

## **CLIMATE-SMART AGROFORESTRY IN VIETNAM: A REVIEW OF CURRENT PRACTICES, CHALLENGES, AND OPPORTUNITIES**

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(Received: April 17, 2025; Accepted: November 11, 2025)

### **ABSTRACT**

This paper reviewed the current practices, challenges, and opportunities of Vietnam's climate-smart agroforestry (CSAF). The study aimed to conduct climate-smart agroforestry in Vietnam during 2024 - 2025 through evaluating the resilience to climate change, socio-economic and environmental impacts, identifying the obstacles to its scaling, and providing recommendations for sustainable development. Through a systematic analysis of policy documents, case studies, and stakeholder consultations, the study found that CSAF enhances land-use efficiency, promotes biodiversity conservation, and supports climate change mitigation by increasing carbon sequestration. However, the adoption of CSAF faces significant barriers, including policy fragmentation, limited technical knowledge, and insufficient financial resources. Agroforestry models remained small-scale and subsistence-oriented, with few transitioning to commercial production. The study recommends improving policy alignment between the agriculture and forestry sectors, providing targeted financial support, and enhancing farmer capacity through training and technology transfer. Strengthening market access for agroforestry products and fostering public-private partnerships are also crucial for scaling CSAF in Vietnam. These efforts are essential for achieving Vietnam's climate adaptation and mitigation goals while supporting rural livelihoods and sustainable agricultural development.

**Key words:** agriculture, forestry, sustainability, policy

### **INTRODUCTION**

Climate change poses profound challenges to agriculture worldwide, affecting food security, rural livelihoods, and ecosystem health (FAO 2021). In Vietnam, where agriculture remains a crucial sector, the impacts of climate change are increasingly evident, including rising temperatures, shifting rainfall patterns, and more frequent extreme weather events (World Bank Group 2019). These challenges threaten both productivity and the sustainability of rural landscapes across the country's diverse agroecological zones.

In response to these challenges, Climate-Smart Agroforestry (CSAF) has emerged as a promising solution. Agroforestry integrates trees, crops, and livestock within agricultural landscapes to increase resilience, enhance carbon sequestration, and support biodiversity (FAO 2013), making agroforestry climate-smart. Globally, agroforestry practices span nearly 1 billion hectares of land and engage millions of farmers, especially in tropical regions (Baral 2022). CSAF is mentioned as a part of Climate-Smart Agriculture (CSA) as “a transformative approach which is built on three interlinked pillars, including (i) increasing agricultural productivity and incomes; (ii) enhancing resilience; and (iii) reducing or removing greenhouse gas emissions” (Palombi and Sessa 2013; Tesema and Mekoya 2025).

Vietnam's long-standing tradition of agroforestry offers a rich foundation for scaling CSAF. With an estimated 77.8% of agricultural land featuring more than 10% tree cover, agroforestry practices have been widely adopted across the country (Baral 2022). These systems range from traditional home gardens and integrated farming systems to more specialized models tailored to specific regions, such as coffee agroforestry in the Central Highlands or mangrove-based systems in coastal areas.

Despite Vietnam's commitment to sustainable development and climate adaptation, as evidenced by its inclusion of agroforestry in its Nationally Determined Contributions (NDCs), the widespread adoption of CSAF remains limited. Barriers include policy fragmentation and being hidden in the Forestry Policy, limited access to technical knowledge, and resource constraints for smallholder farmers (Nguyen et al. 2022). Additionally, the diverse agroecological zones of Vietnam, from the Northern Mountains to the Mekong Delta, present unique challenges and opportunities for CSAF implementation. It is likely that a gap in a comprehensive review of the existing climate-smart agroforestry systems in Vietnam.

This paper aimed to provide a comprehensive review of climate-smart agroforestry (CSAF) in Vietnam, focusing on several critical areas. First, it examined the current status of agroforestry and CSAF practices across Vietnam's key agroecological zones, highlighting both traditional and modern approaches. Second, it reviewed the institutional and policy frameworks that support CSAF development, identifying strengths and gaps in governance. Third, the paper evaluated the socio-economic and environmental impacts of CSAF systems, including their role in improving food security, increasing farmer incomes, enhancing biodiversity, and mitigating climate change. Fourth, it discussed the challenges and opportunities for scaling up CSAF in Vietnam, considering factors such as market access, land-use rights, and climate-related risks. Finally, the paper offered recommendations for enhancing CSAF adoption and effectiveness, focusing on policy reforms, capacity-building, and financial mechanisms to promote sustainable and scalable agroforestry models.

By synthesizing current knowledge, identifying gaps, and proposing targeted recommendations, this review seeks to inform policymakers, researchers, and practitioners on strategies to promote CSAF as a key approach for sustainable agriculture and climate resilience in Vietnam. The findings of this study will contribute to ongoing efforts to align agricultural development with Vietnam's climate commitments and sustainable development goals.

## **MATERIALS AND METHODS**

This study employed a systematic review approach to examine CSAFs in Vietnam, drawing from a combination of peer-reviewed literature, policy documents, and case studies across diverse agroecological zones. The methodology was designed to address the key objectives outlined in the introduction. The study was conducted in Vietnam during 2024 – 2025.

**Literature search and selection.** A comprehensive literature search was conducted using academic databases including Web of Science, Scopus, and Google Scholar. Key search terms included “climate-smart agriculture”, “agroforestry”, “Vietnam”, “climate change adaptation”, and “sustainable agriculture”. The search was limited to publications from 2014 to 2024 to ensure up-to-date information. Additional grey literature, including government reports and policy documents, was sourced from relevant Vietnamese government websites and international organizations working in Vietnam.

**Policy analysis.** National and regional policies related to climate-smart agriculture and forestry, were reviewed including Vietnam’s Nationally Determined Contributions (NDCs), the National Strategy on Climate Change, and the Agricultural Development Plan 2021-2030. Emphasis was placed on

understanding how these policies support or limit CSAF models and their scaling potential, particularly for sustainable land use and carbon sequestration.

