

The Roles of Perennial Crop Systems to Rural Households: A Case Study in Dak Lak Province, Central Highlands, Vietnam

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Abstract

This study investigated the role of perennial crop systems in enhancing sustainable livelihoods among rural households in Dak Lak province, Vietnam, with a particular focus on coffee and pepper crops. To gather data for this study, structured interviews were conducted with 86 households (90 farms) through a multi-stage sampling approach from January to May 2019. Moreover, the effectiveness of two agroforestry systems, monoculture and multitrophic agroforestry, was compared. The findings highlighted numerous significant conclusions. First, perennial crop systems contributed significantly to the improvement of rural households' livelihoods through improved monetary income, job creation, the participation of women, and expanded work prospects. Second, intercropping systems were the most economically viable sources of income and less susceptible to market price risk. This conclusions emphasize the importance of farmers and local governments understanding the roles of perennial crops to livelihoods.

Keywords

Agroforestry, multistrata agroforestry, livelihoods, Dak Lak province, Vietnam

Introduction

Agriculture, the primary source of income for rural families, has moved to the forefront of rural development thinking and practice (FAO, 2007; Scoones, 2009). The importance of farming to livelihoods and development economics must be considered. According to FAO, in order to get the best results, households should use cost-effective livelihood strategies that leverage their existing assets (FAO, 2008). Of which, more diverse crop farms, such as intercropping systems, may help maintain or enhance sustainable agriculture and be a way to reduce uncertainties in the farmers' income (Beillouin *et al.*, 2019; Feliciano, 2019).

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Vietnamese cash crops, such as coffee and pepper, have made important contributions to the national economy, serving as essential products for generating income and for rural development. The perennial crop sector has grown rapidly, accounting for around 1,678.8 thousand tons in 2019 (GSO, 2019). Over 40% of the population of the Central Highlands, Vietnam's second poorest region, makes a living from coffee farming (D'haeze, 2020). Perennial crop systems have been able to enhance their economic efficiency and support sustainable development in both direct and indirect ways thanks to these significant responsibilities.

Dak Lak, a province in the Central Highlands of Vietnam, is a valuable research region with distinct characteristics such as high immigration rates, a diverse ethnicity, and plentiful resources. Perennial crops, such as coffee and pepper, have made contributions to provincial economic development, agricultural expansion, and the rural people. Coffee, in particular, is the province's principal export crop and a substantial source of cash, employing around 300,000 people and approximately 200,000 related jobs in 2020 (Thai Huynh Anh Chi, 2018). Over 90% of households in the province rely on agriculture and perennial crops, with coffee and pepper being especially important. While coffee and other perennial crop farms have been shown to deliver economic benefits to households, there is no evidence that these systems generate social benefits such as job creation, the involvement of women, or expanded employment options. In other words, there has been little empirical research on the influence of perennial crop systems on livelihoods in Dak Lak province. Thus, the purpose of this research was to highlight the importance of perennial crops for household subsistence by evaluating coffee and pepper crops in monoculture and intercropping systems.

Materials and Methodology

Conceptual framework of the study and models of analysis

A conceptual framework based on the sustainable livelihood model was used in this study to present the relationships among capital,

shocks, trends and seasonality, structure and processes, household livelihood strategies, and livelihood outcomes; and how these factors interact to produce livelihood outcomes. Ellis (2000) defined livelihood as "the assets (natural, physical, human, financial, and social capitals), the activities, and the access to them (mediated by institutions and social interactions) that collectively determine the living gained by the individual or household". The model was derived from prior studies by Carney (1998; 2003) and Scoones (1998) where inputs and outputs were described (**Figure 1**).

The goal of this research was to look into how mono-perennial crop systems and intercropping systems affect livelihoods. In other words, the study clarifies two main perspectives: (i) the contributions of perennial crop systems to different aspects of income wages and (ii) the effectiveness of intercropping systems.

According to the British Department for International Development - DFID (2000), the consequences of livelihood strategies can be split into two categories: effects on livelihood security and impacts on environmental sustainability. As a result, in the event of greater access to livelihood assets, the outcomes of increased livelihood security are usually critical objectives in rural livelihood plans. Higher incomes, more steady incomes, and less vulnerability are the results. Furthermore, the relationship between livelihood and rural economics involves increased household income and capability, genetic conservation of species, and enhancement, all of which are prerequisites for a sustainable livelihood (Woyesa & Kumar, 2020).

Data collection methods

Study sites

This study was conducted in Buon Ma Thuot city, and CuMgar and CuKuoin districts of Dak Lak province (**Figure 2**).

