



RESEARCH ARTICLE

Investigating the Role of the Cultivated Banana Value Chain as a Potential Source of Sustainable Income for Local Communities in Lao PDR

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Abstract: Cultivated bananas have gained attention due to the environmental and social impacts of Cavendish bananas in the northern part of Laos. This study investigated the value chain of cultivated bananas and its implications for sustainable income generation. Basic statistical analysis was used to assess the value added by cultivated bananas, while stakeholder analysis and value chain mapping were used to identify key actors and relationships. The determinant of commercialization is observed through the regression model and the impact of commercialization is investigated through the second stage regression. The study found that the banana value chain in Laos is driven by the export market. Farmers generate the highest profit, but they receive the lowest distribution of value-added. Banana commercialization can significantly increase the income of farmers, but the impact is not equal for all farmers. Bananas are a sustainable income source for households in Laos, and they have the potential to be promoted in high-value markets if the farmers create new products and improve skills of management, marketing, and finance with the support from government policies.

Keywords: Cultivated banana; Value chain; Commercialization

1. Introduction

In the Lao PDR, which is primarily an agrarian society, agriculture, and forestry contribute to 30% of the country's GDP and employ over 75% of the workforce. The Agriculture Development Strategy 2025 has identified bananas as a prioritized crop for agricultural exports.

In 2020, bananas hold significant importance as one of the key crops, with an estimated production of 385,000 tons. The development of commercial banana production, largely driven by Chinese investments, brings economic benefits and employment opportunities, particularly in the northern region of Lao PDR. Approximately 88% of the exported bananas were shipped to China, while the re-

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maining 12% were sent to Thailand.

In recent years, the demand for bananas in neighboring countries has increased, leading to a rapid expansion of banana production and area in Lao PDR. One of the banana types that is being heavily invested in Lao PDR is Cavendish, which is a high-yielding variety that requires extensive use of chemical fertilizers, pesticides, and herbicides. The use of these chemicals has had significant negative impacts on both the environment and the well-being of workers and consumers.

The use of chemicals in banana production can have several negative impacts on the environment, workers, and consumers. Environmental impacts include water pollution, soil contamination, and ecosystem damage. Worker health impacts include respiratory problems, skin problems, and cancer. Consumer health impacts are less well-understood, but there is some evidence that exposure to chemicals in bananas can cause health problems. Workers on banana plantations are often from impoverished communities and may have a limited understanding of safe chemical handling practices. This puts them at even greater risk of exposure to harmful chemicals. The costs of healthcare and environmental rehabilitation may outweigh the benefits of income generation and job opportunities from banana production^[1].

Due to concerns over the spread of Fusarium wilt in Cavendish banana plantations in Northern Laos, cultivated banana varieties known locally as “Kuay Nam” have gained increased attention^[1]. Cultivated bananas play a crucial role in the agricultural sector of Lao PDR, providing food security and income generation opportunities for local communities. Traditionally, banana plants grew naturally in backyards or small farms for household consumption and animal husbandry. However, in recent years, there has been a growing interest in commercializing Kuay Nam bananas due to their high yields and resistance to pests and diseases.

There has been limited research on the potential of the cultivated banana value chain to provide sustainable income for local communities. To address this gap, this study focuses on investigating the role of the cultivated banana value chain in supporting sustainable income for communities in the provinces of Houaphan, Vientiane, Savannakhet, and Salavan.

Several studies have been conducted to analyze value chains in the Lao PDR. For instance, Wongpit and Sisaphanthong^[2] examined the value chain of organic vegetables in Vientiane Capital and found limited value addition and processing due to small market size, lack of knowledge, and low consumer awareness. In another study, Small-scale Agro-Enterprise Development in the upland^[3]

analyzed the cultivated banana value chain in the Poukoud district, Xieng Khuang Province, identifying challenges such as insufficient inputs and equipment for farmers. However, with access to funding, farmers were able to increase production and sales, highlighting the significance of middlemen in connecting farmers to the market.

The commercialization of agricultural products is a priority policy of the Lao government. Farmers are being encouraged to change from traditional production methods to more commercial practices, such as expanding production and processing their products. The government is providing support to farmers in this transition, such as providing access to credit and training on commercial production techniques. The commercialization of agriculture is expected to benefit both farmers and the economy. Farmers will be able to increase their incomes, and the economy will benefit from increased exports.

