CLIMATE-SMART AGRICULTURE IN VIETNAM'S COFFEE SECTOR:

Adoption, Barriers, and Opportunities in the Central Highlands

InsuResilience Solutions Fund

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LIST OF ABBREVIATIONS

4C	Common Code for the Coffee Community
ACOM	Atlantic Commodities Vietnam Ltd
C	Carbon
CH	Central Highlands
CIAT	The International Centre for Tropical Agriculture
EM	Ethnic minority
EU	European Union
EUDR	European Union's Deforestation-free Regulation
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHG	Greenhouse gases
IPHM	Integrated Plant Health Management
IPM	Integrated Pest Management
KII	Key Informant Interview
MAE	Ministry of Agriculture and Environment
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
NAEC	National Agriculture Extension Centre
NGOs	Non-governmental organizations
NSO	National Statistics Office of Vietnam
RA	Rainforest Alliance
US	The United States
VietGAP	The Vietnamese Good Agricultural Practices
WASI	Western Highlands Agriculture and Forestry Science Institute
WB	The World Bank
WTP	Willingness to Pay

EXECUTIVE SUMMARY

Vietnam's Central Highlands (CH) is the country's most important coffee-producing region and a critical livelihood source for millions of smallholder farmers. However, the sector is facing growing pressures from climate change, environmental degradation, rising input costs, unstable markets, and labor shortages. These challenges threaten both farm productivity and the long-term sustainability of coffee-based livelihoods. In this context, Climate-Smart Agriculture (CSA) offers a promising pathway to strengthen resilience, enhance productivity, and reduce vulnerability.

The study on "Climate-smart agriculture in Vietnam's coffee sector: Adoption, Barriers, and Opportunities in the Central Highlands" was conducted as part of the project "De-risking coffee from climate disasters: Upscaling coffee climate protection insurance for Vietnamese smallholder coffee producers", funded by The InsuResilience Solution Fund. This study provides an evidence base to support the project implementation by accessing the current extent of CSA adoption among coffee farmers in the CH, identifies its key determinants, and examines the barriers and enabling factors for shaping effective implementation. The research also investigates the perceptions, needs, and priorities of farmers and relevant stakeholders to propose context-specific strategies for scaling CSA in the region. The findings directly contribute to project's objective of improving income and climate risk resilience of coffee smallholder famers through adoption of CSA and Good Agricultural Practices (GAP).

The study is guided by four objectives:

i. Identify socio-economic, environmental, and climate-related challenges affecting coffee production.
ii. Assess farmers' adaptation strategies, including CSA practices, and the factors influencing adoption.
iii. Identify barriers, constraints, and enabling conditions for CSA implementation and scaling; and
iv. Examine perceptions, needs, and priorities of farmers and relevant actors to inform recommendations.

A mixed-methods approach was applied, combining document review, household surveys with 404 individual farmers across 3 provinces (including Dak Lak, Gia Lai and Lam Dong), Focus Group Discussions (FGDs) among representative farmers in each province, and Key informant interviews (KIIs) with key farmers and relevant actors in the CH during April – August 2025. Quantitative analysis captured adoption patterns and determinants, while qualitative data provided deeper insights into institutional, behavioral, and contextual factors influencing CSA uptake.

Key findings:

1. Production challenges are multi-dimensional and increasing: Farmers face degrading soil fertility, high input prices, fluctuating markets, and labor shortages. These challenges significantly undermine production efficiency and household resilience.

2. Climate change poses substantial risks to coffee production: Drought is the most critical climate hazard, followed by extreme rainfall, and increased pest and disease pressures. Similar situation was observed across all surveyed areas; though farmers in Dak Lak province reported more serve drought impacts compared to those of Gia Lai and Lam Dong province. Overall, these risks contribute to yield decline, rising production costs, and greater uncertainty in farm management.

3. CSA and sustainable practices are being adopted, but unevenly: Farmers apply a range of adaptation and CSA strategies, including water-saving irrigation, mulching, shade management, intercropping, and soil conservation, etc. While overall adoption levels are above average, uptake remains uneven across farmer groups. Farmers in Dak Lak and Lam Dong show significantly higher levels of adoption. Ethnic minority farmers, smallholders, and low-income households adopt fewer CSA practices due to limited financial resources, lower technical capacity, and weaker access to institutional support.

4. Barriers to CSA implementation remain significant: Key constraints include high investment costs, limited access to finance, fragmented and inconsistent technical support, labor shortages, and gaps in policy implementation. These barriers reduce farmers' ability and willingness to adopt more sustainable and climate-resilient practices.

5. Farmers and stakeholders have clear priorities for strengthening CSA adoption: Farmers consistently identify the need for affordable financing, practical and context-specific training, localized climate information, improved irrigation technologies, soil-testing services, stronger cooperatives, and better market linkages. Stakeholders confirmed similar needs and highlighted the issues of weak coordination and short-term support (project-based support).

Recommendations

Based on these findings, the study proposes six strategic directions for strengthening CSA adoption and climate resilience in the CH coffee sector:

1. **Strengthen financial access and risk-management mechanisms**, including agricultural credit, climate or agricultural insurance, with tailored solutions for disadvantaged groups.
2. **Improve technical capacity and extension systems** through hands-on CSA training, demonstration models, farmer field schools, and targeted support to ethnic minority and women.
3. **Enhance local climate services and farm-level decision support** by developing downscaled agro-climatic advisories and delivering them through multiple and user-friendly channels. This includes integrating bundled services such as credit, insurance, market information, and farm management support (e.g., soil testing services).
4. **Promote behavioral change and awareness** through communication campaigns, success stories, and community influences to encourage the adoption of sustainable farming practices.
5. **Strengthen cooperatives and value-chain partnerships** to facilitate collective action, technical assistance, certification, and stable market incentives for CSA adoption.
6. **Improve multi-actor coordination and co-investment** by aligning public and private interventions, establishing coordination mechanisms, and promoting integrated landscape-level CSA planning.

Overall, the study concludes that scaling CSA in the CH requires a holistic, inclusive, and well-coordinated approach that integrates financial innovation, climate information services, technical support, market incentives, and long-term collaboration among government agencies, private companies, cooperatives, NGOs, and research institutions. Strengthening these systems will be essential for building resilience and ensuring the sustainable development of Vietnam's coffee sector.

1. INTRODUCTION

1.1. Project Description

The project "De-risking coffee from climate disasters: Upscaling coffee climate protection insurance for Vietnamese smallholder coffee producers" is funded by The InsuResilience Solution Fund and are coordinately implemented by Willis Towers Watson (WTW); University of Southern Queensland (UniSQ); Atlantic Commodities Vietnam Ltd (ACOM); International Center for Tropical Agriculture (CIAT) and Bao Minh Insurance Corporation (BMI). The project objective is to increase the capacity of smallholder farmers in Vietnam to adapt to climate change through the introduction and use of climate risk insurance products. The project targeted Smallholder farmers and businesses engaged in the coffee production system. It is expected that by the end of the project, about 5,000 coffee farmers (or 27,500 total beneficiaries) will be using coffee insurance to protect from the financial impacts of climate. The project objective will be achieved through the following outcomes:

- Enhanced the capacity of smallholder coffee producers and associated supply chain to adapt to climate variability and change risk reduction and risk transfer.
- Improved income of coffee smallholder famers through adoption of CSA and GAP.

Within the project framework, two baseline studies were conducted. The first is a willingness to pay (WTP) study to assess farmers' WTP for insurance products and schemes and gather feedback for the improvement of the insurance product. The second is the study "Climate-smart agriculture in Vietnam's coffee sector: Adoption, Barriers, and Opportunities in the Central Highlands", which aims to understand farmers' exposure to climate impacts and their adaptation responses through climate-smart and sustainable agricultural practices.

1.2. Rationale for study

Vietnam is the world's second-largest coffee exporter, accounting for 20% of global supply in 2024 (USDA, 2024). As one of the country's 13 key agricultural products, coffee contributes around 3% to Vietnam's GDP and provides employment and stable income for over 600,000 farming households (MOIT, 2022). In addition, the coffee industry also creates many jobs, from production to harvesting, processing and sales.

Despite its importance to Vietnam's economy, the coffee sector has been facing growing challenges, including environmental degradation and climate change-induced impacts (USDA, 2025). Additionally, the sector encounters strong competition from other coffee-producing countries, and new regulations of the coffee import market on traceability, food safety, and coffee quality, etc. (Tran et al., 2024). Climate hazards have been disrupting production and reducing yields (Doan et al., 2025; USDA, 2025). The 2015/16 El Niño in the CH triggered the worst drought in over 60 years, damaging nearly 15% of perennial crops in the CH, with the lost-most notably in Dak Lak (27.2%), Lam Dong (16.6%), and Dak Nong provinces (10.1%) (UNDP, 2016). On the other hand, unsustainable farming practices have led to soil, water, and forest degradation, contributing to plant diseases, higher production costs, and environmental impacts (UNEP, 2021). In addition, the Vietnam's small-scale farming is vulnerable to changes in the market prices, especially export markets (UNEP, 2021). Rising global demand for high-quality, environmentally responsible products along with new regulations like the EU Deforestation-free Regulation (EUDR) are driving the Vietnamese coffee sector to adapt in meeting the evolving market requirements (USDA, 2025).

The afore-mentioned challenges underscore an urgent need for more sustainable approaches. In addressing part of the challenges, CSA has emerged as a promising strategy amid growing demand for sustainable agriculture and food security. FAO introduced a concept of CSA in 2009 and officially presented it at the 2010 Hague Conference on Agriculture, Food Security, and

Climate Change (Lipper et al., 2017). According to FAO, CSA is a holistic approach to agricultural production through "achieving triple wins of increasing productivity and income, adapting to climate change, and reducing greenhouse gas emissions" (Lipper et al., 2017). Various CSA practices have been adopted worldwide to enhance agricultural productivity and respond to climate change. As one of the countries most affected by climate change, Vietnam is promoting CSA practices in agriculture, including coffee production. Popular practices include mulching, intercropping, and agroforestry, etc. These practices help sustain yields and quality, enhance soil fertility, optimize input use, and conserve environmental resources. They also support efforts in reducing greenhouse gases (GHG) emission, protecting the environment, and meeting the international coffee quality standards.

While many studies have been conducted to assess climate change impacts on coffee, few have examined the level of CSA adoption in the coffee sector, especially in the CH, and/or explored related challenges and opportunities. Therefore, updating this information is crucial for developing strategies to scale up CSA in the coffee sector. The findings of this study will support project efforts to enhance farmers' resilience to climate change through strengthening the application of CSA practices in coffee production.

1.3. Study objective

To assess the adoption of CSA practices in the CHs coffee sector by examining current production challenges, climate and non-climate risks, farmer adaptation strategies, and the key barriers, needs, and opportunities for scaling effective CSA solutions.

Specific objectives

1. Identify and analyze the socio-economic, and environmental challenges affecting coffee production in Vietnam and the CH.
2. Assess current farmer adaptation strategies, including CSA and other sustainable practices, and evaluate adoption levels and the factors influencing farmers' decisions to adopt these practices.
3. Identify the major barriers, constraints, and enabling conditions that influence the effective implementation and scaling-up of CSA practices in the coffee sector in CH.
4. Examine the perceptions, needs, and priorities of farmers and relevant actors regarding CSA, and to generate context-specific recommendations to strengthen resilience and support CSA upscaling.

2. METHODOLOGY

2.1. Research questions

Based on the formulated objectives, the following research questions have been defined:

1. What are the current socio-economic and environmental challenges in coffee production in the CH?
2. How is climate change affecting coffee farming, and what climate risks pose the greatest threat to production systems?
3. What adaptation strategies, including CSA practices, are farmers currently using, to what extent have these practices been adopted, and what factors influence adoption?
4. What key barriers, constraints, and enabling factors affect the effective implementation and scaling of CSA practices?
5. What are the perceptions, needs, and priorities of farmers and relevant stakeholders regarding CSA adoption and upscaling?

2.2. Desk review, data collection and sampling

Information and data were collected through a desk review, including materials from government agencies, private sector companies, and previous studies. Quantitative and qualitative primary data and information from coffee farmers and relevant stakeholders (government officials, local experts) in major coffee-growing areas. Household surveys, KIIs, and FGDs were conducted across three provinces in the CH: Dak Lak, Gia Lai, and Lam Dong (See Annex 1).

Table 1: Data collection methods, surveyed locations, timeline, and participants

Tools	Location[1]	Date	Objective	Respondents
Desk review	• Home-based	Apr- Sep, 2025	• Literature review about the coffee sector and CSA practice typologies	NA
FGD	• Ia Bang commune and Ia Hrung commune, Gia Lai Province • Ea Tul commune, Dak Lak, province • Dinh Trang Thuong commune and Hoa Bac commune, Lam Dong Province.	Apr 10-11, 2025 Jul 31-Aug 2, 2025	• Identify climate risks and impacts on coffee production. • Assess the adoption and effectiveness of CSA practices. • Understand farmers' needs, perceptions, and priorities for climate adaptation.	39 farmers
KII	• Gia Lai Province • Dak Lak Province • Lam Dong Province	Jul 24, Aug 25-26, 2025	• Understand local needs, perceptions, and priorities for climate adaptation. • Identify barriers and enablers for scaling CSA among stallholders and in localities	6 farmers 7 communal, 4 provincial agricultural staff, 2 Local experts
Household survey	• Gia Lai Province • Dak Lak Province • Lam Dong Province	Jul-Aug, 2025	• Understand household demographics, perceptions of climate change impacts, and level of CSA adoption.	404 individual farmers

[1] After 1 July 2025, the names of locations may change due to administrative restructuring, in accordance with Resolution No. 202/2025/QH15 on the reorganization of provincial-level administrative divisions. In this case, new names of the study sites were used

Desk review

This study extensively reviewed CSA-related studies from a wide range of international and national organizations and research institutes, with key focuses on: (i) the current status of the coffee sector in Vietnam and related production issues, (ii) current understanding on enabling environment for CSA, and (iii) typologies and application of CSA in the coffee sector. The literature review was conducted via online search from credible sources, using keywords such as CSA, climate-resilient practices, sustainable farming, organic, and coffee production, etc. (both English and Vietnamese).

