Research Article

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The transition of small-scale coffee farming systems and new pathways for coffee production: A case study in the central highlands of Vietnam

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Abstract

The dynamics of agriculture in general and coffee farming systems need to be investigated to derive insights for policies and interventions to promote sustainable agriculture. Through a systematic approach, including historical and adaptive ones, the study aims to probe the spatial-temporal transition of coffee farming systems. We found evidence for the diverse adaptive capacity of the coffee farming systems in Dak Lak province in their response to various factors. Moreover, an economic comparison was made between coffee farming systems, including mono-coffee farms and coffee-based intercropped ones. The study showed that coffee-based intercropped farms yield higher returns than mono-cropping ones by productivity enhancement, land equity ratio, and gross margin. These findings provided empirical evidence to design appropriate policies for the sustainable development of coffee farming.

Keywords: Central highlands; coffee farming systems, pathways, transition, Vietnam

Introduction

Lowder *et al.* (2016) estimated that 84 per cent of farms are small (less than 2 ha), with around 570 million small farms globally. Smallholders face growing pressure on their livelihood, low prices in the world market and climate changes (FAO, 2018). Therefore, new pathways for sustainable agricultural development to obtain the target of global development policies are essential, especially in regions of limited farming land. For instance, agroforestry and diversification are strategies to mitigate risks and improve benefits (Lin, 2010; Niether *et al.*, 2020; Byrareddy *et al.*, 2021; Ricciardi *et al.*, 2021).

Vietnam benefits from good climatic conditions to cultivate tropical perennial crops. During the last decade, the development of these crops dramatically accelerated, and Vietnam is presently the world's second-largest coffee producer (ICO, 2019). Coffee production in the central highlands accounts for ninety-seven per cent of Vietnam's coffee beans. Although perennial crops contribute to the socio-economic development of Vietnam, considerable crop losses are mainly due to climate change, such as drought. For instance, in 2017, agricultural production from 152,000 ha was affected with direct losses of VND 6,004 billion (US$ 269 million) (Grosjean *et al.*, 2016; World Bank, 2017).

According to Vietnam's guidelines, agricultural development needs to generate "more from less." Put differently; farming is oriented to create more economic value for farmers. Still, it uses fewer natural resources, human capital, and a smaller amount of harmful intermediate inputs to minimise the negative impact on the environment. Further growth must rely principally on increased efficiency, diversification, and innovation to take advantage of value addition. The Vietnamese Ministry of Agriculture and Rural Development (MARD)

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addresses economic efficiency while concerned with sustainability and environmental conservation. Eventually, in recent years, the national and local governments have contributed to the success of perennial crop sectors by implementing various policies that are considered to improve farmers' technical, economic, and environmental efficiency (Ho *et al*., 2021).

The coffee farming systems have considerably and successfully evolved in Dak Lak province over the years. Specifically, coffee has become an important income-generated crop for provincial farmers. Unfortunately, coffee production faces declining yields, high costs, low profits, and pests and diseases. Mono-coffee farming systems are highly susceptible to increasing temperatures and frequent droughts (Pham *et al.*, 2020). In response, monocultures of coffee have been substituted with crop-diversified systems, where coffee is grown in a mixture with fruit, other perennial crops, or annual crops. The intercropping approach between coffee and other cash crops mostly appeals because it can deal with environmental and socio-economic problems, such as water loss reduction and coffee price volatility (Priess *et al.*, 2007; Lin, 2010). For instance, the coffee intercropped with pepper system has more economic return than monocultures and is considered a new pathway for coffee production (Ho *et al.*, 2017; Thuy *et al.*, 2019a).

This study focused on the transition of coffee farming systems in the research site and conducted an economic comparison of these systems. Additionally, we seek alternative pathways for coffee farming systems in the province.

Materials and methods

Study area

Coffee and other cash crops are widely grown in Dak Lak province. However, to ensure the province's representativeness in the coffee farming system, we chose three districts Cu M'gar, Cu Kuin and Buon Ma Thuot city, to conduct our survey (Fig. 1).

Data inventory

Qualitative and quantitative data collected from primary and secondary sources were used in this study. We applied the participatory methods and household surveys using a semi-structured questionnaire to collect the primary data regarding 32 mono-coffee and 30 coffee-pepper intercropping farms. We selected the secondary data from official sources, including publications by the General Statistics Office (GSO), the Dak Lak Statistics Office (DSO), historical books, maps, project reports, and annual reports in local departments.