The impact of agricultural commercialization on livelihoods and food access in the Lao PDR has been analyzed by Wright^[4]. The study highlights policy-driven shifts from traditional to intensive agriculture and increased demand for agricultural products from neighboring countries. These developments have expanded markets and facilitated smallholder access to markets through improved road infrastructure. Goletti^[5], Bouahom et al.^[6] and Setboonsarng et al.^[7] have discussed commercial crop production, there has been a lack of comprehensive examination and quantification of the determinants and implications of agricultural commercialization in the Lao PDR, particularly for crops like cultivated bananas.

This paper aims to describe and analyze the value chain of cultivated bananas in domestic and foreign markets, filling the gap in existing research. To analyze the effects of commercialization on local incomes, this study focuses on the cultivated banana value chains, examining their organization, key actors involved, value added throughout the process, and potential opportunities.

2. Material and Methods

The methodology employed in this study involved the use of value-chain analysis to examine the cultivated banana industry in four provinces. The value chain analysis includes stakeholder analysis, value chain mapping, and value-added. The objective of value chain analysis is to break down the chain into its individual components to gain a better understanding of its structure and functioning^[8]. A preliminary value-chain framework was developed based on existing studies, reports, and consultations with researchers. Stakeholders were then invited to participate in a focused group discussion where the draft value chain was presented and explained. Valuable input and sugges-

tions from the participants were incorporated, leading to the revision of the value chain and the identification of key bottlenecks.

The determinants of commercialization were analyzed through a regression model. There are many discussions about what agriculture commercialization is and how to measure commercialization. Govereh et al. [9] suggest that agriculture commercialization is the proportion of sold products to total production and commercialization can be measured along a continuum from zero (total subsistence-oriented production) to unity (100% production is sold). The measurement of the commercialization of agricultural pre is expressed as the equation below:

$$Commercialization = \frac{Sale\ value}{Production\ value} \tag{1}$$

The agricultural product in this paper refers to cultivated bananas. The sale value is the value of cultivated bananas that farmers sell to middlemen or exporting companies. Production value is the value of cultivated banana production by farmers. The equation model to identify the determinants of banana commercialization is as follows:

$$C_i = \alpha_0 + \alpha_1 Age_i + \alpha_2 Edu_i + \alpha_3 Exp + \alpha_4 Mem + \alpha_5 Dm + \alpha_6 Df + \varepsilon_i \tag{2}$$

Household income, I_i , is a function of instrumented agricultural commercialization (\hat{C}_i), labor, capital, and land; a vector of household characteristics (H_i); and a govern-

ment policy variable, P_i .

$$\ln I_i = \beta_1 + \beta_1 \hat{C}_i + \beta_2 \ln K_i + \beta_3 \ln L_i + \beta_4 \ln S_i + \beta_5 P + \beta_6 D_2 + \beta_7 D_3 + \beta_8 D_4 + \varepsilon_j \tag{3}$$

The definition and measurement of variables in Equations (2) and (3) are explained in Table 1.

Data for the study were collected through a household survey conducted in four provinces: Houaphan, Vientiane, Savannakhet, and Salavan. Banana production has increased significantly in recent years, particularly in Vientiane Province, Salavan Province, and Savannakhet Province. In Xanakhm district, Vientiane Province, which is located in the central part of Laos, most of the bananas are sold to Vientiane Capital or exported to Thailand. Some of the bananas are also processed into banana crisps and solar-dried bananas. Salavan Province is in the southern part of Lao PDR where most of the bananas are exported to Thailand. Some bananas are also used to produce whiskey or processed into banana fiber for handicrafts. However, the demand for these products is low. In Houaphan Province, which is in the northern part of Laos and shares a border with Vietnam, the commercialization of cultivated bananas is at an early stage. The main obstacles to the expansion of banana production are the lack of a market, the high costs of materials and transportation, and the limited availability of land. In Savannakhet Province, bananas

Table 1. Definition and measurement of the variables.