Focus Group Discussions

FGD is a cost-effective way to gain in-depth understanding and to engage communities with limited numerical literacy. In this study, FGDs were used to gather experience and insights of smallholder coffee farmers in the 3 selected provinces (Dak Lak, Gia Lai, Lam Dong) on the vulnerability of their farming systems to climate risks and their adoption of CSA practices to mitigate the climate change impacts. The discussion was topic guided to get views of the participants and identify their experience on adaptation strategies, challenges, and support needed in scaling CSA adoption. Farmers' perspectives on climate information services were also examined to inform the development of tailored services that facilitate CSA adoption. A guide for the discussion was prepared based on literature from prior research and was pre-tested for clarity and relevance.

FGDs were conducted in each of the three study provinces, with 6–8 representative participants per group. Farmers were selected for a study to capture diverse perspectives on coffee farming. Both male and female smallholder farmers participated, all directly involved in farm management and decision-making. The selection included households under the supply chain of ACOM and non-ACOM households, enabling comparisons of farming practices, access to support, and climate adaptation strategies. Additionally, farmers with varying experience levels in coffee cultivation and adaptation methods were included to enhance the quality of the discussions.

Key Informant Interviews

KIIs were conducted to gather in-depth perspectives from a diverse group of stakeholders. For this study, KIIs were conducted in the three studied provinces, including lead farmers, local agricultural experts, and government officials involved in the promotion and implementation of CSA. Each interview followed by a stakeholder-specific checklist to ensure consistency and relevance in data collection. The KIIs explored stakeholder views on climate-related vulnerabilities, adaptation strategies, perception on CSA, and challenges in adoption. In addition, interviews captured stakeholder roles in facilitating CSA adoption and identified the availability and accessibility of CSA-related resources and support services, as well as priorities and recommendations for improving CSA implementation.

The KIIs involved representative farmers in the studied locations. Other participants included local experts from extension units and agricultural agencies and provincial agriculture extension centers, and researchers from national institutes. These actors are knowledgeable about coffee production and sustainable agricultural practices in the target provinces, holding positions that directly interact with farmers and contribute to the design and implementation of CSA related support policies and programs. Gender and ethnicity balance were considered in participant selection.

Household survey

Data related to the CSA were integrated into a broader WTP study conducted in three selected provinces. A multi-stage stratified random sampling design targeted farmers with varying exposure to structured institutions and insurance programs. The sampling defined three strata: (1) Communes with existing Weather Index Insurance (WII) program villages; (2) Communes with agribusiness links (specifically ACOM), but no direct WII exposure; and (3) Control communes with neither WII nor agribusiness involvement. The selection process included identifying districts with high climate risk and ACOM activity; Categorizing communes into the three strata, and a specified number were randomly selected (12 for types 1 and 2, and 4 for type 3); Choosing two villages within each commune, prioritizing those with a high number of ECOM or WII farmers. Finally, approximately 11 coffee-growing households were selected from each village in consultation with local leaders to ensure representativeness. The final sample comprised 404 households across the three provinces (see more details in the WTP study report). Data collection focused on household demographics, perceptions of climate change impacts, and CSA adoption levels.

The level of CSA adoption for each practice was defined as follows:

1 = No adoption (Never apply the technique)

2 = Limited adoption (Apply sometimes on some coffee land plots)

3 = Moderate adoption (Apply sometimes on most coffee land plots)

4 = Strong adoption (Apply regularly on most coffee land plots)

5 = Full adoption (Apply regularly on all coffee land plots).

2.3. Data analysis

Qualitative data from FGDs and KIIs were summarized, organized into templates, and analyzed them thematically. Quantitative and semi-quantitative data were subject to statistical analysis in SPSS (version 20). Descriptive statistics, ANOVA, Chi-square and z-tests were conducted to compare among different farmer groups regarding their level of climate risks and CSA adoption level.

3. OVERVIEW OF THE VIETNAMESE COFFEE SECTOR

3.1. Status of the coffee sector in Vietnam

3.1.1. Coffee production

Coffee is a strategic sector of Vietnam's agriculture, which contributes to 10% of agricultural GDP, 3% of the national GDP in 2024; provides millions of jobs for people and thus plays an important role in improving living standards for local communities (Dang et al., 2025). In the past 30 years, the coffee industry has grown rapidly in terms of area, yield, and productivity. The biggest coffee area is the CH, comprising Dak Lak, Lam Dong, Gia Lai, and Quang Ngai provinces, which accounts for 92% of the country's coffee cultivation area and 90% of its total production (USDA, 2025).

According to Vietnam's National Statistics Office of Vietnam (NSO), coffee cultivation area has expanded consistently in Vietnam, from 554.8 thousand ha in 2010 to 730 thousand ha in 2024, together with the overall increase in production in the given period, despite a decline between 2023 and 2024 due to extreme weather events (Figure 1). While some media have reported a shift of production systems toward high-value crops like durian and macadamia, official statistical data indicate a continuing expansion of coffee cultivation. Noticeably, in 2021, the Ministry of Agriculture and Rural Development (MARD) (now called the Ministry of Agriculture and Environment (MAE)) has launched a specialty coffee development plan (Decision No. 1392/QD-BNN-TT, 2021) aiming to increase coffee product quality and production value. This strategy drives strong demand for coffee seedlings, 4–5 million plants annually for new planting and replanting, supplied by the Western Highlands Agriculture and Forestry Science Institute (WASI) (USDA, 2025). This effort is considered essential for improving yields, quality, and climate resilience, while also meeting the increasingly strict standards of key export markets such as the EU, Japan, and the US (USDA, 2025).

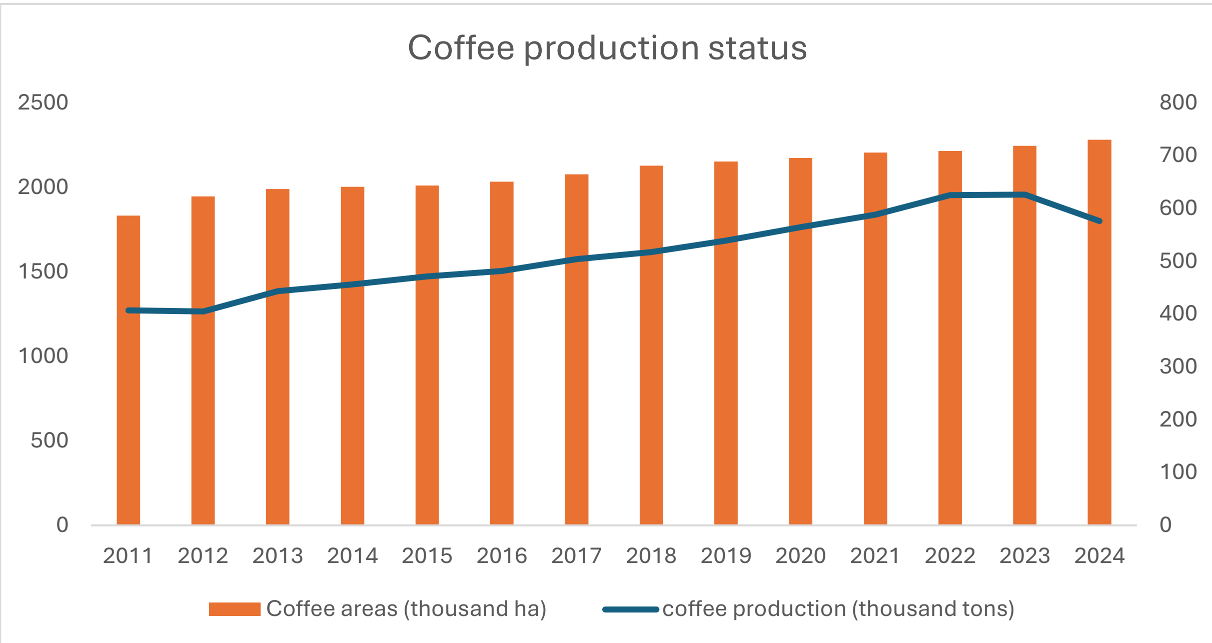

Figure 1: Coffee areas and productivity of Vietnam between 2011 and 2024

Source: NSO, 2025

3.1.2. Coffee trade and markets

Vietnam is the world's second-largest coffee exporter, with Robusta accounting for 90% of its total coffee exports (Doan et al., 2025). In which, the main markets include the EU, the US, and Japan (Figure 2). Coffee exports contribute significantly to the national economy. In 2022, Vietnam exported 1.78 million tons of coffee worth USD 4.06 billion - the highest value in over a decade, representing nearly 18% of total agricultural export turnover (Nguyen et al., 2024a). Although the export volumes fluctuated overtime, export turnover has increased significantly in recent years due to the rising prices (Figure 3). This is because global coffee demand has grown in recent years, due to the world economy beginning to recover after the Covid-19 pandemic, creating increasing demand for coffee. Additionally, adverse weather events in major coffee-growing regions and geopolitical tensions in certain countries have disrupted container availability and reduced the stability of shipping routes to key markets (Tran et al., 2024). In Vietnam, the recent surge in Robusta prices was due to the growing global demand coupled with supply shortage, largely caused by El Niño-induced drought and pest outbreaks, affecting key producing countries like Vietnam and Indonesia (Tran et al., 2024) (Figure 4).

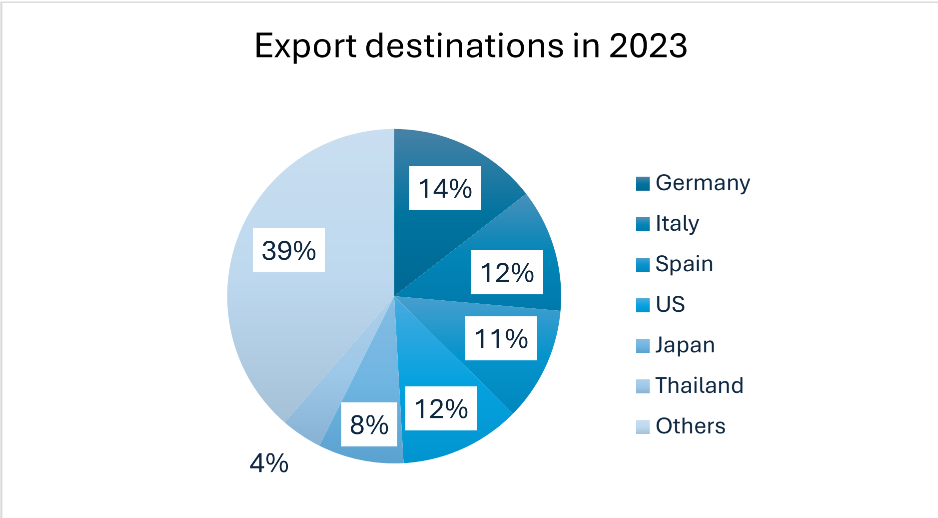

Figure 2: Vietnam's main coffee export destinations in 2023

Source: The Observatory of Economic Complexity, 2023

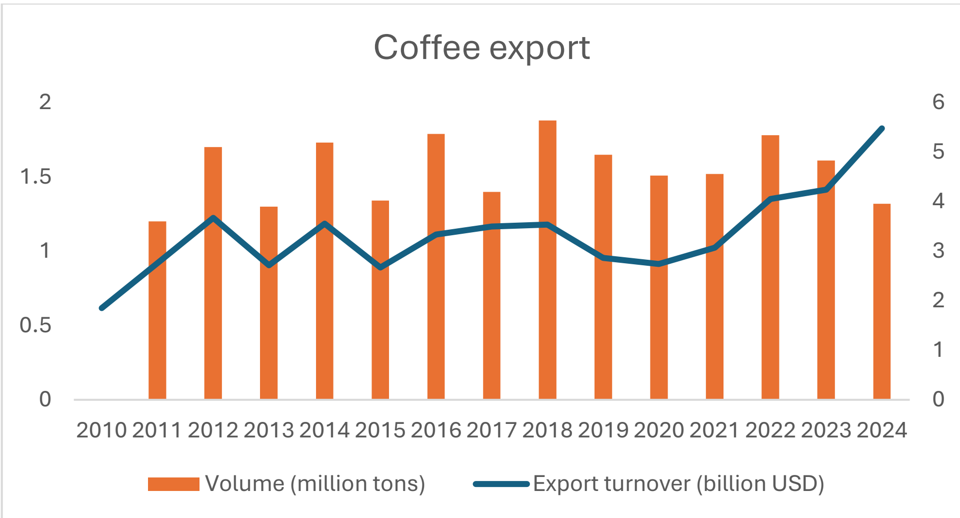

Figure 3: Vietnam's coffee export volume and turnover between 2010-2024

Source: NSO, 2025

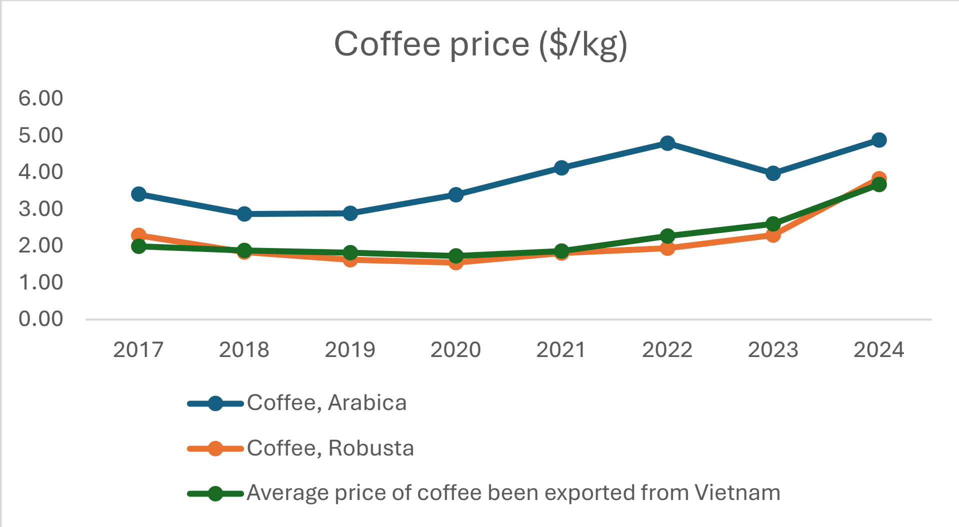

Figure 4: Average coffee price in the world market and Vietnam's exports from 2017 to 2024

Source: WB Commodity Price Data (The Pink Sheet) and calculated from data of NSO, 2017-2024

Despite its large export volume and strong position in the global coffee market, Vietnam's coffee industry remains limited in export efficiency. Most coffee exports are unprocessed Robusta. The country remains focused mainly on raw production; consequently, the added value generated from processing and exporting each unit of Vietnamese coffee is still very limited compared with other in the global coffee industry (Nguyen et al., 2024a; Tran et al., 2024).

