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Impact of the coronavirus pandemic on financial returns of smallholder coffee plantations in Lao PDR

Somvang Phimmavong · Tek Narayan Maraseni · Rodney J. Keenan · Chanhsamone Phongoudome · Boonthavy Douangphosy

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Abstract Laos is among the top twenty coffee producing country in the world—producing about 39,000 tonnes per year—and most of its production is currently exported to over 26 countries, contributing about 1.1% of the total export value or US$64.3 million in 2019 to Laos' national economy. COVID-19 restrictions on trade and movement of people have largely impacted on coffee markets and production. As a strategic crop in Laos, it is supported by a range of policies and programs to generate greater benefits to both independent smallholder farmers and those involved in cooperatives, including support for agroforestry production models involving coffee and tree crops. However, studies of the profitability of different coffee agroforestry models are limited. This study compares financial returns from four most popular coffee agroforestry models in two coffee production provinces of Laos, before and during COVID-19 pandemic. The data were gathered from 20 farmers, five coffee traders and an integrated coffee processing company. These data were then triangulated with, and supplemented by, interviews with coffee exporters ($n=3$) and key informants ($n=4$). Financial indicators suggest that all four agroforestry models were profitable before COVID, but profits for cooperative growers were higher than for smallholders due to higher crop productivity and lower costs. Despite higher prices due to COVID restrictions, other factors reduced profitability of all four models and one smallholder model became unprofitable. The reasons for such differences and related policy implications are discussed.

Keywords Coffee plantations · Growers · Traders · Coffee processing industry · Profit · Lao PDR

S. Phimmavong (✉) · C. Phongoudome
Ministry of Agriculture and Forestry, P.O. Box 6238, That Dam Road, Vientiane, Lao PDR
e-mail: somvang2003@yahoo.com

S. Phimmavong · B. Douangphosy
Faculty of Forest Science, National University of Lao PDR (NUOL), P.O. Box: 7322, Vientiane, Laos

T. N. Maraseni
University of Southern Queensland (UniSQ), Toowoomba, Queensland 4350, Australia

R. J. Keenan
University of Melbourne, Victoria 3010, Australia

Introduction

Laos PDR is a small landlocked country in the Mekong River basin. Most of the country is mountainous and forested and the population of 7.5 million is still largely subsistence-based rural dwellers growing upland and paddy rice and vegetables and grazing animals for subsistence. Cassava, sugar cane, vegetables, bananas, maize and watermelons are produced for developing markets. Coffee was introduced in Laos about a century ago, initially on a small scale,

by French colonialists by the Commerciale du Laos, founded in 1922 (Stuart-Fox 1995) cited in (Gunn 1990). In 1935, about 30,000 tonnes of coffee were exported to Vietnam from Laos. Since the early 90 s coffee has become more important and is now a strategic crop in Laos and is currently the country's third highest agricultural export (ITC 2021). The main driver of growth has been rising demand from coffee-consuming countries namely Vietnam, Thailand, Belgium, Cambodia and Japan (MOF 2020). Laos is now among the top twenty coffee producing country in the world, with most of its production is exported to over 26 countries, contributing about 1.1% of the total export value or US$64.3 million in 2019 to Laos' national economy. According to the recent figure from the International Coffee Organization,[1] in 2019, Laos was the world's 20th largest coffee exporter by volume with exports of 37,310 metric tonnes- far behind Brazil (3.5 million metric tonnes) and Vietnam (1.8 million metric tonnes).

Coffee export contributed almost US$97 million in Laos' national economy in 2018, accounting for 1.7% of the total export value (ITC 2021), with coffee exported to over 60 countries since 2013. Vietnam and Thailand are the major markets for green coffee representing about 70% of the total export value in Laos in 2019. In the year 2019/2020, Vietnam and Thailand remained the top importers of Lao green coffee with Belgium, Cambodia, and Japan, completing the list of the top five consumer countries.

Laos now has approximately 90,000 ha of coffee plantations, largely owned by smallholders. Coffee provides livelihood for up to 25,000 households (ITC 2021) and generates income for all economic agents in the coffee value chain. Coffee is mainly grown on the Bolaven plateau in southern Laos between the Annamite Mountain Range and the Mekong River, at an elevation from 1,000 to 1,300 masl (Michael 2018). This region is regarded as the best place for coffee growing in Laos because of a suitable climate, steady rainfall, and rich volcanic soil (Allen 2017). In this region, coffee is planted with other crops and trees in a complex form of agroforestry system.

[1] Historical Data on the Global Coffee Trade available at International Coffee Organization https://www.ico.org/new_historical.asp?section=Statistics (accessed on December 08th 2022).

Though Laos remains a small producer in the global context, there is a high potential for expansion on the coffee production in Laos due to the following reasons: suitable climate and soil for growing coffee; the establishment of infrastructure such as the railway, and ASEAN highway linking Laos to Thailand, China, and Vietnam; an improvement in the business and investment environment; and historical account of accessing European and other international coffee markets.

In the early 2020, the world experienced a serious outbreak of the novel SARS-CoV-2 virus (COVID-19). Governments around the world have imposed various COVID-19 mitigation measures: home confinement, travel restriction, business closure, trade restriction, border closure and many others (Laudari et al. 2021; Maraseni et al. 2022). The COVID-19 pandemic restrictions have had some of the worst negative impacts on societies and economies since World War II (World Bank 2021).

The containment measures of the COVID-19 pandemic also affected the global coffee industry on which more than 25 million farmers and downstream value chain actors across the world depend for their livelihood (ICO 2020). In Laos, there has been no exception, with all economic sectors, including the coffee sector, severely affected (Dixon et al. 2021). Due to lockdowns, traders and contractors did not operate as they could not transport the coffee, disrupting the entire coffee value chain. The coffee industry also faced a rapid increase in expenditures on coffee plantation establishment and management due to the COVID-19 pandemic, affecting their profitability and competitiveness in the longer term (ITC 2021).