These regions were selected thanks to their comparable soil fertility and favorable climatic conditions for crop production. Among these areas, CuMgar is the largest coffee-growing area while CuKuoin is the third largest producer of pepper. Additionally, Buon Ma Thuot city has

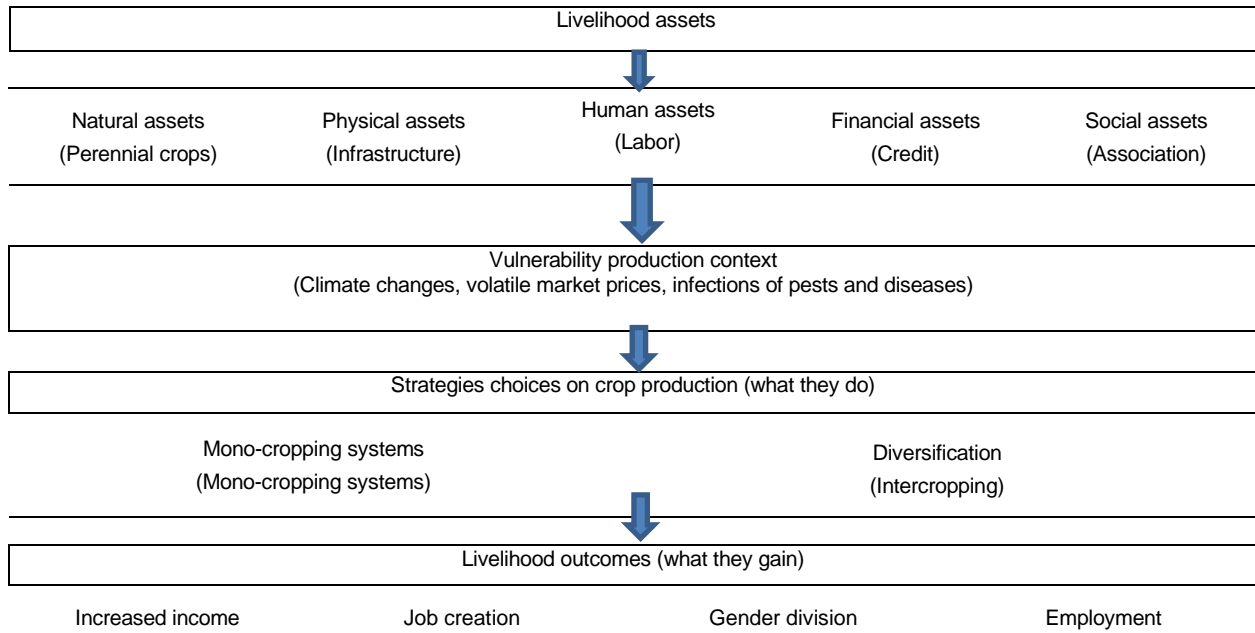


Figure 1. Sustainable livelihood conceptual framework model

Source: DFID's sustainable livelihoods framework (Carney, 1998) and IDS's sustainable rural livelihoods framework (Scoones, 1998)

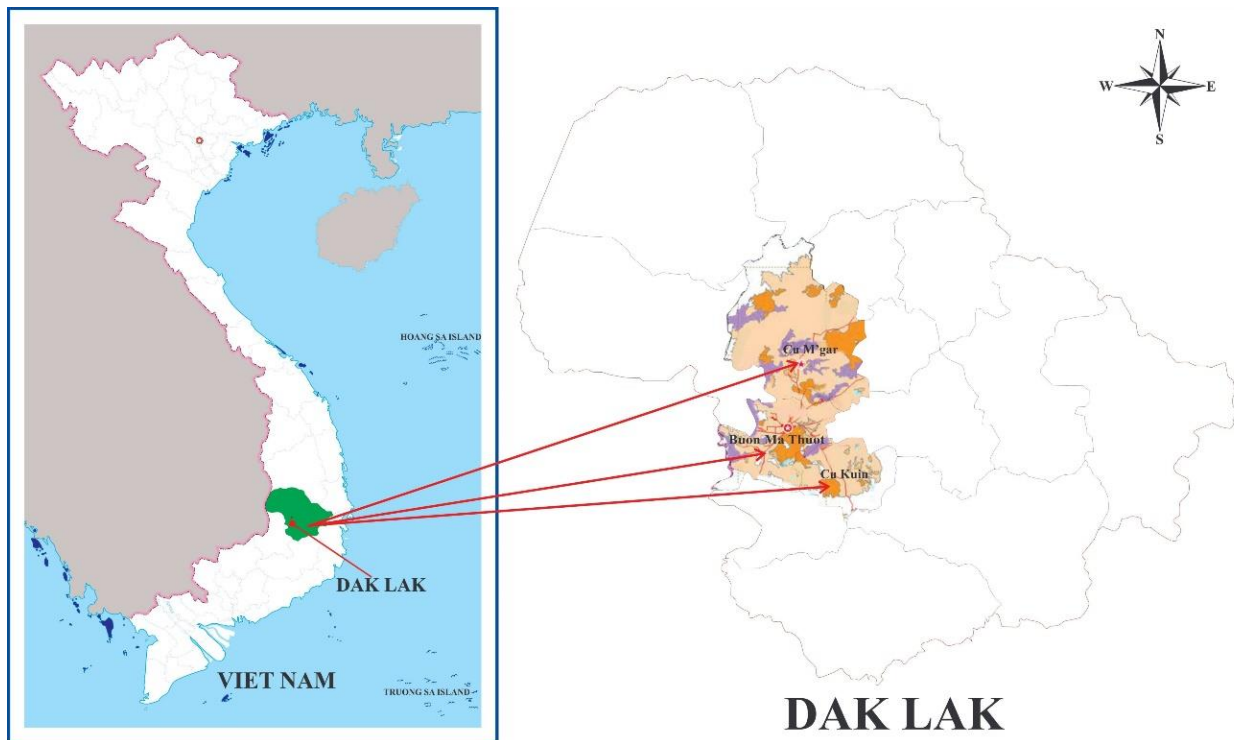


Figure 2. Map of Research Sites

Source: The official administrative map of the Socialist Republic of Vietnam and the Dak Lak official land use map