Variable	Definition	Measurement
<i>C</i>	Commercialization ratio	The ratio of the value of the banana sale to the total production value where rank from 0 to 100
<i>Gen</i>	Gender	Gender of the head of the household where 1 is male and 2 is female
<i>Age</i>	Age	Age of head of household
<i>Edu</i>	Education	Year of education of the head of household
<i>Exp</i>	Experience	Year of experience in the banana plantation
<i>Mem</i>	Member of household	Number of members in the household
<i>Dm</i>	Distance to market	Distance from farm to market in Kilometers
<i>Df</i>	Distance to farm	Distance from home to farm in Kilometers
<i>lnI</i>	Natural logarithm of to income of the household	Total income of a household in million Lao Kip (LAK) per year
\hat{C}	Predicted commercial ratio	Predicted commercial index derived from Equation (2)
<i>lnL</i>	Natural logarithm of labor	Number of workers used to cultivate bananas
<i>lnK</i>	Natural logarithm of capital	Value of capital use in the banana farm in million LAK per year
<i>lnS</i>	Natural logarithm of land	Land area of the banana farm measuring in hectares
<i>P</i>	Policy	Dummy variable for policy support where 1 if received support and 0 otherwise
<i>D1</i>	Dummy variable for Houaphan	1 is Houaphan and 0 otherwise
<i>D2</i>	Dummy variable for Vientiane	1 is Vientiane and 0 otherwise
<i>D3</i>	Dummy variable for Savannakhet	1 is Savannakhet and 0 otherwise
<i>D4</i>	Dummy variable for Salavan	1 is Salavan and 0 otherwise
ε_i	Error term	

are mainly planted in the Xepon district, near the border with Vietnam. Most of the bananas are exported to China through Vietnam.

The selection of districts within each province was based on recommendations from provincial authorities actively promoting agriculture commercialization. Random sampling methods were used to select households, middlemen, and banana processors for interviews. The survey questionnaires covered various topics such as respondent information, revenue, production costs, market accessibility, and financial access. The interviews aimed to gather the necessary information. Table 2 shows the sample size which consists of 474 households involved in banana cultivation, along with 8 middlemen and 9 banana processors.

Table 2. Sample size across the different categories.

Provinces	Farmers	Middlemen	Processors
Houaphan	111	2	2
Vientiane	251	3	3
Savannakhet	73	2	3
Salavan	36	1	1
Total	474	8	9

Source: Authors' survey in 2017.

3. Results

3.1 Value Chain of Cultivated Bananas

Value Chain of Cultivated Banana in Huaphan

In the banana value chains in Houaphan Province, four main stakeholders can be identified: farmers, processors, middlemen, and importers. Farmers are responsible for cultivating and collecting bananas from their farms and selling them to middlemen and customers at the market in Xam Nuea district. On average, farming households have a farm area of 1.3 hectares, with 0.6 hectares dedicated to banana farming. The total cost of banana production for farmers, including fixed and variable costs, amounts to approximately 2.02 million LAK per household per year. In contrast, the total income from bananas reaches around 3.06 million LAK per household, resulting in a profit of approximately 1.04 million LAK.

Processors in Houaphan purchase bananas from farmers and use them to produce ripe banana crisps. It takes about four hours to produce ripe banana crisps from 20 bunches of bananas. Processors sell these banana crisps directly to customers at the market in Houaphan Province. The main costs incurred by processors include fixed costs

for equipment and variable costs such as labor, purchasing bananas, cooking oil, and packaging materials. On average, processors earn an income of 1.5 million LAK per month, while their total costs amount to 0.9 million LAK, resulting in a profit of 0.6 million LAK per month.

Middlemen play a role in buying bananas from farmers and selling them to customers in the market in Xam Nuea district. Their fixed costs primarily include trucks, while their variable costs consist of expenses for gasoline, rental fees at the market, maintenance, and labor. The average total cost for middlemen is 13 million LAK per month, and their income amounts to 4 million LAK per month. Consequently, the average profit for middlemen is 9 million LAK per month.

Figure 1 depicts the value chain map of cultivated bananas in Houaphan Province. The percentages displayed above the arrows represent the market share of each stakeholder. Farmers utilize three distribution channels, selling 20% to middlemen, 10% to processors, and 70% directly to customers at the market in Xam Nuea district. Middlemen acquire Kuay Nam bananas from farmers, distributing 75% to consumers at the market, 20% to processors, and exporting 5% to Vietnam. The quantity of processed bananas is relatively low, with processors producing banana chips or grilled bananas for sale in the local market.