Coffee and annual crops are often incorporated under shade trees, which play a key role in controlling diseases, increasing economic outcome, and providing ecosystem services (Cerda et al. 2020). However, there has been limited economic analysis of the coffee agroforestry system in Laos. Most economic analysis of agroforestry in Laos has focused on commercial timber trees and rice or other crops (Maraseni et al. 2018; Phimmavong 2004; Phimmavong et al. 2020; Phimmavong et al. 2019; Phimmavong et al. 2022; A. van der Meer Simo et al. 2020a, b), with these studies revealing that integrated agroforestry systems could bring greater economic benefits to plantation owners and smallholder growers than crops alone. For example, van der Meer Simo et al., (2020a, b) found

smallholder farmers growing 'Yang bong' (*Persea kurzii*) plantation integrated with rice and banana in Sepone District, Central Laos could obtain more net income (averaging $2652 per household) than from traditional swidden cultivation. The effect of COVID-19 pandemic on agricultural crop including Yang bong' (Persea kurzii) is also high as a result of input costs, a rising price of transport of agricultural inputs and outputs (World Bank 2021, 2022).

With the majority of the Lao population living rurally, policy to promote outgrower schemes, community cooperation arrangements, and public private partnership schemes (Phimmavong et al. 2019; A. van der Meer Simo et al. 2020a, b) and agroforestry systems at different spatial and temporal scales can provide significant benefits for rural people and local industry development (Phimmavong and Keenan 2020; Phimmavong et al. 2020).

This study aimed to investigate coffee agroforestry systems in Laos, and how they have been impacted by restrictions due to COVID 19 pandemic using case studies of coffee agroforestry models in two coffee production provinces of Laos. Two different smallholders' plantation models and two cooperative plantations were investigated. The study compared financial returns from coffee growing before and after the initial constraints of the COVID-19 pandemic and assess the financial impacts of COVID-19 on these growers. Research findings have implications for policy, planning and investment strategies for coffee growing during times of supply chain disruption.

Methodology

Study area and agroforestry plantation model

The main coffee plantation sites in Laos are on the Bolaven Plateau, in two Provinces: Champasak and Xekong Province where over 70% of coffee is produced (Fig. 1). Champasak and Xekong province together accounted for 91% of total production in the county in 2018. In Champasak province, the two main districts on the Plateau are Paxong and Bachieng, while Thateng is the main coffee-growing District in Xekong Province. These two districts are known as a coffee grower's 'utopia' in Laos. The Bolaven Plateau is located at longitude 105°00′E–107°00′E and latitude 14°00′N–16°00′N locating in four provinces of Laos namely Champasak, Saravan, Xekong, and Attapeu provinces. The climate of these regions is dominated by "Monsoon-influenced humid subtropical climate with pronounced wet and dry season (Kottek, 2006), with an average annual temperature of 20–30 °C and annual rainfall of 1250–3750 mm. The Plateau's landscape is moderately mountainous with steep valleys, schists, and Triassic Cretaceous clastic sedimentary strata. The forming of the plateau was influenced by the spill over and a powerful volcanic eruption during the Late Pleistocene and the Early Pleistocene period (Ouyang et al. 2019). These created a very favourable to the formation of fertile volcanic soil together with the favourable climatic conditions and drainage conditions in the area which enrich coffee cultivation in this plateau.

On the Plateau, two main coffee varieties are grown: Arabica coffee (*Coffea arabica*) and Robusta coffee (*Coffea canephora*). The Robusta and Arabica coffee plantation areas respectively account for over 60% and 30% area of total coffee plantation in Laos (ITC 2021). The common high-yielding Arabica variety currently planted by small and medium private companies are Catimor dwarf-variety, Typica, and Arabica Java Specialty. All coffee plantation models in the current study are Arabica coffee.

Coffee harvesting generally commences in year 3, but the initial yield is low with the productivity from 1.5 and 4 tonnes of cherries ha^{-1}. It gradually increases and peaks at between years 9 and 14. During the mature period, the average yield can be up to 16 tonnes ha^{-1} of cherries. The coffee production cycle is about 22 to 25 years. Farmers replace coffee trees as yield becomes lower and annual income is lower than annual cost. As soon as the cherries are harvested, they are transported to a processing facility. Local traders or middlemen arrange the purchase of coffee cherry from growers and sell it to processing and exporting companies.

Most coffee plantation models in these districts adopt an organic production system integrating trees in an agroforestry model. Organic coffee refers to that planted under an integrated agroforestry systems with varying input–output mixes of annual crop and coffee under the shade-tree. It involves minimal use of agrochemicals to conserve the ecosystem and reduce input costs. In many cases, for instance Outspan (Olam) and Jhai Coffee Farmer Cooperative growers are producing and selling certified organic and sustainable

Fig. 1 Map showing key topographic and administrative characteristics of coffee producing area "Bolaven Plateau" Source: Toro (2012)

coffee under the Fair Trade label which guarantee minimum, and often premium, prices for growers (Saysana 2011). In this study we collected data on coffee agroforestry systems established by 20 coffee farmers in four different villages in two districts of Champasak and Xekong Province in the Bolaven Plateau. These twenty plantations were grouped by plantation model and location (Table 1).

Integrating trees with coffee plants can restore ecosystem services, provide shade, improve the resilience of coffee systems, and increase economic performance (Jezeer et al. 2018; Pinoargote et al. 2017). The most common shade trees used in Laos are *Erythrina subumbrans* (Ton Thong, a local name), a leguminous fodder tree. Erythrina are common trees occurring in both the tropical and warm temperate regions (Kongmanila et al. 2013) and are typically utilized for either house and garden fencing or shade trees (Kongmanila et al. 2012). In this analysis, it was assumed growers do not receive financial returns from harvesting trees but some growers report that leaves from Ton Thong have large amounts of potential protein and are good source for cattle fodder and trees also provide fuelwood. These can increase overall potential financial returns for coffee agroforestry production in Laos. However, in this analysis, this benefit is not included.