history of continuous production of perennial crops. The close proximity of CuMgar and CuKuIn districts to Buon Ma Thuot city affords

favorable market access, efficient transportation networks, and access to agricultural services.

Data collection procedures

Data collection was implemented with a three-stage procedure, based on the guidelines of the United Nations Department of Economics and Social Affairs (UN, 2005). In the first stage, three communes (subdivisions of the research sites) in three research sites (Buon Ma Thuot, and Cu Kuin and CuMgar districts) were selected, with one commune chosen from each district. The second stage involved the selection of villages, with one village in each commune chosen as the representative based on its prevalence of mono-cropping and intercropping of coffee and pepper. The final stage involved determining the sample size, which was calculated using the methods of Salvatore and Reagle (2002), where the sample size can be obtained using the formula $n = 0.1N$ (N is the population size). Accordingly, from the list provided by the village leaders, 860 households practiced monoculture and coffee-pepper intercropping (out of 900 farms). Therefore, 10% of the farms from the total list were chosen, with a total of 90 farms being selected for the survey (**Table 1**). The survey was conducted from January to May of 2019, collecting data for the 2018-2019 crop season.

Quantitative and qualitative data were collected through a household questionnaire related to the production of perennial crop farms towards socio-economic indicators (cost, income, hired labor, permanent labor, gender of participants, and market price), as well as the opportunities and constraints in coffee and pepper production. Specifically, the questionnaire covered cultivated land area, production, the selling price, cash costs for

fertilizers, pesticides, herbicides, and weeding, total labor working days, gender, and hired labor.

Moreover, focus group discussions (FGDs) were used. These activities were conducted in each of the three selected villages. The mixture of participants consisted of men and women, and younger and more experienced farmers. Each FGD was comprised of six participants, and there were a total of nine FGDs. The qualitative aim concerned information related to developments in cropping systems and the gender of participants.

Data analysis

The study used the gross margin analysis to identify the capacities of perennial crop systems on creating a household's income, (the value was converted to USD at an exchange rate of 23,000 VND for 1 USD), as follows (FAO, 2016):

Total output is the total revenue of production outputs

$$GO = P_i * Q_i \quad (1)$$

where P_i is the market price of i products (the prices were calculated based on the price paid after harvest) and Q_i is the product quantity of i products with:

$$GM = \sum Y_i \times P_i - \sum C_j \quad (2)$$

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 the inputs. The cost of items used in the study included intermediate costs, labor cost, and depreciation, which were calculated as follows:

Table 1. The surveyed farms in the research sites

Regions	Sub-regions	Sample size = 10% of total population		
		Monoculture systems		Intercropping
		MCSes ^a	MPSes ^b	CPI ^c
Buon Ma Thuot	Cao Thanh (n = 300 farms)	11	11	8
Cu Kuin	Muoi (n = 290 farms)	9	8	12
CuMgar	Sut M gur (n = 310 farms)	12	9	10
Total		32	28	30

Note: ^a Mono-coffee systems, ^b Mono pepper systems, ^c Coffee and pepper intercropping

Intermediate costs (IC) = $\sum_{i=1}^n$ Total product x Unit price

Labor cost = number of working days (person-days) x labor price at the local region

The depreciation included fixed assets (machine, well, storehouse), and coffee and pepper orchards.

Moreover, to examine the stability of income from perennial crop systems, a sensitivity analysis was performed to evaluate profits under different variations of coffee and pepper price changes. Sensitivity analysis provides priorities for research (Cariboni *et al.*, 2007) and helps in identifying and prioritizing the most crucial factors that contribute to significant improvements in output (Marino *et al.*, 2008). The sensitivity analyses involved three scenarios: (1) Good: an increase in coffee and pepper prices; (2) Moderate: constant coffee and pepper prices; and (3) Bad: a decrease in coffee and pepper prices. Furthermore, descriptive statistical analysis was employed to compare the differences among the mono-cropping systems and intercropping systems that focused on coffee and pepper crops.

The Kruskal–Wallis method was applied to the test results to examine the significant differences among the three independent groups (MCSes, MPSes, and CPI) and dependent

variables, including input cost items and economic performance indicators. Alternatively, in this study, the test was used to determine if the continuous dependent variables, such as production costs, gross margin, labor productivity, and return to family labor, differed among the three groups of the MCSes, MPSes, and the CPI.