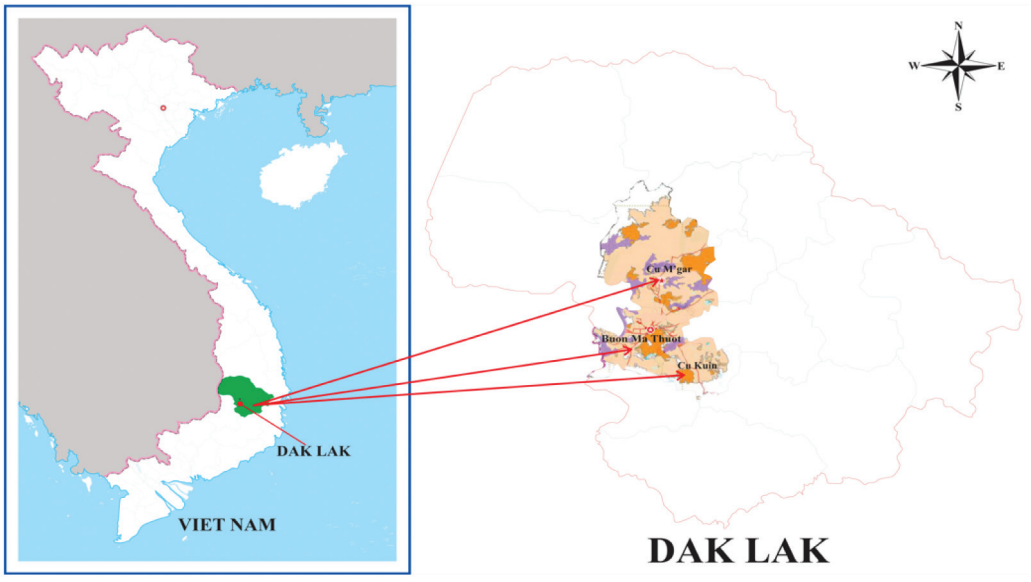

Fig. 1. Map of research sites

Source: Political map of Vietnam

Table 1. The surveyed samples

	Mono coffee farms (MCFs)	Coffee and pepper intercropped (CPI)
Cu M'gar	12	10
Cu Kuin	9	12
Buon Ma Thuot	11	8
Total	32	30

Because farming systems, in transition, vary in adaptation approaches, we identified the periods of coffee farms based on types of activities reconstructing the coffee crop system. In contrast, changes in these activities connect with socio-economic and political transformation. We followed Barral *et al.* (2012), Diepart and Allaverdian (2018), and Byrareddy *et al.* (2021) to use chronological, historical, and timeline event methods in spatial and temporal assessments. Moreover, the region can be divided into three zones through map-based visualisation and transect walks. The zone includes areas highly favourable for coffee farms with high fertility capacity (Zone 1- dark orange and orange sites), places that are moderately suitable for coffee growing (Zone 2- light orange sites) and locations that are unfavourable for coffee farms (Zone 3- purple sites). In each zone, we clarified the types of coffee farming systems.

Data analysis

Gross margin analysis

For each farming type, the gross margin of a given surveyed farm was calculated as follows FAO (2016).

$$GM = \Sigma Y_i \times P_i - \Sigma C_j$$

Where Y_i is the coffee and pepper production outputs (i = 1,2) of the farm, and P_i is the farm-gate prices of coffee and pepper. The cost of production denoted by *C* is related to inputs (*e.g.*, herbicides, fertilisers, pesticides, compost, hired labour, or energy).

Land equivalent ratio (LER)

LER is land productivity that compares the yields obtained by intercropping two or more crops and those obtained by growing one crop as pure systems. In this paper, we compared the yields of MCF and CPI (coffee agroforestry) to calculate LER.

The formula is $LER = \Sigma (Y_{pi}/Y_{mi})$, with Y_p being the yield of each crop (coffee and pepper) in the coffee agroforestry system. Y_m is the yield of coffee in the coffee monoculture (Utomo *et al.*, 2016). Following Mead and Willey (1980), LER is more than 1.0, indicating mixed systems are advantageous, whereas LER less than 1.0 shows the disadvantage of the hybrid system. The ratio is calculated to find the partial LER for each crop. Then the partial LERs are summed to give the total LER for the coffee and pepper intercropping. In a sense, the LER shows the intercrop interference levels in the coffee and pepper cropping system.

Results and discussion

The transitions in coffee farming systems in the study region

Firstly, coffee farming systems in Dak Lak have undergone rapid development for decades (Phan *et al.,* 2022). As a result, the dynamics and practices must be adjusted to suit agroecological and socio-economic transformation. The transformation story of coffee farming systems can vary in system type, production location, farm size, and government support across space and in time.

Mainly, coffee farming systems were often large-scale and heavily dependent on natural resources such as favourable soils in the early development stage (Duong, 2016; Thuy, 2016). In other words, coffee monocultures were dominant before reunification in 1975. For instance, coffee areas, including companies and households, accounted 1,928 ha, while rubber area was only 135 ha (Duong, 2016). Coffee plantations were principally concentrated in the high-fertility region (Zone 1). Coffee underwent a quick expansion while other crops remained unchanged. During the colonial era, coffee crops were planted in Zone 1. In this period, the moderate soil fertility region (Zone 2) was only for growing annual crops such as maise, beans, and rice for food subsistence. Meanwhile, fallow and forest land covered a large area in the unsuitable region (Zone 3) (Duong, 2016; Thuy, 2016, Minot, 1998; Doutriaux *et al.,* 2008; DSO, 1986).

