGIAR). Digital financial services enable farmers to access financial products, even in remote regions. Examples include mobile money and mobile insurance. For example, platforms like M-Pesa in Kenya allow farmers to access loans, make payments, and purchase insurance through their mobile phones. This helps overcome barriers related to the lack of physical infrastructure and financial literacy (IPA, 2017). Mobile money "lowers transaction costs for domestic remittances and thus allows households to weave a wider net of informal insurance and risk sharing" (Jack & Suri, 2013, 2014, 2016; Bharadwaj et al., 2019, in Volz et al., 2020). Thus, digital finance has enormous potential to provide low-cost, targeted financial services to the poorest and most vulnerable. (Volz et al., 2020).

4.1.2 Barriers to Financial Inclusion in Agriculture

As mentioned in the first chapters of this document, significant barriers exist to financial inclusion in agriculture. At the global level, investment gaps are significant, and investment in green agriculture remains low compared to the growing needs and challenges. Efforts to fill this gap exist, but they are often skewed toward mitigation strategies. According to the UNCC report on National Determined Contributions (NDC), by

2024, the share of adaptation components was 90% for food production and nutrition security, and 89% for agriculture. These percentages, together with the recently agreed USD 300 billion annual goal by 2035 during COP29—which tripled the previous goal—are important steps toward enhancing financial inclusion and addressing climate change.

Despite these efforts, the funding gap faced by smallholders in Africa, Latin America, and Asia continues to be a cause for concern[2] (ISF Advisors, 2020, as cited in Chiriac, 2023). This gap creates many barriers for smallholder farmers, particularly in accessing financial services. Some of the most relevant challenges found in the literature are:

Limited access to formal financial systems. Many farmers in developing countries are excluded from formal financial systems due to low literacy levels, lack of collateral, and irregular income. This limits their ability to secure loans for sustainable investments. Reliance on informal financial systems can increase financial risk for households due to a lack of regulatory oversight, which may result in exploitative practices and limited consumer protection (Ramírez et al., 2015).

The design of inclusive services is inadequate. Financial products are not always tailored to the specific needs of farmers. Loan terms, interest rates, and repayment schedules may not align with the seasonal nature of farming or the capital-intensive requirements of sustainable agriculture (Volz et al., 2020). Even when accessibility is not an issue, lending methodologies, financial products, and services are not tailored to farmers' needs. For instance, farmers require access to long-term investments, yet short-term capital is often the only option available (Marshall et al., 2023).

High transaction costs are a major barrier to accessing climate finance because it requires significant investment without sufficient compensation for the risk (ITC, 2022, as cited in ICO and UNIDO, 2024). CGIAR states that "smallholders are often highly disaggregated and scattered across remote areas far away from lending institutions, meaning dispersing funds is difficult. The transaction costs are rarely outweighed by the small loan amounts farmers require" (Marshall et al., 2023).

High risk and perceived financial risk are significant challenges. For much of the population in developing countries, existing financial instruments are risky, poorly designed for their needs, unreliable, or expensive (Volz et al., 2020). These factors influence how farmers perceive financial services and shape their preferences. Research has shown that farmers often distrust financial service providers due to limited access to information and inadequate consumer protection mechanisms (Eakin et al., 2009; Rubiano-Lizarazo & Astudillo, 2022). For example, in Colombia, Rubiano-Lizarazo & Astudillo (2022) describe how farmers' distrust of the formal financial sector, driven by information asymmetry and improper practices by institutions, significantly influences their preference for informal provider).

[2] "Sub-Saharan Africa, East Asia and the Pacific, and South Asia, together accounting for around 95% of the world's small-scale farms, received just under three-quarters of total climate finance for small-scale agri-food systems in 2019/20" (Chiriac. D., 2023)

4.1.3 A Differential Approach to Inclusive Finance for Sustainable Agriculture

Barriers to accessing financial services vary among different groups of people, particularly between men and women. For example, women face specific obstacles in accessing formal credit, stemming from economic, financial education, caregiving, and household work constraints (Ramírez et al., 2015). Studies have shown that gender inequalities shape rural financial markets (Pyburn & Hallin, 2023), and unequal social norms that assign women caregiving responsibilities restrict their property rights, asset control, and access to education and training. Moreover, institutional biases often perceive women as less experienced, making them less attractive clients for financial institutions (Fletschner et al., 2014; FAO, IFAD & WFP, 2024).