Results and Discussion

Contribution of perennial crop systems to household profit

Table 2 indicates a summary of the cost and returns analysis, and shows that the total value outputs of monocultures (MCSes and MPSes) at 3.22 and 6.13 thousand USD per ha, respectively, were lower than the total value output of the CPI (6.80 thousand USD per ha). Interestingly, the results showed that the CPI had a higher gross margin of 4.56 thousand USD per ha, compared to the monoculture values of 1.9 for MCSes and 3.82 thousand USD for MPSes. This, therefore, implies that CPI is a more profitable business and helps to reduce the financial risks associated with monoculture systems (D'haeze, 2020).

The results of this study align with previous findings that agroforestry and diversified

Table 2. The cost and returns analysis

Variables	Value in thousand USD/ha			Sig
	MCSes	MPSes	CPI	
Total Output¹	3.22	6.13	6.80	0.01*
Total variable cost	1.32	2.31	2.24	0.00*
1. Intermediate cost (IC)	0.98	1.32	1.30	0.01*
2. Labor cost	0.14	0.35	0.51	0.03*
3. Depreciation	0.08	0.27	0.24	0.04*
4. Others	0.11	0.38	0.19	0.03*
Gross margin²	1.90	3.82	4.56	0.00*
Labor productivity	0.02	0.04	0.04	0.00*
Return to family labor³	0.01	0.03	0.04	0.05**

Note: The significance levels are indicated as *****, ***, **, and * for $P < 0.1$, 0.05, and 0.01, respectively. The Kruskal–Wallis test: 0.00

¹Total output is the total revenue of production outputs; ²Labor productivity was calculated by dividing the total output by the total number of laborers (Commission, 2016), 1 labor day = 8 hours; ³Return to family labor was calculated by dividing the gross margin by the total number of family laborers (Commission, 2016)

Source: Surveyed data in 2019.

systems can enhance agricultural productivity and serve as primary livelihood sources through economically viable activities (Wilson & Lovell, 2016; Brown *et al.*, 2018; Pham *et al.*, 2018). For example, in the EU region that encompasses Finland, Norway, Sweden, and a part of Russia, agroforestry systems that integrate trees and crops on the same land have been shown to have positive impacts on the local rural economy. These systems are known to lower costs and improve productivity, as demonstrated by Mosquera-Losada *et al.* (2018). In Indonesia, participants agreed that practices centered around coconuts, as well as home gardens and mixed gardens, have more benefits for livelihoods than maize farms and horticulture plots (Mulyoutami *et al.*, 2016).

Given the challenges facing production, such as vulnerability to natural disasters, market price fluctuations and climate change, agroforestry like CPI and other intercropped systems are likely to be the most viable options for smallholders. This is logical when CPI as an agroforestry system has been demonstrated to produce sustainable and resilient agriculture, contribute to human well-being, and help to achieve the Millennium Development Goals (Brown *et al.*, 2018; Chen *et al.*, 2019).

This agroforestry system has been successfully applied in many countries, such as the Mediterranean region and the United States (Hunt *et al.*, 2019; Alcon *et al.*, 2020). However, it is worth noting that due to the increased capital and investment expenses, the intercropping model may pose a financial challenge for those who are less well-off. Furthermore, these systems are more complex and require a greater level of knowledge, which may present a burden for agroforestry and intercropped farms. Going forward, it will be important to provide support and encouragement, including access to reliable technical guidance for farmers and financial assistance. This will help to shift the mindset of farmers and facilitate the development of intercropping systems. Such

efforts will be critical to the success of these systems in the future.

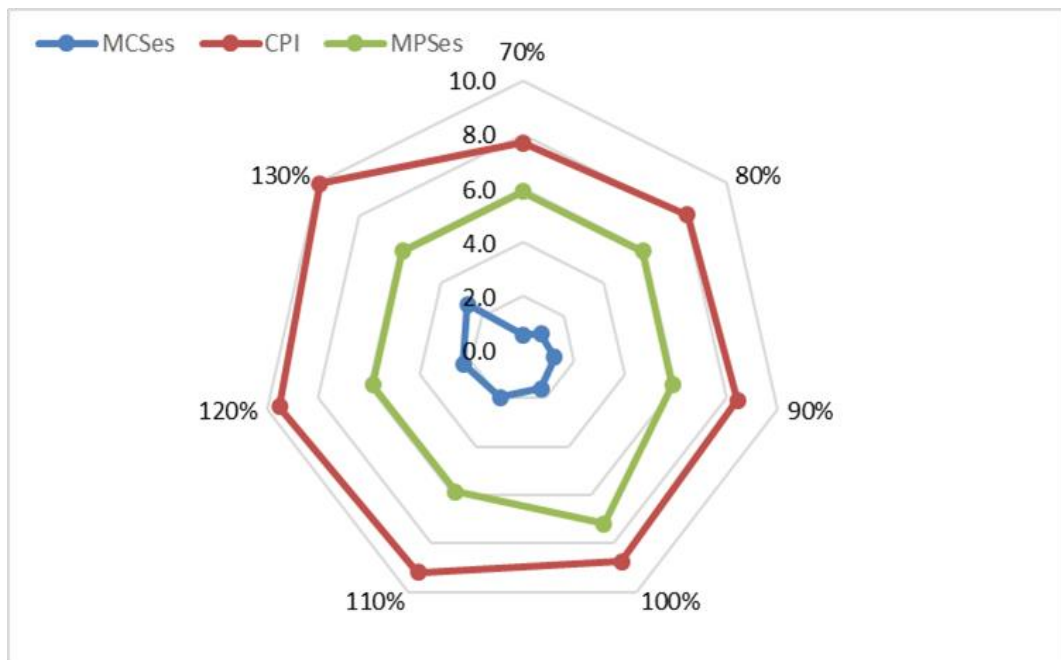
A sensitivity analysis of MCSes, MPSes, and CPI under different price scenarios to analyze profit