In the state-owned period (1975-1985), coffee production remained as large-scale plantations (Minot, 1998). For instance, there were 28

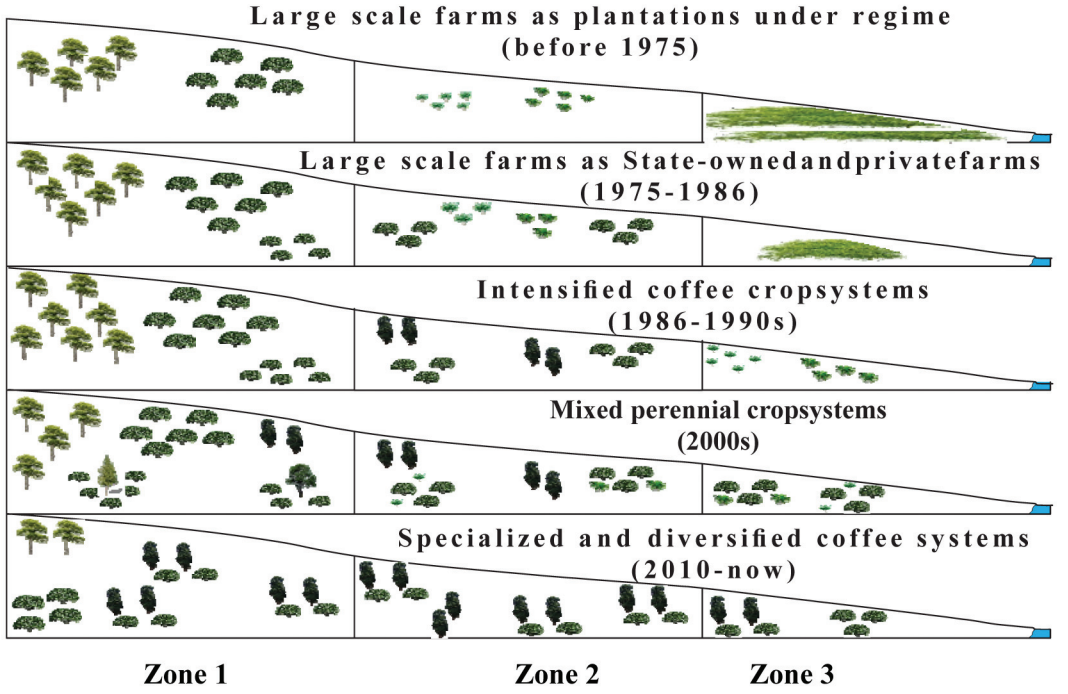

Fig. 2. A chronological diagram of the local transect of the coffee farming systems in Dak Lak province (Source: Author's elaboration)

state-owned farms, and 184 cooperate farms in 1985 (DSO, 1986). Under the pressure of the increasing population, coffee crops gradually expanded onto Zone 2 by individuals and households. In this period, diverse systems of annual crops such as rice and maise were initiated in Zone 3 (DSO, 1986; Minot, 1998; Ha *et al.*, 2001). Most coffee farming systems had simple technology in the reconstruction period (1986-1990). Still, they intensively used fertilisers, pesticides, and herbicides to raise coffee productivity and quickly expanded the coffee cultivation area to increase the output. For this reason, annual crops were rapidly replaced with coffee in the moderate region (Zone 2). Fallow and the forested regions were exploited to grow paddies and vegetables. Along with the physical expansion, the growing population was also a pressure on the land (Minot, 1998; DSO, 2001; Cheesman *et al.,* 2007a; Chi and D'haeze, 2005; D'haeze *et al.*, 2005a; Lindskog *et al.*, 2005). In the 2000s, the patterns of coffee cropping underwent the most significant evolution, with mixed crop systems established in Zone 1 and Zone 2 (Ha *et al.*, 2001; D'haeze *et al.*, 2005b; Minot, 2006; Ha and Shively, 2008; Hoang *et al.*, 2010). Since 2010, natural conditions and market issues have caused significant challenges to cropping structures. Accordingly, coffee farms in most areas have shown an overall increase in their proportion, using specialised and diversified approaches (Cheesman *et al.,*2007b; Doutriaux *et al.,* 2008; Meyfroidt *et al.,* 2013; Phuc and Nghi, 2014; Amarasinghe *et al.*, 2015; Scherr *et al.*, 2015; CCAFS SEA, 2016). Coffee-based intercropping systems have become more common (Thuy *et al.,* 2019a; Thuy *et al.*, 2019b; Phan *et al.*, 2022).

Prospects and new pathways to coffee farming systems

Although some studies showed that certified coffee farms have a better performance than non-certified farms (Ho *et al.,* 2018; Hung Anh *et al.,* 2019), the area and number of households under certified coffee production showed a declining trend in most cases (Table 2). Ho *et al.* (2018) showed that sustainability-certified coffee production does not help increase farmers' economic benefits or reduce negative environmental impacts.