**Case study compilation.** To contextualize the application of CSAF, detailed case studies were compiled across different agroecological zones (Mulia and Nguyen 2021). The case studies covered traditional agroforestry practices and their climate-smart adaptations. For example, in the Northern Mountains, focus was on the integration of leguminous trees into maize and cassava systems, and on shade-grown coffee production supported by CSAF initiatives in the Central Highlands.

## RESULTS AND DISCUSSION

**Current status of agroforestry and climate-smart agroforestry practices in Vietnam.** CSAF is recently defined as “an integrated approach to land use that combines trees, crops, and sometimes animals within managed farmlands, offering a sustainable farming system that helps mitigate and adapt to climate change” (Kabato et al. 2025). Therefore, the differences between Climate-Smart Agroforestry (CSAF) and Business-as-usual (BAU) Agroforestry are likely paired by categories involving: purpose and goals; management practices; climate impact; economic & social context; and technology & data use.

In summary, CSAF = Agroforestry redesigned for climate mitigation + adaptation + sustainable productivity, using planned, measurable, climate-smart strategies, while Business-as-usual agroforestry = Traditional agroforestry without explicit climate objectives or systematic planning (Table 1).

**Table 1.** Differences between Climate-Smart Agroforestry (CSAF) and Business-as-usual (BAU) Agroforestry

Category	Climate-Smart Agroforestry (CSAF)	Business-as-usual (BAU) Agroforestry
Purpose and goals	<ul style="list-style-type: none"> <li>• Designed explicitly to address climate change.</li> <li>• Has three core goals:                             <ul style="list-style-type: none"> <li>○ Increase productivity (sustainably)</li> <li>○ Enhance climate resilience/adaptation</li> <li>○ Reduce or remove greenhouse gas emissions</li> </ul> </li> <li>• Focused on long-term sustainability and climate outcomes</li> </ul>	<ul style="list-style-type: none"> <li>• Traditional or conventional agroforestry practised without a climate-focused strategy.</li> <li>• Main goals are usually livelihood, shade, soil protection, or production, not climate mitigation.</li> </ul> <p>Often follows existing local customs or market-driven decisions</p>
Management practices	<p>Uses deliberate, evidence-based design:</p> <ul style="list-style-type: none"> <li>• Improved tree–crop species selection for climate tolerance</li> <li>• Soil carbon management</li> <li>• Water-efficient layouts</li> <li>• Diversification to spread climate risks</li> <li>• Monitoring of carbon, yields, and resilience metrics</li> </ul>	<p>Practices may be inherited, informal, or simplified:</p> <ul style="list-style-type: none"> <li>• Limited species diversity</li> <li>• Minimal climate risk planning</li> <li>• Little or no monitoring of carbon or climate impacts</li> </ul> <p>Management may be reactive rather than strategic</p>

Climate impact	Explicitly aims to: <ul style="list-style-type: none"> <li>• Sequester carbon</li> <li>• Reduce emissions (e.g., through nitrogen-fixing trees, reduced fertilizer use)</li> <li>• Improve climate resilience for farmers</li> </ul>	<ul style="list-style-type: none"> <li>• May still sequester carbon and provide ecosystem benefits, but not intentionally or optimally.</li> <li>• Climate impacts are usually not measured or maximized.</li> </ul>
Economic and social context	Often part of: <ul style="list-style-type: none"> <li>• Climate finance programs</li> <li>• Certification schemes</li> <li>• Government or NGO climate-adaptation projects</li> <li>• Corporate sustainability supply-chain commitments</li> </ul>	<ul style="list-style-type: none"> <li>• Typically low-investment, small-scale, or traditional.</li> <li>• Less likely to be integrated with climate finance or monitoring systems.</li> </ul>
Technology and data use	Frequently uses: <ul style="list-style-type: none"> <li>• Mapping/GIS for planning</li> <li>• Climate models or risk assessments</li> <li>• Digital tools for monitoring trees, soil, and carbon</li> <li>• Traceability systems in supply chains</li> </ul>	<ul style="list-style-type: none"> <li>• Usually low-tech, relying on farmer knowledge and local practice.</li> </ul>

Agroforestry is an integral part of Vietnam’s agricultural heritage, practised widely across the country’s diverse agroecological zones. This integration of trees, crops, and livestock has provided Vietnamese farmers with sustainable livelihoods for centuries. Today, agroforestry remains a crucial component of rural development, especially in regions vulnerable to climate change, such as the Northern Mountains, Central Highlands, and the Mekong Delta. In Vietnam, a project named Reduce Emissions through Climate Smart Agroforestry (RECAF) was conducted under the REDD+ framework to guide practical measures to reduce deforestation, promote forest regeneration and agroforestry aimed at increasing forest carbon capture, which is likely a key to Viet Nam’s Climate Change Strategy (FAO 2023).

**Northern Mountains: Traditional and modified agroforestry systems.** In the Northern Mountains, agroforestry is primarily practised by ethnic minority communities who rely on traditional models like shifting cultivation and mixed tree-crop systems. These systems incorporate native tree species such as *Acacia*, *Eucalyptus*, and fruit-bearing trees like longan and litchi, alongside staple crops like maize and cassava (Mulia and Phuong 2021). These practices not only provide food security but also play a key role in reducing soil erosion and improving water retention in the region’s steep terrains (Mulia and Nguyen 2021).

Recently, CSAF models have been introduced to increase the resilience of these traditional systems. For example, ICRAF and other development partners have piloted projects that integrate leguminous trees with maize and cassava, enhancing soil fertility and sequestering carbon (Simelton et al. 2019). In addition, the planting of fast-growing species like *Acacia* helps generate quick economic returns while also providing biomass for energy. These modified systems, which apply diverse potential forest trees, demonstrate how CSAF can enhance productivity and environmental resilience in the Northern Mountains while diversifying income sources for farmers (Baral 2022).