3.2. Challenges in coffee production

3.2.1. Market access and competitiveness

The coffee sector in Vietnam is dominated by smallholders who are vulnerable to fluctuations of market prices (UNEP, 2021). High fluctuations in coffee prices make coffee growers' profits unstable. When prices fall too low, many farmers switch to more profitable crops. Conversely, when prices rise, farmers often expand coffee cultivation without adhering to land-use plans or government recommendations. This unregulated expansion can lead to oversupply, driving prices down again and ultimately reducing the long-term benefits for both farmers and the broader economy (Tran et al., 2024).

On the other hand, growing global demand for high-quality, sustainable products is placing increasing pressure on the competitiveness of Vietnamese coffee. Particularly, main coffee-producing countries such as Brazil, Colombia, and Indonesia, etc., are very strong competitors of Vietnam in the global coffee market. These countries have been increasingly invested in coffee production and processing, improving product quality, and using many effective marketing measures to attract international customers (Tran et al., 2024). As such, Vietnam’s coffee sector shall continue innovating and adapting to evolving market demand to stay competitive.

Recently, the European Union’s Deforestation-free Regulation (EUDR), aimed at reducing deforestation, greenhouse gas emissions, and biodiversity loss, requires exporters to demonstrate deforestation-free supply chains will take into effect from 2026 (Delegation of the European Union to Vietnam, 2023). As the EU accounts for nearly 40% of Vietnam’s coffee export, compliance to the regulation would be essential to maintain market access and promote sustainable agriculture. Additionally, the EU’s stricter pesticide residue limit for coffee adds pressure on producers to adopt more sustainable practices (Nguyen et al., 2024a). This presents another challenge, as Vietnam’s coffee sector has long prioritized yield over sustainability, with many farmers still relying on monoculture and unmanaged production area expansion.

3.2.2. Environmental degradation

Forest depletion can be attributed to land conversion, especially coffee plantations (Catacutan et al., 2015). The CH is one of the areas with a high percentage of land and forest in use, over 81%, ranking 4th among 7 ecological regions in Viet Nam (Nguyen et al., 2024). However, this area experienced extensive land conversion, partly driven by agricultural-related deforestation. Between 1976 and 2012, forest cover fell from 67% to 50.7% in CH, with key forest types lost including evergreen and deciduous broadleaf forests and pine forests. Much of the cleared land has been converted to perennial cash crops such as coffee, pepper, and cashew (Meyfroidt et al., 2013). Alarmed by rapid forest/agricultural land conversion, the government shifted its strategy and promulgated forest protection and reforestation policies. Although government protection and reforestation policies led to partial recovery, forest biodiversity, quality and ecosystem services remain diminished.

Soil degradation in Vietnam's coffee farms stems largely from unsustainable, yield-driven intensive farming practices. Long-term monoculture and excessive use of inorganic fertilizers (e.g. Nitrogen), coupled with limited organic amendments, poor land management, and cultivation on steep slopes, have depleted soil nutrients, reduced organic matter, and weakened soil structure (Van et al., 2025, Tran et al., 2024, D'haeze, 2019). Farmers often neglect organic byproducts such as coffee husks, rarely plant cover crops or nitrogen-fixing species, and frequently cultivate on sloping land, inducing increased soil erosion (Tran et al., 2024). Overuse of chemical fertilizers further accelerates soil acidification and alters soil's physical and chemical properties, leading to nutrient imbalances, weakened soil structure, higher prevalence of soil-borne diseases and increased greenhouse gas emissions (Van et al., 2025, D'haeze, 2019). Continuous monoculture further weakens soil structure, while minimal ground cover exposes soils to intense water-driven erosion that strips away nutrient-rich topsoil and undermines long-term productivity (Van et al. 2025, FAO, 2023, Trinh et al., 2021).

Reduced water availability in the CH is driven by large-scale coffee monoculture with inefficient irrigation (Nguyen et al., 2024b). Between 56.6% and 95% of irrigation water is sourced from groundwater, with substantial losses from over-irrigation (Amarasinghe et al., 2015). Traditional hose irrigation remains dominant (74%), while more efficient systems like drip and root sprinklers are used in less than 2% of farms (Nguyen et al., 2024b). Intensive input use, poor irrigation management, and increasing drought severity together threaten the long-term sustainability of coffee production (Tran et al., 2021). As a result, groundwater levels have steadily declined; in Dak Lak, dry-season levels are now 1.4–1.5 m lower than in the early 1980s. In 2016, water shortage reduced irrigation capacity on about 470 ha of coffee farms, with only 72% of households having access to sufficient irrigation water supplies (Tran et al., 2024).

3.2.3. Climate change and its implications

Vietnam is among the most climate-vulnerable countries. According to MONRE (2020), average annual temperatures in the CH are projected to rise by 0.4–1.2°C (mean: 0.8°C) under the RCP4.5 scenario by 2035, and by 0.6–1.2°C (mean: 0.9°C) under RCP8.5. Annual rainfall is expected to increase by 6.5% under RCP4.5 and 5.3% under RCP8.5, though high variability remains. CIAT's projections indicate that by 2050, drought periods in southern Vietnam could extend well beyond the current March–May window, possibly into June, exacerbating water stress during critical crop stages (Figure 5) (Grosjean et al., 2016). These changes are subjected to impact on coffee production in the CH, as suitable areas for coffee cultivation are projected to shrink, with average losses of 27% under RCP2.6 and up to 36% by 2060–2070 (Dinh et al., 2022). Furthermore, an analysis using the IMPACT model assessed climate change effects on crop yield, area, and net trade from 2020 to 2050. Compared to a no-climate-change scenario, coffee yield growth under the climate change scenario is projected to decline by 1.7% in 2020 and 6.5% by 2050 (Robinson et al., 2015).

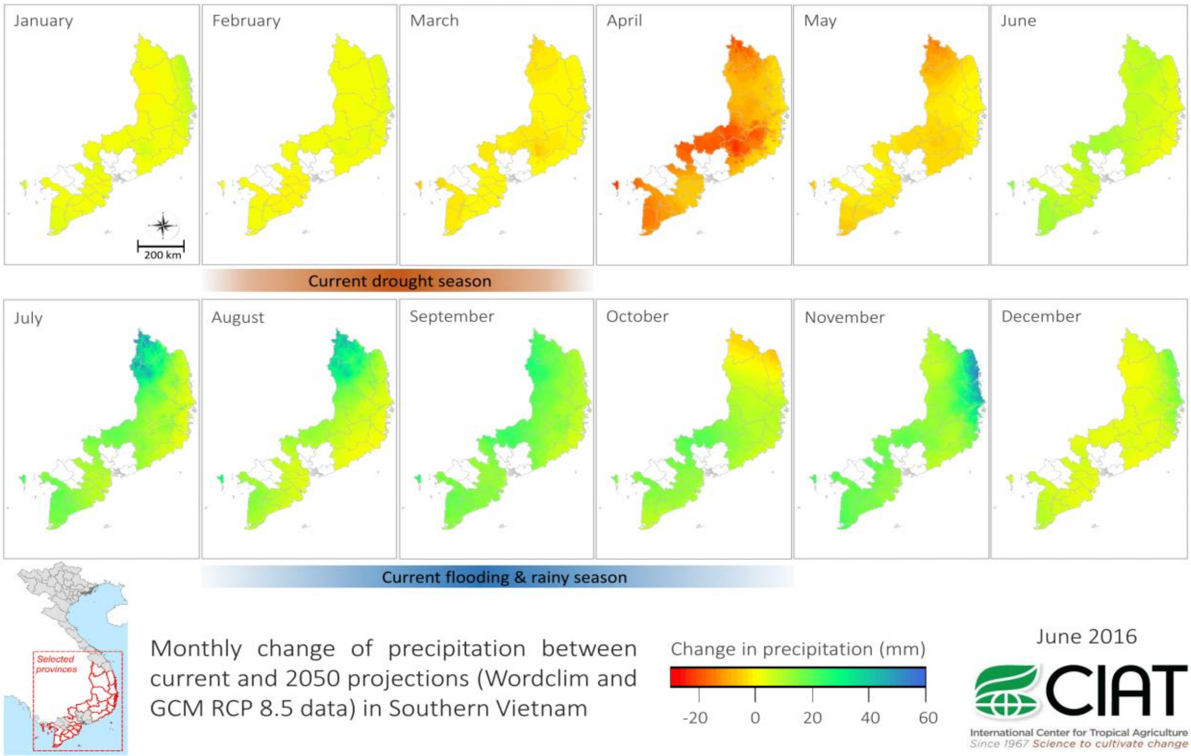

Figure 5: Monthly change of precipitation between current and 2050 projections in southern Vietnam

Source: Grosjean et al., 2016

Coffee is highly sensitive to climatic stress, particularly heat, drought, and irregular rainfall during flowering and fruiting, which can reduce yields, raise production costs, and lower farmer incomes (Doan et al., 2025). Yield variability is closely tied to precipitation and temperature patterns, with a 1°C increase above optimal thresholds linked to a 14% yield decline in robusta coffee (Kath et al., 2020). Elevated temperatures disrupt coffee phenology by impairing flowering and fruit set, while prolonged droughts further limit water availability during key developmental stages, compounding yield losses (Bhattacharya & Nair, 2024).

On the other hand, excessive rainfall affects coffee bean size and quality. Unseasonal rain during flowering and harvesting period (notably increasing in December–January) disrupts pollination, delays drying, and increases defects such as mold and black beans, reducing market value (Kath et al., 2021). Two climate windows are critical for Robusta: (1) a prior rainy season that boosts vegetative growth, and (2) low rainfall during bean formation that suppresses yield. These patterns can help predict yield anomalies 3–6 months in advance, though sensitivity varies by location, up to 36% of yield variability is explained by weather in Dak Lak and parts of Lam Dong, but less so in Dak Nong and Gia Lai provinces (Kath et al., 2021).

Climate change has intensified the spread of pests and diseases in coffee-growing regions. Rising humidity and temperatures create favourable conditions for fungal infections such as coffee leaf rust (*Hemileia vastatrix*) and coffee berry disease as well as pests like the coffee berry borer (*Hypothenemus hampei*) and mealybugs. These threats significantly reduce coffee yields and quality. Coffee leaf rust, now widespread in Vietnam, is strongly linked to warm, wet weather conditions and causes premature leaf drop, which weakens the plant's ability to photosynthesize and produce fruits (Bhattacharya & Nair, 2024; D'haeze, 2019). Similarly, elevated temperatures and increased rainfall promote mold growth and accelerate the reproduction of damaging insects, compounding the challenges for coffee farmers (Kath et al., 2021).

3.2.4. Gender and social issues

The impact of environmental degradation and climate change may contribute to labor migration from the sector. Most of Vietnam's coffee producers are smallholder farmers, with average farm sizes ranging from 0.8 to 1.2 hectares per household (Dang et al., 2025). They are particularly vulnerable to the impacts of climate change. Declining yields and quality directly reduce their incomes and limit their ability to invest in farm improvements. At the same time, rising costs for pest and disease control and coping with water scarcity further strain household budgets. These growing uncertainties are driving farmers, especially younger generations away from coffee farming, threatening the sector's long-term sustainability (Bhattacharya & Nair, 2024).

Regarding gender, women play an important role in coffee farming. For example, they contribute up to 50% of labor on coffee farms in Lam Dong, and play key roles in cultivation, processing, and marketing (ICO, 2018). Despite this significant involvement, gender inequality remains in the sector. Women often face limited access to land, credit, technology, training, markets, and extension services (FAO, 2019). These disparities restrict their participation in decision-making and leadership roles, ultimately increasing gender gap and inequality.

Limited land rights and low access to resources and support results in ethnic minorities and poor communities being highly vulnerable to climate and market changes. Kinh households (the Vietnamese majority) typically own larger farms, benefit from better infrastructure and market access, and employ more advanced farming techniques, including higher use of inputs like fertilizer and irrigation, leading to greater resilience. Conversely, the smaller resource base and poorer infrastructure access of ethnic minority (EM) groups restrict their capacity to invest in adaptation measures, consequently making them far more susceptible to economic losses from climate change (Dang et al., 2025).

