Project report

Potential mitigation contribution from coffee agroforestry in three regions of Viet Nam

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September 2018

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Published by: World Agroforestry Centre (ICRAF) Viet Nam, Southeast Asia Program, Hanoi, Viet Nam

Abstract

Coffee agroforestry is one of the main agroforestry systems in Viet Nam in terms of total land area in the country, potential economic contribution, and ecosystem services provided by the shading tree species in the system. This report presents the results of a study that aimed to estimate potential mitigation contribution from carbon storage from coffee agroforestry systems in the three regions of the country. The estimated C storage of arabica coffee systems in the Northwest region of Viet Nam ranges from 2.6 to 17.0 ton ha^{-1}. Potential storage at province level reaches 246,224 ton in Son La province, as it has a higher total area of coffee plantations than Dien Bien province. In the Southeast and Central Highlands region, the estimated C storage of robusta and arabica coffee agroforestry systems ranges from 5.8 to 10.4 ton ha^{-1}, in general due to variation in shading tree species and density. The potential C storage at province level can reach up to 2.1 million ton as in the case of Dak Lak province. From local interviews with provincial authorities and smallholder farmers in the three regions, stakeholders could see the economic and environmental benefits that can be derived from the coffee agroforestry systems. However, the lack of knowledge in planting design and plot management options constrain farmers from transforming their coffee monoculture into agroforestry systems, or expanding the system into available areas for coffee cultivation. We recommend that the provincial authorities keep supporting and encouraging research on coffee agroforestry and provide reliable technical guidance for farmers to develop coffee agroforestry systems with appropriate design.

Keywords: carbon storage, coffee agroforestry, climate change mitigation, Viet Nam, Central Highlands, Northwest Viet Nam, Southeast Vietnam.

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Acknowledgements

The authors express their gratitude to colleagues from Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI); Dr. Bao Huy and Mrs. Phan Thi Hang from Tay Nguyen University; Dr. Nguyen Phu Hung and Mrs. Nghiem Phuong Thuy from VNFOREST (MARD); Mrs. Nguyen Mai Phuong, Mr. Nguyen Manh Cuong, and Mr. Duong Minh Tuan from ICRAF Viet Nam; Provincial Departments of Agriculture and Rural Development (DARD) of Son La, Dien Bien, Dak Lak, Dak Nong, Gia Lai, Binh Phuoc, Lam Dong, Kon Tum provinces as well as district and communal staffs in the study sites who provided assisstance during the study in the provinces.

This work was implemented as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is carried out with support from the CGIAR Trust Fund and through bilateral funding agreements. We thank USAID specifically for funding this work. For details please visit https://ccafs.cgiar.org/donors. The views expressed in this document cannot be taken to reflect the official opinions of these organizations.

Introduction

The Government of Viet Nam (GoV) is revising its Nationally Determined Contribution (NDC) target, especially from the Land Use, Land Use Change, and Forestry (LULUCF) sector, and plans to release the final revision in March 2019. For this revision, there is an opportunity to include a potential mitigation contribution from agroforestry (AF), provided the contribution from this system in the country can be estimated. AF can be defined simply as the integration of trees into farms and has been identified as a potentially significant contributor to global climate change mitigation and adaptation goals. Climate change mitigation can be achieved through several ways (Duguma et al. 2017): first, through carbon sequestration especially from the perennial or tree components in the system; second, by reducing the use of chemical fertilizer by integrating the nitrogen fixing plants or trees that results in maintained or enhanced soil fertility; and third, indirectly, agroforestry could help reducing leakage of carbon emission from adjacent forests by allowing for sustainable intensification and contributing to reducing deforestation and forest degradation (Minang et al. 2014; Mbow et al. 2014).

The first step in estimating the potential mitigation contribution is to select the main AF systems in Viet Nam, based on their total area in the country. According to the Spatially Characterized Agroforestry (SCAF) database produced by the World Agroforestry Centre (ICRAF), which is a central repository of AF data collected in 2012-2013 from smallholders across Viet Nam, the systems with coffee are the largest AF system in the country in terms of total area. More recently, according to the 2017 data from the General Statistics Office (GSO) of Viet Nam, by 2016, the total area of coffee systems as one of main export products of the country reached 645,000 ha. Indeed, this figure has surpassed the national target for the year 2030 (MARD, 2012).