**Central Highlands: Agroforestry for coffee and pepper production.** The Central Highlands, known for its coffee and black pepper production, is a region where agroforestry plays a vital role in both economic development and environmental protection. Traditional agroforestry systems here typically integrate shade trees with coffee plantations, offering both ecological and economic benefits (Ntawuruhunga et al. 2023). Trees like *Canarium* and *Albizia* provide shade, improve microclimates, and enhance soil health, reducing the need for chemical inputs.

In recent years, CSAF models have been promoted to further improve the sustainability of coffee and black pepper production. These models include the integration of nitrogen-fixing trees, which enhance soil fertility and reduce the reliance on synthetic fertilizers. In some areas, farmers are also adopting multi-strata agroforestry systems with multiple vertical layers of vegetation, similar to a natural forest, where trees of different heights are intercropped with coffee, providing various ecosystem services such as carbon sequestration and new habitats for biodiversity (Nguyen et al. 2022). These practices are gaining attention due to their potential to mitigate the effects of climate change, particularly in regions prone to droughts and irregular rainfall (Mulia and Nguyen 2021).

**Mekong Delta: Agroforestry for climate resilience in flood-prone areas.** In the Mekong Delta, agroforestry systems have long been adapted to the region's unique hydrological conditions. Farmers here traditionally practice integrated farming systems that combine fish farming, rice cultivation, and tree planting, known as '*Vuon-Ao-Chuong*' (VAC) or garden-pond-livestock systems. This model allows for the sustainable management of floodplains by diversifying production and reducing risks associated with climate variability (Tran and Tran 2024b).

With rising sea levels and increased flooding due to climate change, CSAF models are being piloted to enhance the resilience of these integrated systems. For example, flood-tolerant trees such as *Melaleuca* are being introduced in combination with rice and aquaculture to create buffer zones that protect farmlands from flooding while providing additional income sources through timber and honey production (Nguyen et al. 2022). These CSAF approaches are proving valuable in flood-prone areas, where the risks from climate change are especially acute.

**Central Coast: Agroforestry for coastal protection and livelihood diversification.** In Vietnam's central coastal regions, where sandy soils and saltwater intrusion present significant challenges, agroforestry has been adopted as a strategy for coastal protection and livelihood diversification. Farmers in these areas traditionally integrate cashew, coconut, and fruit trees with crops like peanuts and sweet potatoes. These systems help stabilize sandy soils and prevent desertification (Mulia and Phuong 2021).

CSAF models in the region focus on planting salt-tolerant tree species, such as *Casuarina* and *Rhizophora*, which serve both economic and ecological purposes. These trees not only provide timber and non-timber forest products but also protect coastal areas from storm surges and soil degradation (Octavia et al. 2022). Additionally, farmers are experimenting with silvofishery systems, where trees are planted along the edges of shrimp or fish ponds to provide shade, improve water quality, and enhance biodiversity (Baral 2022).

**Red River Delta: Urban and peri-urban agroforestry.** In the Red River Delta, where urbanization is rapidly expanding, agroforestry is being promoted as part of peri-urban farming systems. Traditional home garden systems, or *vuòn nhà*, have long been practised in this densely populated region, integrating fruit trees, vegetables, and small livestock in compact spaces (Nguyen et al. 2022).

CSAF initiatives here focus on enhancing the ecological functions of these systems by introducing more diverse tree species and promoting organic farming practices. These urban agroforestry systems contribute to food security, improve air and water quality, and provide green

spaces that mitigate the urban heat island effect (Simelton et al. 2019). Additionally, they offer an opportunity for cities like Hanoi to develop sustainable urban agriculture models that can be replicated in other densely populated areas.

## **Institutions and policies supporting agroforestry development**

**Policy document system related to climate-smart agroforestry.** Several national policies and legal frameworks have been established to support agroforestry, although there are no specific standalone policies exclusively dedicated to it (Hoang et al. 2018). Instead, agroforestry is often embedded within broader agricultural, forestry, and environmental policies. Resolution No. 26 (Vietnam Gov. 2008) was one of the foundational documents that provided strategic directions for rural development, emphasizing the integration of sustainable practices like agroforestry. This resolution promoted innovations in CSAF, improved land use, and increased investments in rural infrastructure and farmer training. Decision No. 1895 (Vietnam Gov. 2012) focused on developing high-tech agriculture, including the application of advanced technologies to improve productivity and promote CSAF.

In 2016, two key decrees were issued: Decree No. 119 (Vietnam Gov. 2016a), which provided specific policies for managing coastal forests in response to climate change, supporting agroforestry in these sensitive areas; and Decree No. 168 (Vietnam Gov. 2016b), which regulated the assignment of forest and water surface areas to ensure sustainable resource management in state-owned agricultural and forestry companies, which directly benefits CSAF.

The Forestry Law (Vietnam Assembly 2017) is a cornerstone for agroforestry development, as it outlines clear regulations on forest management, encouraging the integration of crops and trees in CSAF models. Additionally, Decision No. 419 (Vietnam Gov. 2017) approved the national program to reduce greenhouse gas emissions through sustainable forest management, reinforcing CSAF's role in carbon sequestration and forest conservation efforts.

Policies regarding payment for forest environmental services (PFES), established under Decree No. 156 (Vietnam Gov. 2018b), created financial mechanisms that incentivize CSAF models by providing funds for forest protection and development. The 2020 Environmental Protection Law also ensures that agroforestry models align with sustainable environmental standards, requiring efficient resource use and minimal environmental harm.

Circular No. 02/2020 (MARD 2020) sets criteria for recognizing agroforestry farms based on production scale and product value, facilitating state support for qualifying CSAF models. Moreover, the Sustainable Agricultural Development Strategy outlined in Decision No. 150/2022 (Vietnam Gov. 2022a) emphasizes sustainable agricultural practices, including CSAF, as key to optimizing resource use and protecting the environment.