Table 2. Area and participants in certified coffee production

Certificate	2013			2015			2017			2018		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
UTZ	25.0	16.8	14.5	29.0	19.5	14.5	17.0	15.6	11.0	7.0	6.2	5.6
4C	-	36.8	23.0	-	37.1	25.4	14.0	25.2	15.5	4.0	8.7	6.7
RFA	5.0	7.4	3.2	3.0	4.3	-	3.0	2.1	-	3.0	5.1	2.8
FLO	-	0.2	0.4	1.0	3.0	0.5	5.0	0.6	0.3	6.0	0.7	0.5
GI	-	-	-	10.0	-	-	12.0	-	-	12.0	-	-

Note: GI: Geographical Identification
(1): Unit; (2): Area (thousand hectares); (3) Participants (thousand households)
Source: Dak Lak Provincial People's Committee (2019a)

So it indicates a declining preference for coffee production under accredited schemes.

As certificated production is not a favourable option for coffee growers, coffee-based intercropping is another direction for farmers, widely observed in the research site, dominated 19.3 per cent (with CBIS 39,100 ha). However, coffee and pepper intercropping held the leading position in CBIS, about 20,000 ha (Fig. 3).

Unlike annual crops, new pathways for coffee production should be built through gradual transformation. The authorities should carry out a master plan concerning coffee cultivation zones to reduce coffee's physical expansion and enhance cost-efficient production. In Zone 1 and Zone 2, the production of speciality coffee beans should be encouraged to increase competitiveness for more value addition (Dak Lak Provincial People's Committee, 2019b). In Zone 3 (soil of unsuitable or low fertility), there should be encouragement and enhancement measures to rejuvenate old coffee farms or transfer them to other crops. To facilitate this policy, the local government should expand access to financial services at a low-interest rate. Besides government involvement, it is essential to enlarge the role and participation of social organisations such as women, youth, and farmers' unions to create diverse credit sources. In addition, sustainability-certified coffee should be re-evaluated based on economic and environmental aspects.

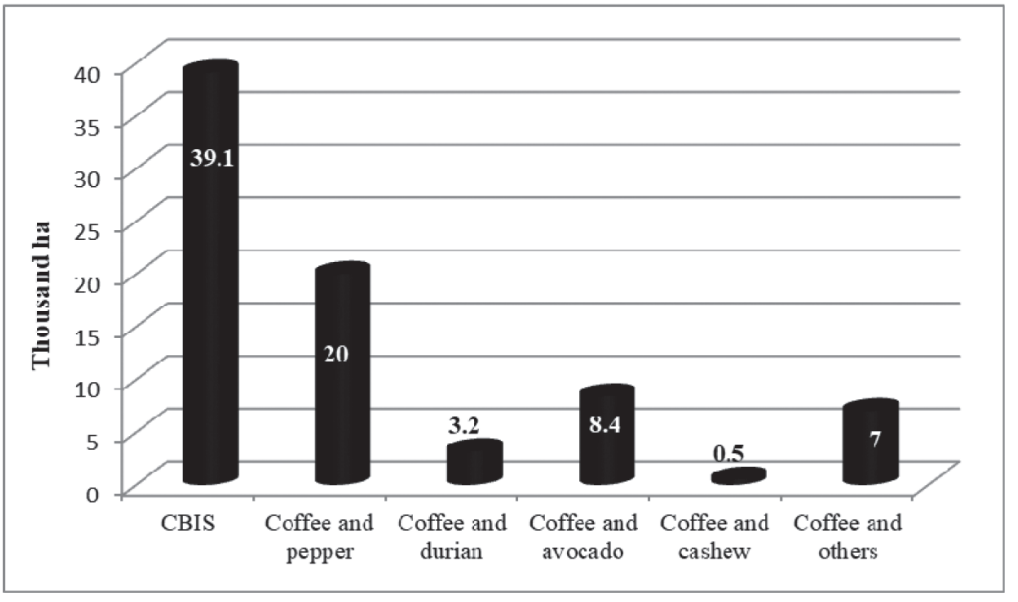

Fig. 3. The contribution of coffee-based intercropping systems (CBIS) in Dak Lak, 2018
Source: Dak Lak Provincial People's Committee (2019a)

Coffee growers are encouraged to employ a suitable certification in suitable locations to reduce ecological impacts, decrease production costs (*e.g.*, irrigation costs), and improve households' income from by-products (timber, fruit) (Ho *et al.*, 2018; Jezeer *et al.*, 2018).

Additionally, coffee farms should produce under agroforestry systems rationale because of the utility in providing ecosystem services, mainly when producing certified coffee (Pico-Mendoza *et al.*, 2020). The government should pay more attention to quality certification for farms rather than quantity certification. Finally, coffee tourism could provide a potential additional market segment to maintain stability or improve livelihood and rural development in difficult economic situations.

For coffee-based intercropping, it is recommended that farmers and local authorities pay more attention to intercropped systems, especially coffee-based ones. Farmers should be encouraged to learn modern practices in contemporary production and management. They will reap benefits in saving costs, reducing environmental impacts, and identifying and treating pests and diseases. Consequently, in the coming years, farmers need to consider technical advice, optimised density and manage costs to boost crop productivity, increase the land utilisation ratio and enhance the benefits for second crops. In other words, farmers' perceptions and knowledge concerning the role of intercropping on farms need to be reinforced in future.