Introduced in Viet Nam for the first time in 1857 by the French, coffee has become an important part of the country's economy and its agriculture sector, in particular. According to the GSO, coffee is the second largest perennial crop of Viet Nam in terms of area, following rubber, and it contributes about 2-3 percent of the national Gross Domestic Product. Central Highlands, the Southeastm (SE), and Northwest are the three regions featuring the most coffee plantations, the powerhouse of more than 90% of national coffee production.

Unlike arabica coffee trees which are usually shaded and common in the Northwest region, two-thirds of robusta coffee plantations in Central Highlands and SE region are full-sun systems (Jha et al. 2014). The latter, together with more intensive fertilizer application, produces higher yield, but at the same time reduces tree species diversity and potentially leads to systems which are vulnerable to pest and diseases.

Currently, after some periods of market volatility, farmers tend to develop coffee in agroforestry systems again, by combining coffee with shaded tree species such as fruit trees. The Ministry of Agriculture and Rural Development (MARD) also is showing interest and support to promote coffee AF systems through organizing a series of workshops on coffee intercropping systems with fruit trees, providing support on researches on coffee AF systems, and is planning to publish a national guideline on coffee AF practices.

In the literature, coffee AF systems have also been recognized as important carbon (C) sequestration sources. Ehrenbergerova et al. (2015) compared three coffee AF systems, i.e. Coffee - *Inga* spp. and Coffee – *Pinus* spp. and Coffee – *Eucalyptus* spp. with sun-grown coffee in Villa Rica, Peru. Their study showed that the system with Pinus spp. stored the highest amount of C stock above and belowground to include soil biomass both from shading trees and coffee shrubs, namely 177.5 ± 14.1 ton ha-1. These figures are substantially higher than sun-grown systems, with a typical C stock of 99.7 ± 17.2 ton ha-1. Similarly, Schmitt-Harsh et al. (2012) reported a range from 74 to 259 ton C ha-1 in smallholder coffee AF systems in the western highlands of Guatemala. With a difference of about 30 tons in total C stock per ha between shaded coffee and sun-grown systems, AF systems

with coffee can be considered compensation to C loss in forest-to-coffee transitions (van Noordwijk et al. 2003). In Viet Nam, the popular tree species intercropped with coffee are *Cassia seamia* or *Leueucaeana* sp., but nowadays, there is a trend that smallholder farmers prefer to intercrop with fruit trees, both as shading trees and to bring higher economic return. The most popular shading fruit tree species areplum and longan in the Northwest region; durian, avocado, and persimmon in Central Highlands; and cashew in Southeast region.

In this report, we present the results of a study that aimed to provide the first estimate of aboveground C stock from coffee AF systems in Viet Nam. The study was conducted in eight provinces located in the three main regions of coffee cultivation, namely Northwest for arabica coffee,and Central Highlands as well as Southeast region for robusta coffee. We also conducted key informant interviews with provincial authorities to identify the total area of coffee in the provinces and to estimate the potential C stock that can be generated from the coffee systems at province level.

Materials and methods

Description of study sites

The C storage estimation of coffee AF systems was conducted in three regions that have the largest coffee plantations in the country, namely the Northwest (NW), Central Highlands (CH) and Southeast (SE) regions, that cover eight provinces namely Dien Bien, Son La, Kon Tum, Gia Lai, Dak Lak, Dak Nong, Lam Dong and Binh Phuoc (Figure 1).