4. OVERVIEW OF CLIMATE SMART AGRICULTURE IN THE COFFEE SECTOR

4.1. Definition of CSA and related concepts

CSA is defined by FAO as “agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces or removes GHG (mitigation) where possible, and enhances achievement of national food security and development goals” (FAO, 2013). CSA emerged as a framework to address the interconnected challenges of food security, climate change adaptation, and environmental sustainability. While the coffee literature does not consistently present a single, coffee-specific formal definition of CSA, the approach is broadly understood as encompassing interventions that simultaneously pursue three complementary objectives: (1) sustainably increasing agricultural productivity and incomes, (2) adapting and building resilience to climate change, and (3) reducing and/or removing greenhouse gas emissions where possible (Koutouleas et al., 2025).

Previous studies show that CSA-based coffee farming approaches share a core set of practical methods, including shade-grown systems, soil and water management, climate-tolerant varieties, integrated pest management, and farm diversification (Bracken et al. 2023; Soilueang et al. 2024). This shared focus exists because all coffee farmers face the same basic challenges: unpredictable weather, soil degradation, pest and disease risks, and unstable income. These practices provide multiple benefits, including enhanced biodiversity, improved soil health and carbon storage, diversified income sources, and greater resilience to climate change (Teixeira et al. 2022; Poncet et al. 2024). However, they can sometimes result in negative outcomes such as reduce the coffee harvest in the short term, unless the farm management (like choosing and pruning shade trees) is carefully planned (Tscharntke et al. 2011; Teixeira et al. 2022).

The literature on coffee production uses several related but distinct terms (including sustainable agriculture, sustainable production practices, agroecological practices, regenerative agriculture, and organic farming), which differ in their focus, principles, and ways of implementation (Table 2). The choice of terminology in coffee research reflects different objectives across studies, policies, and farmer needs. For instance, supply-chain research often uses the term CSA to emphasize farm upgrading and training, while adaptation studies also focus on CSA, and agroecological research highlights diversification and farmer participation (Meter et al. 2022). In practice, these approaches often overlap in Vietnam, the shift to organic coffee is seen both as a climate adaptation strategy and a market opportunity (Le et al. 2021). Overall, studies agree that climate-smart coffee production is most effective when practices are tailored to local conditions and supported by both farm-level adaptations and market incentives (Bracken et al. 2023; Pham et al. 2020; Meter et al. 2022).

Table 2: CSA related terminologies and distinctions

Terminology	Primary Emphasis & Goal	Key Distinctions	Sources
Sustainable Agriculture	Triple-bottom-line: Balancing environmental stewardship, social equity, and economic viability.	Broadest approach, often driven by economic benefits (e.g., reduced costs, premium prices) alongside environmental practices (e.g., shade encouragement)	Hung Anh et al., 2019).
Sustainable Production Practices	On-farm techniques to reduce negative environmental impact while maintaining yields.	Focuses specifically on technical on-farm techniques like shade tree integration and soil conservation	Young, 2003).
Agroecological Practices	Systemic and principle-based: Enhancing biodiversity, ecosystem services, and integrating ecological processes.	Prioritizes social transformation (e.g., food sovereignty, farmer empowerment, participatory decision-making) alongside ecological practices like agroforestry; extends beyond purely technical/market approaches	Guzmán Luna et al., 2022).

Terminology	Primary Emphasis & Goal	Key Distinctions	Sources
Regenerative Agriculture	Active rebuilding of soil health, reducing external inputs, and enhancing farm-level biodiversity.	Often framed for climate mitigation potential and market differentiation. A study in Vietnam showed comparable or better soil health than conventional systems with reduced input costs	Le et al., 2021
Organic Farming	Adherence to certification standards prohibiting synthetic pesticides/fertilizers, relying on biological/mechanical control.	A standards-driven approach for market access/price premiums; defined by input restrictions rather than a holistic system redesign (Koutouleas et al., 2025)	

4.2. CSA practice typologies and benefits

4.2.1. Practice typologies

This section classifies major interventions used in coffee systems, linking each to objectives and typical techniques. Table 3 summarizes the principal practice categories that recur across global reviews and coffee-focused case studies.

Table 3: CSA practice groups in coffee farming

Practice category	Key techniques and/or methods	Primary objectives	Typical benefits reported	Source
Agroforestry, shade-grown coffee and crop diversification and farm management	Multi-strata shade trees, selected fruit/legume trees, diversification/intercropping, resilient coffee varieties (e.g., drought/heat/disease-tolerant cultivars, high yield clone), managed tree pruning,	Provide microclimate buffering, nutrient inputs, improve air flow, protects ecosystem services, biodiversity habitat; Increase resilience to climate and pest risks.	Enhanced biodiversity, pollinators, pest regulation, and long-term carbon storage Improved economic returns when paired with system-level practices	Bacon & Sundstrom, 2025; Perfecto & Vandermeer, 2015
Water conservation and management	Terracing, contouring, mulching, shade trees, micro-irrigation, water channels, water harvesting (pond, tank, etc.)	Reduce run-off, increase infiltration, maintain soil moisture, reduce evapotranspiration	Reduced runoff/erosion, improved drought resilience in slope areas	Bracken et al., 2023; Young, 2003
Soil management and organic amendments	Organic amendments (compost, manure, coffee husks, biochar), cover crops, mulching, reduced tillage, balanced fertilization, contouring and terracing, agroforestry, vegetative strips	Build soil organic carbon, improve fertility and soil structure Reduce soil erosion	Higher soil organic matter and microbial biomass in agroforestry systems	Malaver et al., 2025; Parrales-Reyes et al., 2024
Integrated pest and disease management	Monitoring, biocontrol, cultural & mechanical methods; reduced use of chemical pesticides	Reduce pest outbreaks while lowering chemical inputs	Lower input costs and maintained pest control when integrated with shade/bio-diversity	Bacon & Sundstrom, 2025; Shapiro-Garza et al., 2020b
Climate adaptation and mitigation strategies	Altitudinal/varietal shifts, shade optimization, soil/water conservation; Climate risks management (e.g. climate advisory, crop insurance).	Increase resilience and/or reduce risks to temperature/ rainfall shifts and sequester C.	Increased resilience; agroforestry as a mitigation pathway via biomass and soil C	Koutouleas et al., 2025; Malaver et al., 2025

Practice category	Key techniques and/or methods	Primary objectives	Typical benefits reported	Source
"Green" certification schemes, organic and regenerative farming	Elimination/reduction of synthetic agrochemicals, livestock integration, agroecological diversification	Restore soil health and reduce external input dependence	Comparable or improved soil health and profitability in reported case studies	Parrales-Reyes et al., 2024

Description of some typical "green" certification schemes:

Table 4: Main types of coffee certifications in Vietnam

Green label	Description
VietGAP	The Vietnamese Good Agricultural Practices (VietGAP) is a voluntary standard to guide producers to improve quality and ensure food safety on the basis of controlling hazards towards a sustainable agriculture, and is compiled based on the criteria of AseanGAP, GlobalGAP, Freshcare. VietGAP gathers criteria for each product, product group to guide producers to apply and to ensure: Production technology, food safety, food traceability, environmental protection and good health. The VietGAP for rice and coffee was issued in 2010 by MARD (Dao et al., 2019)
UTZ Certified	UTZ is a certification program for sustainable farming of coffee, tea, cocoa, and hazelnuts. The program is part of the Rainforest Alliance, an international non-profit organization working to create a better future for people and nature (UTZ Website).
Rainforest Alliance (RA)	Rainforest Alliance certification helps farmers produce better crops, adapt to climate change, increase their productivity, and reduce costs. The Rainforest Alliance is an international non-profit organization that builds an alliance to protect forests, improve the livelihoods of farmers and forest communities, promote their human rights, and help them mitigate and adapt to the climate crisis (Rainforest Alliance Website).
4C	The Common Code for the Coffee Community (4C) was created through a participatory, extensive, transparent and balanced consultation with coffee stakeholders worldwide, and is operationalized by 4C Services. The 4C certification aims to gradually raise the social, economic, and environmental conditions of coffee production and processing worldwide (4C Website).
Organic	Organic coffee refers to coffee grown and processed without synthetic fertilizers, pesticides, herbicides, or other chemicals. To qualify as organic, coffee farms must adhere to strict guidelines and practices that promote sustainability, soil health, and biodiversity. Some popular certificates including USDA Organic, EU Organic, etc. (Helena Coffee Website)

4.2.2. Impacts of CSA practices

Water saving irrigation is one of the most recommended practices for climate-resilient agriculture (Nguyen et al., 2017). Water saving technologies such as drip and sprinkler irrigation as well as other water harvesting and storage techniques to improve water use efficiency can reduce irrigation volume, save labor and energy, and lower overall water use in coffee cultivation (Pham et al., 2020). Improving water efficiency in coffee cultivation also reduces competition for irrigation with other crops in the same area. This allows farmers to maintain irrigated coffee areas while ensuring sufficient water for other crops, supporting crop diversification, production stability, and overall agricultural system resilience (Nguyen et al., 2024b).

Although dripping irrigation has many advantages (e.g. saving about 20% of water, and reducing labor cost), many coffee producers, however, cannot afford it due to costly investment (Hung Anh et al., 2019).

***Agroforestry** and/or intercropping* is a common practice that allows farmers to diversify their income, improve crop productivity, and resilience to climate change (Nguyen et al., 2024b). Some common species planted with coffee in CH include durian (*Durio zibethinus*), black pepper (*Piper nigrum* L.), macadamia (*Macadamia*), avocado (*Persea americana*), and cashew (*Anacardium occidentale* L.), acacia (*Acacia),* black cassia (C*assia siamea*). However, farmers have recently favored durian, pepper, and macadamia because of their higher economic value (Nguyen et al., 2024b).

Previous studies show that intercropping systems can increase income by 40–120% (Nguyen et al., 2024). For example, intercropping black pepper at spacings of 3×6 m or 6×6 m, and durian at 12×12 m or 12×15 m on coffee farms offers higher economic returns compared to coffee monoculture (Dinh et al., 2019). However, success varied by location and by the type of intercrop used, and was influenced by farmers' technical knowledge, market incentives or price premiums, and access to financing for renovation (Bracken et al., 2023; Perfecto & Vandermeer, 2015).

Environmentally, intercropping improves water use efficiency by nearly 18% compared to monoculture systems, especially models with durian, pepper, or avocado (D'haeze, 2019). The average amount of GHG emissions in intercropping farms is 6,500 kg CO_2e/year, which is comparably lower than that of monoculture farms (7,459 kg CO_2e/year) (Doan et al., 2025). Intercropping also reduces heat stress (microclimate regulation), reducing soil moisture loss, etc., (Nguyen et al., 2024). Coffee intercropped with forest trees increases biomass, while conventional monoculture has lower microbial biomass, indicating agroforestry's role in enhancing soil fertility (Malaver et al., 2025).

On the other hand, agroforestry and regenerative systems may increase labor demand for planting, pruning, and management, but can also diversify labor timing. Additionally, organizational support (e.g. cooperatives, value-chain models) increases feasibility of adoption (Bracken et al. 2023; Meter et al. 2022).

In addition, synthesis reviews show that the ways coffee farms diversify vary significantly by region. Areas with high-intensity farming follow a different path compared to other coffee landscapes that maintain low-intensity farming and high biodiversity. This difference means that effective policy and market strategies must be region-specific rather than one-size-fits-all (Babin, 2015).

Shade trees and wind break trees are recommended to promote sustainable coffee production and environmental protection. These trees help lower evaporation, reduce irrigation needs during the dry season, and protect coffee plants by decreasing wind speed, radiation, and temperature while enhancing soil moisture. Leguminous species like black cassia also improve soil fertility, further reducing water requirements and production costs (Nguyen et al., 2024b). They also contribute to carbon sequestration, drought resistance, natural weed and pest control, and therefore reducing the need for agricultural chemicals, lowering pollution and input costs (Scott & Gheyssens, 2020).

In addition, shade trees and their associated products (e.g. fruits, timber) can also be consumed or sold, helping compensate for income losses when cash crop prices fall. A comparative study in Lam Dong found that regenerative shade-grown farms had soil health comparable to or better than conventional farms, and lower external input costs due to diversification and integrated livestock. However, they also had higher humidity-related disease risks that can reduce yields if unmanaged (Meter et al., 2022)

Improved crop varieties show resilience to drought, flooding, pests, and diseases. WASI has developed several high-yielding, climate-resilient coffee varieties. Notable examples include late-ripening types suitable for water-scarce areas (e.g., TR14, TR15) and rust-resistant varieties like TRS1, which are now being widely adopted in production) (Nguyen et al., 2024b). These clones provide the productivity of 4–6 tons per hectare with good quality beans with the percentage of R1 seed size over 80%. They are also highly resistant to *Hemileia vastatrix* disease, ripen evenly, and are suitable for the local natural conditions. Moreover, late ripening varieties such as 2/1, 12/1, and 11/12 could lengthen the harvest time to December. Those traits are convenient for harvesting, drying, and reducing the amount of watering for coffee in the dry season (Hung Anh et al., 2019).

Integrated Pest Management (IPM) and Integrated Plant Health Management (IPHM) *are* the important guidelines for weed, pest, and disease management. The management practices help reduce the excessive use of agrochemicals, lowering production costs, and GHG emission, while supporting biodiversity and profitability for farmers (Reay, 2019).

Despite these benefits, adoption of IPM/IPHM remains limited in the region. In Dak Lak, approximately 78.5% of farmers use pesticides through self-experience, and only 21.5% apply IPM acquired from the training. Additionally, over 60% still apply chemical pesticides more than recommended, even when infestations affect only small areas. This highlights the need for expanded training and awareness raising to promote more targeted and sustainable pest management practices (Hung Anh, et al 2019).