The economic contribution of MCF and CPI

Table 3 shows that CPI seems to be higher productivity than MCF. For instance, when CPI reached 2.3 tons of coffee and 1.8 tons of pepper per ha, MCF only obtained 2.1 tons of coffee per ha. It is the reason for the farmers to intercrop their coffee with pepper. However, CPI tends to have higher costs (C) than MCF, especially hired labour costs (VND 12 million in CPI compared with 3 VND million in MCF) (Table 3 and Fig. 6A). It could create some difficulties for no-financial assets or limited-financial households. Therefore, to reduce this cost (labour demands), the level of management of the plantation on CPI is always considered a future benefit for farmers. In addition, a loan with a low-interest rate from institutions such as banks

Table 3. The cost and benefits analysis of coffee farming by different scenarios

Items	Mono coffee farm (MCF) (N=32)		Coffee and pepper intercropping (CPI) (N=30)		Sig
	Mean	SD	Mean	SD	
Production (t ha^{-1})					
Coffee	2.1	0.7	2.3	0.9	
Pepper	-	-	1.8	0.5	
Price (1000 VND kg^{-1})					
Coffee bean	37	-	37	-	
Dry black pepper	-	-	110	-	
I. Gross output	74.0	33.0	156.7	66.3	0.00 ***
II. Cost (II.1+II.2 +II.3)	30.5	9.7	54.8	15.8	0.03 **
II.1 IC (Mill VND ha^{-1})	22.6	9.0	30	10.8	0.00 ***
Fertilisers	18.3	7.8	21.0	7.7	0.03 **
Pesticides	2.0	1.9	6.0	4.7	0.00 ***
Water	1.4	1.0	1.5	1.2	0.70 N/S
II.2. Hired labor	3.0	3.0	12.0	10.0	0.00 ***
II.3 Others	4.9	2.8	12.8	10.8	0.00 ***

Note: Unit: Million VND ha^{-1}; GM has a high standard deviation (SD) due to the difference between farm characteristics. Mann-Whitney test$^{***, **, N/S}$ Significance level at 99%, 95% and Non-significance
Source: Survey data (2019)