The spacing for coffee is either 1.8 × 1.8 m or 1.5 × 1.5 m (at Site 1) and Ton Thong trees are planted on a 5 × 5 m spacing, giving initial tree stockings of 400 stems/ha, and 3086 or 4444 stems/ha for coffee. In S2 and S3, villagers also grow cabbage

Table 1 Characteristics of coffee agroforestry in the four locations

Criteria	Site1 (S1)	Site2 (S2)	Site3 (S3)	Site4 (S4)
Village	Kongtayoun	Lakkhao	PhouOy	PhouOy
District	Xekong	Xekong	Pakxong	Pakxong
Number of farmers	5	5	5	5
Rotation age	22	22	25	25
Management plan	Low maintenance	High maintenance	High maintenance	Low maintenance
Mode and type	Smallholders; organic	cooperative farming; organic	cooperative farming; organic	smallholders; organic
Coffee variety	*Coffea arabica*	*Coffea arabica*	*Coffea arabica*	*Coffea arabica*
Shaded tree species	*Erythrina subumbrans*	*Erythrina subumbrans*	*Erythrina subumbrans*	*Erythrina subumbrans*
Crop species	NA	Cabbage in year 1	Cabbage in year 1	NA
Spacing	1.5 m × 1.5 m (coffee); 5 m x 5 m (*Erythrina*)	1.8 m × 1.8 m (coffee); 5 m x 5 m (*Erythrina*)	1.8 m × 1.8 m (coffee); 5 m x 5 m (*Erythrina*)	1.8 m × 1.8 m (coffee); 5 m x 5 m (*Erythrina*)

between the shaded trees and coffee plants. This usually only occurs for the first year of the 22–25-year coffee rotation.

Data collection

We used purposive sampling to pick the four dominant coffee plantation villages from two districts of two provinces of Laos. Household surveys were conducted in two different growing and marketing types. The first type was independent smallholders adopting coffee agroforestry system (S1 &S4). The second was a coffee farmers' Cooperative, which is owned and managed by farmers (S2&S3).

We conducted household surveys in 2018 and in 2021. The 2018 data were used as a baseline with the same households surveyed to determine the impact of COVID-19 restrictions on different activities. We used a semi-structured questionnaire to collect data on costs of plantation establishment, management, and other inputs. Interviews were carried out by a team of researchers from the Faculty of Forest Science, National University of Lao PDR with the help of the local staff of Provincial Agriculture and Forestry Office. We made several visits to coffee plantation sites to confirm information given in the interview notes and compared these with documents from Provincial Office for Commerce and Industry. These data were further triangulated and supplemented with the interview of coffee experts ($n=3$) and key informants ($n=4$). All costs were recorded in Lao Kip and converted to US dollars (give exchange rate) to enable comparison with other studies.

We employed discounted cash flow analyses and capital budgeting criteria to compare financial returns from four most popular coffee agroforestry models in two coffee production provinces of Laos, before and during COVID-19 pandemic, including net present value (NPV), annual equivalent value (AEV), land expectation value (LEV), and internal rate of return (IRR).

NPV, LEV, AEV and IRR were chosen for this study, as they have been widely used to evaluate agriculture and forestry investments, including in Lao PDR. The methods for the financial analysis are comprehensively elaborated elsewhere (Cubbage et al. 2022; Duerr 1993; Gregory 1987; Klemperer 1996; Maraseni et al. 2018; Phimmavong 2004; Phimmavong et al. 2019).

Results

Production and costs

The productivity of Arabica coffee varies between different villages and production systems (Fig. 2). The estimated average yield of green arabica coffee cherries was higher for those in cooperatives, with yields in Thateng District (S2) and in Pakxong District (S3) approximately 9.1 and 9.4 tonnes ha-1 year-1 respectively, than smallholder counterparts (S1 & S4)—4.7 and 5.4 tonnes ha-1 year-1) respectively. Differences

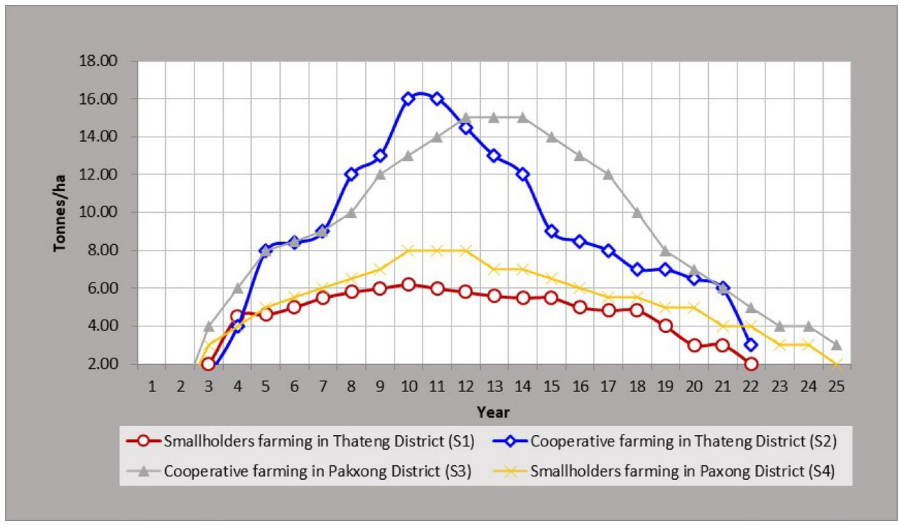

Fig. 2 Productivity of all coffee agroforestry systems in the study area

in productivity are due to different practices used by cooperative growers, including higher-quality germplasm, improved silviculture and plantation management, more fertiliser application, integration of shade trees, and ages of coffee plants (Saysana 2011). Other factors influencing productivity include farmer access to support and training that enhances their knowledge regarding organic production, processing and marketing of coffee (ITC 2021). Therefore, increasing smallholder access to the best germplasm and silvicultural knowledge are crucial in improving their productivity. With proper investments, their coffee can be more profitable and offer a pathway out of rural poverty.