The distribution of value-added among the stakeholders in each channel. Farmers achieve an average profit of approximately 753 LAK/kg, corresponding to a profit margin of 193%. Middlemen obtain profits of 1,316 LAK per bunch, representing a profit margin of 78%. Their sale price amounts to 20,000 LAK/kg or 28 packs, resulting in a profit of 3,098 LAK/kg or an 18% profit margin.

Value Chain of Cultivated Banana in Vientiane Province

In the value chain of bananas in Vientiane Province, there are four main stakeholders: farmers, processors, middlemen, and distributors. Farmers collect bananas from their farms and sell them, with an average farm area of 3.7 hectares per household and 2 hectares dedicated to banana farming. The average total cost of banana production is 3 million LAK per household per year, while the total income from bananas amounts to 13.7 million LAK per household, resulting in a profit of approximately 10.7 million LAK per household.

Processors in Vientiane produce various banana products, with the knowledge and techniques transferred from JICA. The production process for banana crisp takes 8 hours with 3 workers, using around 400 bunches of bananas to produce 220 kg of banana crisp. Solar-dried banana production requires 4 man-days and 300 bunches of

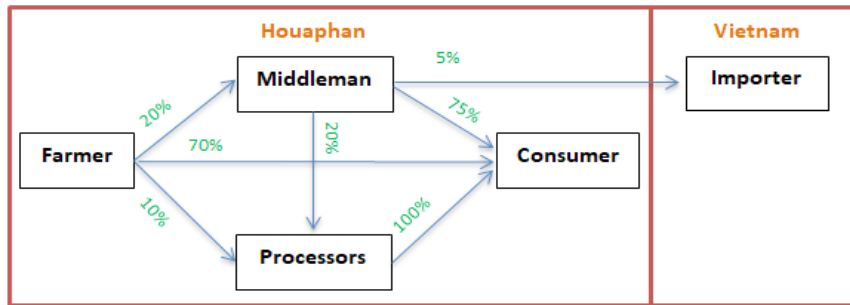


Figure 1. Mapping of value-chain of cultivated banana in Houaphan Province.

bananas to produce 125 kg. Processors sell their products to retailers in Vientiane Capital and occasionally export to retailers in Thailand, generating an average monthly revenue of 8 million LAK and a profit of approximately 2.5 million LAK.

Middlemen purchase bananas from farmers and sell them to customers at the market in Vientiane Capital. Their main fixed costs include trucks, and variable costs consist of gasoline, rental fees, maintenance, and labor costs. The average monthly income and cost for middlemen are 27 million LAK and 20 million LAK, respectively, resulting in an average profit of 7 million LAK per month.

Distributors, a Lao-China joint company, are responsible for collecting, packing, and exporting bananas to distribution centers in China. The bananas are then distributed to markets, retail shops, or department stores in China. Occasionally, Thai importers buy bananas directly from the farm when there is a supply shortage in Thailand. The demand for processed bananas from retail shops and markets in Thailand is irregular.

Figure 2 shows that approximately 50% of bananas are sold in the domestic market, primarily at the market in Vientiane Capital. Processors purchase 10% of bananas from farmers for their production. For export, around

15% of bananas are sold to the distributor and exported to China, while 5% are exported to Thailand. Processors sell 80% of their total product to retailers, 15% to domestic customers, and 5% to Thai importers. Middlemen sell 90% of the bananas to retailers at the market and 10% to customers in Vientiane Capital.

The average profit for farmers selling bananas in Lao PDR is approximately 153 LAK/kg, resulting in a profit margin of around 16%. Middlemen, who act as intermediaries, make an average profit of 3,000 LAK/kg, equating to a profit margin of approximately 23%. Processors in the industry produce four flavors of banana crisps and solar-dried bananas, with an average profit margin of around 77%. Retailers purchase processed bananas from processors, pack them into small packages, and sell them in retail shops, achieving a profit margin of approximately 50%. Additionally, retailers also sell unprocessed bananas, gaining an approximate profit margin of 67%.