Profits for MCSes, MPSes, and CPI are relatively price sensitive, according to the findings. Based on modeling, we might expect fluctuations in the coffee selling price of up to 10% and 20% in particular, leading to profits increasing and declining by 22 (0.3USD) and 43 percent (0.7USD) for MCSes, respectively, and by 5 and 9 percent per hectare for CPI (**Figure 3A**). Similarly, with 10% and 20% increases in the pepper selling price, earnings are expected to climb and decline 16.5 and 31.5 percent for MPSes, and 10% and 20% per ha for CPI, respectively. Modeling with these variables revealed the considerable impact of earnings and their vulnerability to selling prices for MCSes, MPSes, and CPI (**Figure 3B**).

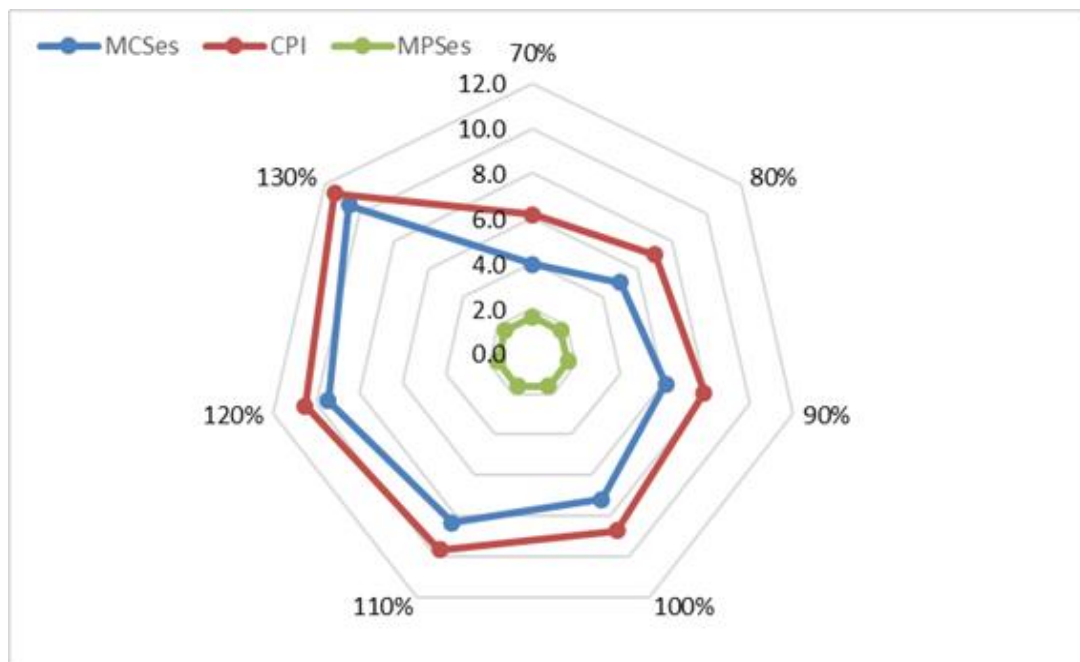
Additionally, a 30% reduction in the coffee price results in a 65% reduction in profit for MCSes and 12% for CPI (**Figures 3A and 4A**). Similarly, a 30% decrease in the pepper price leads to a 45% decrease in profit for MPSes and 30% for CPI (**Figures 3B and 4B**). CPI is likely to be less sensitive to these coffee and pepper price fluctuations than MCSes and MPSes. In terms of this model, these results, which were predicted with 30% coffee and pepper price decreases, seem to be similar to the current prices in the previous section. Both for the model and surveyed data, CPI has higher economic benefits and lower sensitivity to market risk in comparison to the other systems (**Figures 3 and 4**).

Contributions of perennial crop systems to job creation

This section assesses the various workforce requirements among and amongst selected agricultural systems throughout the labor calendar of activities. The labor calendar sets the number of labor-hours involved in a specific crop year, which is an important instrument for measuring the labor situation and improving its



A: The fluctuation of coffee price



B: The fluctuation of pepper price

Figure 3. The variation of profits under different scenarios of coffee and pepper prices in 2019

efficient usage shows how many person-days are required for various farming system tasks.