Prices, costs and net income from coffee production varies between the four sites and over time (Table 2). The revenue from coffee depends on cherries prices and the coffee productivity. Price of cherries at the farm gate was between 1500 and 3300 Kip per kg and varied with market demand. Before COVID-19, the reported prices of cherries were between LAK1,700–1,800 (US$0.18–0.19) per kilogram during the 1st and 3rd rounds of picking and increased to approximately LAK2,750 (US$0.29) per kilogram at the peak season during 2018–2019. During the COVID-19 virus outbreak prices increased and the cherries sold to traders for LAK3, 100–3,300 (US$0.32–0.35) per kilogram.

The greatest cost component in all four models was day labour employed in almost all plantation activities throughout the rotation (Table 3): manual land preparation, fencing, planting, labour for weeding, fertilizing, harvesting, thinning, pruning and picking. Labour costs includes family labour. The wage rate was relatively stable at 50,000 Kip per day from 2005 until 2019. The minimum wage in the Bolaven Plateau is higher, 60,000 Kip per day. Wages for picking coffee cherries are on a per kg rate and varied from 600 to 1000 Kip per kg. All land clearing for new coffee planting was done manually by local villagers and varies between smallholders and cooperative farming at a cost of about US$96–322 ha^{-1}.

Other costs included annual land tax (about $US4 ha^{-1}) and fuel, spraying, watering, monitor fees, and general farming operation overheads. These costs varied amongst the four site and decrease with larger areas of plantations.

Coffee growers in the study area do not use the same coffee management regime. Some growers often adopt less productive farming practices due to their being familiar with these methods and to reduce costs, while other growers lack of knowledge and skill of pruning and tree management techniques. Pruning is used in various coffee sites to revitalize coffee trees and maximize yield and bean flavour. Cooperative growers invest more by installing irrigation and electricity. Organic or non-organic fertiliser and foliar protection is applied more than twice a year by smallholders and cooperatives. Those in S1, S2, S3 use a single application of NPK in Year 1 with eight 50 kg bags NPK fertilisers per ha. For years 2 and 3, about 125 twenty-kg bags of coffee waste (10,000 Kip each bag) were used per hectare of coffee plantation. Micronutrients ("Flower nutrient spraying", Zn, B, Fe, Mg, Mo, Cl) are applied in Years 1,

Table 2 Comparison of costs and revenue over a 22 and 25-year rotation for four coffee agroforestry models before the COVID-19 virus outbreak, Lao PDR (US$ ha^{-1}). Selling prices originally in Lao KIP (exchange rate 9,327 per USD). Source: Field survey, 2018, 2021

	Activities	Smallholders in Thateng district (S1)		Cooperatives in Thateng district (S2)		Cooperatives in Pakxong district (S3)		Smallholders in Paxong district (S4)	
		Costs	Revenue	Costs	Revenue	Costs	Revenue	Costs	Revenue
Year 1 (Coffee)	Land preparation	174		96		322		116	
	Fencing cost	161		193		193		129	
	Digging and planting & replanting in the end of year	381		264		265		265	
	Cleaning the burned waste	39		45		35		39	
	Lining & basic equipments/ tool	27		27		38		38	
	Seedlings and seedlings transportation costs	313		315		229		296	
	Fertilizers + transportation	356		343		348		134	
	Weeding	129		309		232		154	
	Flower nutrient Spraying	32							
	Irrigation (groundwater pumping)			322		322			
Year 1 (Tree tonthong)	Digging & lining	19		16		32		32	
	Cutting from nearby forests + transportation cost	10		6		6		6	
	Planting	8		6		6		6	
	Cubbage production			96	1072	109	268		
	Cabbage seeds			16		16			
Year 2	Weeding	96		412		412		257	
	Fertilizers from coffee seeds waste	118		32		166		161	
	Flower nutrient Spraying	23		17		23		23	
Year 3	Weeding	96		309		347		232	
	Harvest and sales of coffee	129	386	96	257	257	686	193	515
	Fertilizers from coffee seeds waste	96		32		139		118	
	Flower nutrient Spraying	29		24		23			
Year 4	Weeding	309		309		193		193	
	Harvest and sales of coffee	289	965	257	858	386	1287	257	858
Year 5	Weeding	206		343		322		241	
	Harvest and sales of coffee	395	986	858	3431	686	3431	429	2144
Year 6	Weeding	343		343		322		241	
	Harvest	429	1072	901	3602	729	3645	472	2359
Year 7	Weeding	343		343		322		241	
	Harvest and sales of coffee	472	1179	965	3860	772	3860	515	2573
Year 8	Weeding	343		343		161		161	
	Harvest and sales of coffee	497	1244	1287	5146	858	4289	558	2788
Year 9	Weeding	343		343		161		161	
	Harvest and sales of coffee	515	1608	1394	5575	1029	5146	600	3002
Year 10	Weeding	343		343		161		161	

Table 2 (continued)