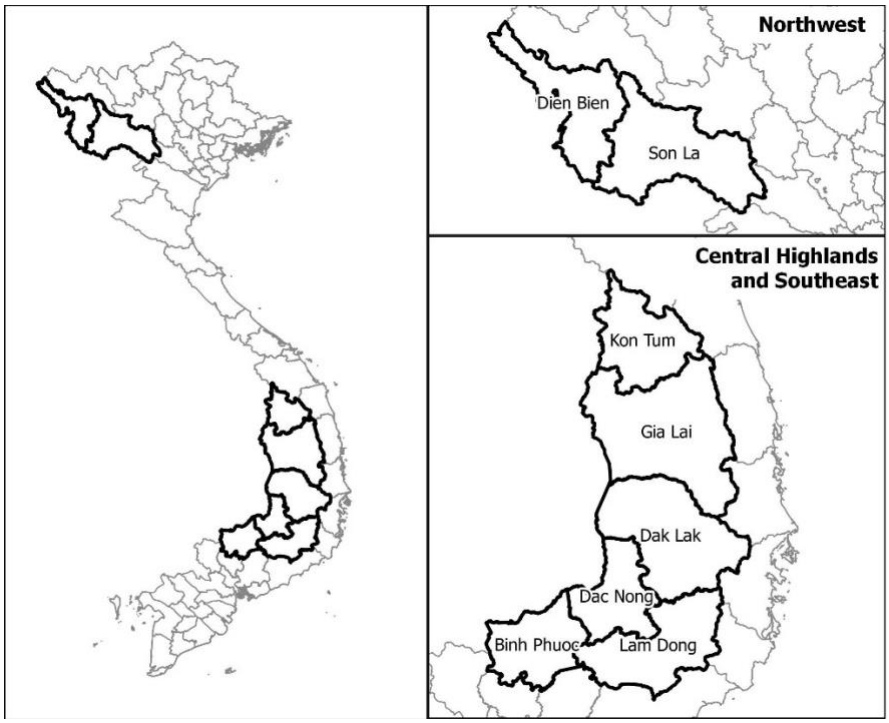

Figure 1. Location of three regions, including covering eight provinces, in which the the coffee AF study was carried out

The study sites in the NW region cover two provinces, Son La and Dien Bien. The region is characterized by high mountainous areas and is home to multiple ethnic minority groups, including H'mong, Khang, and Thai people. The altitude in the two provinces ranges from 300 to 1,200 m above sea level. The climate in the two provinces is sub-humid tropical, with an average annual temperature of 21 degrees C and annual rainfall from 1,200 mm to 1,600 mm. The local people have

been practicing shifting cultivation and farming systems with maize, upland rice, and cassava in the sloping areas for decades, mostly in the form of monoculture.

Arabica coffee was introduced in the region by the French in the late 19th and early 20th centuries. Thereafter, the region has become an important producer of raw arabica coffee for the French coffee industries. In 1995, arabica coffee system was introduced in Dien Bien and Son La province, transforming these two provinces into main arabica coffee powerhouses in the country, besides Lam Dong province in CH region. Nowadays, with a total area of 21,600 ha, Son La and Dien Bien together become the main arabica coffee plantation regions in Viet Nam.

The second and third study sites are located in CH and SE regions, that cover six provinces namely Dak Lak, Dak Nong, Gia Lai, Kon Tum, Lam Dong and Binh Phuoc. CH region, consisting of the first 5 provinces, has elevation ranges from 500 m to 1,500 m asl (Viet Dung 2017). It has cool weather with air temperature ranging from 20-25 degree C. The annual rainfall ranges from 1,500 mm to 2,400 mm, with a rainy season from May to October, accounting for about 80% of the annual rainfall amount (CCAFS-SEA, 2016). Binh Phuoc province, which represents SE region, is located in the southeast of CH, with average elevation of only 200 masl., but with steep lands. Comparing to CH, Binh Phuoc, as well as, SE region has ahigher average temperature which ranges from 25.8 to 26.2 degree Celsius with contrasting temperature between day and night time. Annual rainfall ranges from 2,045 to 2,325 mm, of which 90% fall between May and November. The provinces in CH are dominated by indigenous ethnic groups such as Ede, Jarai, M'nong, and Kho Me. Since the 1970s with New Economic Zones (NEZ) policy promulgated by the Vietnamese Government, that encourages citizens from populated areas such as Hanoi, Ho Chi Minh city and the Red River Delta, to migrate to CH, Kinh people becomes a dominant group with population up to 70% of CH population (FAO, 2007), followed by Tay and Nung people, who also migrated from the North. Similarly, 80% of the total population of Binh Phuoc province are Kinh. Other ethnic minority groups in the province such Khmer, Xtieng, Hoa, Nung, and Tay, account for 20% of the province's population (Central Population and Housing Census Steering Committee, 2010). Like in NW, the climate condition in CH is suitable for coffee plantation introduced during the French colony, but with poor development until the late 1970s. After the Doi Moi reform in 1986 and an era of land privatization, the coffee industry started to grow rapidly, along with permission to establish private enterprises. Since the 1990s, the country experiences a booming in coffee production, making it the world's third biggest exporter after Brazil and Ecuador, and the world's second in 2000 (Dang and Shively, 2008). Among the six provinces of these two regions, Kon Tum and Lam Dong have both arabica and robusta coffee area due to their diverse topography. The remaining four provinces namely Gia Lai, Dak Lak, Dak Nong, and Binh Phuoc only have robusta coffee.