Nutrient management plays a critical role in maximizing coffee yields and reducing susceptibility to pests and diseases (Muller et al., 2009). In CH, a climate-smart coffee cultivation program (2023–2026) is being implemented by Binh Dien company in collaboration with the National Agriculture Extension Centre (NAEC) and WASI. The program promotes improved, site-specific fertilization practices and incorporates several innovations, including Coating NPK fertilizer granules with Bio Spring microbial preparations; applying soil-balancing fertilizers to address soil acidity and deficiencies in exchangeable calcium and magnesium; using multi-purpose organic fertilizers to enhance soil health. A trial conducted in Gia Lai province demonstrated that farmers applying the improved fertilizer formula reduced NPK usage from 3 kg to 2 kg per coffee tree annually without compromising yield. Additional benefits observed included better soil moisture retention, increased humus levels, higher earthworm density, healthier trees, and higher yields in the 2024–2025 season (NAEC, 2025)

Cover crops (also called living mulches) help retain rainfall in the soil and enhance water penetration (Dzvene et al., 2023). Coffee farms with soil cover demonstrated higher effectiveness in yield, natural resources conservation, and household welfare than farms with no soil cover. On average, farms with soil cover emitted 6,519 kg CO_2e per year, which was lower than farms without soil cover (7,044 kg CO_2e/year) (Doan et al., 2025).

Pruning is a technique aimed at creating a balanced canopy of coffee trees. Fully exploiting the individual space of each tree helps promote a balance between growth, flowering, fruiting, and stable yield. There are two main coffee pruning methods. These include multi-stemmed pruning (with coffee cherries mainly harvested on basic stems) and single stem pruning (cutting off the plant top at a height of about 2 m with the coffee cherries harvested on secondary stems). These methods create favorable conditions for pest control and harvesting. However, both methods are rather labor-intensive with an average of 30 to 40 man-days/hectare/crop season. In fact, many farmers practice pruning based on their own experience (35.4% of the coffee area). This leads to improper structure of stems that reduce productivity (Hung Anh, et al 2019).

Table 5: Summary impacts of CSA from literature review

	Environmental impact	Economic impact	Social impact
Positive	Increased carbon sequestration	Yield and profitability improvement	Livelihood diversification
	Increased biodiversity	High quality coffee and thus higher selling prices.	Diversified labor timing
	Improved resource use efficiency and conservation	High crop value and thus ease of loan access	Organizational support (cooperatives, value-chain models)
	Climate resilience	Input saving	Peer learning promoted
Negative	Higher humidity-related disease risk if unmanaged	High upfront investment costs (e.g. water-saving irrigation systems, seedlings).	Increase labor demand (for planting, pruning and management)

4.3. Institutions and policies for CSA in Vietnam

Institutions for climate change adaptation and the coffee sector development

Vietnam's climate change policymaking involves various stakeholders, including the Central Communist Party, the government and relevant Ministries. The MAE leads in drafting policies and allocating financial resources. The National Committee on Climate Change coordinates these ministries and plays a key role in international cooperation for climate change-related programs. Provincial authorities lead local planning and implementation of national policies, investment in project formulation, and budget allocation processes (Nguyen et al., 2017).

For the coffee sector, MAE is also the lead Ministry for coffee, overseeing the industry through various departments and organizations such as the Plant Production and Protection Department (PPPD), Argo-processing and Market Development Authority (Agrotrade), International Cooperation Department (ICD), Vietnam Coffee Coordinating Board (VCCB), etc. as well as a number of public research institutions such as the Institute of Strategy and Policy on Agriculture and Environment (ISPAE), WASI, etc. (Nguyen et al., 2017). The Ministry of Industry and Trade plays a vital role in market access and global economic integration. The Vietnam Bank of Agriculture and Rural Development (Agribank) is the loan provider for coffee farmers, with 1,600 branches in rural areas. Institutional reform is a priority for sustainable development of the coffee sector (Nguyen et al., 2017).

Policy supporting CSA in Vietnam's coffee sector

Vietnam's agricultural policy has increasingly emphasized quality over quantity, captured by the "value not volume" approach. This shift is reflected in key policies like *the Agricultural Restructuring Plan for 2021–2025 (*Decision No. 255/QD-TTg), which promote "modern", "clean", "sustainable", and "high-tech" agricultural models. The strategy stresses the importance of strengthening value chains, enhancing farmer groups and cooperatives, and aligning production with climate adaptation and low-emission goals.

The National Green Growth Strategy for 2021–2030 (Decision No. 1658/QD-TTg*)* and MARD's Green Growth Action Plan (Decision No. 3444/QD-BNN-KH) further reinforce agriculture's transition toward ecological, organic, circular, and low-carbon development. These frameworks aim to enhance productivity, value addition, environmental protection, and efficient use of resources, providing a strong foundation for CSA.

Additionally, the Strategy for Sustainable Agricultural and Rural Development for 2021–2030, vision to 2050 (Resolution 19/NQ-TW/2022) identifies smart and CSA-oriented agriculture as a key solution. It promotes building a national agricultural database integrated with climate, demographic, and economic data to inform smart agricultural planning and reduce GHG emissions by 10% from the 2020 level.

For the coffee sector, the government has introduced a range of policies promoting the adoption of CSA related practices through credit support, standards promotion, sustainable farming models, and innovation. Key policy highlights include:

- **Provide technical and financial backing for coffee rejuvenation** through a Decision on *Technical and economic norms for rejuvenation* (Decision 340/QĐ-BNN-TT 2013); the *Coffee rejuvenation project* (2021–2025) (Decision 1178/QĐ-BNN-TT 2022), etc. This is also backed by numerous policies on credit support, seedling production assistance, and organic agricultural promotion, land use right certification support, and partial support for seedlings, etc.
- **Encourage Organic, Specialty, and Certified Coffee** though *Support for applying good agricultural practices (GAP) in agriculture, forestry, and aquaculture* (Decision 01/2012/QĐ-TTg) with support up to 100% of basic survey costs and 50% of investment cost; the *Project for developing key industrial crops until 2030 (including coffee, rubber, tea, and pepper)* (Decision 431/QĐ-BNN-BNNPTNT 2024) with targets for 2% organic

coffee production, 3% specialty coffee, 35–40% certified coffee (RA, 4C, Flo, C.A.F.E. Practices), 70% of coffee areas assigned planting area codes (PAC) and/or production unit codes (PUC) for traceability by 2030. the National Product Development Framework Project for "Vietnam high-quality coffee" (Decision No. 4653/QD BNN-KHCN 2017) with refining sustainable high-quality coffee cultivation processes following GAP standards, climate-resilient and intercropping cultivation processes.

- **Encourage good practices** such as IPHM through the *National project promoting IPHM practices to reduce chemical use and enhance sustainability* (Decision 5416/QĐ-BNN-BVTV 2023); The water saving practices through *the Action plan for developing advanced and water-saving irrigation for restructuring irrigation sector* (Decision 1788/QĐ-BNN-TCTL 2015); Support for the development of small-scale irrigation, in-field irrigation, and advanced, water-saving irrigation (Decree 77/2018/ND-CP), with the state support up to 50% of the costs for water-saving irrigation systems for dryland crops, with support capped at 40 million VND (equivalent to 1,517 USD) per hectare for farm areas above 0.3 ha.
- **Support for innovation and technology research and adoption** through the *Plan to promote research and development for the agriculture restructuring program* with include technologies such as improved coffee varieties, water-saving irrigation systems, and sustainable replanting guidelines (Decision 986/QĐ-BNN-KHCN 2014)
- **Strengthening market actor linkages** through Decree 98/2018/NĐ-CP on *Incentivizing cooperatives and private sector partnerships* for contract farming, certified production, farmer training, and infrastructure development (irrigation, storage), etc.

Overall, the promotion of CSA in the coffee sector is backed by a range of support policies covering research, technology enhancement, technical and financial assistance, and market access. Nevertheless, the implementation of these policies faces considerable obstacles. A review by Dang et al. (2025) notes that some policy constraints pose considerable obstacles to CSA implementation. In terms of financial support, for example, farmers practicing intercropping or rotation often find it difficult to obtain loans for rejuvenation. This is because MARD's stipulated a minimum criterion of at least 2 hectares of land to be eligible for the bank loan. Loan amount is inadequate for costly investments such as modern irrigation systems. Additionally, the process of receiving financial support is hindered by multi-stage disbursement and high co-financing demand, particularly impacting resource-poor and ethnic minority farmers, who frequently lack land use right certificates and financial capacity to meet the co-financing requirements. Support for GAP application through Decision 01/2012/QĐ-TTg is limited to farmers who have secured purchase contracts with off-taker companies. Besides, the actual funding is dependent on budget availability of the provincial governments. These resulted in inconsistent implementation of the support policies. Furthermore, many farmers remain unaware of existing support mechanisms (i.e. policy support for adoption of water-saving irrigation systems) (Dang et al., 2025).

5. ASSESSMENT OF CLIMATE SMART AGRICULTURE PRACTICE ADOPTION IN THE CENTRAL HIGHLANDS

5.1. Climate risks and vulnerability of coffee production

5.1.1 Climate risks and impacts on coffee production

Drought and excessive rainfall are key climate hazards that significantly impact coffee production in Gia Lai, Lam Dong, and Dak Lak. These climate hazards vary in intensity and frequency across the CH but collectively pose challenges to coffee productivity and farmer livelihoods.

Drought, occurring from February to May, is considered the most critical, as it severely affects the flowering and pinhead stages of coffee development. Drought, along with extreme heat, and water shortages directly reduce water availability, cause soil degradation, and impair coffee growth, leading to immediate yield and income loss. Specifically, water scarcity results in flower and cherry drops, leaf burn, and uneven flowering. In addition, the long dry condition favors pests and diseases, particularly mealybugs. Furthermore, drought-induced delayed irrigation leaves plants more vulnerable, intensifying the impact of frost when it occurs.

Excessive rainfall, typically from July to November, directly disrupts cherry development. Also, prolonged rains cause flooding and excessive water that leads to root rot, soil erosion, and nutrient loss. Excessive moisture causes flowers and cherry drops, rotting, and disrupts harvesting. This high-moisture environment also fosters an increase in pests and diseases like Coffee Anthracnose, which can affect up to 7–9% of coffee production areas and may reduce yields by 30–40% if left uncontrolled.

Other climate risks: Strong winds, prevalent from January to May, further damage coffee flowering and pinhead stages, break trees and lead to cherry drops, and worsens soil erosion. Frost, which occurs between January and February, also poses a threat during the flowering stage, especially in high-altitude areas, causing the loss of flowers and young leaves. Unseasonal rain disrupts harvesting, triggers unexpected flowering, and adversely affects fertilization. Finally, hail damages plants, resulting in cherry drops and branch breakage. These events lead to decreased productivity and income loss for coffee farmers.

Table 6: Climate hazards across coffee growing stages

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Growth stage	Start Flowering	Flowering		Pin head period		Cherry development				Start harvesting	Harvesting	
Climate risks		Drought	Drought	Drought	Drought							
							Excess rain	Excess rain	Excess rain	Excess rain	Excess rain	
							Moist	Moist				
	Strong wind	Strong wind	Strong wind	Strong wind	Strong wind							Strong wind
								Storm	Storm	Storm		
	Frost	Frost										

Source: Compiled from KIIs and FGDs in Gia Lai, Dak Lak, and Lam Dong, 2025

Results from a household survey with 404 farmers in three provinces show that, within the last five years, **drought induces the highest ratio of farm households impacted** (69.6%), followed by excessive rainfall (66.8%), and other extreme weather events (26.7%). Statistical analysis reveals that a smaller share of farmers in Lam Dong (61.2%) is affected by drought compared to those in Dak Lak (75.0%) and Gia Lai (74.3%). While most farmers experience slight to moderate impacts, Dak Lak has the largest ratio of farmers (18.3%) suffering significant impacts (P < 0.001; Table 7). There is no significant difference regarding the impact level of excessive rainfall among farmers in the three provinces. More than one third of farmers in all the provinces are not affected by excessive rainfall. The remaining farmers reported a slight to moderate level of impact. Other extreme weather events have the smallest impact on coffee production among the farmers surveyed. Gia Lai has the highest ratio of farmers impacted (43.9%) compared to Dak Lak (16.3%) and Lam Dong (17.1%) (P < 0.001) (Table 7).

Table 7: Level of climate-induced impacts on coffee farming in 3 provinces over the past five years

Climate related hazards	Provinces	No impact	Slight impact	Moderate impact	Significant impact	Extreme impact
Drought (***)	*Dak Lak (N=104)*	25.0%	46.2%	10.6%	18.3%	0.0%
	Gia Lai (N=148)	25.7%	33.8%	29.7%	8.1%	2.7%
	Lam Dong (N=152)	38.8%	47.4%	12.5%	1.3%	0.0%
	Total (N=404)	30.4%	42.1%	18.3%	8.2%	1.0%
Excessive rainfall	*Dak Lak (N=104)*	37.5%	39.4%	18.3%	4.8%	0.0%
	Gia Lai (N=148)	31.1%	29.7%	28.4%	10.1%	0.7%
	Lam Dong (N=152)	32.2%	43.4%	16.4%	7.2%	0.7%
	Total (N=404)	33.2%	37.4%	21.3%	7.7%	0.5%
Other extreme weather events (***)	*Dak Lak (N=104)*	83.7%	14.4%	1.9%	0.0%	0.0%
	Gia Lai (N=148)	56.1%	29.1%	13.5%	0.7%	0.7%
	Lam Dong (N=152)	82.9%	16.4%	0.7%	0.0%	0.0%
	Total (N=404)	73.3%	20.5%	5.7%	0.2%	0.2%

Note: * p < 0.05; ** p < 0.01; *** p < 0.001.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

The household survey shows the highest yield loss (16.42%) in Dak Lak due to drought compared to the other two provinces. There is no statistically significant difference in terms of yield loss caused by excessive rainfall among the three provinces. For other climate extremes, Lam Dong is the least impacted with only 4.65% of yield reduced, followed by Dak Lak (7.71%) and Gia Lai (10.83%) (P < 0.01; Table 8).