The overall number of working persons differed significantly among the cropping systems. CPI, in particular, required more laborers than MCSes and MPSes, which was

estimated to be 286 workdays (Table 3). Following that, MPSes came in second in terms of average employment demand, accounting for 245 working days. MCSes had the fewest labor needs compared to the others, totaling 134 people. This means that CPI is more likely than

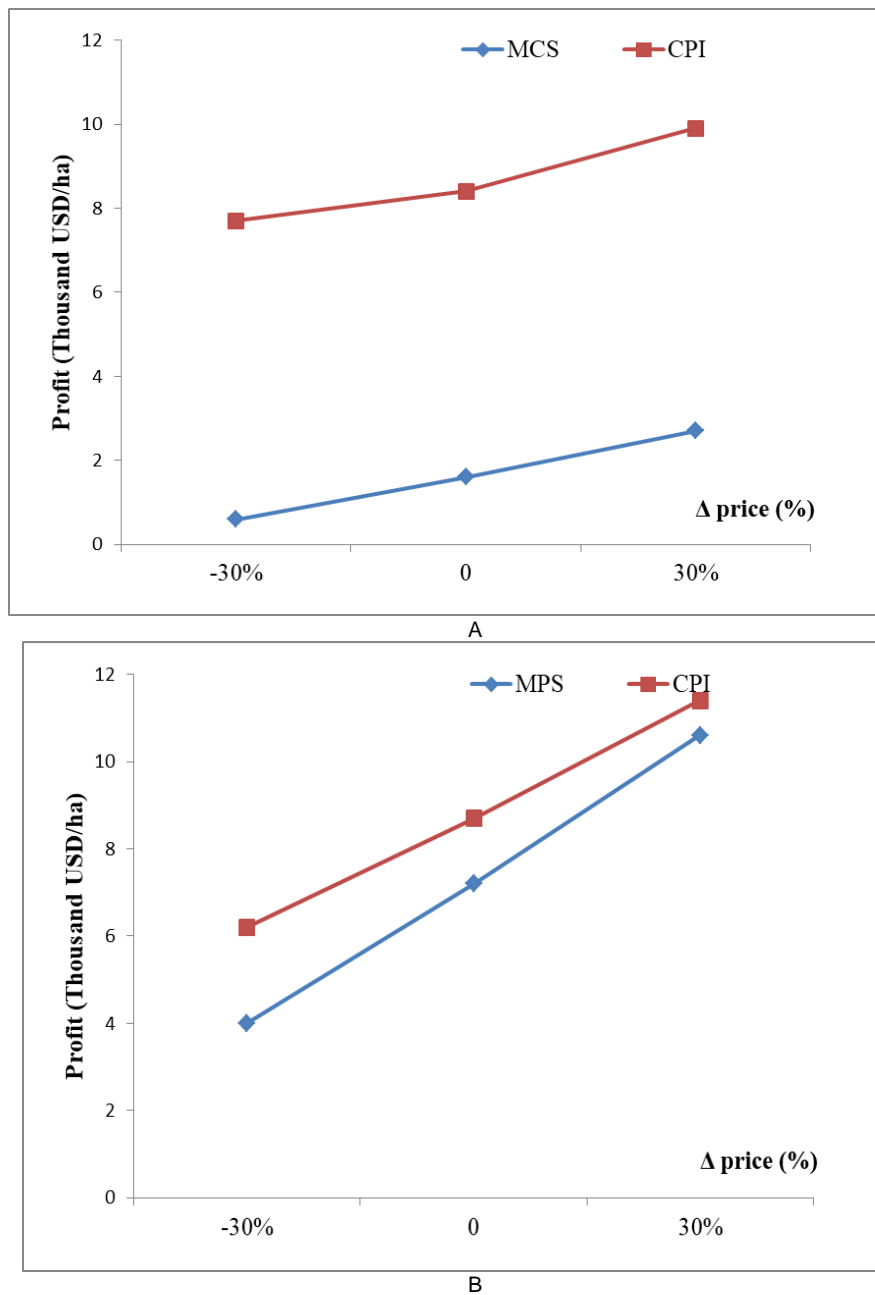


Figure 4. Sensitivity analysis of profits considering variation between -30% and +30% in the coffee and pepper selling prices in 2019

the others to entice more individuals per ha to move into that area. As a result, when the majority of rural families in Dak Lak rely on perennial crop systems, CPI should be deemed an appropriate system that will permit high employment in contrast to the other systems.