Coffee survey in NW region

In this region, we investigated the coffee systems in 124 coffee AF farmers in two provinces namely Son La (76 farmers) and Dien Bien (48 farmers), that covered four sampled districts and eight sampled communes, through individual interviews. The dominant ethnic groups in the sampled communes are Kinh, Thai and H'mong. The commune selection was conducted by Northern Mountainous Agriculture and Forestry Science Institute (NOMAFSI) that has years of experience working in the two provinces and the districts. We recorded the types of coffee system, component of tree species, and tree spacing among other characteristics of different coffee systems that the households manage (i.e. generally each household manages more than one coffee plots/systems), either monoculture or AF form. To crosscheck the accuracy of the data provided by the individual farmers, a visit to the most complicated AF system that they manage was also conducted. We also interviewed the provincial authorities namely the Department of Agriculture and Rural Development (DARD) of each province to investigate the provincial programs and their perspective on upscaling coffee AF in the province.

Focus group discussion in the Central Highlands and Southeast regions

We conducted coffee survey only in NW region, due to a join activity with another project that needed a more detail information of households that managed the coffee systems. In other regions however, we focused more on the plant components and density in the coffee systems for C stock calculation, and collected the data through focus group discussions (FGDs). The FGDs were conducted in two districts per province, and one commune per district. In each commune, we conducted one or two FGDs depending on the farmers' availability, with five farmers per group. We found nine ethnic minority groups attended the FGDs namely Ede, Jarai, Xe Dang, M'nong, Ro Ngao, Dao, Khmer, Nung and San Chi beside the Kinh people. Different with the study in NW region, in the CH region we only focused on coffee AF systems, not including the sun-grown or monoculture. We also interviewed the provincial authorities (DARD) to investigate the provincial programs and their perspective on upscaling the coffee AF system in the provinces.

Carbon estimation for coffee

For arabica coffee, as a common variety in NW region, and that exists in some provinces in the CH region, the aboveground biomass (AGB) of single arabica coffee tree is estimated according to allometric equation given by Segura et al. (2006).

$$Log\ (AGB) = 1.181 + 1.991 * Log\ (d15)$$

Where d_{15} is the diameter at 15 cm from the soil surface. For each coffee plot belongs to the households (either monoculture or AF), we estimated AGB of coffee trees with d_{15} at 2, 4, and 6 cm.

For robusta coffee, the AGB of single robusta coffee tree is estimated according to allometric equation given by Guillemot et al. (manuscript under review):

$$Ln\ (AGB) = -4.033 + 1.408 * ln\ (Ci) + 0.818 * ln\ (PCA)$$

Ci is the stem circonference at 30 cm above soil surface (cm) and PCA is projected crown area (m^2).

For each system with robusta coffee, we estimated AGB of coffee trees with d_{30} at 8, 10, and 12 cm; and PCA at 4, 6, and 8 m^2.