A Chinese-Lao company operates as a distributor, supplying bananas to a distribution center in Guangxi Province. Due to privacy concerns, the specific cost and sale price of bananas is not known. However, the distributor obtains an estimated profit margin of approximately 20-30%. It is important to note that the value-added distributions may vary depending on the market channels utilized.

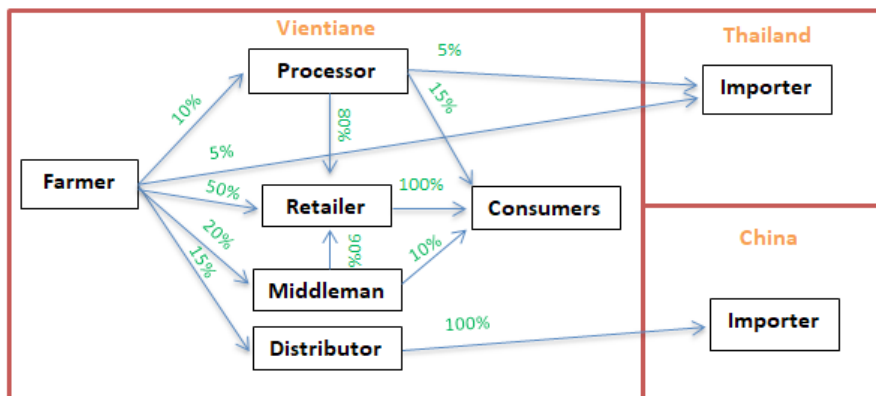


Figure 2. Mapping of value-chain in Vientiane Province.

Value Chain of Cultivated Bananas in Savannakhet

The value chain in Savannakhet Province comprises four key stakeholders: farmers, processors, distributors, and retailers. Farmers play a crucial role in collecting bananas from their farms and selling their products. On average, each household has a farm area of 3.26 hectares, with an average of 2.25 hectares dedicated to banana cultivation. The average total cost of banana production per household per year is 5 million LAK, while the total income from bananas amounts to 7.7 million LAK per household. This results in an approximate profit of 2.7 million LAK per household.

Processors in the province are engaged in producing various banana products, including banana crisps, solar-dried bananas, and dried flattened bananas, which is a unique product in Savannakhet Province. The production process for dried flattened bananas takes two days and requires two workers. On average, processors generate a monthly revenue of 8.4 million LAK, with an average cost of 5 million LAK, resulting in an approximate profit of 3.4 million LAK per household per month.

Distributors, in this case, are Vietnamese companies that purchase bananas from farmers in the Xepon district. They transport the bananas to the Danang seaport in Vietnam and subsequently ship them to China (See Figure 3).

The average profit for farmers is 334 LAK/kg or 32% of the profit margin. For middlemen, the average profit per kg is 542 LAKs or 31% profit margin. Processors have many products from cultivated bananas and those are ripe banana crisp, raw banana crisp, butter banana crisp, and dried flattened banana. The processor makes an average profit of 16,000 LAK/kg or 114% profit margin. The retailers who buy and sell banana products as a vendor make an average profit of 1,000 LAK/pack or a 33% profit

margin. Finally, distributors who are the final actor make 500 LAK average profits per kg or 20% profit margin.

Value-chain in Salavan Province

The value chain in Salavan Province involves six key stakeholders, namely middlemen, farmers, retailers, and exporters. Middlemen play a significant role in the value chain by purchasing bananas from farmers in both Savannakhet and Salavan Province. They then sell the bananas to retailers in Savannakhet and Salavan Province. Additionally, middlemen occasionally export products to Thailand. On average, middlemen generate a monthly revenue of 17 million LAK, with a cost of 11 million LAK, resulting in a profit of approximately 6 million LAK per month.

Farmers are responsible for collecting bananas from their farms and selling their products to middlemen and retailers in Salavan and Champasack Province. Each household, on average, possesses a farm area of 6.2 hectares, with an average of 1.9 hectares allocated for banana cultivation. The average total cost of banana production per household per month is 4 million LAK. However, the total income from bananas amounts to 0.8 million LAK per household per month, resulting in a profit of approximately 3.2 million LAK per household per month (See Figure 4).

Farmers in Salavan Province make an average profit of 1,040 LAK/kg or 84% profit margin. Middlemen who collect bananas from farmers make an average profit of 1,009 LAK/kg which creates a 50% profit margin. In Salavan, there are two main types of banana processors, solar-dried banana, and butter banana.