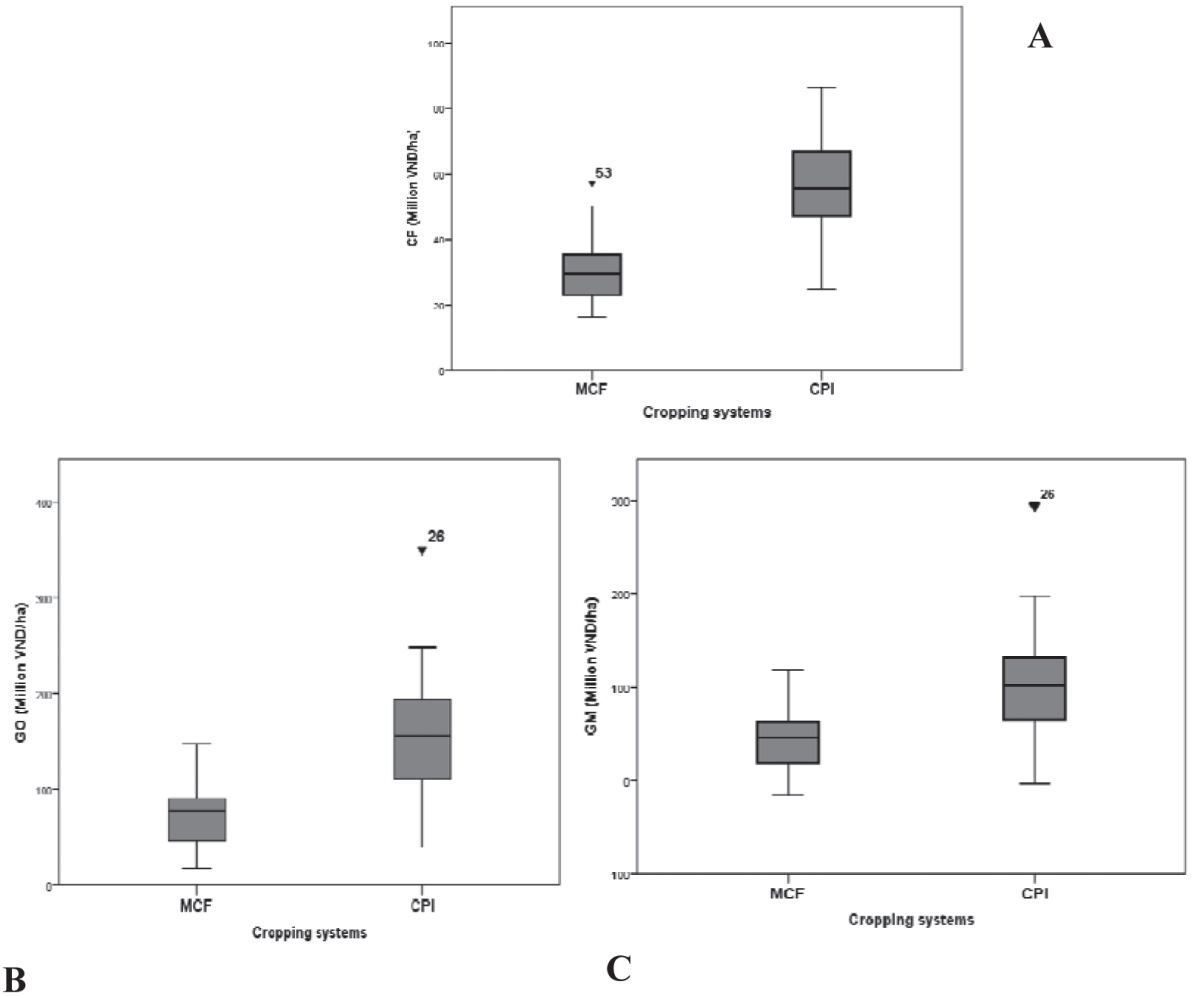

Fig. 4. Boxplot of (A) cost of production (CP), (B) gross output (GO), and (C) gross margin (GM) between MCF and CPI. The upper and lower borders of the boxes represent the 3rd and 1st quartiles, respectively. The line within the box represents the median value. Bars extend to the minimum and maximum values. Black triangles are the outliers Source: Surveyed data (2019)

or agricultural insurance could be managed by the Vietnamese government to deposit it.

CPI had more economic contribution than MCF concerning gross output (GO) and gross margin (GM) to farmers (Table 3 and Fig. 6 B, C). For instance, the GM of CPI had VND 102 million while MCF only had VND 43.4 million per ha. It will be offered to households having long-term credit. Additionally, previous studies supported that agroforestry creates more benefits than monocultures (Pham *et al.,* 2018; Niether *et al.,* 2020; Byrareddy *et al.,* 2021; D'haeze, 2020). Thus, coffee agroforestry should be encouraged. In addition, it also suggested that farmers should be provided with market information, technical training, and management knowledge.

Land productivity for coffee cultivation

The land equity ratio (LER) of CPI was more significant than one, indicating that the CPI system was superior to the coffee monoculture. In the CPI model, the highest value of LER is 1.88 implies the area of MCF must increase by 88% to have an equivalent output of the CPI model (Table 4). Thus, CPI is a suitable option for farmers of limited land.

Table 4. Representative data for LER cultivation

Using constant crop yield for pepper in the pepper monoculture is 2.3 T ha^{-1} (Thuy *et al.*, 2019 a)

	Yield in CPI (Y_p)	Yield in MCF (Y_m)	LER (Y_{pi}/Y_{mi})	Total LER for CPIΣ (Y_{pi}/Y_{mi})
Coffee	2.3	2.1	1.10	1.88
Pepper	1.8	-	0.78	

Source: Surveyed data (2019)

Conclusion

The study highlights the transition of small-scaled coffee farming systems during spatial-temporal scale and new pathways for coffee production. Coffee systems have been well adapted and transformed from monocultures to others, where coffee and pepper intercropping systems (CPI) have recently become typical in the research site. Moreover, this study compared the economic contribution between MCF and CPI. In detail, CPI creates higher productivity, LER, and GM than MCF. In other words, CPI seems like a high-input-high-output system, and farmers have been incentivised to gradually transit to CPI in recent years. However, some constraints, such as knowledge and loan constricting CPI expansion, should be considered. Therefore, farmers need to be supported by local authorities and institutions so that CPI can be an agroecological pathway for a coffee farming system in the province.

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References

Amarasinghe, U.A., Hoanh, C.T., D'haeze, D. and Hung, T.Q. 2015. Toward sustainable coffee production in Vietnam: More coffee with less water. *Agricultural Systems* **136:** 96-105.

Barral, S., Touzard, I., Ferraton, N., Rasse-Mercat, E., and Pillot, D. 2012. *Assessing smallholder farming. Diagnostic analysis of family-based agricultural systems in a small region*. SEARCA, Philippines, 159 pp.

Byrareddy, V., Kouadio, L., Mushtaq, S., Kath, J. and Stone, R. 2021. Coping with drought: Lessons learned from robusta coffee growers in Vietnam. *Climate Services* **22:**100229.

CCAFS SEA. 2016. Assessment Report: The drought crisis in the Central Highlands of Vietnam. Hanoi. Available at: https://cgspace.cgiar.org/handle/10568/75635.

Cheesman, J., Son, T.V.H., Thuy, T.D., Vu, V.D.H. and Bennett, J. 2007a. Managing ground water access in the Central Highlands (Tay Nguyen), Viet Nam. https://crawford.anu.edu.au/pdf/staff/jeff_bennett/vietnam/RR7IntegratedWaterModelling.pdf

Cheesman, J., Son, T.V.H. and Bennett, J. 2007b. Valuing irrigation water for coffee production in DakLak, Viet Nam: A marginal productivity analysis. *Crawford School of Economics and Government, The Australian National University, Canberra, Australia***(6)**.

Chi, T. T. Q. and D'haeze, D. 2005. Assessment of water, fertiliser and pesticide use for coffee production in Dak Lak Province, *Institute for Policy and Strategy for Agriculture and Rural Development, Working Paper. Ha Noi: Ministry of Agriculture and Rural Development, Institute of Policy and Strategy for Agriculture and Rural Development, Centre for Agricultural Policy*.