Overall, these legal frameworks provide essential support for developing CSAF models in Vietnam by encouraging sustainable practices, offering financial incentives, and ensuring alignment with environmental and rural development policies. The impacts of related policies on climate-smart agroforestry in Vietnam are summarized in Table 2.

Table 2 shows that the policy landscape supporting climate-smart agroforestry (CSAF) in Vietnam has evolved significantly over the past two decades. Key policy documents have laid the groundwork for CSAF development, beginning with Resolution No. 26/2008/NQ-TW (Vietnam Gov. 2008), which emphasized agricultural innovation and rural infrastructure investment. Subsequent policies, such as Decree No. 119/2016/ND-CP (Vietnam Gov. 2016a) and the 2017 Forestry Law (Vietnam Assembly 2017), established frameworks for sustainable forest management and integrated land use practices. The national program for reducing greenhouse gas emissions (Vietnam Gov. 2017)

aligned closely with CSAF objectives, providing financial support for such models. The 2020 Environmental Protection Law (Ministry of Natural Resources and Environment 2020) ensured that agricultural practices, including CSAF, prioritize resource efficiency and environmental protection. Recent policies, including the new Land Law (Vietnam Assembly 2024), further promote sustainable agricultural production and provide flexible land-use regulations conducive to CSAF implementation. These policies collectively create a supportive environment for CSAF, addressing various aspects from land use and forest management to climate change mitigation and sustainable agricultural development. However, while this policy framework is comprehensive, the effectiveness of implementation and the need for more specific CSAF-focused policies remain areas for further consideration in Vietnam's pursuit of sustainable and climate-resilient agriculture. The gap is likely an issue that needs to be dealt with in the future (e.g. improving tree–crop species selection for climate tolerance; soil carbon management; water-efficient layouts; diversification to spread climate risks; monitoring of carbon, yields, and resilience metrics; and using digital tools for monitoring trees, soil, and carbon).

**Table 2.** Direct and indirect impacts of policies on the development of CSAF

Document Title	Direct and Indirect Impacts on Climate-smart Agroforestry
Resolution No. 26/2008/NQ-TW dated August 5, 2008, on Agriculture, Farmers, and Rural Areas by the Central Executive Committee of the Communist Party (Vietnam Gov. 2008)	<ul style="list-style-type: none"> <li>• Supports the innovation and development of climate-smart agroforestry models.</li> <li>• Improves the efficiency of land and resource use.</li> <li>• Invests in rural infrastructure, supporting agroforestry models.</li> <li>• Provides training and support for farmers to adopt new models.</li> </ul>
Decree No. 119/2016/ND-CP dated August 23, 2016, by the Government on Regulations for Policies on the Management, Protection, and Sustainable Development of Coastal Forests in Response to Climate Change (Vietnam Gov. 2016a)	<ul style="list-style-type: none"> <li>• Provides policies for the protection and sustainable development of coastal forests, supporting the integration of forests and agriculture in climate-smart models.</li> <li>• Encourages the use of agroforestry models to enhance resilience and adaptation to climate change, such as soil protection and erosion reduction.</li> <li>• Issues regulations on the management of coastal forest resources, helping maintain and improve soil and water quality in agroforestry models.</li> <li>• Provides support mechanisms and encourages research and the application of new technologies in coastal forest management and the development of climate-smart agroforestry models.</li> </ul>
Decree No. 168/2016/ND-CP dated December 27, 2016, by the Government on Regulations for the Assignment of Forests, Gardens, and Water Surface Areas in Special-use and Protective Forest Management Boards, and State-owned Agricultural and Forestry Companies (Vietnam Gov. 2016b)	<ul style="list-style-type: none"> <li>• Assignment of forests and water surface areas helps ensure sustainable resource management.</li> <li>• Facilitates investment in new technologies and techniques.</li> <li>• Clarifies management responsibilities, enhancing the efficiency of models.</li> <li>• Provides financial and technical support mechanisms.</li> <li>• Supports the testing and optimization of climate-smart agroforestry models.</li> </ul>

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<b>Document Title</b>	<b>Direct and Indirect Impacts on Climate-smart Agroforestry</b>
Law No. 16/2017/QH14 Forestry Law issued by the National Assembly on November 15, 2017 (Vietnam Assembly 2017)	<ul style="list-style-type: none"><li>• Clearly regulates forest protection and development, enabling the integration of forest trees into climate-smart agroforestry models.</li><li>• Supports models combining crops and forest trees, improving the efficiency of land and resource use.</li><li>• Promotes sustainable forest resource management, helping agroforestry models maintain sustainability and enhance environmental protection.</li><li>• Provides legal and policy frameworks to support research, application, and scaling up of climate-smart agroforestry models.</li></ul>
Decision No. 419/2017/QĐ-TTg by the Prime Minister on the Approving the national program on reduction of greenhouse gas emissions through the mitigation of deforestation and forest degradation; conservation and enhancement of forest carbon stocks and sustainable management of forest resources through 2030 (Vietnam Gov. 2017)	<ul style="list-style-type: none"><li>• Strengthens forest conservation and sustainable management, improving soil quality and increasing carbon stock.</li><li>• Agroforestry models contribute to enhancing carbon stock in soil and vegetation.</li><li>• Implements pilot models to assess the effectiveness of agroforestry models.</li><li>• Provides training and raises awareness on sustainable forest resource management.</li><li>• Offers policies and financial support for the application of agroforestry models.</li><li>• Encourages cross-sector cooperation to achieve conservation and sustainable development goals.</li></ul>
Decree No. 83/2018/ND-CP by the Government on Agricultural Extension (Vietnam Gov. 2018a)	<ul style="list-style-type: none"><li>• Encourages the application of new technology and innovation in agriculture, supporting the development of climate-smart agroforestry models.</li><li>• Provides training and technical guidance on climate-smart agroforestry for farmers.</li><li>• Provides financial support and materials for agroforestry models, including equipment and necessary resources.</li><li>• Encourages the testing and research of climate-smart agroforestry models through pilot projects.</li><li>• Promotes cooperation between government agencies, NGOs, and businesses to develop climate-smart agroforestry models.</li></ul>
Decree No. 156/2018/ND-CP by the Government dated November 16, 2018, on the Mechanism for Payment for Forest Environmental Services (Vietnam Gov. 2018b)	<ul style="list-style-type: none"><li>• Payments for forest environmental services provide financial resources for forest protection and development activities. Climate-smart agroforestry models can utilize these financial resources to invest in sustainable forest and agricultural management methods, promoting sustainable development and improving production efficiency.</li></ul>
Law No. 72/2020/QH14 dated November 17, 2020, Environmental Protection Law 2020 issued by the National Assembly (Vietnam Assembly 2020)	<ul style="list-style-type: none"><li>• Ensures that models use resources efficiently and do not harm the environment.</li><li>• Encourages the application of advanced technology to optimize resource use and reduce pollution.</li><li>• Requires effective waste management, including recycling in agroforestry.</li></ul>