Carbon estimation for other tree species in coffee systems

For the shading tree species in coffee AF systems, we calculated the biomass based on the allometric equation given by Kettering et al. (2011) that distinguishes species by wood density (ρ).

$$AGB = 0.11 * \rho * DBH^{.62}$$

DBH is diameter at breast height (cm). For each shading tree species observed in the coffee systems, we calculated their AGB with DBH ranges from 10-20 cm. The wood density of each tree species was obtained from several sources including the ICRAF library on tree species wood density. Both for coffee and other tree species, C stock is estimated as 46% from the AGB.

Potential Carbon stock from the coffee agroforestry system at province level

The potential C contribution from coffee AF systems at province level was calculated by assuming that the total area of coffee plantations in the provinces in 2017 are thoroughly converted into coffee AF systems. The data on the 2017 provincial area of coffee plantations were obtained from the interviews with the provincial authorities.

Results

Potential Carbon storage in Northwest region

The estimated C storage of coffee systems in Son La province ranges between 3.5-6.5 ton ha^{-1} (Fig. 2), with higher storage in AF compared to monoculture systems. The estimated figures are the total of C stock from coffee and shading tree species. In Dien Bien province, the C storage ranges between 2.6-6.6 ton ha^{-1} (Fig. 2), also with higher C storage in AF compared to monoculture systems. Comparing the two provinces, the average C storage of coffee AF systems in Son Lan and Dien Bien are comparable.

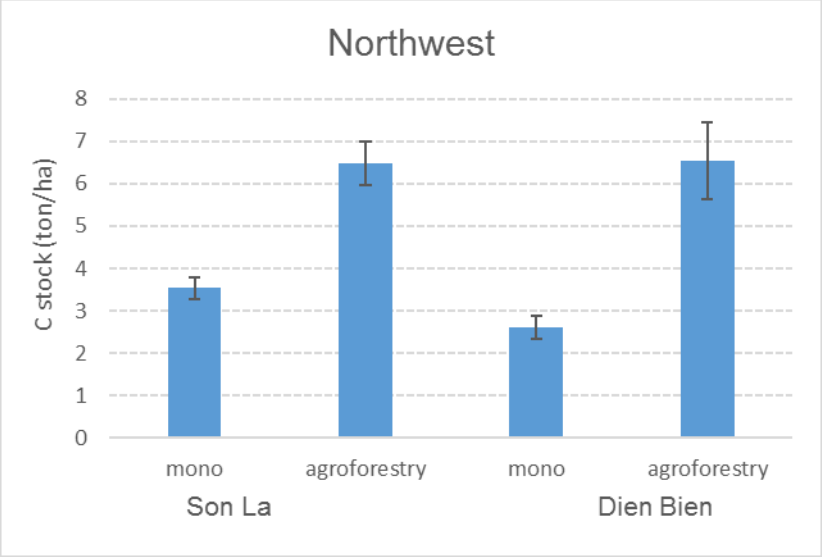

Figure 2. C storage from monoculture (mono) and AF (AF) in two provinces of Northwest region

The coffee systems in Son La, both monoculture and AF, have a higher coffee density per hectare than in Dien Bien (Table 1). This explains a higher difference of C stock of coffee monoculture systems in Son La than in Dien Ben. However, the C stock in the coffee AF systems between the two provinces is comparable due to the contribution from shading tree species. In Dien Bien, the average coffee density in AF systems belong to the sampled farmers is surprisingly higher than the average density in monoculture systems.

Table 1 Coffee density and estimated C storage in coffee systems in two provinces of Northwest Viet Nam

Province	System	Average coffee density (tree ha^{-1})	Average C stock (ton ha^{-1})	SE	Total area of coffee plantation in the province (ha)	Potential C stock from coffee AF (ton)
Son La					17,600	105,400 ± 7,900
	Mono	6,332	3.53	0.26		
	AF	5,439	6.47	0.51		
Dien Bien					4,052	24,833 ± 3,377
	Mono	4,671	2.61	0.27		
	AF	5,238	6.53	0.91		