Table 8: Level of yield loss due to climate risks

Province	Dak Lak (N=104)	Gia Lai (N=148)	Lam Dong (N=152)	Total (N=404)
% of yield loss caused by drought (***)	16.42	14.88	9.41	13.5
% of yield loss caused by excessive rainfall	12.78	13.13	11.26	12.33
% of yield loss caused by other extreme weather events (**)	7.71	10.83	4.65	8.85

Note: * p < 0.05; ** p < 0.01; *** p < 0.001.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

5.1.2. Other risks and impact on coffee production

Results from FGDs and KIIs also indicate that farmers face several **other risks such as soil degradation, market fluctuation, high input costs,** etc., that impact the sustainability of coffee production**.** Soil degradation, caused by unsustainable farming practices such as the overuse of chemical inputs and insufficient application of organic fertilizers, has led to erosion, nutrient runoff, declining pH level, and reduced soil fertility, affecting an estimated 10–15% of cultivated areas. Furthermore, the rising cost of inputs during the 2020–2022 period placed additional financial pressure on farmers. Additionally, market fluctuations continue to create income instability. According to the farmers interviewed, access to stable coffee prices could help farmers achieve up to 40% profit margins.

5.2. Adaptation to Climate Risks - Farmer Perspectives and Determinants

5.2.1. Status of CSA adoption and determinants

Demographic characteristics of farm households show key trends: gender, ethnic minority, education level, income, average household size, a dominance of small-scale farmers, and a strong dependence on coffee production. The characteristics of surveyed coffee-growing households in Dak Lak, Gia Lai, and Lam Dong was showed in Table 9. In overall, males dominated the sample (68%), with the share of female farmers slightly higher in Lâm Đồng (38%) compared with Đắk Lắk and Gia Lai (around 30% each). Ethnic composition differed across regions. While Kinh farmers represented 73% of the whole sample, Gia Lai was characterized by a large share of Gia Rai (47%), and Đắk Lắk by a significant proportion of Ede (29%). In contrast, Lâm Đồng was almost entirely Kinh (96%). Education levels were generally modest, with majority of farmers having completed secondary (43%) or high school (28%). About one quarter had only primary education or less, particularly in Gia Lai. Household size averaged 4.3 members, with Đắk Lắk slightly larger and Lâm Đồng slightly smaller. Income distribution revealed a clear regional difference. Farmers in Lâm Đồng were relatively better off, with nearly half earnings above 700 million VND (equivalent to approximately 27,000 USD), while Gia Lai had the highest share of low-income households (18% below 120 million VND or 4,600 USD) and the lowest share earnings above one billion.

Regarding an average household size of 4.31 members, with Dak Lak having the largest (4.57) and Lam Dong the smallest (4.11). On average, 2.75 income earners reside per household, with Dak Lak again leading in both income earners and farm workers. Coffee is the primary income source, contributing 81.29% of household income, with Gia Lai and Lam Dong showing higher dependencies (83.01% and 83.26%, respectively), compared to Dak Lak (75.96%). This heavy reliance on coffee indicates vulnerability to price fluctuations and climate risks, emphasizing the need for diversification and resilience practices. The average coffee production area is 1.62 ha per household, with Lam Dong at 1.8 ha, compared to 1.52 ha and 1.50 ha in Gia Lai and Dak Lak. These findings underscore the predominance of smallholder farms and the necessity for tailored extension services and technologies for small-scale systems.

Table 9: Household characteristics in the studied locations

Variables	Categories	Dak Lak (N=104)	Gia Lai (N=148)	Lam Dong (N=152)	Total (N=404)
Gender	*Male*	70%	71%	62%	68%
	Female	30%	29%	38%	32%
Ethnicity	*Kinh*	70%	52%	96%	73%
	Ede	29%	0.7%	0	7.8%
	Gia Rai	0	47%	0	17%
	Ma	0	0	0.70%	0.3%
	Others	1.0%	0.7%	3.4%	1.8%

Variables	Categories	Dak Lak (N=104)	Gia Lai (N=148)	Lam Dong (N=152)	Total (N=404)
The highest education	*Primary school and below*	18%	28.7%	22.%	23.5%
	Secondary school	41%	44%	43%	43%
	High school	38%	23%	27%	28%
	College and above	4%	4.3%	8.2%	5.7%
Total income last year	*Below 120mil VND*	9%	17.8%	2.1%	9.6%
	120-360 mil VND	21%	21%	13%	17.9%
	360-500 mil VND	23%	27%	20%	23%
	500-700 mil VND	19%	19%	20%	19%
	700mil-1bil VND	18%	7.9%	23%	16%
	Above 1bil VND	11%	6.5%	23%	14%
Family size (people) (*)		4.57	4.34	4.11	4.31
Number of income earners within the family (people) (**)		3.01	2.52	2.8	2.75
No. of family members working on the farm (people) (**)		2.9	2.48	2.71	2.68
Share of coffee income in the HH's annual income (%) (**)		75.96	83.01	83.26	81.29
Total coffee production area (ha) (*)		1.5	1.52	1.8	1.62

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

Adoption of CSA is above average in the surveyed areas (average of 59%) although adoption rates vary by practices and locations. Overall, farmers in Dak Lak and Lam Dong have significantly higher rates of CSA adoption (with on average 66.8% and 61.8% of farmers adopted, respectively) compared to those in Gia Lai (51.0%) (Table 10). Particularly, Gia Lai has the lowest ratios of farmers that adopted climate-resilient coffee varieties (40.5%) ($P < 0.001$), effective cover crop (weed) management (62.2%) ($P < 0.01$), appropriate cropping structure (34.5%) ($P < 0.001$), efficient irrigation (59.5%) ($P < 0.01$), and water conservation (37.2%) ($P < 0.001$). It is interesting to note that there is no significant difference in terms of CSA adoption level (in all practices) among ACOM and non-ACOM farmers.

Table 10: Level of CSA adoption among farmers in 3 provinces

CSA practice	Provinces			Total (N = 404)
	Dak Lak	Gia Lai	Lam Dong	
(1) Climate-resilient coffee varieties (***)	77.90%	40.50%	84.20%	66.60%
(2) Effective cover crop (weed) management (**)	67.30%	62.20%	65.80%	64.90%
(3) Adequate fertilizer management (*)	74.00%	66.20%	64.50%	67.60%
(4) Appropriate cropping structure (***)	68.30%	34.50%	42.10%	46.00%
(5) Smart pest and disease management	61.50%	56.80%	57.90%	58.40%
(6) Efficient irrigation (**)	62.50%	59.50%	61.20%	60.90%
(7) Water conservation (***)	55.80%	37.20%	57.20%	49.50%
Average (all practices combined)	66.80%	51.00%	61.80%	59.10%

Note: Only full adoption of the CSA practices was counted. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

The characteristics of adoption of adaptive practices vary significantly influenced by ethnicity, educational level, financial situation (i.e., income level), farming scale, location, and access to resources. In terms of ethnicity, Kinh households have higher rate of CSA adoption than EM group overall. Quantitative data indicate that Kinh households demonstrate significantly higher adoption rates for climate-resilient coffee varieties (74.7%) and adequate fertilizer management (68.6%) compared to EM groups (44.4% and 64.8% respectively) (Figure 6). Contributing factors include differences in farmer awareness, literacy, and household economics, with EM farmers having a higher proportion of poor and average income households and lower literacy levels. In addition, FGDs and KIIs results pointed out that Kinh farmers show higher uptake of diversified cropping, improved soil and water management, and certification participation, while ethnic minority farmers lag due to limited access to knowledge, finance, and extension services.

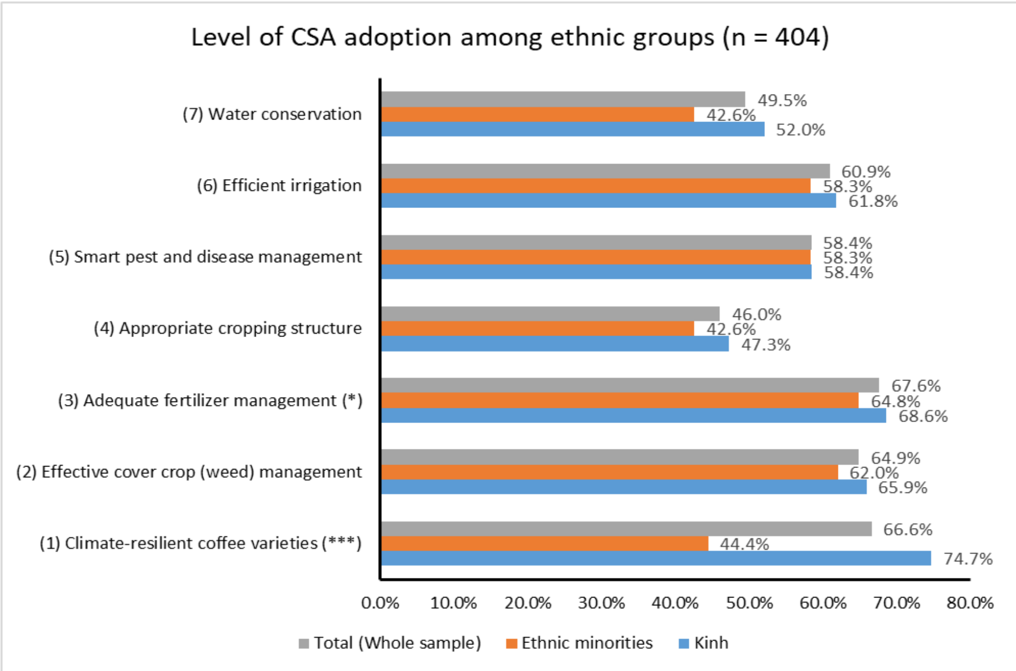

Figure 6: Level of CSA adoption among ethnic groups

Note: Only full adoption of the CSA practices were counted. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

Literacy and/or educational level among the coffee farmers have positive impacts on adoption of some CSA practices, namely, adequate fertilizer management ($P < 0.01$), smart pest and disease management ($P < 0.05$), efficient irrigation ($P < 0.05$), and water conservation ($P < 0.01$). Table 11 depicts an increasing trend of CSA practice adoption among farmers corresponding with their level of education.

Table 11: Relationship between educational level and CSA practice adoption

CSA practices	Edu. Level	CSA adoption level				
		No adoption	Limited adoption	Moderate adoption	Strong adoption	Full adoption
Adequate fertilizer management (**)	*illiterate (n = 22)*	13.6%	9.1%	9.1%	22.7%	45.5%
	Primary school (n = 73)	5.5%	4.1%	12.3%	15.1%	63.0%
	Secondary school (n = 174)	0.0%	3.4%	8.0%	17.8%	70.7%
	High school (n = 111)	0.9%	2.7%	4.5%	24.3%	67.6%
	Above high school (n = 24)	0.0%	0.0%	4.2%	16.7%	79.2%
Smart pest and disease management (*)	*illiterate (n = 22)*	18.2%	4.5%	18.2%	31.8%	27.3%
	Primary school (n = 73)	6.8%	4.1%	13.7%	19.2%	56.2%
	Secondary school (n = 174)	6.3%	6.3%	9.2%	16.7%	61.5%
	High school (n = 111)	0.9%	1.8%	8.1%	29.7%	59.5%
	Above high school (n = 24)	4.2%	0.0%	12.5%	16.7%	66.7%
Efficient irrigation (*)	*illiterate (n = 22)*	22.7%	0.0%	4.5%	36.4%	36.4%
	Primary school (n = 73)	5.5%	1.4%	11.0%	31.5%	50.7%
	Secondary school (n = 174)	4.6%	2.3%	5.2%	24.1%	63.8%
	High school (n = 111)	3.6%	0.9%	4.5%	24.3%	66.7%
	Above high school (n = 24)	4.2%	4.2%	0.0%	25.0%	66.7%
Water conservation (**)	*illiterate (n = 22)*	31.8%	13.6%	22.7%	9.1%	22.7%
	Primary school (n = 73)	16.4%	19.2%	20.5%	12.3%	31.5%
	Secondary school (n = 174)	13.8%	13.8%	12.6%	9.8%	50.0%
	High school (n = 111)	17.1%	8.1%	5.4%	5.4%	64.0%
	Above high school (n = 24)	8.3%	12.5%	12.5%	8.3%	58.3%

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

Household income levels significantly affect farmers' adoption of CSA, particularly in utilizing climate-resilient coffee varieties ($P < 0.01$) and effective cover crop management ($P < 0.05$) (Table 12). Better-off households show greater adoption compared to poorer households. Results of the FGDs and KIIs also reveal that low-cost CSA measures, like ground cover maintenance, have seen high uptake while more advanced or costly practices, such as water-saving irrigation systems and organic farming, remain limited despite strong farmer interest.

Table 12: Level of CSA adoption among farming households by income level

CSA practice	Income level	No adoption	Limited adoption	Moderate adoption	Strong adoption	Full adoption
Climate resilient coffee varieties (**)	*Poor - average HHs*	15.80%	5.30%	28.90%	7.90%	42.10%
	Better-off households	6.80%	4.40%	9.80%	9.80%	69.10%
	Total	7.70%	4.50%	11.60%	9.70%	66.60%
Effective cover crop (weed) management (*)	*Poor - average HHs*	10.50%	10.50%	7.90%	13.20%	57.90%
	Better-off households	6.00%	2.20%	4.40%	21.90%	65.60%
	Total	6.40%	3.00%	4.70%	21.00%	64.90%

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Source: Household survey in Gia Lai, Dak Lak, Lam Dong, 2025

The coffee production area of the farming households was found to influence the level of adopting smart pests and disease management among the farmers interviewed. In which, the non-adopters have the highest land area compared to other groups ($P < 0.01$). The field survey found that the current labor shortage challenge is one of the main barriers to this practice adoption. Farmers tend to use quicker and lower cost methods (i.e. use of chemical pesticides). Besides, the FGD results uncovered a high proportion of farmers having limited knowledge on proper pest and disease management. It is worth noting that better-off households have higher coffee land area (1.71ha) than the poor and average households (0.81ha) ($P < 0.001$). Yet, due to the labor shortage, these households had to hire farm laborers who are very often untrained and have limited knowledge of pest and disease management (Results from the FGDs and KIIs in 3 provinces).