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Document Title	Direct and Indirect Impacts on Climate-smart Agroforestry
<p>Decision No. 150/QĐ-TTg dated January 28, 2022, by the Prime Minister on the Approval of the Sustainable Agricultural and Rural Development Strategy for the Period 2021-2030, Vision to 2050 (Vietnam Gov. 2022a)</p>	<ul style="list-style-type: none"> <li>• Conducts environmental impact assessments for major projects to ensure compliance with environmental protection standards.</li> <li>• Designs models to withstand climate change and promote sustainable development.</li> <li>• Promotes education and awareness on environmental protection.</li> <li>• Emphasizes the development of sustainable agriculture, including the application of agroforestry models to optimize resource use and protect the environment.</li> <li>• Provides policies and support mechanisms to encourage investment in sustainable agricultural models, including agroforestry. This may include financial, technical, and training policies to help farmers and businesses implement these models.</li> <li>• Outlines climate change adaptation measures, in which agroforestry models can play a key role. The models help improve the resilience of agricultural systems to harsh climatic conditions and enhance carbon sequestration.</li> </ul>
<p>Resolution No. 19-NQ/TW dated June 16, 2022, of the Central Executive Committee on Agriculture, Farmers, and Rural Areas until 2030, Vision to 2045 (Vietnam Gov. 2022b)</p>	<ul style="list-style-type: none"> <li>• Sets goals to promote the transition to sustainable agricultural production models, with agroforestry being a key solution to improve production efficiency and protect the environment.</li> <li>• Emphasizes the application of advanced technology and innovation in agricultural production. Climate-smart agroforestry models often incorporate new technology to optimize production and enhance resilience to climate change.</li> <li>• Aims to improve the lives and incomes of farmers, including supporting agroforestry models to create stable and sustainable income sources for rural communities.</li> <li>• Sets policies and mechanisms to support agricultural development, including agroforestry models, to promote sustainable development and address current challenges.</li> </ul>
<p>Circular No. 12/2022/TT-BNNPTNT dated September 20, 2022, by the Ministry of Agriculture and Rural Development providing guidance on certain forestry activities under the Sustainable Forestry Development Program and the National Target Program for Socio-economic Development in Ethnic Minority and Mountainous Areas for the Period 2021-2030, Phase I from 2021 to 2025 (MARD 2022)</p>	<ul style="list-style-type: none"> <li>• Provides detailed guidance on forestry activities under the Sustainable Forestry Development Program, including policies and measures to support forestry development in ethnic minority and mountainous areas. These activities may include the application of agroforestry models to improve livelihoods and protect the environment.</li> <li>• Links forestry activities with sustainable development goals, where agroforestry models are encouraged as they help maintain ecological balance, protect forest resources, and enhance rural livelihoods.</li> <li>• Supports the implementation of the National Target Program for socio-economic development in ethnic minority and mountainous areas, where agroforestry models can contribute to raising incomes and improving living conditions in these areas.</li> </ul>

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<b>Document Title</b>	<b>Direct and Indirect Impacts on Climate-smart Agroforestry</b>
Law No. 31/2024/QH15 dated January 18, 2024, Land Law issued by the National Assembly (Vietnam Assembly 2024)	<ul style="list-style-type: none"><li>• Helps coordinate policies and resources from forestry and socio-economic development programs, creating conditions for the implementation of agroforestry.</li><li>• Facilitates the application of climate-smart agroforestry models by providing flexible land-use regulations, allowing the integration of multiple types of crops and livestock on the same piece of land. This supports the implementation of agroforestry models, optimizing land resource use.</li><li>• Can include areas designated for agroforestry models into land use planning, making it easier to implement these models, particularly by combining agricultural and forestry cultivation.</li><li>• Provides incentives and support mechanisms for developing sustainable production models, including climate-smart agroforestry models. Supportive policies, such as tax incentives, financial assistance, and training, can help farmers adopt and sustain these models.</li><li>• Regulates the management and protection of land resources, ensuring that agroforestry models are implemented within the legal framework while also contributing to environmental protection and maintaining ecosystem sustainability.</li></ul>

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**Institutions and stakeholders promoting the development of CSAF.** Numerous public sector institutions and stakeholders play important roles in promoting climate-smart agroforestry models in Vietnam, notably: (1) The Government of Vietnam: The highest authority in managing and directing policies and programs related to agroforestry; and The Ministry of Agriculture and Rural Development (MARD) is the primary agency responsible for managing agriculture, forestry, and rural development, including agroforestry activities; (2) The General Department of Forestry: Under MARD, it manages forest-related activities, including programs and policies on agroforestry; (3) The General Department of Irrigation: Also under MARD, it supports agricultural activities related to irrigation and water resource management, affecting agroforestry models; (4) The Vietnam Academy of Forest Science and related units: Plays a role in researching and developing agroforestry models, and providing policy recommendations and technical solutions; (5) The National Agricultural Extension Center and Provincial Agricultural Extension Centers: They transfer technology and guide farmers and cooperatives in applying agroforestry models; (6) The Vietnam Academy of Agricultural Sciences (VAAS): Participates in researching and developing agricultural solutions, including agroforestry; and (7) Universities offering agricultural education: These institutions contribute to the conduct scientific research and training and extension to promote high-quality human resources for the development of climate-smart agroforestry models.