Discriminatory gender norms often imply that women have limited or no decision-making power, especially within their households. Low literacy levels, a lack of accessible information channels, and a lack of essential resources and assets to serve as collateral, such as land, are key constraints that result in women being unable to take on active roles in decision-making and access formal credit (Pyburn & Hallin, R., 2023; Acosta et al., 2025). Enhancing women's access to and control over financial resources strengthens their decision-making power and improves their influence on household resource allocation (Fletschner et al., 2014). Supportive networks and programs tailored to the needs of rural communities, alongside flexible options and childcare support, address unique challenges and enable women to fully engage in economic opportunities (Ramírez et al., 2015).

4.1.4 Transformative Change: A Holistic Approach to Transition Towards Sustainability

Given the critical role of finance in achieving a sustainable and lasting response to climate change, it is essential to consider this transition as a transformative process. As this literature review and IFAD argue, "Financing for adaptation and resilience needs to be adequate, accessible, and appropriate to align with adaptation and resilience needs, rural development, and food system transformation" (Lipper et al., 2022). This represents a transition that addresses the needs of the most vulnerable and those who greatly contribute to agriculture and food security.

Financial services based on Inclusive Green Finance (IGF) approaches should support all groups in adapting and accessing economic opportunities, thereby fostering a just transition to a low-carbon, sustainable economy (AFI, 2021). However, research shows that access to finance alone is insufficient for ensuring a sustainable value chain. Effectively addressing these issues requires integrating technical assistance, blended finance structures, and active industry participation—elements often absent from current initiatives (ICO and UNIDO, 2024).

The literature recommends implementing a holistic approach to address the vulnerabilities of smallholder farmers, as clearly shown in the adaptation process cycle graph from the UNFCCC (see Figure 1 in Chapter 3) (UNFCCC, n.d.; Lipper et al., 2022). A holistic approach should also be considered when examining financial inclusion mechanisms for transitioning towards sustainability. The following are key approaches, interventions, strategies, and overall recommendations from the literature review to achieve this:

- According to finance ministers from the 58 countries participating in COP27, an estimated 98% of their citizens (nearly 1.5 billion people) lack financial protection (Álvarez & Totolo, 2023). Inclusive Green Finance (IGF) can help these individuals and communities adapt and access economic opportunities, supporting a just transition to a low-carbon economy. Additionally, environmental and social risks threaten financial stability by impacting loan repayments and customer bases. To safeguard the financial system, central banks and regulators must address these risks with prudent policies and support IGF (Volz et al., 2020).

- There is a need for technical and financial support. Linking small-scale actors with investments for innovation and mobilizing resources can address the funding gap for equitable access to technology (ICO et al., 2022). Financial practices and initiatives related to adaptation efforts include targeted subsidies to enhance the purchasing power of smallholders, grant financing for activities such as capacity building, loan- and equity-based financing, supply chain financing to reduce financial loss, insurance services, and microcredits (Rubiano-Lizarazo & Astudillo, 2022; IDH, 2019).

- Local and community-based support and financing. Community-based savings organizations, such as Village Savings and Loan Associations (VSLA), have been shown to significantly contribute to filling the financial access gap for many smallholder farmers in developing countries, particularly in Africa (Burkina Faso, Ghana, South Sudan, Uganda, etc.). (2Scale, 2022; Okello & Mwesigwa, 2022; Seidu, 2018; Hendricks et al., 2011; Lipper et al., 2022). These services improve access, make interventions more cost-effective, and increase incomes. This incentivizes local actors to invest and use their financial resources more effectively (Solidaridad, 2023).

- One key barrier mentioned in this literature review is that green finance depends heavily on non-concessional loans. This worsens debt burdens in vulnerable countries and limits access for smallholder farmers and SMEs due to high costs and misaligned financial products. Private finance, concentrated in developed economies, underfunds adaptation projects due to low bankability and weak regulations. Streamlining processes, improving instruments, and redirecting financial flows are essential to supporting vulnerable communities and climate-resilient systems (Marshall et al., 2023).

- National institutional investors should lead locally driven climate finance by creating risk-mitigating tools and accessing climate funds directly. Doubling adaptation finance, prioritizing grants and concessional loans, and revising Multilateral Development Bank (MDB) policies can unlock more funding. Streamlined processes and blended finance instruments can further mobilize private-sector investments (Marshall et al., 2023).

- Realign existing finances by redirecting harmful subsidies and Special Drawing Rights (SDRs) to bolster climate financing and support sustainable initiatives. Reforms should balance environmental goals with food security. Digital finance and local bank support can empower smallholder farmers and promote sustainable agriculture (Marshall et al., 2023).