	Activities	Smallholders in Thateng district (S1)		Cooperatives in Thateng district (S2)		Cooperatives in Pakxong district (S3)		Smallholders in Paxong district (S4)	
		Costs	Revenue	Costs	Revenue	Costs	Revenue	Costs	Revenue
	Harvest and sales of coffee	532	2194	836	3431	1115	2788	686	1715
Year 11	Weeding	80		80		161		161	
	Harvest and sales of coffee	515	2123	1029	3088	1201	7505	686	4289
Year 12	Weeding	343		343		161		161	
	Harvest and sales of coffee	497	2052	933	2954	1287	8041	686	4289
Year 13	Weeding	343		343		161		161	
	Harvest and sales of coffee	480	1981	836	2788	1287	3216	600	1501
Year 14	Weeding	343		343		150		150	
	Harvest and sales of coffee	472	1946	1029	2573	1287	3216	600	1501
Year 15	Weeding	343		343		161		161	
	Harvest and sales of coffee	472	1946	772	1930	1201	3002	558	1394
Year 16	Weeding	343		343		161		161	
	Harvest and sales of coffee	429	1769	911	1823	1115	2788	515	1287
Year 17	Weeding	343		150		161		161	
	Harvest and sales of coffee	415	1710	858	1715	1029	2573	472	1179
Year 18	Weeding	80		80		161		161	
	Harvest and sales of coffee	415	1710	751	1876	858	2680	472	1474
Year 19	Weeding	80		80		161		161	
	Harvest and sales of coffee	343	1415	751	1876	686	2144	429	1340
Year 20	Weeding	80		80		161		161	
	Harvest and sales of coffee	257	1061	697	1742	600	2477	429	1769
Year 21	Weeding	80		80		161		161	
	Harvest and sales of coffee	257	1061	643	1608	515	2123	343	1415
Year 22	Weeding	80		80		161		161	
	Harvest and sales of coffee	214	708	322	1061	429	1769	343	1415
	Cleaning and burinig/managing	804		804					
Year 23	Weeding					161		161	
	Harvest and sales of coffee					343	1415	257	1061
Year 24	Weeding					161		161	
	Harvest and sales of coffee					343	1415	257	1061
Year 25	Weeding					161		161	
	Harvest and sales of coffee					322	1061	214	708
	Cleaning and burning/managing					804		804	
Years 8–21 (S1,2), Year 11–24 (S3,4))	Thinning and pruning	48		48		48		48	
Years 1–22,25	Overhead cost	54		75		86		64	
Years 1–22,25	Land tax	4		4		4		4	
Total		17,542	29,117	26,855	52,268	25,214	63,043	16,082	35,976

The exchange rate used is derived from Banque Pour Le Commerce Exterieur Lao Public (BCEL) on 21st January, 2021: 1USD = 9327LAK.

Table 3 Comparison of prices of production costs for coffee plantations in Southern Laos before and during COVID-19 pandemics. Source: Field survey, 2021

	Before COVID-19	During COVID-19	% Change
Mechanical land preparation	3,000,000.0	3,500,000.0	14
Seedlings	800.0	1,000.0	20
Irrigation (groundwater pumping)	3,000,000.0	3,500,000.0	14
Digging and planting & replanting in the end of year	800.0	1,000.0	20
Lining & basic equipments/tool (average per ha)	300,000.0	350,000.0	14
Transportation costs	250,000	300,000.0	17
NPK fertilizers (NPK (50 kg/bag)	130,000	180,000.0	28
Animal dung (20 kg/bag)	12,000.0	15,000.0	20
Wage	50,000.0	60,000.0	17
Picking coffee cherries (Kip/Kg)	800.0	1,000.0	20

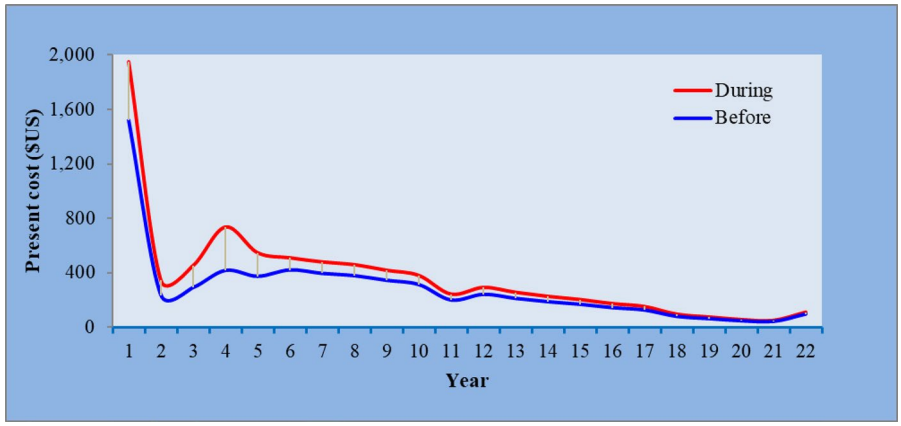

Fig. 3 Present costs of Site 1 before and during the COVID-19 in Laos

2, 3 in relatively small quantities. Typically, a mixture of Zinc and Boron at the rate of 2–3 kg of each/ha (40–60 g of each/20 l of water) will be required about a few months prior to the flowering season.

Impact of COVID-19 on production costs of coffee plantation establishment

COVID-19 restrictions impacted on all costs and prices of related goods and services between 2020 and 2021 (Table 3). The costs of mechanised land preparation rose by 14%, the cost of animal dung increased by 20%, NPK fertilisers by 28%, digging and planting & replanting by 20%, seedling by 20%, picking coffee cherries by 20%. Wage rate increased by 17%, as the government of Laos have a strong policy to encourage farming production during the lockdown while large influx of workers forced to Returned to rural areas due to factories closing in Thailand. Approximately 10 percent of workers laid off in manufacturing and service sector shifted to agriculture (World Bank 2021). As a result, supply of labour was not much a problem in regional Laos (Figs. 3, 4, 5, 6).

Increased international and national coffee prices during the COVID-19 pandemic restrictions resulted a positive impact for coffee owners but increased production costs impacted its long run profitability (Figs. 3, 4, 5, 6). The most significant difference before and during the COVID-19 years was in establishment costs of coffee plantations. Farmers establishing new areas of coffee plantations in Site 1 invested about US$ 1906/ha in 2019 but paid 50% (US$1048) more during the pandemic, because of cheaper labour cost in that time. Those farmers with long established plantations