In addition to the public agencies mentioned above, private domestic and international organizations support the development of climate-smart agroforestry in Vietnam. Notably, agroforestry systems have been implemented through projects from ICRAF Vietnam, including the Agroforestry for Smallholder Livelihoods in Northwest Vietnam (AFLi) Project (2011–2021) funded by the Australian Centre for International Agricultural Research; Research on Fruit-based Agroforestry Practices in Northwest Vietnam (2020) self-funded by ICRAF; Research on the Contribution of Agroforestry to Vietnam’s Nationally Determined Contributions (NDC) (2017-2020) co-funded by the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) and ICRAF; and the Climate-Smart Agriculture Practices in North Central Vietnam Project (2015–2018) funded by CCAFS.

The AFLi project introduced several agroforestry models in the Northwest region, including simple models with 2-3 crops and more integrated models with more than three components.

The research on fruit-based agroforestry in the Northwest identified nine agroforestry practices, providing information on annual income and estimated carbon sequestration to demonstrate the potential for climate change mitigation. The study on the role of agroforestry in Vietnam's NDCs compiled information on agroforestry practices in several provinces based on data from local partners. The Climate-Smart Agriculture Practices Project disseminated information about three agroforestry practices with scalability in suitable regions.

Additionally, cooperatives, businesses, farms, and individual farmers are the actual implementers of agroforestry models, under the guidance and support of management and research agencies. These groups need to be made aware of the roles of climate-smart agroforestry models to leverage individual and local potential and promote the development of these models.

**Institutions and policies on the development of CSAF.** Vietnam is increasingly aware of the benefits of agroforestry. The country's institutions and policies play an important role in promoting the development of climate-smart agroforestry models. Agroforestry has been included in Vietnam's 2020 Nationally Determined Contributions (NDC) as a key measure for soil conservation, maintaining food production, and carbon sequestration in response to climate change. The online database on agroforestry (SCAF) reported that Vietnam's total agroforestry cultivation area reached about 900,000 hectares during the 2013-2014 period (Nguyen et al. 2022).

Agroforestry models in Vietnam have developed rapidly and are highly diverse (Pham 2015). Statistics show 13 main agroforestry models, namely: (1) traditional home gardens, (2) the garden-pond-livestock (VAC) system, (3) the garden-pond-forest-livestock (VACR) system, (4) mangrove forest and aquaculture systems, (5) *Melaleuca* forest systems integrated with agriculture and aquaculture, (6) forest systems combined with upland fields and gardens, with or without livestock, (7) intercropping agricultural crops in regenerating forests, (8) intercropping perennial crops with planted forests, (9) intercropping annual crops with planted forests, (10) livestock grazing under forest canopies or in regenerating forests, (11) growing fodder crops within forests, (12) intercropping annual crops in fruit orchards or perennial plantations, and (13) mixed cropping systems with support trees, shade trees, or multipurpose trees.

Additionally, the International Centre for Research in Agroforestry (ICRAF) notes that Vietnam's agroforestry models have evolved into smart farming models through strategies that combine livelihood diversification and environmental protection. According to this organization, Vietnam's agroforestry models can be grouped into: (1) wood-based agroforestry systems, (2) perennial crop-based agroforestry systems, (3) fruit tree-based agroforestry systems, and (4) agroforestry systems in mangrove forests (Nguyen et al. 2022).

Regardless of how they are classified, previous studies (Muchane et al. 2020; Nguyen et al. 2022; Pham 2015) have emphasized the roles of climate-smart agroforestry systems in terms of economic, social, and environmental aspects.

*Economic impacts:* Agroforestry improves livelihoods, diversifies products, reduces production costs by lowering input material use, and facilitates quicker capital turnover, thereby increasing and stabilizing farmers' income (Muchane et al. 2020; Nguyen et al. 2022).

*Social impacts:* A recent study highlighted the importance of improving food security and nutrition for the population, as well as empowering women in economic and family development

activities. According to the research restoring degraded land through agroforestry could enhance food security for 1.3 billion people (Muchane et al. 2020).

*Ecological and environmental impacts:* Agroforestry contributes to reducing water and chemical inputs through the efficient use of resources. It has a high potential to sequester significant amounts of carbon in soil and vegetation, helping mitigate emissions and absorb greenhouse gases while playing an important role in forest landscapes. Agroforestry also effectively reduces soil erosion and sedimentation when trees are planted along contour lines and strips (Nguyen et al. 2022). It can reduce soil erosion by up to 50% and increase soil carbon content by 21%. Furthermore, agroforestry helps increase biodiversity, conserve forests, and enhance ecosystem services.

The role of agroforestry in addressing climate change is clear (e.g. Agroforestry plays a crucial role in mitigating and adapting to climate change through carbon storage, increasing adaptive capacity, reducing vulnerability, and reducing climate risk (Quandt et al. 2023)). As it is included in national climate change strategies and commitments. Among the Nationally Determined Contributions (NDCs) of 147 countries, about 40% propose agroforestry as a solution, with the highest mention in Africa, where 71% of the countries include it.