Processors make an average profit of 7,050 LAK/kg or a 34% profit margin. In addition, retailers in Salavan make a profit of 1,200 LAK/kg and create a 67% profit margin. Finally, distributors make a profit of 1,700 LAK/kg or a 94% profit margin. Overall, distributors make up the high-

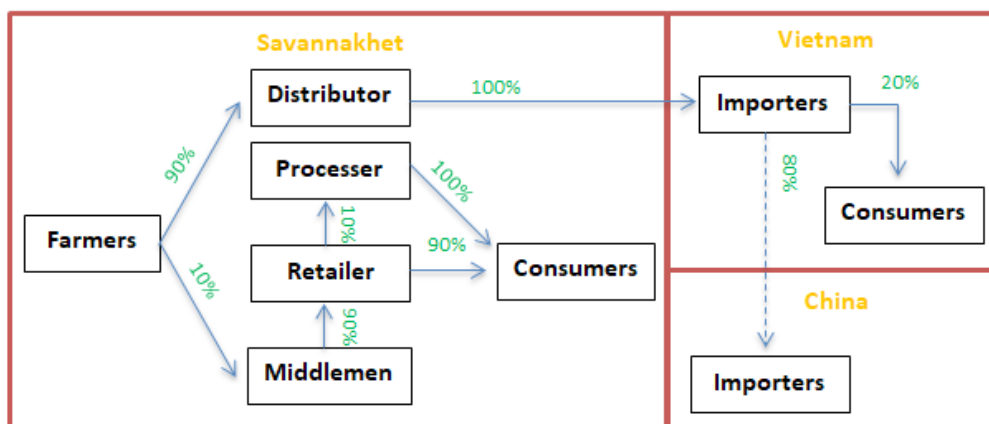


Figure 3. Mapping of value-chain in Savannakhet Province.

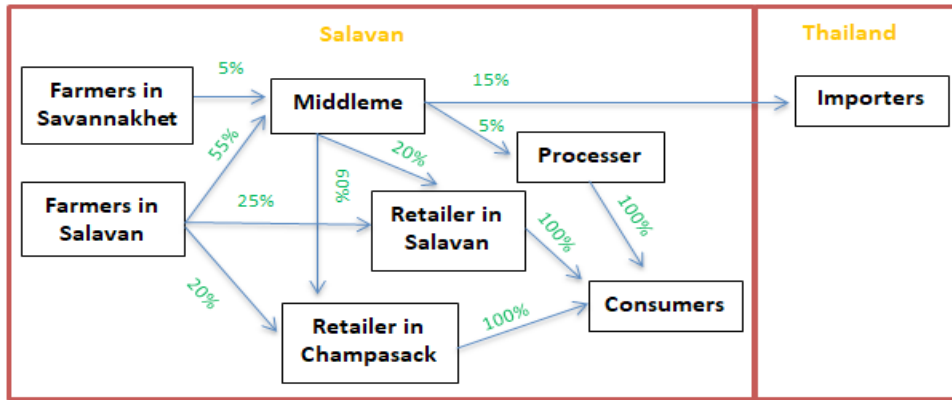


Figure 4. Mapping of value-chain in Salavan Province.

est percentage of profit margin.

3.2 Impact of Cultivated Bananas on Household Income

This section presents the regression results of factors affecting commercialization and the impact of commercialization on income. The summary statistics indicate that there are no outliers in the sample (See Table 3). The correlation matrix shows that there is no multicollinearity issue among the independent variables.

The model of factors affecting banana commercialization shows a very low goodness of fit 0.1049; however, the F-statistic is 11.457 > F-test is 2.78 which means the model is valid. Gender (*Gen*), the age of the head of household (*Age*), education (*Edu*) and distance to the farm

(*Df*) did not play any role in banana commercialization (Table 4). The distance to the market (*Dm*), experience (*Exp*) and the number of family members (*Mem*) positively and significantly influenced banana commercialization.