Coffee Carbon storage in Central Highlands and Southeast regions

In the two regions, Dak Lak and Kon Tum province have highest C storage of per hectare coffee AF system among the six provinces (Fig. 3). The lowest C storage per hectare was found in Dak Nong and Gia Lai province with 9.4-9.7 ton ha^{-1}. Kon Tum and Dak Lak provinces have a higher C storage per hectare because in these provinces the farmers also cultivated arabica coffees that have narrower planting distance compared to the robusta. Therefore, the coffee density in the two provinces is higher than in the other provinces (Table 2). To compare with the monoculture system, the common coffee spacing in the full-sun systems is 3 m x 3 m or 3.5 m x 3.5 m that yields a density of about 900 coffee trees per ha. Using the equation from Guillemot et al., the C stock per ha in the full-sun system is around 5.4 (±0.5) ton ha^{-1}.

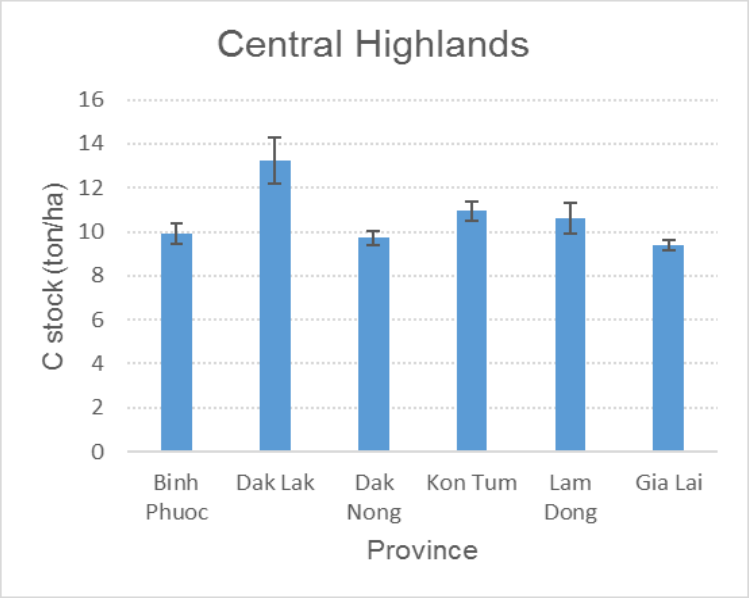

Figure 3. C storage from AF coffee systems in six provinces belong to SE and CH region

According to the data from the provincial authorities, Dak Lak has the largest area of coffee plantation namely around 202.5 thousand ha (Table 2). Due to this large area, the potential C stock of AF system in the province, assuming that the monoculture systems in the areas were thoroughly converted into AF systems, reaches 2.67 million ton C (Table 2).

Table 2. Estimated C storage in coffee AF systems of six provinces in SE and CH region

Province	Average coffee density (tree ha^{-1})	Average C stock (ton ha^{-1})	SE	Total area of coffee plantation in the province (ha)	Potential C stock (ton)
Binh Phuoc	564	9.9	0.47	16,041	159,242 ± 20,681
Dak Lak	742	13.2	1.05	202,479	2,677,176 ± 211,669
Dak Nong	826	9.7	0.31	125,888	1,223,862 ± 96,064
Kon Tum	1643	10.9	0.43	16,607	181,804 ± 84,538
Lam Dong	1320	10.6	0.72	158,624	1,684,547 ± 268,493
Gia Lai	699	9.4	0.23	94,025	883,921 ± 58,998

Provincial planning on coffee AF in the regions

According to Department of Crop Production (2018), by the end of 2017, except in Dien Bien province, the total area of coffee plantations in all other study provinces have exceeded the targeted area for 2020, formulated in the Decision 1987/QĐ/BNN-TT on provincial development planning for coffee sector until 2020. According to the interview with provincial authorities, the main driver of this rapid expansion is most likely the good market, that encourages the smallholder farmers in the regions to convert the land use to coffee systems. However, despite this circumstance the provincial authorities confirmed that there is still plenty of lands available and suitable for coffee AF in the provinces.