Globally, CSAF is likely considered an approach of the REDD<sup>+</sup> framework (e.g. Reduce Emissions through Climate Smart Agroforestry (RECAF) project addressed in Vietnam (FAO 2023). Of the 73 countries with National REDD<sup>+</sup> Strategies, about 50% identify agroforestry as a measure to reduce forest degradation (Muchane et al. 2020; Nguyen et al. 2022; Pham 2015; Pham et al. 2020). In conclusion, agroforestry models can contribute to multiple Sustainable Development Goals (SDGs), including (i) No Poverty, (ii) Zero Hunger, (iii) Good Health and Well-being, (iv) Gender Equality, (v) Clean Water and Sanitation, (vi) Affordable and Clean Energy, (vii) Climate Action, and (viii) Life on Land (Octavia et al. 2022).

Despite the clear benefits of agroforestry and CSAF, their adoption at scale in Vietnam faces several challenges. Policy gaps, limited access to financial and technical support, and the high initial investment costs required for transitioning to agroforestry systems are significant barriers. Many farmers lack the resources or knowledge to implement CSAF practices, and there is often a preference for monoculture systems that promise quicker economic returns (Simelton et al. 2019).

However, the potential for scaling up CSAF in Vietnam is immense. With growing government support, international collaboration, and a clear recognition of the need for sustainable agriculture, there are opportunities to expand agroforestry practices across the country. The integration of agroforestry into national policies on climate change adaptation and rural development, along with incentives for ecosystem services, can help overcome these barriers (Ministry of Natural Resources and Environment 2020).

**Strengths and opportunities.** CSAF is redesigned much better than the traditional ones because of its larger scale, which is appropriate for climate mitigation, adaptation, and sustainable productivity, using planned, measurable, climate-smart strategies. The very nature of agroforestry systems in different ecological systems, plus the Government's appointment of 'Net Zero Carbon by 2045' is an opportunity to apply CSAF in Vietnam. CSAF offer numerous advantages over traditional agricultural models, providing mitigation and adaptation to climate change, economic, ecological, and social benefits. These systems enhance crop yields, diversify agricultural products, and contribute to poverty reduction in rural areas by increasing the production of valuable goods such as wood, fruits, and agricultural products for consumption and trade (Nguyen et al. 2021). In Vietnam, agroforestry plays a significant role in food security by restoring soil fertility and supporting the cultivation of drought-tolerant species, which helps provide essential food products such as fruits and edible oils (Do et al. 2020). Furthermore,

agroforestry reduces deforestation and mitigates climate change by increasing carbon sequestration (Mulia and Phuong 2021).

CSAF contributes to food security by producing a wide range of nutritious food products on the same land, often requiring minimal inputs. For example, the VAC system has been widely adopted in rural Vietnam, integrating livestock, crops, and aquaculture into a small area. This system enhances food production and supports household livelihoods while promoting sustainable land use practices (Tran and Tran 2024b). Agroforestry systems also align with national strategies for sustainable development in mountainous and rural regions by utilizing land efficiently and reducing reliance on chemical inputs (Hoang et al. 2018).

From an ecological perspective, agroforestry systems help conserve ecosystems and improve soil health. Well-managed systems reduce soil erosion, enhance water retention, and limit surface runoff, which are essential for maintaining soil fertility in regions prone to land degradation. By promoting nutrient cycling, agroforestry increases nutrient-use efficiency, reducing the demand for chemical fertilizers and mitigating groundwater contamination. Agroforestry also regulates stream flows, mitigates the risks of flash floods and landslides, and improves resilience to droughts (Nguyen et al. 2022).

In terms of biodiversity conservation, agroforestry reduces the pressure on natural forests by providing alternative sources of forest products such as timber and fuelwood, lessening the need for deforestation. Integrating trees into farming systems increases biodiversity at both the farm and landscape levels and helps maintain critical ecosystem services such as water regulation and carbon sequestration (Pham et al. 2020). Agroforestry plays a vital role in protecting buffer zones around nature reserves and promoting biodiversity conservation (Mulia and Phuong 2021). In mountainous regions of Vietnam, agroforestry has proven effective in reducing human pressure on natural forests and supporting forest regeneration (Do et al. 2020).

Finally, agroforestry contributes to climate change mitigation by sequestering carbon through tree planting and maintaining soil carbon levels. These systems enhance the capacity for carbon storage in both trees and soil, reducing atmospheric CO<sub>2</sub> levels and mitigating greenhouse gas emissions (Nguyen et al. 2021). Agroforestry also helps reduce deforestation, which plays a key role in Vietnam's efforts to combat climate change (Pham et al. 2020).

Institutional and policy mechanisms are essential for promoting agroforestry development in Vietnam. The 2017 Forestry Law provides a robust legal foundation for agroforestry by regulating land use and forest planting. Articles 57 and 60 of the law specifically address agroforestry in protective forests, supporting household and business participation in agroforestry systems (Vietnam Assembly 2017). These legal frameworks are critical in scaling up climate-smart agroforestry models across the country (Nguyen et al. 2022).

Circular No. 02/2020/TT-BNNPTNT (MARD 2020) defines the scale and legality of agroforestry models in Vietnam, recognizing those that meet specific size and product value criteria as farms. This recognition opens up access to financial support, technical assistance, and extension programs, promoting sustainable development. Recognized agroforestry farms can also benefit from state preferential policies, fostering growth and productivity.

Agroforestry is a key component of Vietnam's REDD+ strategy, as outlined in the National REDD+ Strategy until 2030 (Vietnam Gov. 2017b). This strategy prioritizes sustainable solutions like agroforestry to restore forests and improve local livelihoods. Extension and technology transfer policies have brought advanced practices from research institutions to farmers, enhancing productivity and environmental protection.

In Vietnam, agroforestry is mentioned or hidden in the policies on forest protection, reforestation, and sustainable resource, therefore these policies use promote agroforestry by reducing soil erosion, protecting biodiversity, and enhancing climate resilience. Water management policies also support agroforestry by encouraging efficient water use.