The second stage least squares model was used to examine the impact of commercialization on household incomes. The model shows acceptable goodness of fit. *Gen* and *Edu* are statistically significant at the 5% level. \hat{C} shows statistically significant at a 1% level. *lnK* and *lnS* land area are statistically significant at 0.1% level. However, *Age*, *Exp* and *P* are statistically insignificant. To ensure the validity of the analysis, various tests including an endogeneity test, instrument test, and over-identification restriction have been conducted. The results confirm the validity of the instrument variable used in the analysis.

Table 3. Summary of statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Commercial	475	0.82	0.10	0.2	0.95
Gender	475	1.24	0.43	1	2
Age	475	42.74	11.04	17	98
Education	475	9.13	2.19	5	16
Experience	475	11.13	7.77	1	40
Policy	475	0.35	0.48	0	1
Labor	475	3.78	2.20	1	25
Cultivated labor	475	2.88	1.30	1	11
Land	475	1.47	2.05	0	24
Capital	475	12,600,000	21,800,000	271,550	53,000,000
Income	475	28,900,000	45,600,000	1,000,000	200,000,000
Market access	475	0.69	0.46	0	1

Table 4. Regression results.

Variable	C	lnI
<i>Gen</i>	0.002 (0.21)	-0.161* (-2.18)
<i>Age</i>	4.76E-05 (0.10)	-0.004 (-1.84)
<i>Edu</i>	-0.002 (-0.83)	0.029* (2.10)
<i>Dm</i>	0.001*** (5.53)	
<i>Exp</i>	0.001* (2.10)	-0.004 (-0.86)
<i>Df</i>	0.003 (1.42)	
<i>Mem</i>	0.009** (2.91)	
<i>lnK</i>		0.259*** (6.65)
<i>lnL</i>		-0.114 (-1.52)
<i>lnS</i>		0.237*** (6.20)
\hat{C}		4.259** (2.80)
<i>P</i>		0.124 (1.85)
<i>D2</i>		0.564*** (3.95)
<i>D3</i>		0.372*** (3.42)
<i>D4</i>		-0.016 (-0.12)
Cons	0.697*** (13.90)	9.257*** (6.91)
R2	0.1049	0.5607
N	475	475

Note: t statistics in parentheses. * < 0.05, ** p < 0.01, *** p < 0.001.

4. Discussions

The value chain of cultivated bananas in four provinces has been significantly driven by the export market. Farmers generate the highest profit, but they receive the lowest distribution of value-added. They face several challenges, including disease and pests that lead to lower yields, limited financial knowledge among farmers for effective management of household income and expenses, and insufficient local market capacity to absorb the banana supply. Cultivated bananas provide a nutritious food source, particularly in areas with limited nutritional options. As organic bananas, there are opportunities to promote them in high-value markets driven by global health concerns.

Processors have the highest value-added potential in the banana value chain. They produce a variety of products from cultivated bananas, such as banana chips, dried bananas, and cakes. The local market has limited processed banana products, creating an opportunity to introduce new products. Processed banana products typically yield higher profit margins than raw bananas. However, processors face some challenges, such as a lack of marketing knowledge, limited product innovation and limited access to funds.

Distributors mainly export raw bananas to Vietnam, Thailand, and China, as demand for bananas has increased in recent years. However, transportation from farms to markets involves multiple inspections, and export procedures require various documents from government offices, resulting in high costs and administrative burdens. The implementation of the dry port in 2021 has further increased the cost and complexity of exporting.

The result of regression suggests that determinants of banana commercialization in Lao PDR include the distance from farm to market, experience, and number of household members. A study found that the coefficient of distance from farm to market (*Dm*) was positive and significant at the 0.1% level, which means that the farther the distance from farm to market, the higher the rate of commercialization. This is because land rent diminishes from the outward center city to offset both lower revenue and higher operating costs^[10]. In Laos, most banana farms are located far from the city (market) where the price of land is low. For example, most bananas in Salavan Province are sold in Champasack Province and exported to Thailand. In the same direction, most bananas produced in Vientiane Province are sold to Vientiane Capital.

Household experience and size are positively associated with the commercialization of bananas. The coefficient of household experience was positive and significant at the 5% level, indicating that an increase in one year of

experience leads to a higher commercialization ratio. This suggests that households with more experience in banana cultivation and marketing are more likely to sell a greater quantity of bananas. The coefficient of household size was also positive and significant at the 1% level, suggesting that larger household size is associated with a higher commercialization ratio. This may be because larger households have more labor available to help with banana cultivation and marketing, or because they have more financial resources to invest in banana production.