On the other hand, findings from FGDs and KIIs suggested that medium- and large-scale farmers are more likely to adopt sustainable practices due to their greater investment capacity, larger land areas, and better access to information, technology, and value chain linkages. They are also more engaged in certification schemes like the 4C and Rainforest Alliance (RA). In contrast, small-scale farmers face challenges due to limited capital and market access. However, their adoption capacity significantly improves when they join cooperatives or farmer groups, gaining better access to inputs, technical support, and market opportunities.

In addition, according to KIIs and FGDs with farmers and local experts, other factors such as location play a vital role in adoption. Farmers near commune or former district centers; agricultural extension stations benefit from easier access to training and technical services. In contrast, those in remote areas face more barriers due to limited infrastructure and outreach. Age and mindset matter as well. Younger and middle-aged farmers tend to be more open to innovation and investment, while older farmers may be more hesitant unless provided with targeted support. Experience, willingness to innovate, and a focus on quality also increase adoption rate.

5.2.2. Farmers perception of CSA benefits and challenges

The FGDs and KIIs with farmers and local experts revealed that farmers have significant awareness about the benefits of CSA practices for their farming activities. Farmers are aware of the economic benefits, including reduced input costs (water, labor, and fertilizers), income diversification (through intercropping and multi-cropping), and increased selling prices (via certified coffee). They also recognize the climate resilience benefits like moisture retention and temperature regulation. These suggest that farmers are knowledgeable about the advantages of CSA practice adoption, and they are also actively incorporating them into their production.

Table 13: Adoption of adaptation strategies in surveyed areas

Specific CSA practices	Benefits (from farmers' opinions)	Challenges in adoption
Use of sprinkler/drip irrigation systems	• Reduced watering frequency. • Saved 30–40% of water (~300L/tree); • Lower labor costs, • Reduced fertilizer leaching. • Increased water use efficiency in the context of drought.	• Limited affordability of resource-poor farmers to adopt due to high investment costs (around 50-60 million VND per system/ha). • Direct hose watering on the base of coffee trees is a more common habit than sprinkler/drip irrigation. • Hose watering for coffee is preferred by farmers in mixed cropping systems where different crops require different level of water, while coffee requires high amount of water near the flowering stage

Specific CSA practices	Benefits (from farmers' opinions)	Challenges in adoption
Pond construction and/or rainwater harvesting	• Drought resilience. • Increased water availability in dry seasons.	• Drilled wells depend on topology, available water resources, and policy of the local authorities (i.e., some areas are not permitted due to a concern of underground water depletion. • Limited financial resources and access to necessary equipment. • High investment cost (ranging 50–80 million VND for a combined well and pond system, or 60–70 million VND for 500 m^2 lined pond),
Use of agricultural waste for mulching	• Retained soil moisture. • Improved resource recycling from agricultural residues.	• NA
Intercropping and multi-cropping/agroforestry. (Main intercrops: avocado, durian, black pepper, macadamia, etc.	• Enhanced soil moisture, and reduced evaporation. • Reduced ground and canopy temperatures, minimized heat stress. • water saving (e.g., reduced watering from 4 to 3 times, saving ~200L/tree). • Diversified income. • Landscape and biodiversity conservation	• Farmers find it difficult to manage multiple crops simultaneously. For example, in the dry season, irrigation should be focused only on the base of durian trees; if coffee is over-irrigated, it will produce non-opening flowers. • High establishment costs for crop diversification (e.g. costs of seedlings) hinder the adoption of poor farmers. • Households with smaller land areas tend to adopt monoculture of coffee due to the ease of care and intensive farming.
Wind breaks trees (use of multipurpose trees such as fruit crops) on the farms, and forest trees along the farm borders.	• Avoid crop damage caused by strong winds and storms. • Diversified incomes from multipurpose crops.	• Fear of uncertain market outlets for products from the intercrops.
Proper and balanced use of fertilizers	• Increased soil fertility and thus crop yield. • Stronger crop health and thus higher tolerance to pests and diseases.	• Lack of knowledge on fertilizer use, particularly on intercropping and multi-cropping systems. • Limited demo-plots at the localities for practical learning. • Inherent habits of overuse of agrochemicals.
Sloping Agricultural Land Technology (SALT) on sloping land	• Increased shade cover and reduced soil erosion. • Improved soil moisture. • Diversified income from the intercrops.	• Lack of knowledge on SALT on different slope degrees. • Lack of model farms at localities for local learning and sharing.

Specific CSA practices	Benefits (from farmers' opinions)	Challenges in adoption
Cover crops/ ground cover • Farmers maintain 3–5 cm of weed cover. • Farmers can plant cover crops such as, legumes or vetiver grass when coffee crops are at the establishment stage. • Leave branches and crop residues on the farms.	• Retained soil moisture (up to 70%) • Reduced herbicide use, • Reduced soil erosion, • Enhanced soil fertility and preserve essential nutrients. • Reduced nutrient leaching during heavy rainfall. • Increased humus content • Easier management during the rainy season.	• Limited access to training and study visit opportunities for farmers in some locations. • Language barriers in EM communities.
Use of drought resistant and pest tolerant varieties (e.g. Varieties TR4, TS1, and TS5, Xanh Lun, Thien Truong, etc.).	• Drought tolerance and increased productivity. • Pest and disease tolerance.	• Expensive prices for certified seedlings, which are very often not affordable for the resource-poor households. • Lack of knowledge on coffee variety traits and benefits. • Lack of access to credible suppliers.
Smart pest & disease management. (i.e. IPM)	• Improved plant health and reduced yield loss.	• Most of the training classes conducted by the extension workers are theories with no and/or limited hands-on training on the farms. • Strong reliance on the advice of local agrochemical sellers.
Composting (i.e. from coffee husks, livestock manure, etc.) and organic fertilization	• Increased soil moisture & fertility, and thus crop productivity. • Reduced input costs. • Reduced environmental pollution and waste of resources.	• Lack of knowledge on proper composting techniques. • Limited access to practical training. • Lack of access to effective bio-stimulants for composting. • Lack of livestock manure to produce compost.
Adjustment of planting dates and watering time based on weather data/forecast	• Reduced crop damage caused by climate risks. • Yield stability.	• Low accuracy of weather forecasts. • Most farmers do not trust weather forecasts, and thus they mainly rely on experience and self-observations and information provided by agricultural agencies
Journaling of production inputs, yields and profits	• Improved traceability and thus price premiums for farmers under the supply chains of big companies;	• Time-consuming and low incentives for journaling. • Habit of experience-based production without detailed cost-benefit analysis.
Sustainability certifications (e.g. 4C, VietGAP, RA)	• Improved product quality. • Reduced use of chemical pesticides. • Increased selling prices (for farmers under the supply chains of credible companies); • Access to technical training, seed provision, and other inputs by the off-taker companies and/or support programs.	• Unstable market outlets and linkages with off-taker companies, and thus no and/or limited incentives for adoption. • No and/or low-price premiums discourage farmers from adopting sustainable practices.

Source: Compiled from KIIs and FGDs in Gia Lai, Dak Lak, Lam Dong, 2025

Farmers continue to face major barriers, most notably limited knowledge, technology, and financial capacity; market instability; weak production linkages; and the severity of climate change, which hinder the adoption of climate-smart and/or sustainable coffee farming practices. One of the main challenges is the high initial costs for technologies such as water-saving irrigation systems, organic fertilizers, and seedlings. Many smallholders have unstable incomes and face significant obstacles in accessing agricultural credit and insurance, due to complicated procedures and a lack of tailored financial mechanisms. This makes it difficult to invest in necessary infrastructure and technologies (According to KIIs and FGDs with farmers). In addition, the complex technical requirements and market instability associated with some practices limit their application. For instance, while organic farming is environmentally beneficial, its adoption is constrained by lower yields, increased labor costs, and unpredictable market access, resulting in a low incentive for adoption.

Knowledge gaps and limited technical capacity further hinder adoption, particularly in remote and ethnic minority areas. Training in advanced and sustainable farming is often short-term, infrequent, and not locally adapted. There are few training courses on CSA in coffee production. Many farmers, especially in ethnic minorities and remote areas, are unfamiliar with sustainable farming practices such as intercropping, cover cropping, water-efficient irrigation, integrated pest management, and the appropriate use of fertilizers and pesticides. In these areas, awareness of CSA remains low, while traditional production habits, such as monoculture and conventional fertilization and watering, continue to dominate. These practices reduce the resilience of coffee farms to climate change and delay behavioral change, particularly among older farmers who are more reluctant to shift away from their conventional practices (According to KIIs and FGDs with farmers).

As climate change has been becoming more frequent and intense, inadequate access to localized climate information and early warnings limits farmers' ability to adjust farming calendars or respond to emerging pests and extreme weather events. Market instability and the absence of long-term purchase commitments also weaken incentives to invest in sustainability. Institutional challenges, such as underperforming cooperatives and limited group capacity, further restrict sustainable interventions (According to KIIs and FGDs with farmers).

Support from the private sector companies and governments remains limited in scope, duration, and reach. While contract farming and certification initiatives, often facilitated by private companies, offer some support, farmers still cite uncompetitive prices and project-based limitations. Government assistance is perceived as insufficient, typically benefiting only a small subset of farmers with complex and sometimes unfavorable supporting mechanisms. For example, 5–6 years ago there was a program providing compensation for drought-affected farmers, but many did not receive full payment due to issues in impact assessment and registration (According to KIIs and FGDs with farmers).

5.3. Available resources and needs for CSA implementation

5.3.1. Available support from the private sector and government for CSA

Sustainable coffee farming in the region has been supported through efforts of private companies, local government agencies, and central level support. Coffee companies such as ACOM and Nestlé play an active role in providing technical support to farmers, including regular training programs (e.g., twice per year by ACOM) on intercropping, weed management, water-saving irrigation, and coffee tending. These companies also supply essential materials such as organic fertilizers, blooming fertilizers, shade trees, and intercrops, while supporting farmers with credit, technical guidance, and access to sustainable farming techniques. Training programs from these companies often focus on promoting certified sustainable coffee production, including standards like 4C and RA (According to KIIs with farmers and local experts).

The local governments have issued a number of support policies related to sustainable and advanced farming practices as well as market linkages in the coffee sector which provide a legal framework and support on a large scale. Together with relevant support policies, programs and projects encourage investments in agricultural extension services and communication efforts to ensure farmers have ongoing access to information and capacity building services. This includes encouraging investments in the field, distribution of official dispatches to villages, and broader outreach through conferences, leaflets, television programs, and social media platforms. For example, the government has collaborated with the Pepper Research and Development Center to train ethnic minority households in climate-adapted coffee production and improve their technical capacity (According to KIIs with local experts).

At a broader level, NAEC plays a key role in supporting climate-smart and sustainable production models. The center promotes high-tech, organic, smart, and circular agriculture through training, technology transfer, pilot models, and communication campaigns. These efforts include capacity building for extension staff, application of digital tools in production and service delivery, and promotion of value chain linkages between farmers and businesses to enhance market access and reduce risks. Additionally, efforts are underway to streamline and restructure the agricultural extension system, particularly by building a network of grassroots-level community extension officers to enhance the reach and effectiveness of support services for farmers (According to KIIs with local experts). Detailed support programs at the locals can be found in Annex 2.

5.3.2. Needs for promoting CSA: viewpoints of farmers and experts

From farmers' perspectives, to enhance the adoption of climate-smart practices in coffee production, particularly in response to increasing drought and water scarcity, several key actions are recommended. First, advanced models (i.e. water-saving irrigation) should be expanded, and supported by materials, installation equipment, and partial financial assistance, ideally covering up to 50% of costs, to make implementation more accessible for small-holder farmers. Farmers expressed the need for sustainable certification schemes; price support policies should be introduced alongside ongoing engagement from companies like ACOM, including guaranteed purchase prices and technical assistance. Greater support is also needed by farmers, not only for coffee but also for intercropped trees (e.g., durian) (According to KIIs and FGDs with farmers).

Training programs should also be strengthened, focusing hands-on training in irrigation techniques and system operation, soil improvement (e.g., organic and biofertilizers), intercropping techniques, and integrated pest management. For example, practical training in intercropping methods, including planting distances and proper densities among crops, should be delivered. Training should prioritize differently based on targeted groups and farmers' experience. Kinh people reported limited training needs due to their extensive experience, while EM households, with less technical support to date, require focused training in climate change adaptation, crop management, and pest control. Preferred delivery methods include printed manuals, hands-on demonstration models, and digital platforms to facilitate peer learning and broader reach. In addition, study tours and regional learning exchanges should be organized to expose farmers to successful practices and locally suitable irrigation models. Research institutes shall be involved in the development of context-specific models and direct technology and knowledge transfer to farmers (According to KIIs and FGDs with farmers).

Farmers additionally see localized climate information services as critical enablers for CSA. Farmers currently rely on TV and weather apps; these sources are often too general or delayed, with accuracy rated at only at around 70% for their specific locations. This limits their ability to plan irrigation, spraying, and other time-sensitive activities. To improve decision-making, farmers request weekly, commune- or commune cluster-level forecasts (i.e rainfall, drought, temperature extremes, and pest outbreaks) aligned with crop growth stages and delivered through traditional, existing and other potentially accessible channels such as Zalo and mobile apps, platforms, etc. There is also the demand for seasonal and annual climate projections to support long-term planning and investment, along with historical rainfall data to self-assess drought severity. In addition, farmers expressed their needs for bundle services that combine real-time market prices and information on agricultural inputs. In addition, there are needs for digital tools like mobile apps and rapid soil testing kits for improving nutrient management and tailoring practices to site-specific conditions (According to KIIs and FGDs with farmers).