The majority of the workforce was engaged in harvesting and pruning and budding activities with these tasks occupying a significant

proportion of the labor for each of the cropping systems. Specifically, 51 and 15% of workers were assigned to harvesting and pruning and budding for MCSes, 64 and 10% for MPSes, and 69 and 10% for CPI. As a result, these labor-intensive activities should be carefully planned and managed to ensure there is a sufficient workforce, especially during harvest season. Additionally, there were substantial differences

Table 3. Labor allocation by activity in the three selected systems in 2019

Workdays (days/hectare/crop season)	MCS (n = 32)	MPS (n = 28)	CPI (n = 30)	Sig.
Weeding	13.0	17.0	12.0	NS
Fertilizer	7.0	14.0	12.0	0.08***
Pruning, bud breaking	20.5	24.0	30.0	NS
Irrigation	12.0	11.5	15.0	NS
Pesticides	6.0	11.0	6.0	0.02**
Harvesting	69.0	158.0	198.0	0.05**
Post-harvest	3.0	3.5	7.0	NS
Others	3.5	6.0	5.0	0.04**
Total	134.0	245.0	286.0	0.02**

Note: The significance levels are indicated as ***, **, and * for $P < 0.1$, 0.05, 0.01, and non-significant, respectively. The Kruskal-Wallis test: 0.00

in the use of fertilizers and pesticides, and the management of personnel among the three cropping systems. Interestingly, the use of personnel for weeding was the lowest in CPI, requiring only 12 workdays, indicating that CPI provides weed control benefits while reducing the dependence on harmful chemical inputs (Table 3).

Contribution of perennial crop systems to gender labor division

Figure 5 presents the extent of women's participation in the labor force within the three cropping systems. Generally, both men and women were equally involved in the production of perennial crops. However, the distribution of labor between men and women varied considerably among activities and across systems. Men were predominantly engaged in tasks such as pruning, weed control, disease treatment, irrigation, and management, while women tended to take part in activities such as fertilizer application, harvesting, and post-harvest processing. For instance, during harvesting, the majority of workers involved in the collection of ripe cherries were women, which aligns with the findings of Schreckenberg *et al.* (2002) and Kalaba *et al.* (2009) who reported that over 90% of women participated in the gathering of shea nuts in West and Central Africa.

The results demonstrated that MCSes and CPI offer greater opportunities for women than MPSes. For example, women's participation in activities such as pruning, irrigation, and management were 40%, 30%, and 30% in MCSes; while these figures were 30%, 35%, and 20% in CPI, and only reached 10%, 20%, and 5% in MPSes, respectively (Figure 5). This disparity may be attributed to the specific cultivation requirements in these systems, which attract more women to certain activities. In other words, the gender gap is wider in MPSes compared to the other systems for these labor activities. To enhance women's involvement in MPSes, various policies should be implemented, including technological and institutional interventions such as training to improve women's access to knowledge and information.

Contributions of perennial crop systems to extended employment for farm workers year-round

Workers are notably needed for the pre-harvest and harvest stages of the production of coffee, peppers, and other perennial crops. Aside from family work, smallholders have historically used non-paid labor extensively. These laborers are frequently friends and neighbors who are hired through labor exchanges (*Đổi công*). Some houses had annual contracts with one or two employees. Hiring outside help has been more