Banana commercialization can increase the income of farmers, but the impact is not equal for all farmers. A second-stage regression analysis found that gender, education, commercialization, capital, and land are the key factors that impact the income of farmers. The coefficient of gender was found to be negatively significant at the 5% level, indicating that households led by females had lower average incomes compared to households led by males. This could be attributed to factors such as divorce or widowhood, which may lead female-headed households to work harder to earn sufficient income.

Furthermore, the coefficient of education was positively significant at the 5% level, suggesting that higher levels of education were associated with higher household incomes. This finding aligns with previous studies such as Chialue et al. ^[11], Xangsaysane et al. ^[12] and Ha et al. ^[13] that have highlighted the role of education in providing access to information, knowledge, and techniques for increasing income.

The coefficient of predicted commercialization was found to be positive and significant at the 0.1% level, indicating that a 1% increase in banana commercialization resulted in an 8% increase in household income. Bananas were identified as the primary income source for households, and their sustainable income potential was supported by factors such as low production costs, high demand from neighboring countries, and environmentally friendly cultivation practices. The main variables in the income function, including capital and land, demonstrated positive and significant coefficients at the 0.1% level, consistent with production theory.

In contrast, the coefficient of labor was not statistically significant. This can be attributed to the fact that labor is primarily intensive during the plantation phase rather than cultivation. On average, two individuals working for three hours are sufficient to harvest one hectare of bananas.

The coefficient of the policy variable, indicating government support for farmers, was not significant, suggesting that there was no discernible impact of government policies on household income. Most farmers did not

receive support from the government of Laos, although some support was provided by organizations such as Japan International Cooperation Agency and The Agrobiodiversity Initiative.

Additionally, the coefficients of the dummy variables D2 and D3 were positive and significant at the 1% level, indicating that average household incomes in Vientiane and Savannakhet Provinces were higher than those in Houaphan Province. However, the coefficient of D4 was not significant, suggesting that the average income of households in Salavan Province did not differ significantly from that of households in Houaphan Province.

5. Conclusions

Numerous studies have raised concerns about the sustainability of Cavendish banana production, citing negative environmental, health, and social impacts despite increased income for farmers. This study analyzes the value chain of cultivated bananas and demonstrates that the commercialization of cultivated bananas can generate sustainable incomes for farmers. The findings reveal significant value-added for farmers, with processors earning the highest value-added but lacking marketing and financial knowledge. Key factors driving commercialization include market access, family members, and experience. The study confirms that the commercialization of bananas leads to increased household income, but questions arise about the long-term sustainability of banana production, particularly given the dependence on demand from neighboring countries.

To address these challenges and promote the sustainable development of cultivated bananas, the following policy implications are recommended:

Farmers should consider creating processed products such as banana cakes, chips, or candies during periods of excess supply or when supply exceeds demand. This approach reduces losses, enhances food security, and improves household nutrition.

Farmers often do not keep track of their income and expenses, which makes it difficult for them to manage their money. Training in basic financial accounting would be very beneficial for households.

The government can help farmers and producers by purchasing their products. For example, banana cake and candy can be used as snacks in schools, as well as during coffee breaks at meetings, seminars, and conferences.

The Ministry of Industry and Commerce (MOIC) should establish exchange programs for farmers and processors, providing training and facilitating the exchange of ideas to create new products. Effective marketing strat-

egies, including attractive packaging and design, can help stimulate sales of processed banana products.

To facilitate distributors, it is better to reduce the number of stops during transportation. This will reduce the cost of transportation for distributors and reduce the risk of damage to bananas during transport.

Villages should initiate activities to promote bananas, such as banana contests or award programs. This will help to raise awareness of bananas and increase demand for them.

Author Contributions

The first author as well as corresponding author Piya Wongpit took the lead in research design, analysis, interpretation as well as writing of the manuscript while co-authors Bounmy Inthakesone, Keuangkham Sisengnam, Pakaiphone Syphoxay support first author in the writing and analysis.

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Data Availability

The data are available upon request from the corresponding author.

Conflict of Interest

The authors disclosed that they do not have any conflict of interest.

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