- Integrate a differential approach and a strong gender perspective into financial sector interventions. As women become more visible in the formal agricultural sector, it becomes clear that both economic opportunities and the sociocultural and political factors driving gender inequality must be addressed. Tailoring gender sensitization and responsive work to the local context allows resources to be allocated more effectively to support meaningful and sustainable change beyond superficial integration (Bilfield et al., 2020a). Improving women's access to financial services is essential to promoting their decision-making power and supporting the adoption of climate-resilient practices. According to Fletschner et al., women's access to finance can be categorized into three areas:

    a. Regulatory Changes: Revising financial regulations to support organizations in providing accessible and safe financial products for rural women. For example, eliminating restrictions on savings mobilization and clarifying interest rate policies can improve outreach.
    b. Organizational Reforms: Promoting gender sensitivity within financial institutions through training, portfolio analysis, and fostering a women-friendly culture. This includes consulting with women during the decision-making process and ensuring that marketing and service delivery address their needs.
    c. Innovations in Product Design and Delivery: Conducting market research to tailor financial products to women's needs, such as offering flexible loans, savings options, and insurance. Simplifying procedures, improving accessibility, and leveraging technology (e.g., branchless banking) can reduce barriers. Educational initiatives that enhance women's financial literacy and confidence are also crucial. (Fletschner et al., 2014).

The literature offers one final suggestion that is well summarized by IFAD's call to distinguish adaptation financing from development finance. Understanding this distinction is fundamental to navigating the relationship between Official Development Assistance (ODA) and climate finance. This is important to consider, given that climate finance currently falls far short of the substantial financial gap, and there is an urgent need to ensure fair and effective support for small-scale agriculture (Lipper et al., 2022). As discussed in Chapter Two, initiatives supporting inclusive finance in climate change have mainly focused on mitigation strategies and fall under ODA (e.g., the ICO initiative on INDC and the NCQG). However, specific financial services and interventions targeting small farmers or SMEs are less common. The CGIAR study highlights the need to **build resilience through strategic partnerships**. Financial institutions can achieve this by partnering with research bodies that can support them in evaluating agricultural risks, identifying management strategies, and developing de-risked financial products (e.g., risk-contingent credit) (Marshal et al., 2023).

5 Research Gaps

This literature review reveals several significant areas for further exploration. It sheds light on the complexities and nuances of the challenges that farmers face in the context of climate change. These areas underscore the need for deeper investigation and provide a foundation for shaping targeted, effective interventions. Based on

these findings, this section presents key questions to promote a comprehensive understanding of how financial inclusion can enhance climate resilience. These questions bridge the gap between existing knowledge and unaddressed issues, paving the way for future research to inform policy and practice.

The questions were developed based on research gaps identified in this review. Following the structure of this document, the gaps have been organized into three themes:

a. The struggles faced by farmers

b. Adaptation and mitigation strategies

c. Transitioning towards sustainability.

5.1 The Struggle of Farmers

As discussed in previous chapters, climate change and its effects are a significant turning point for coffee farmers' livelihoods. This vulnerability especially affects smallholder farmers and stems from limited access to information, insufficient financial resources, and a lack of adequate technology to implement effective adaptation and mitigation strategies to combat climate change (Jawo et al., 2023).

Several areas have not yet been sufficiently studied in this context. The problems farmers face require urgent exploration to better understand the differences in climate change impacts they experience. This includes analyzing how climate change affects individuals differently based on categories such as gender. Some authors emphasize the necessity of further qualitative research to investigate the obstacles encountered by various individuals in different settings. For instance, the lived experiences of rural women are an important topic for further exploration (Ramírez et al., 2015). Similarly, the literature emphasizes that the focus on social processes that increase vulnerability to climate change is still limited (Ruiz Meza, 2015). Thus, more research should focus on the structural dynamics that shape social inequalities, which ultimately influence farmers' struggles and their capacity to adapt to and/or mitigate climate hazards.

Thus, the literature portrays farmers as a heterogeneous group and emphasizes that their issues vary. At the same time, the literature emphasizes the need for interdisciplinary research on climate-resilient coffee production policies that address farmers' diverse needs (Jawo et al., 2023). In this regard, it is crucial to further study how the state and civil society should engage and interact (Eakin et al., 2006).