Local experts' perspectives had similar suggestions on targeted support on knowledge, technology, and finance. Key actions include providing regular training and specific guidance on climate smart practices; Expanding hands-on training and demonstration models to help farmers to learn directly from proven practices; Study tours and on-site coaching by research institutes to help build up farmer capacity (According to KIIs with local experts).

Local experts recommend communication campaigns to drive behavioral changes toward sustainable farming; Policy support (i.e. credit, input subsidies); Sharing success stories, peer learning, and social media; Investment in infrastructure and greater enterprise involvement in processing and market linkages; Digital tools like weather apps, pest alerts, and farm management platforms to support timely decisions; and Collaboration among local governments, research institutes, enterprises, and cooperatives (According to KIIs with local experts).

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusions

Vietnam's coffee sector plays a vital role in rural livelihoods and national agricultural exports, with continued expansion in cultivation area, production capacity, and quality. Despite this significant growth, the sector faces increasingly complex socio-economic and environmental pressures. Farmers are struggling with declining soil fertility, rising input prices, unstable markets, labour shortages, and increasing climate risks. These challenges are impacting farm productivity and farmers' resilience.

Climate change is further worsening socio-economic and environmental issues. Farmers report more frequent and severe droughts, changing rainfall patterns, storms, and increased pest and disease risks. These hazards cause yield losses, increase production costs, and create uncertainty in farm management.

In adapting to these challenges, farmers apply multiple adaptation strategies, including water-saving irrigation, mulching, soil conservation, shade management, and intercropping. Adoption levels of CSA and sustainable practices are generally above average, but uneven across farmer groups. Ethnic minority farmers, those with lower education, and those with low financial capacity often have limited access to knowledge, finance, and support, resulting in the low adoption of adaptive strategies. These disparities highlight the need for inclusive, context-specific, and targeted support to meet the specific needs of targeted producers.

Despite promising adoption patterns, several barriers limit broader CSA implementation and scaling. From farmers' view, these include high investment costs, limited access to finance, inadequate technical capacity, poorly tailored training, labour shortages, fragmented support from service providers, and gaps in policy enforcement, limited access to localized climate information, and unstable markets. These factors reduce farmers' capacity and incentives to invest in climate-resilient practices. Other actors highlight additional challenges in CSA development. While sustainable coffee farming is supported by private companies and local authorities through training, inputs, policies, and extension services, these efforts remain limited in scale and sustainability due to weak coordination and fragmented, project-based support.

Farmers and stakeholders identify clear needs to improve future support systems. These include affordable finance, practical training that suited to local conditions, localized climate information, better irrigation, soil-testing services, stronger cooperatives, and more reliable market linkages. Local experts highlight similar priorities, especially the need for better coordination among actors.

Overall, the study concludes that addressing CSA barriers and scaling adoption in the CH requires a holistic, inclusive, and multi-stakeholder approach. Strengthening financial mechanisms, improving climate services, enhancing extension systems, supporting vulnerable groups, empowering cooperatives, and aligning public–private investments are essential for building resilience and ensuring the long-term sustainability of Vietnam's coffee sector.

6.2. Recommendations

1. Improve financial access and risk management mechanisms

- Expand green credit schemes and affordable loans for irrigation, replanting, and climate-resilient varieties.
- Introduce crop and/or climate insurance to reduce climate risks for vulnerable farmers.
- Develop tailored financing support for ethnic minorities and smallholders to address unequal access.

2. Strengthen technical capacity and extension systems

- Offer practical, context-specific training, in cooperate with public extension systems.
- Establish farmer field schools, demonstration plots, and lead farmer networks for peer learning.
- Prioritize support for disadvantaged groups, especially ethnic minority and remote farmers.

3. Enhance local climate services and farm-level decision support

- Develop downscaled climate advisories and seasonal forecasts aligned with coffee crop stages.
- Integrate weather, soil, pest, and market information into accessible and user-friendly digital advisory platforms (e.g., Zalo/SMS/mobile apps).
- Expand soil testing services to support precision nutrient management and reduce input waste.

4. Promote behavioral change and awareness

- Implement communication campaigns to promote long-term benefits of CSA and sustainable water/nutrient management.
- Share success stories and use community influencers to encourage CSA adoption.

5. Strengthen cooperative and value-chain partnerships

- Support cooperatives in organizing collective purchasing, technical assistance, certification, and marketing.
- Promote contract farming and value-chain partnerships to ensure stable markets for CSA.

6. Improve multi-actor coordination and co-investment

- Strengthen coordination mechanisms between provincial agencies, private companies, NGOs, and research institutions.
- Align public and private investments with provincial sustainable agriculture strategies.

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ANNEXES

Annex 1: Details on field survey implementation and participation

Table 1: Lists of interviewees for KIIs

No	Name	Gender	Organization	Province
1	Phạm Văn Nghĩa	Male	Farmer	Lam Dong
2	Vũ Mạnh Phong	Male	Farmer	Lam Dong
3	Trần Đức Vinh	Male	Farmer	Gia Lai
4	Lê Minh Đào	Male	Farmer	Gia Lai
5	Trần Thị Thiện	Female	Farmer	Dak Lak
6	Trần Tuấn Oanh	Male	Farmer	Dak Lak
7	Nguyễn Trọng Tấn	Male	Communal Extension Unit	Lam Dong
8	Phạm Thị Phương	Female	Communal Extension Unit	Lam Dong
9	Vĩnh	Male	Communal Agriculture Unit	Gia Lai
10	Triệu Thị Hợp	Female	Communal Agriculture Unit	Gia Lai
11	Bùi Trung Tín	Male	Communal Farmer Union	Dak Lak
12	Phan Bá Thuy	Male	Communal Farmer Union	Dak Lak
13	Lê Quang Hiệp	Male	Agricultural Station-Bao Loc area	Lam Dong
14	Phạm Thanh Sơn	Male	Provincial Agriculture Extension Centre	Lam Dong
15	Nguyễn Văn nghị	Male	Provincial Agriculture Extension Centre	Gia Lai
16	Vũ Thị Thuỳ Linh	Female	Dept of Agriculture and Environment (DAE)	Gia Lai
17	Huỳnh Thị Thu Phượng	Female	Provincial Agriculture Extension Centre	Dak Lak
18	Đặng Bá Đàn	Male	National Agriculture Extension Centre - Dak Lak based	Dak Lak
19	Đinh Văn Phê	Male	WASI' expert	Dak Lak

Table 2: Lists of interviewees for FGDs

No	Name	Gender	Old commune	New commune	Province
A. Ia Yok and Dak Doa, Gia Lai					
1	H Do	Male	Ia Bang	Dak Doa	Gia Lai
2	CNui	Male	Ia Bang	Dak Doa	Gia Lai
3	Ju	Male	Ia Bang	Dak Doa	Gia Lai
5	Sui R	Male	Ia Bang	Dak Doa	Gia Lai
6	Thi L	Male	Ia Bang	Dak Doa	Gia Lai
7	Hai	Male	Ia Pet	Dak Doa	Gia Lai
8	Nguyễn Xuân Nghiêm	Male	Ia Yok	Ia Hrung	Gia Lai
9	Nguyễn Thị Tình	Female	Ia Yok	Ia Hrung	Gia Lai
10	Nguyễn Thị Tâm	Female	Ia Yok	Ia Hrung	Gia Lai
11	Dương Văn Nghiệm	Male	Ia Yok	Ia Hrung	Gia Lai
12	Trần Đức Vinh	Male	Ia Yok	Ia Hrung	Gia Lai
13	Nguyễn Quang Bôi	Male	Ia Yok	Ia Hrung	Gia Lai
14	Trần Thị Hồ	Female	Ia Yok	Ia Hrung	Gia Lai
15	Võ Văn Thông	Male	Ia Yok	Ia Hrung	Gia Lai
B. Ea Tul, Dak Lak					
1	Nguyễn Hữu Điền	Male	Ea Tar	Ea Tul	Dak Lak
2	Nguyễn Duy Khánh	Male	Ea Tar	Ea Tul	Dak Lak

No	Name	Gender	Old commune	New commune	Province
3	Đinh Thế Anh	Male	Ea Tar	Ea Tul	Dak Lak
4	Đinh Chí Hiệp	Male	Ea Tar	Ea Tul	Dak Lak
5	Đinh Thanh Tùng	Male	Ea Tar	Ea Tul	Dak Lak
6	Trần Đăng Thanh	Male	Ea Tar	Ea Tul	Dak Lak
7	Lại Quốc Tâm	Male	Ea Tar	Ea Tul	Dak Lak
8	Phạm Thị Hoàng	Female	Ea Tar	Ea Tul	Dak Lak
9	Mai Thị Bốn	Female	Ea Tar	Ea Tul	Dak Lak
10	Lê Văn Hải- on farm	Male	Ea Tar	Ea Tul	Dak Lak
11	Trần Tuấn Oanh- on farm	Female	Ea Tar	Ea Tul	Dak Lak
12	Hoàng Văn Đàn- on farm	Male	Ea Tar	Ea Tul	Dak Lak
C. Dinh Trang Thuong, Lam Dong					
1	Trần Thị Quế	Female	Tan Lam	Dinh Trang Thuong	Lam Dong
2	Đỗ Thị Quy	Female	Tan Lam	Dinh Trang Thuong	Lam Dong
3	Nguyễn Đức Hòa	Male	Tan Lam	Dinh Trang Thuong	Lam Dong
4	Doãn Phương Linh	Female	Tan Lam	Dinh Trang Thuong	Lam Dong
5	Nguyễn Văn Đài	Male	Tan Lam	Dinh Trang Thuong	Lam Dong
6	Vũ Văn Lam	Male	Tan Lam	Dinh Trang Thuong	Lam Dong
7	Nguyễn Văn Hưng	Male	Tan Lam	Dinh Trang Thuong	Lam Dong
8	Phạm Thị Kim	Female	Tan Lam	Dinh Trang Thuong	Lam Dong
9	Phạm Văn Hoàn	Male	Tan Lam	Dinh Trang Thuong	Lam Dong
10	Trần Thị Hoa- on farm	Female	Tan Lam	Dinh Trang Thuong	Lam Dong
11	Hoàng Thị Nhẫn- on farm	Female	Tan Lam	Dinh Trang Thuong	Lam Dong
12	Phạm Văn Phú – on farm	Male	Tan Lam	Dinh Trang Thuong	Lam Dong

Table 3: Number of interviewees in household surveys

Province	Gia Lai		Dak Lak		Lam Dong	Total
No. Farmers	**Dak Doa**	**Ia Grai**	**Cư Mgar**	**Krongbuk**	**Di Linh**	
Male	60	44	36	38	61	274
Female	14	30	17	13	44	130

Annex 2: Policies and Programs support for CSA at the Local Level (synthesize from KIIs with local experts)

- Decision No. 2666/QD-UBND dated November 20, 2020 of the Provincial People's Committee on approving the project on organic agriculture development in Lam Dong province for the period 2020-2025.
- Decision 780/QD-UBND dated March 26, 2021 on the agricultural extension program in Lam Dong province for the period 2021-2025.
- Plan No. 638/KH-UBND dated March 22, 2023 on the implementation of the strategy for sustainable agricultural and rural development for the period 2021-2030, with a vision to 2050 in Gia Lai province.
- Plan No. 306/KH-UBND of Gia Lai province dated May 31, 2024 on the widespread application of advanced, water-saving irrigation techniques; planting windbreak trees, cover trees, mulching and creating coffee landscapes; gradually applying mechanization in the harvesting and production of certified coffee.
- Resolution No. 22/2022/NQ-HDND dated December 21, 2022 of the Dak Lak Provincial People's Council on policies to support the development of agriculture, forestry and fisheries associated with restructuring the agricultural sector until 2025.
- Plan No. 123/KH UBND dated May 28, 2025 of the Dak Lak Provincial People's Committee on the Plan for developing agricultural cooperatives in restructuring the agricultural sector and building new rural areas in Dak Lak province by 2025.

Program/project	Implementor	Support provided
VnSAT Project on sustainable coffee cultivation	Lam Dong Agricultural Extension Center	Guiding farmers to apply techniques such as water-saving irrigation, pruning, nutrient management, integrated pest control, as well as harvesting, preserving and processing coffee properly.
The establishment of The Lam Dong Sustainable Coffee Producers Association	The Lam Dong Sustainable Coffee Producers Association, IDH, IPSARD	Coordinate large-scale coffee production and trading activities, represent farmers' voices, and protect their rights. With 133 members in Di Linh and Lam Ha districts, the association produces over 400 hectares of coffee annually, with plans to expand and recruit more members in other districts.
VnSAT program in cooperation with IDH, implemented from 2020	Gia Lai Agricultural Extension Center	Sustainable farming conversion, landscape management, traceability, technical support and credit access for large-scale coffee producers.
Nescafe Plan's program on conversion to regenerative and sustainable farming from 2020	Gia Lai Agricultural Extension Center	Technical training, value chain support, increased competitiveness and drought resistance, traceability.
Child labor prevention and coffee garden restoration project, implementation from 2021-2024.	Gia Lai Agricultural Extension Center	Training farmers on sustainable farming processes, organic farming (Vinh Hiep company...)
Landscape and biodiversity project (4C, Biodiversity in coffee Landscapes project)	Gia Lai Agricultural Extension Center	Improve landscape ecosystems, conserve biodiversity, implement environmentally friendly farming.
Coffee replanting program	Gia Lai Agricultural Extension Center	Nescafe supports a portion of seedlings for households that need to replant old coffee gardens.

Annex 3. Photos from field trips

ACOM wtw BAO MINH University of Southern Queensland Alliance Bioversity & CIAT

InsuResilience Solutions Fund

https://cacs.unisq.edu.au/InsuResi

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