Dak Lak Provincial People's Committee. 2019a. *Sustainable development of coffee in Dak Lak to 2020 and 2030*. Dak Lak province.

Dak Lak Provincial People's Committee. 2019b. *Focus on developing specialty coffee areas in the 2018-2019 coffee crop*. https://daklak.gov.vn/web/english/-/focus-on-developing-specialty-coffee-areas-in-the-2018-2019-coffee-crop.

D'haeze, D., Deckers, J., Raes, D., Phong, T.A. and Loi, H.V. 2005a. Environmental and socio-economic impacts of institutional reforms on the agricultural sector of Vietnam: Land suitability assessment for Robusta coffee in the Dak Gan region. *Agriculture, Ecosystems and Environment* **105**(1-2): 59-76.

D'haeze, D., Raes, D., Deckers, J., Phong, T.A. and Loi, H.V. 2005b. Groundwater extraction for irrigation of *Coffea canephora* in EaTul watershed, Vietnam - a risk evaluation. *Agricultural Water Management* **73(**1): 1-19.

D'haeze, D.A. (2020). *Transforming coffee and water use in the Central Highlands of Vietnam: case study from DakLak Province*. Hanoi, Viet Nam: IUCN Viet Nam Country Office, 34 pp.

Diepart, J. C., and Allaverdian, C. 2018. Farming Systems Analysis: *A guidebook for researchers and development practitioners in Myanmar*. GRET-Yezin Agricultural University. 86 pp.

DSO. 1986. *Dak Lak Socio-economic Statistical Data Source, 1975-1985 (Dak Lak Provincial Statistical Office, 1975-1985)*. Dak Lak.

DSO. 2001. *Dak Lak Socio-economic Statistical Data Source (Dak Lak Provincial Statistical Office)*. Dak Lak.

Doutriaux, S., Geisler, C. and Shively, G. 2008. Competing for coffee space: development induced displacement in the Central Highlands of Vietnam. *Rural Sociology* **73(4)**: 528-554.

Duong, D. V. 2016. *Achivements and orientation for development of Dak Lak provincial economics during periods*. Science and Society Publishing House. Vietnam, 250 pp.

FAO. 2016. Agricultural cost of production statistics guidelines for data collection , compilation and dissemination. https://www.fao.org/3/ca6411en/ca6411en.pdf.

FAO. 2018. Food security and nutrition in the world the state of building climate resilience for food security and nutrition. https://www.wfp.org/publications/2018-state-food-security-and-nutrition-world-sofi-report.

Grosjean, G., Monteils, F., Hamilton, S.D., Blaustein-Rejto, D., Gatto, M., Talsma, T., Bourgoin, C., Sebastian, L.S., Catacutan, D., Mulia, R. and Bui, Y. 2016. Increasing resilience to droughts in Viet Nam: The role of forests, agroforestry, and climate smart agriculture.*CCAFS-CIAT-UN-REDD Position Paper n. 1*. Hanoi, Vietnam.

Ha, DT and Shively, G. 2008. Coffee boom, coffee bust and smallholder response in Vietnam's central highlands. *Review of Development Economics* **12(2):** 312-326.

Ha, D.T., Phuoc, P.H.D., Nguyen, N.T., Du, L.V., Hung, P.T., Espaldon, V.O. and Magsino, A.O. 2001. Impacts of changes in policy and market conditions on land use, land management and livelihood among farmers in central highlands of Vietnam. *In: Sustaining Natural Resources Management in Southeast Asia. Los Banos, Philippines: SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA)*.

Ho, T. Q., Hoang, V. N., Wilson, C., and Nguyen, T. T. 2017. Which farming systems are efficient for Vietnamese coffee farmers? *Economic Analysis and Policy* **56:** 114-125.

Ho, T.Q., Hoang, V.N., Wilson, C. and Nguyen, T.T. 2018. Eco-efficiency analysis of sustainability-certified coffee production in Vietnam. *Journal of Cleaner Production* **183**: 251-260.

Ho, T. Q., Hoang, V.-N. and Wilson, C. 2021. Trade-off analysis of cost and nutrient efficiency of coffee farms in vietnam: A more generalised approach. *Journal of Environmental Management* **279**: 111601.

Hoang, M.H., Do, T.H., Van Noordwijk, M., Pham, T.T., Palm, M., To, X.P., Doan, D., Nguyen, T.X. and Hoang, T.V.A. 2010. An assessment of opportunities for reducing emissions from all land uses - Vietnam preparing for REDD. *Final National Report*, p. 85.

Hung Anh, N., Bokelmann, W., ThiThuan, N., Do Nga, T., and Van Minh, N. 2019. Smallholders' preferences for different contract farming models: Empirical evidence from sustainable certified coffee production in Vietnam *Sustainability* **11(**14**)**: 3799.

ICO. 2019. Country coffee profile: Vietnam. http://www.vicofa.org.vn/country-coffee-profile-vietnam-bid385.html.