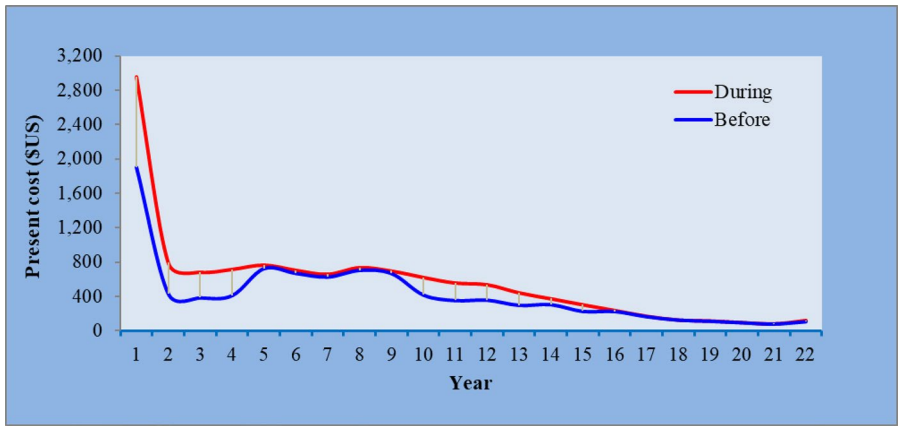

Fig. 4 Present costs of Site 2 before and during the COVID-19 in Laos

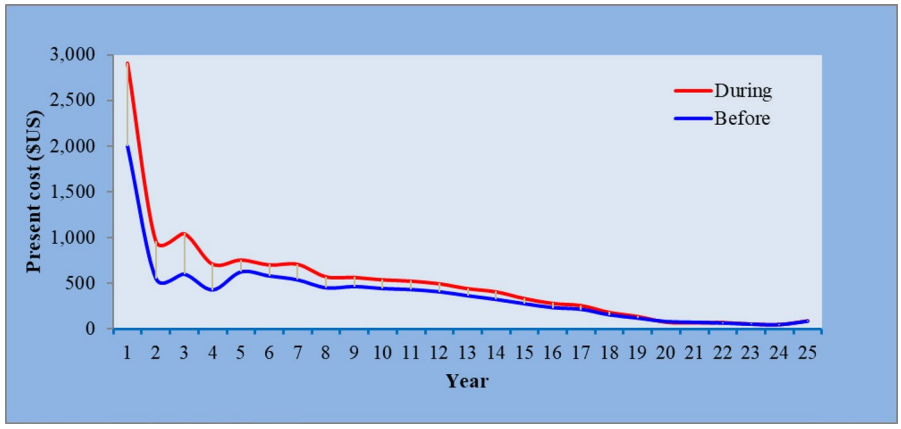

Fig. 5 Present costs of Site 3 before and during the COVID-19 in Laos

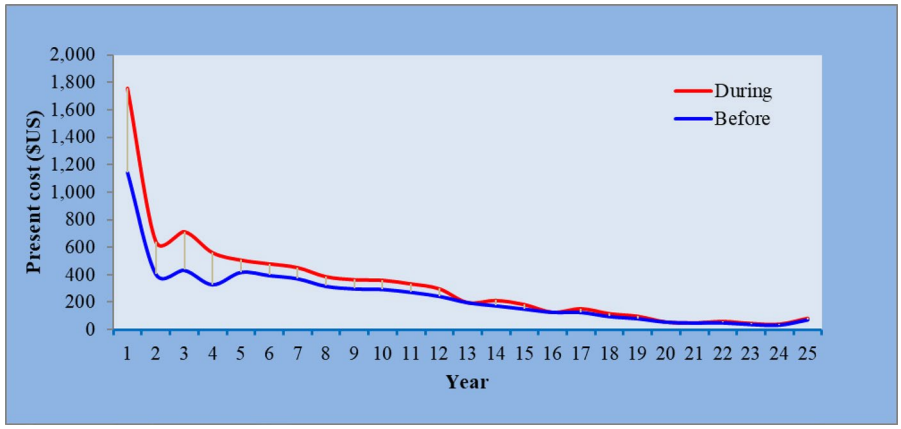

Fig. 6 Present costs of Site 4 before and during the COVID-19 in Laos

were able to employ labour for 30,000 Kip/person/day between 2000 and 2004. In 2019, the cost was 50,000 Kip/day and is increased to 60,000 Kip in 2020 and 2021. More labour is also required for weeding and tending during the initial phase of coffee production compared to later in the rotation, for example year 5 and 9 was required for farmers in Site 2.