- CSAF models optimize land use, increase productivity, and boost household incomes. These models are particularly beneficial for ethnic minorities and poor households, contributing to poverty reduction. National climate change policies further encourage climate-smart agroforestry as a solution for land protection, biodiversity conservation, and greenhouse gas reduction.
- International cooperation and open-door policies have allowed Vietnam to access advanced technologies, experience, and funding, fostering the development of climate-smart agroforestry models. Investment incentives have attracted domestic and foreign businesses to participate in this growth.
- Training and decentralization policies have empowered local authorities, allowing flexibility in agroforestry model development to meet local needs.

**Weaknesses and challenges.** Alongside the proven advantages and opportunities, agroforestry models in Vietnam still face several challenges and risks. Many farmers lack concrete business strategies due to limited knowledge of production techniques and insufficient information on market demand forecasting for agroforestry products (Do et al. 2020). As a result, agroforestry products are often sold at 20-30% lower than the market price, leading to reduced profitability (Nguyen et al. 2021). Furthermore, farmers encounter difficulties related to land-use rights, as land allocation by local authorities is slow due to budget constraints and complex administrative procedures (Mulia and Phuong 2021). Extreme weather events caused by climate change, such as hailstorms, frost, dry season water shortages, and pest infestations, also heavily impact agroforestry in Vietnam, further complicating its sustainability (Nguyen et al. 2022).

The fragmented and small-scale nature of agroforestry production presents another challenge, as very few models have transitioned towards commercial-scale production (Do et al. 2020; Pham and Nguyen 2022; Tran and Tran 2024a). In some cases, the diversity of crops and livestock within agroforestry systems reflects a subsistence-level production system, limiting opportunities for market expansion. Additionally, many farmers lack access to modern technology and information on successful agroforestry practices, leading to inefficiencies in production (Hoang et al. 2018). Competition between industrial crops, annual crops, perennial crops, and livestock also threatens ecosystem diversity within agroforestry models (Nguyen et al. 2021).

Despite the existence of a legal framework supporting agroforestry, several challenges remain:

- Agroforestry is an interdisciplinary activity involving agriculture, forestry, livestock, and fisheries, yet comprehensive policies covering these fields are lacking. Agroforestry is primarily addressed in forestry-related policy documents, and there is a policy gap in promoting climate-smart agroforestry practices in agriculture (Do et al. 2020).
- Additionally, policies like Circular No. 02/2020/TT-BNNPTNT set criteria for farm recognition based on production scale and value but fail to reflect the unique benefits of climate-smart agroforestry, such as biodiversity conservation and ecosystem services. These economic criteria often overlook the non-economic benefits of agroforestry, reducing its appeal to potential investors (Hoang et al. 2018). The criteria are also unsuitable for small-scale and diverse production models, particularly in difficult rural areas, preventing many from qualifying for state support and incentives (Nguyen et al. 2021).

- As highlighted agroforestry models lack insurance mechanisms to protect against risks (Hoang et al. 2018). The flexible application of scientific and technological advancements in specific contexts is necessary to improve household capacity. Moreover, the lack of access to loan capital remains a significant barrier to advancing agroforestry development in Vietnam.

## **RECOMMENDATIONS**

To fully realize the potential of CSAF in Vietnam, a multi-faceted approach is needed. First, policies must be refined to address the specific challenges facing smallholder farmers, particularly those related to land tenure, financial access, and technical knowledge. The government should introduce more targeted support through subsidies, low-interest loans, and grants for CSAF systems, ensuring that financial mechanisms are accessible to all farmers, especially those in remote areas. Expanding credit facilities, as well as developing insurance schemes to mitigate the risks from extreme weather events, are also crucial.

Second, coordination between the agricultural and forestry sectors should be strengthened. Given the interdisciplinary nature of agroforestry, new policies should promote integrated models that combine crops, livestock, and forestry within the same legal framework. A comprehensive strategy that links sustainable agriculture, forest management, and water resource conservation will provide a clearer direction for CSAF expansion.

Capacity-building programs are essential for farmers and local officials, providing them with the knowledge and skills needed to implement modern CSAF practices. Collaborations among research institutions, universities, and extension services can play a key role in disseminating technological innovations and successful CSAF examples. Such initiatives will help farmers optimize land use, diversify their production, and increase their resilience to climate change.

Finally, market access for CSAF products must be improved. This can be achieved by strengthening value chains, establishing cooperatives, and fostering partnerships with private companies. Encouraging investments from both domestic and international businesses, particularly in agroforestry-related value-added processing, will further enhance the profitability and sustainability of these systems.

## **CONCLUSIONS**

This study underscores the critical role of agroforestry as a climate-smart cultivation system and helps in enhancing agricultural resilience, promoting environmental sustainability, and supporting rural livelihoods in Vietnam. CSAF systems, which integrate trees, crops, and livestock, offer multiple benefits, including improved land-use efficiency, carbon sequestration, and biodiversity conservation. These systems have been particularly effective in addressing soil erosion, enhancing water retention, and diversifying income sources for smallholder farmers.

However, the widespread adoption of CSAF remains constrained by several challenges. These include fragmented policy frameworks, limited technical support, insufficient financial resources, and small-scale production systems. Farmers often struggle with market access and face barriers to scaling agroforestry models to commercial levels. The impacts of climate change, such as extreme weather events, further complicate the sustainability of these models.

To overcome these challenges, it is essential to align policies across the agricultural and forestry sectors, provide targeted financial incentives, and improve farmers' access to technology and training. Strengthening value chains and enhancing market access for agroforestry products will also be crucial. By addressing these issues, Vietnam can fully leverage the potential of CSAF to meet its

climate adaptation and mitigation goals while promoting sustainable agricultural development and improving rural livelihoods.

### **ACKNOWLEDGEMENT**

This study did not receive external funding.

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