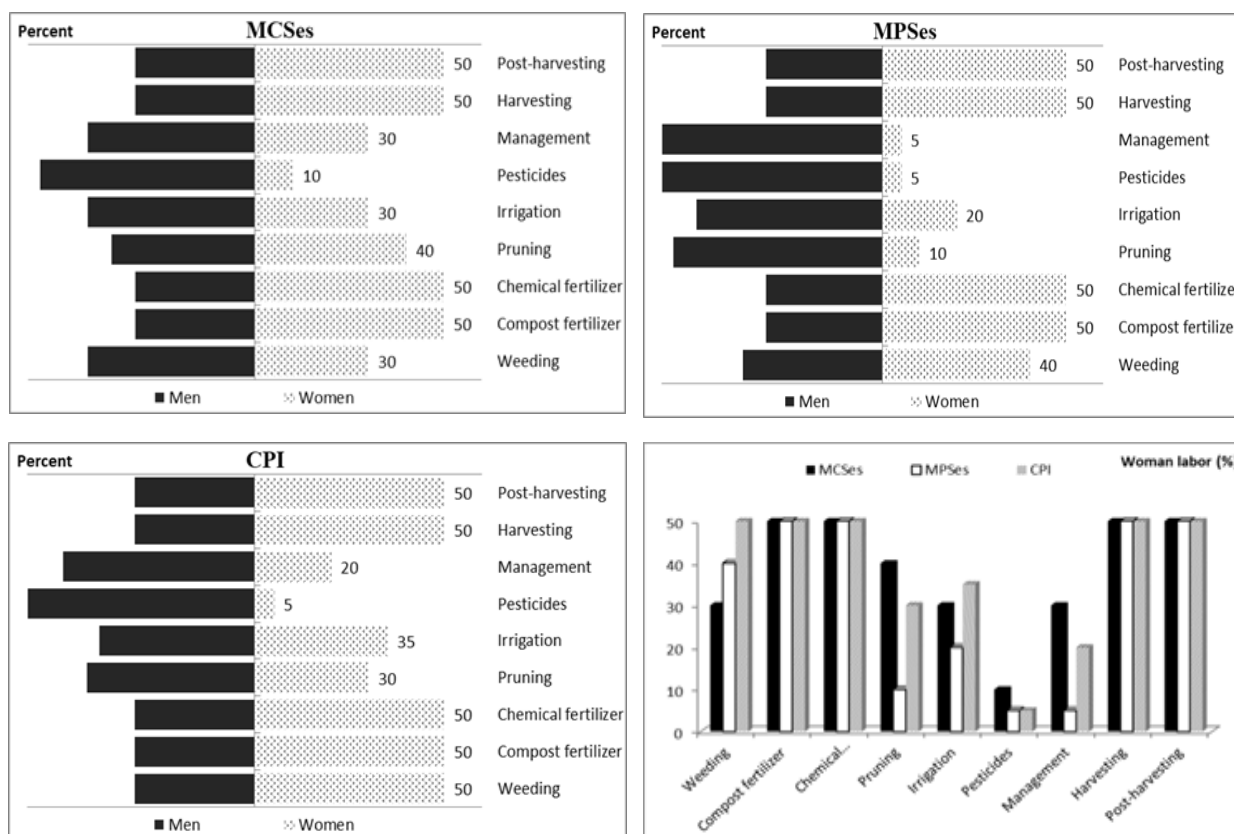


Figure 5. Gender allocations of each task in perennial crop production
 Source: FGDs and surveyed data (2019)

common in recent years for duties like weeding and watering as well as harvesting. Non-family labor is frequently compensated for this by daily wages that include food and drink (one day's work is equal to 7USD) or on the basis of quotas (for example, 0.13USD per coffee tree for trimming or 0.09USD for every 100kg of freshly harvested coffee) (Thuy *et al.*, 2019; 2020; 2021).

The information in **Table 4** highlights a labor shortage in perennial crop systems, specifically in Dak Lak province. This shortage has been a significant factor in the decision-making process for farmers in terms of adopting new technologies, such as micro-irrigation. Additionally, the harvesting process, which requires the highest percentage of total employment, has also been affected by the shortage of seasonal workers. The shift in migration patterns, with workers moving closer to industrial and service parks instead of agricultural areas, has further exacerbated the situation.

Although the local government encouraged harvest levels of at least 80 percent ripe cherries, most farmers are forced to begin harvesting early due to labor shortages, which causes quality issues. In comparison to MCSes and MPSes, CPI had the highest proportion of workers hired. While CPI used 25% of hired labor, MCSes and MPSes only used 15% and 20%, respectively. Furthermore, the ratio of hired labor to family labor was 34%, while the need for paid laborers in MCSes and MPSes was 18 and 24%, respectively (**Table 4**).

At the farm level, the lack of seasonal labor results in increases in the daily wage. When workers are needed in perennial crop systems, unfilled employment opportunities must have increased salary benefits to attract workers. The authors recommend that for perennial crop development strategies involving labor, there should be help for farmers to use machines or technology to reduce labor requirements, or encouragement to form a labor cooperation between households.

Table 4. External labor of the three systems by daily wages in 2019

Items	MCS (n = 30)	MPS (n = 26)	CPI (n = 30)	Sig.
Harvesting (people)	16.0	37.0	57.0	0.01
Others (people)	5.0	11.0	16.0	NS
Total hired labor (people)	21.0	48.0	73.0	0.00
Hired harvesting/total hired labor	0.7	0.8	0.8	NS
Hired labor/total labor	0.2	0.2	0.3	0.09
Hired labor/family labor	0.2	0.2	0.3	0.08

Note: The significance levels are indicated as ****, ***, **, *NS for $P < 0.10$, 0.05, 0.01, and non-significant, respectively. The Kruskal–Wallis test: 0.00.

The lack of seasonal labor in perennial crop systems makes it more difficult for farmers to find enough workers to meet their needs and forces them to offer higher wages to attract workers. In light of these challenges, the authors recommend two potential solutions for the development of perennial crop systems involving labor. The first is to provide support for farmers to use machines or technology to reduce labor requirements, which could help alleviate the labor shortage issue. The second is to encourage the formation of a labor cooperation between households, which could help pool resources and reduce the need for individual households to hire a large number of workers. By implementing these strategies, the authors believe that the perennial crop systems will be better able to overcome the challenges posed by the labor shortage. However, it's important to consider the specific context and constraints of each region and to ensure that any proposed solutions are feasible and appropriate for the local situation.

Conclusions

The study highlights the importance of perennial crop systems in terms of providing economic and social benefits to small farms and rural communities. Perennial crop systems have the potential to create added value, create jobs, increase gender participation, and add extended and potential employment opportunities, which can play a crucial role in livelihood approaches. In particular, the coffee and pepper intercropping (CPI) system was shown to have greater economic benefits and a higher social value compared to the other systems. This indicates

that CPI has the potential to provide economic resilience and contribute to rural development for small farms. However, the study also recognizes that there are constraints on the widespread adoption of CPI practices and that there is a need for support and encouragement from local authorities to promote modernized cultivation practices. Furthermore, the study suggests that enhancing farmers' perception of intercropped-farms is essential for the successful implementation of these practices.

In conclusion, the study provides valuable information and evidence to support the development of perennial crop systems, and underscores the importance of addressing the challenges and constraints faced by farmers in order to maximize the economic and social benefits of these systems.

Acknowledgments

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