Questions for Further Research

- How can the structural dynamics that contribute to social inequalities be better understood in the context of climate change vulnerability in coffee farming? (Exploration of social norms)
- What are the key barriers to effective collaboration between farmers and external stakeholders (e.g., governments, financial institutions, and NGOs) in addressing the impacts of climate change, and how can these barriers be overcome?

5.2 Adaptation and Mitigation Strategies

In relation to the previous section, it is important to understand that the problems and impacts of climate change affect different types of coffee farmers differently. This helps us recognize that these farmers, particularly smallholders, have diverse perceptions of and responses to climate change. This variability underscores the urgent need to develop accessible, contextually tailored adaptation strategies that address the socio-economic and agroecological realities of each group of farmers, ensuring their strategies are effective and appropriate (Celia et al., 2018). This is particularly important given the limited exploration of socio-environmental vulnerability reduction strategies (Suárez et al., 2019). Furthermore, some literature emphasizes the lack of understanding regarding the role of government policies in supporting the adoption of resilience strategies (Yuan et al., 2024), calling for further exploration of the long-term impacts of climate change and resilience strategies.

This document presents various adaptation and mitigation strategies implemented by coffee farmers. It is important to note that information regarding the adaptive potential of nature-based actions is still lacking (Ruiz-García, 2021). Similarly, the potential of regenerative agriculture is an area requiring further exploration (Pyburn, R., et al., 2024). Several studies and reports suggest that more empirical evidence is needed to assess regenerative agriculture's positive impact on addressing climate change's complexities. The literature advocates implementing regenerative agricultural practices and emphasizes the need to combine them with other strategies to effectively address the impacts of climate change. Additionally, we note that the social dimension of regenerative agriculture is just beginning to receive attention, predominantly focusing on building resilience among farmers.

We presented the main adaptation and mitigation strategies used by coffee farmers. However, the literature shows that most policies and programs still treat adaptation and mitigation separately (Qi & Terton, 2022). See Chapter 3.1.2 for a more in-depth explanation of the differences and synergies between adaptation and mitigation strategies. We infer that the strategies employed by coffee farmers also tend to be distinctly separate. This focus on specific strategies leaves other potential strategies (or combinations of strategies) under-explored (Yuan et al., 2024). However, there is a critical gap in our understanding of how adaptation and mitigation can work together, which suggests that both approaches could help address challenges related to productivity and emissions reduction. Therefore, it is important to support sustainable climate actions (Adaptation Committee, 2020).

Furthermore, more research is needed on the trade-offs between mitigation and adaptation strategies in agriculture, particularly with regard to productivity, biodiversity, and carbon sequestration. It is equally important to identify effective financial mechanisms that support sustainable climate actions (see Section 5.4, "Transitioning Towards Sustainability"). Integrating interdisciplinary research combining agronomy, ecology, and the social sciences is also crucial for developing more holistic solutions (Sathyapriya et al., 2024).

Questions for Further Research

- How can adaptation and mitigation strategies in coffee farming be synergized to enhance productivity, reduce emissions, and improve climate resilience?
- What financial mechanisms can effectively support the implementation of adaptation and mitigation strategies in coffee farming, and how can these mechanisms be designed to be context-specific?
- Which socio-environmental vulnerability reduction strategies are most effective for coffee farmers, and how can they be incorporated into existing adaptation and mitigation plans?

5.3 Transitioning Towards Sustainability

In relation to the transition towards sustainability discussed in Chapter 4, it is important to underscore that individual farmers' responses to climate and environmental changes can collectively impact the sustainability of broader environmental and social systems (Eakin, 2009). This underscores the critical role of individual actions while emphasizing the necessity of local strategies to foster greater collective resilience. Despite its significance, this remains a largely unexplored area of study (Eakin et al., 2012). Exploring this area is essential because it would provide deeper insights into the structural dynamics between coffee farmers and institutions. The literature consistently highlights this aspect as requiring further research. This includes analyzing the participation and decision-making capacity of women smallholders (Bilfield et al., 2020a). Without considering local knowledge and ways of doing so as key departure points for effective actions when tackling climate change impacts in the coffee sector and fostering a transition towards sustainability, we would observe persistent gaps in incentivizing value chain relationships for sustainability practices.