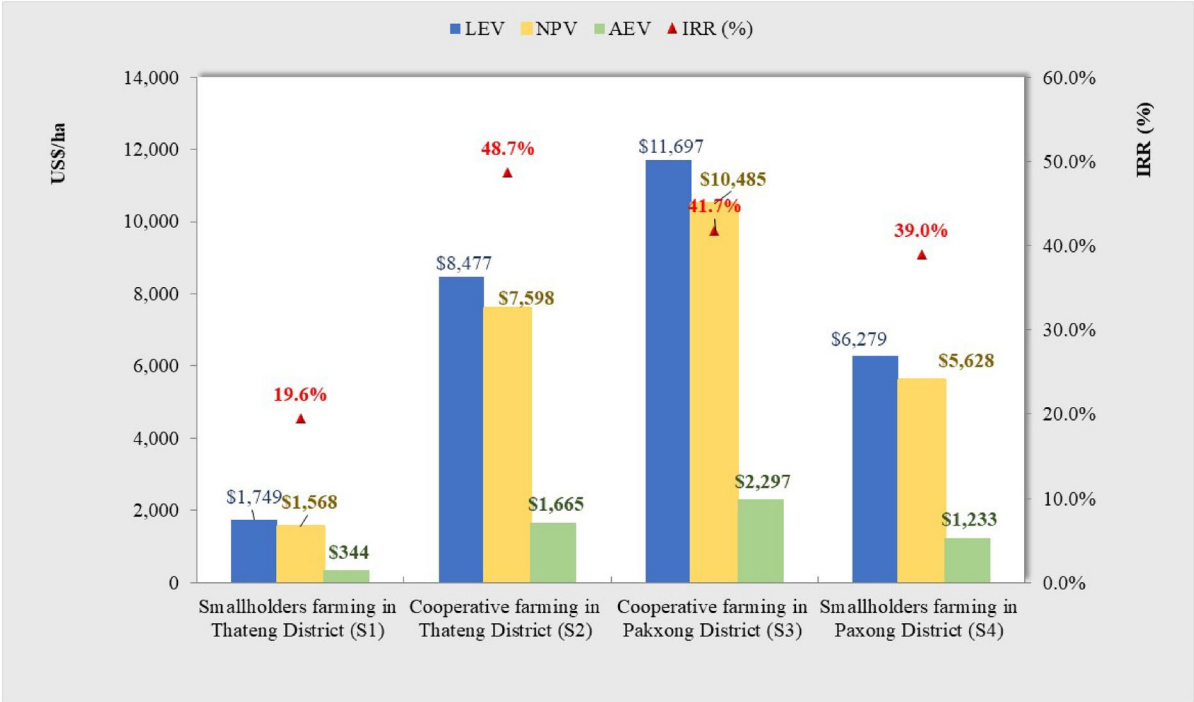

Fig. 7 LEV, NPV and IRRs for three models of Organic coffee plantations in Laos

Financial returns from four coffee agroforestry plantation models

Analysis indicated that all four coffee agroforestry models were profitable in 2018 using four financial indicators (LEV, NPV, AEV, and IRR; Fig. 7), with all models producing positive total NPVs using a discount rate of 12%. IRRs range from 19.6% for coffee smallholders farming (S1) to 49% for cooperative farming in Thateng (S2). Total LEV for cooperative farming in Thateng and Paxong District were much higher than their smallholder counterparts yielding \$8477 ha^{-1} and \$11,697 ha^{-1}, respectively. The net revenue for the cooperative model includes returns from the sale of cabbage of about US\$268 ha^{-1} in Paxong and US\$1,072 ha^{-1} in Thateng,[2] which accrues to the farmer in the first year. Therefore, crop integration plays a major role for the economic success of agroforestry systems in early years of plantation establishment.

[2] Cabbage in Thateng is much more vegetable productivity than that in Paxong.

Effects of COVID-19 restrictions on financial returns

Despite higher coffee prices and yield during the COVID years, increasing prices of labour and inputs due to COVID-19 restrictions increased the cost of establishment and harvesting, and therefore decreased plantation profitability in all coffee models (Fig. 8). LEV decreased by almost 41% for Site 2, by 33% in Site 3, and 37% for Site 4 while growers at Site 1 indicated negative profitability.

Discussion

Profitability

Coffee growing in all four models was profitable before the COVID-19 Pandemic. Cooperative farmers in Thateng and Pakxong districts had similar costs and were more profitable (NPV of US\$7598/ha in Thateng and US\$11,697 in Pakxong) than their smallholder counterparts. Returns from coffee farming in Thateng (S1) (NPV of US\$1568/ha) was lower due to much lower yields. As a result of the COVID-19

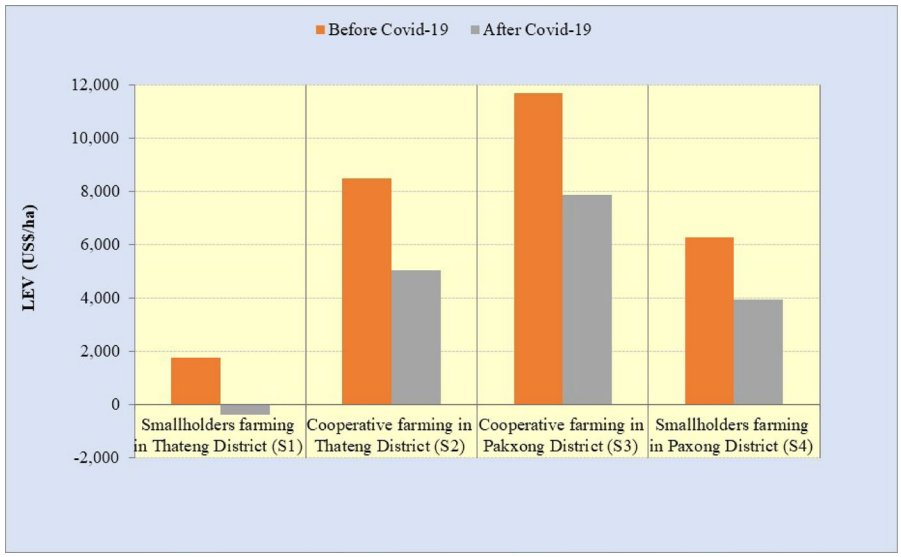

Fig. 8 Impact of COVID-19 on LEV of four coffee agroforestry systems in Southern Laos

restrictions, all coffee plantation models face rising labour and input costs causing a significant reduction in profitability of all plantation models, with smallholders at Site 1 become unprofitable.

There has been surprisingly little financial analysis of coffee agroforestry systems with which to compare this analysis (Goncalves et al. 2021; Mehta and Leuschner 1997). Mixed coffee-crop agroforestry systems are more complex than traditional a "pure-stand or unshaded coffee system, with varying input–output mixes of annual crop and coffee under the shade-tree system. In an analysis comparing effects of shade and input cost management on profitability of smallholder coffee system in the department of San Martin, Peru, (Jezeer et al. 2018) found that, there is no differences in profitability for all shade classes. But combining coffee and cocoa management systems will increase in input and management requirements and result in higher costs, affecting net income and profitability due to rising costs of labour, land, fertiliser, and other input costs.

On the other hand, a systematic review of coffee agroforestry systems mixed with cocoa compared with unshaded coffee plantation (Jezeer et al. 2017) based on 23 studies globally concluded that the agroforestry model is a better investment than monoculture coffee or unshaded coffee farm. Intercropping cocoa with coffee resulted in a 23% higher net income compared to monoculture coffee because of lower costs for management and higher price for their products in the agroforestry system. The agroforestry system also contributed to provide additional income from integrating crops, as also noted in this study. Coffee mixed with trees can reduce costs of tree removal and diversify plantation output, and may minimise risks, and thus lead to increased profitability compared to unshaded coffee plantation (Jezeer et al. 2017).