The large area consists of both coffee monoculture and AF systems, and related to the latter, the provincial authorities emphasized the need of more researches or evidences to show the benefits of coffee AF systems, and the need of technical guidelines on standardized tree density and plot management practice, as well as knowledge sharing on the interaction among coffee and shading tree species. They claimed that because of lack of reliable sources on these matters, no policy so far has been issued to support the farmers on transforming monoculture coffee plantations into AF systems. Furthermore, the Ministry of Agricultural and Rural Development (MARD) has not yet completed their assessment on the benefits and contribution of shading tree species on coffee productivity. At the moment, there is only a temporary guideline provided by MARD on recommended fruit tree density in coffee plantation system. Therefore, the design of most of coffee AF systems in the study provinces are not based on any reliable guideline but entirely based on farmers' knowledge.

Due to this circumstance, the provincial authorities are very cautious in promoting AF practices to the coffee farmers, despite the clear recent trend among farmers to integrate fruit trees into their coffee systems. In the temporary guideline, extension workers in provinces are expected to recommend farmers on the density and plot management practices related to the integration of fruit trees into the coffee farms. Financial support is currently not available for the development of this kind of coffee AF system. However, authorities in some provinces have incorporated coffee AF into the provincial ongoing projects or programs to mobilize related financial resources to support the development of the coffee AF. The Son La province considers the coffee-fruit tree system as the

future coffee plantation model in the province and provides financial supports for coffee-avocado and coffee-maccadamia systems.

Discussion

In Villa Rica (Peru), Ehrenbergerová et al. (2015) reported that *Inga*, *Pinus* and *Eucalyptus* trees are planted in arabica coffee plots with a density of 176, 124 and 472 trees per ha, respectively, while coffee density are 6,830, 4,840 and 2,950 per ha, respectively. In the arabica coffee AF systems in NW region, the average densities of shading tree species are 58 (±5) and 112 (±4) in Dien Bien and Son La provinces, respectively. In Dien Bien, the common shading tree species was *Leucaena leucocephala*, while in Son La dominated by fruit trees such as longan, mango and plum. The coffee density in the NW region and Peru's systems are comparable, namely between 4,000-6,000 coffee trees per ha, except in the Eucalyptus-coffee system in the Peru site that has 2,950 coffee trees, much lower density than in the two other AF systems and in the NW regions.

The aboveground C stocks of coffee systems in Peru were found to be 29.1, 61.3 and 52.7 ton ha^{-1} respectively in Inga, Pinus and Eucalyptus sites, respectively. These figures are much higher than the C stocks estimated in the two provinces of the NW region. Schimitt-Harsh et al. (2012) also estimated aboveground C stock in Guatemala and reported higher figures, namely 12.9 ± 0.9 ton per ha of C stock from coffee trees only. The average coffee density in their study was 9,884 trees per ha, that likely explains the difference. An average of 218 shading trees in their coffee systems with timber, fruit, and leguminous species contributed to additional aboveground C stock of 59.5 ± 5.5 ton ha^{-1}. These two studies and our study clearly indicate that the C contribution from shading trees is substantial in the total of C stock from coffee AF system.

Local knowledge on benefits from coffee AF systems

Most of the interviewed farmers in our study reported their understanding that although intercropping system generally leads to lower coffee productivity, it maintains stability in coffee production and thus provides longer term results in terms of higher economic benefit. Local knowledge described another benefit: f coffee AF systems that integrate coffee and other tree species, usually either fruit tree or timber tree species reduce farmers' economic risk due to product diversification. According to farmers' perspectives, this is a main driver of conversion from monoculture to AF coffee systems. The interviewed farmers also recognize that coffee trees under shade are generally more resistant to pest and disease and to extreme weather events such as hot spells and drought. Particularly in Dien Bien and Son La provinces of NW region that have lower average air temperatures, shading trees can also help to protect the coffee trees from hoarfrost.