In this context, there is limited evidence regarding the impact of sustainability programs in the coffee sector (ICO & UNIDO, 2024). Various authors emphasize the need for rigorous evaluations of agricultural support interventions. The literature also emphasizes the importance of fostering collaboration between governments, industries, and non-profit organizations to address gaps in technical assistance and financial support, among other issues (Alliance Biodiversity & CIAT, 2024). This approach is crucial for enabling farmers to implement regenerative agricultural practices. However, significant gaps in financial services still exist, as products are often designed to fail to meet the specific and differential needs of smallholder farmers. Furthermore, these services are often associated with complex processes and requirements that hinder access (Fletschner & Kenney, 2014). In the agroforestry sector, these limitations are exacerbated by financial intermediaries' lack of knowledge about "climate-smart" projects, such as regenerative agriculture. This leads to mismatched financial products and risk assessments. Meanwhile, micro, small, and medium-sized enterprises (MSMEs) face challenges such as delayed cash flows, a lack of equity or commercial track records, and stringent collateral requirements, which complicate their access to financing (Green Climate Fund, 2017). More research is needed to understand the financial mechanisms that could effectively support joint adaptation and mitigation activities (Rahn et al., 2014). Financial services must also reconcile their support criteria (IPPC, 2014) and improve adaptive

management when contributing to climate change mitigation, adaptation, and sustainable development strategies.

Questions for Further Research

- What innovative financial mechanisms could support joint mitigation and adaptation activities in the agroforestry sector?
- How can financial institutions improve their support criteria and adaptive management to contribute simultaneously to climate change mitigation, adaptation, and sustainable development? • What role do financial intermediaries play in creating or mitigating barriers for smallholder coffee farmers when accessing financial services for climate-smart agriculture?

6 Conclusions

Strengthening climate resilience is now more important than ever for the agricultural sector, especially for farmers and SMEs. In response, various climate-resilient strategies have been implemented over the past few decades, including CSA, precision agriculture, agroecology, and regenerative agriculture. These strategies adopt or recommend different mitigation and adaptation practices. However, these strategies have yet to offer a sustainable solution to the impact of climate change on agriculture. This is especially true as they fail to **effectively address the disproportionate impact on smallholder farmers in developing countries and the most vulnerable groups within them, such as women farmers**.

Work on mitigation strategies has proven to be more widely implemented and funded than work on adaptation strategies. This literature review identified common mitigation strategies, including reducing deforestation and degradation, promoting afforestation and reforestation, enhancing forest management for carbon storage, and increasing carbon stocks in wood products, as well as supporting fuel substitution (FAO, 2008). Adaptation strategies can include crop diversification, water management, irrigation efficiency, weather forecasting, education, training, and policy support. In the coffee sector, three strategies stood out: shade-tree cultivation, income and product diversification, and soil and water conservation practices. These strategies are also commonly used in the cocoa sector.

Despite the numerous mitigation and adaptation strategies implemented in agricultural sectors worldwide and the innovative mechanisms presented or undertaken by various key stakeholders (e.g., FAO, ICO, AGRA, World Bank, WWF, GIZ, IPCC, and private companies such as Nestlé, PepsiCo, Cargill, Unilever, and Walmart), **farmers still face significant barriers when adopting climate-resilient strategies efficiently and sustainably**. Some of the most common constraints for farmers to access and implement both mitigation and adaptation practices are high implementation costs, inadequate policy support, lack of knowledge, lack of access to technology, and social resistance. Financial barriers, policy gaps, and limited access to healthcare, education, and credit further hinder these efforts, especially for marginalized groups. Women face additional challenges due to

discriminatory social norms and unequal access to resources, necessitating gender-transformative approaches such as leadership training and childcare support.

This literature review emphasizes the close relationship between adaptation and mitigation strategies, as one cannot be fully understood without the other. This review concludes that it is essential to identify and address the **synergies between adaptation and mitigation**, and it provides specific examples of such synergies (see Table 2).

This literature review presents the **role of financial inclusion** as a **critical enabler of the transition toward sustainable agriculture**. Financial inclusion requires addressing the specific needs of farmers by providing affordable credit, insurance, and tailored financial products. This approach **contributes to a just transition that leaves no one behind while recognizing that farmers are not homogeneous**. Rather, it considers the various socioeconomic factors that affect farmers' abilities and capacities to access and use climate-resilient strategies.

Finally, this literature review underscores the **need for a holistic approach to effectively address farmers' real needs and struggles regarding climate change in a sustainable manner**. Such an approach is crucial because it seeks and capitalizes on synergies between adaptation and mitigation strategies while considering the socioeconomic elements of entire value chains. In this context, research that considers the need to contextualize mitigation and adaptation strategies provides a more focused understanding. This understanding acknowledges the barriers based on economic status, geographic location, age, or gender that obstruct effective adaptation to the impacts of climate change.

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