Jezeer, R. E., Santos, M. J., Boot, R. G., Junginger, M., and Verweij, P. A. 2018. Effects of shade and input management on economic performance of small-scale Peruvian coffee systems. *Agricultural Systems* **162:** 179-190.

Lindskog, E., Dow, K., Axberg, G.N., Miller, F. and Hancock, A. 2005. *When rapid changes in environmental, social and economic conditions converge: challenges to sustainable livelihoods in DakLak, Vietnam*. Stockholm, Sweden: Stockholm Environment Institute (SEI), pp. 70.

Lin, B.B. 2010.The role of agroforestry in reducing water loss through soil evaporation and crop transpiration in coffee agroecosystems. *Agricultural and Forest Meteorology* **150(**4**)**: 510-518.

Lowder, S.K., Skoet, J. and Raney, T. 2016. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. *World Development* **87:** 16-29.

Mead, R. and Willey, R. 1980. The concept of a 'land equivalent ratio'and advantages in yields from intercropping. *Experimental Agriculture* **16(**3**):** 217-228.

Meyfroidt, P., Vu, T. P. and Hoang, V. A. 2013. Trajectories of deforestation, coffee expansion and displacement of shifting cultivation in the Central Highlands of Vietnam', *Global Environmental Change* **23(**5**)**: 1187-1198.

Minot, N. 1998. Competitiveness of Food Processing in Vietnam: A Study of the Rice, Coffee, Seafood and Fruit and Vegetables Subsectors', *Washington, DC: International Food Policy Research Institute*.

Minot, N. 2006. Income diversification and poverty in the Northern Uplands of Vietnam. *International Food Policy Research Institute.*

Niether, W., Jacobi, J., Blaser, W. J., Andres, C., and Armengot, L. 2020. Cocoa agroforestry systems versus monocultures: a multi-dimensional meta-analysis. *Environmental Research Letters* **15**(10): 104085.

Pham, Y., Reardon-Smith, K., Mushtaq, S. and Deo, R.C. 2020. Feedback modelling of the impacts of drought: A case study in coffee production systems in Viet Nam. *Climate Risk Management* **30:** 100255.

Pham, V.T., Mulia, R. and Dinh, H.T. 2018. Potential mitigation contribution from coffee agroforestry in three regions of Viet Nam. Project report. Ha Noi, Viet Nam: World Agroforestry Centre (ICRAF).

Phan, T.T., Bui, T.T.T., Ho, T.M.H., Le, D.N. and Lebailly, P. 2022. Perennial cropping system development and

economic performance of perennial cropping system in DakLak Province, Vietnam. In: *Global Changes and Sustainable Development in Asian Emerging Market Economies Vol. 2*. Springer, Cham, pp. 189-205.

Phuc, T. X. and Nghi, T. H. 2014. Rubber expansion and forest protection in Vietnam, Tropenbos International Viet Nam. https://www.forest-trends.org/wp-content/uploads/imported/rubber-expansion-and-forest-protection-in-viet-nam_final-pdf.pdf.

Pico-Mendoza, J., Pinoargote, M., Carrasco, B., and Limongi Andrade, R. 2020. Ecosystem services in certified and non-certified coffee agroforestry systems in Costa Rica. *Agroecology and Sustainable Food Systems* **44(7)**: 902-918.

Priess, J. A., Mimler, M., Klein, A. M., Schwarze, S., Tscharntke, T., and Steffan-Dewenter, I. 2007. Linking deforestation scenarios to pollination services and economic returns in coffee agroforestry systems. *Ecological Applications* **17(2)**: 407-417.

Ricciardi, V., Mehrabi, Z., Wittman, H., James, D. and Ramankutty, N. 2021. Higher yields and more biodiversity on smaller farms. *Nature Sustainability* **4(7)**:1-7.

Scherr, S.J., Mankad, K., Jaffee, S. and Negra, C. 2015. *Steps toward green: policy responses to the environmental footprint of commodity agriculture in East and Southeast Asia*. Eco-Agriculture Partners.

Thuy, N. D. 2016. *Migration of ethnic minority people to Central Highlands from 1975 to 2015*. Science and Society Publishing House. Vietnam, pp. 235.

Thuy, P.T., Niem, L.D., Ho, T.M.H., Burny, P. and Lebailly, P. 2019a. Economic analysis of perennial crop systems in DakLak Province, Vietnam. *Sustainability* **11(1)**: 81.

Thuy, P., Niem, L., Ho, T., Burny, P. and Lebailly, P., 2019b. Which perennial crop farm approach generates more profitability? A case study in Dak Lak province, Vietnam. *Asian Social Science* **15(9)**: 1911-2017.

Utomo, B., Prawoto, A.A., Bonnet, S., Bangviwat, A. and Gheewala, S.H. 2016. Environmental performance of cocoa production from monoculture and agroforestry systems in Indonesia. *Journal of Cleaner Production* **134**: 583-591.

World Bank. 2017. *Toward Integrated Disaster Risk Management in Vietnam: Recommendations Based on the Drought and Saltwater Intrusion Crisis and the Case for Investing in Longer-Term Resilience*. World Bank.