Local preference on type of coffee AF system

Related to the type of coffee AF system preferred by farmers, the most popular shading tree species both in NW and CH regions were formerly *Cassia siamea* and *Leueucaena* sp. However, the economic benefit that can be derived from these timber species was low and for longer term. Meanwhile, the market for coffee was also volatile, which discouraged farmers from maintaining coffee systems with these timber tree species. According to a study carried out during the VnSAT (Viet Nam Sustainable Agriculture Transformation) project called Component A, most of 'traditional shaded coffee plantation', i.e. coffee shaded by timber species, in CH have been replaced by shading fruit tree species, which can potentially bring higher income with a relatively more stable market (VnSAT 2018). A number of farmers still keep *Cassia siamea* and *Leueucaena sp*. in the systems, but as living pillar for pepper integrated into the coffee systems. They are not considered as the main sources of income but rather support the growth of the pepper that can provide high economic benefit to the farmers. Some farmers also still keep *Cassia* as a nitrogen-fixing tree species that can help to maintain soil fertility.

In the study sites, farmers are actively transforming their monoculture coffee into AF types. They are doing this conversion independent of provincial support or any replantation program. The farmers integrate the fruit trees in different ways, for example fruit trees are integrated in between coffee rows or by replacing slow growing coffee trees in the plots. Once the fruit trees become mature, the coffee trees around them that are highly shaded can be thinned, providing more space for the fruit trees to develop.

Coffee systems in the forest lands

Based on interviews with provincial authorities, local people also established coffee plantations in forest lands, a practice that is not legally supported by the provincial authorities. The total area of this coffee system is relatively high; for example, in Dak Nong province, there are 60,000 ha coffee plantation area in the forest lands, accounting for 48% of total 125,888 ha coffee plantation in the province. Despite this circumstance, the provincial authorities generally still allow the local people, especially ethnic minority groups, to maintain the systems since these local people lack other sources of financial backup to support their families. The Dak Nong and Lam Dong provincial authorities recommend farmers to integrate indigenous timber species as shading trees in their current coffee farms to improve both the resilience and tree cover in the systems. Farmers who are willing to adopt this practice will obtain tree seedlings support as well as the right to continue cultivating this system in the forest lands.

Current provincial focus on the coffee systems

Since the total area of coffee plantations in most of the study's provinces has surpassed the targeted area, provincial authorities are currently not focusing on expansion but rather on improving post-harvest processing and increasing the plantation area with product certification in order to improve the product quality and economic benefit that can be derived from the current plantations. In terms of improving the productivity of current coffee systems in the two regions, especially CH as the powerhouse of coffee production in the country, many current coffee plantations in the region are in post-peak production stage that needs rejuvenation. According to Decision 4521 issued by MARD, the total coffee area that needs to be rejuvenated is around 120,000 ha. Detailed planning of coffee replantation for CH was issued both in national and provincial levels. The provincial authorities also get support from VnSAT projects to improve the coffee clones, farm design and promote fruit trees to intercrop in coffee farms. Due to the latter initiative, farmers are becoming more aware on the intercropping practices and economic and environmental benefits that can be derived from the coffee intercropping systems.

Constraints in coffee AF adoption

Although there is a clear willingness both from provincial authorities and farmers to expand coffee AF systems in the provinces, some factors constrain adoption. First of all, farmers generally have financial limitations to covering the input cost related to purchasing fruit-tree seedlings or extra costs related to providing fertilizer for the fruit trees. Second, although there is a standard technical guideline on robusta coffee systems provided by MARD, this guideline relates to monoculture rather than AF plantation system. Due to the absence of an AF guideline, provincial funds cannot be used to support the establishment of coffee AF systems. Third, although MARD through the VnSAT project currently focuses on coffee systems in CH provinces, their assessment on interaction between coffee trees and different shading tree species has not been completed. Therefore, a lot of coffee systems in the region were not established with proper spacing between fruit trees and coffee rows. This leads to both lower coffee yield, as claimed by many interviewed farmers, and vulnerability of coffee trees to pest and diseases, which discourages farmers from adopting coffee AF. More research and provision of technical guidelines are necessary to support the adoption of coffee AF in the regions, and in Viet Nam in general. Related to the market, a strategy to encourage adoption of coffee AF practices currently implementied in some study provinces is to encourage farmers to produce

quality coffee that can meet the qualifications for certification, including certifications such as 4C, UTZ, GlobalGAP or Trade Fair. This higher product quality and certification can ensure a more stable market.

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