Over the past few decades, researchers around the world have conducted the research on the evaluation of trade-offs or synergies between the use of shade trees and agronomic investment to boost coffee productivity but consensus is lacking. While coffee production is higher with trees in some regions, especially in Asian countries, in other regions, particularly in Africa, it is lower. Haggar et al. (2021) explored how shade trees affected the productivity performance of coffee to intensification of agronomic management in key coffee growing regions of Costa Rica and Guatemala, covering a wide range of environmental conditions, characterizing different shade types and full sun management systems. It was concluded that agronomic investment, particularly application of N fertilization levels plays a key role in determining the productivity of coffee systems in these two countries but coffee systems with medium levels of shade were found to have the highest productivity, while a high level of shade reduces coffee yield. Consequently, growers

in some regions are reluctant to adopt coffee with shade trees in agroforestry systems.

Climate change and environmental benefits

Agroforestry systems incorporating trees and other crops have been shown to diversify the production and improve livelihoods for smallholder farmers (Dhakal et al. 2015, 2022; Montagnini & Nair 2004; Nátr 2007; Verchot et al. 2007). These systems also contribute to mitigating climate change because of sequestration of carbon in woody trees and soil and, at the local level, the ameliorating effects of trees in temperature (Montagnini and Nair 2004; Murgueitio et al. 2011; Verchot et al. 2007). A study of agroforestry systems by Nair et al. (2012) estimated aboveground carbon sequestration of 0.29 and 15.21 MgC/ha/yr.

Broader environmental impacts are also important. Currently, there are growing concerns about the intensification of coffee plantation management in response to growing global coffee demand. This may have serious consequences, triggering substantial biodiversity losses and the destruction of forest structure to replacing traditional coffee agroforestry system (shaded coffee) which are found to protect the environment and support ecosystem services such as soil improvement, pest control and wildlife habitat (Anil Kumar et al. 2019; Cannavo et al. 2011; Hundera et al. 2013; Moguel and Toledo 1999; Philpott et al. 2008; Souza et al. 2012). Furthermore, this system can create additional economic outcomes for coffee grower such as timber, fuelwood, construction materials, other crop products (Rice 2008; Vaast et al. 2015). A meta-analysis in sub-Saharan Africa found that agroforestry not only significantly maximizes crop productivity and soil improvement but also soil erosion leading to food security and environmental vulnerability (Kuyah et al. 2019).

Unsustainable coffee farming systems based on forest clearing, monocultures and poor fertility management and land utilization techniques can have serious negative impacts on ecosystems and environment (Schmitter et al. 2010) and generate considerable community concern. Rapid expansion of coffee plantations in southern Laos have encroached into natural forest areas sparking controversy amongst the members of the Lao National Assembly. Likewise, Vietnam is experiencing a sudden surge in the area and intensification of management of coffee plantations and negative impacts including deforestation and soil degradation, as well as decrease in the quality of coffee bean and the loss of services such as pollination and pest control (Nguyen and Sarker 2018). Consequently, some coffee growers in Vietnam's Central Highlands are moving to integrate shade trees to prevent soil degradation. If all the ecosystem services are considered, an agroforestry system could be much more attractive than either tree or crop monoculture-based system (Aryal et al. 2023; Holmes et al. 2017; Maraseni et al. 2022; Sharma et al. 2016). Moreover, agroforestry improves farmers' livelihoods, food security and contributes to land degradation mitigation and biodiversity conservation. Therefore, it helps to address many UN sustainable development goals (SDGs) such as eliminating poverty (#1), clean water and sanitation (#6), climate action (#13), and life on land (#15). Factoring in these broader goals environmental and ecosystem services benefits such as pollination, pest control, climate regulation, and nutrient sequestration will change the investment proposition for an agroforestry system (Jha et al. 2014) but mechanisms are needed to reward growers for these benefits, either through direct payments for ecosystem services or through coffee certification and pricing mechanisms.

Cooperatives

The analysis also revealed that growers involved in cooperatives are more profitable compared to their independent smallholder counterparts because technical support is offered to the farmer members in coffee production management activities such as silviculture, pest management, maintenance, processing and quality control. Also, cheap loans are available to farmers to improve coffee production and farmers are supported to access markets for high quality coffee with roasters, processing industries, and exporters. Cooperatives also support coffee processing stations, laboratories and roasting units. The value of cooperatives for smallholder development has been demonstrated in other agricultural production systems (Gelo et al. 2020) and the cooperative model in this study illustrates the importance of addressing the whole value chain of coffee production to improve returns to growers and make them more resilient to shocks such as the COVID-19 pandemic. However,

if not well managed, cooperatives may also reinforce uneven agrarian social relations and some community members may experience loss of access to land, poor wage labour conditions and impacts on food security (Montefrio and Dressler 2019).

Conclusion

This paper investigated the financial returns from four models of coffee agroforestry systems adopted by smallholders and cooperatives in Lao PDR, and the impact of COVID-19 restrictions on returns. Analysis revealed that farmers in cooperatives perform better financially than independent smallholder counterparts. Under prices and growth rates prior to the pandemic, coffee agroforestry in this region was highly profitable. The COVID-19 pandemic had impacts on the Lao coffee sector, especially on production, consumption and international trade. When increased costs and prices are considered, all coffee agroforestry systems were less profitable. LEV decreased by almost 41% for site 2, by 33% in site 3, and 37% for site 4 while some farmers with low yield are facing losses. Based on current costs and prices, integrating cabbage between the shaded trees and coffees brought additional economic benefits.

The Government of Lao PDR can mitigate the impact of COVID-19 on the coffee sector through supportive and appropriate measures, including increasing involvement of independent smallholder growers in cooperatives to increase their access to better germplasm and management techniques, facilitating trade and development of value chains, decrease the costs of trade, alleviate difficulties in supply chains, improve market access and reward provision of environmental services to stimulate investment in a sustainable coffee sector in Laos.

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