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Agricultural inputs on rice yield: A case study of domestic rice production in Preah Vihear province, Cambodia

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Abstract: The key factors affecting domestic rice production in Preah Vihear Province, Cambodia, are investigated in this study. Cambodia's economy depends largely on rice, which is both a main food and a major export. It helps Cambodia's economy and food security. However, rice production is difficult due to lack of water, small farms, and geographical problems. Preah Vihear province is a key rice-producing region with hills and small farms. It helps increase income and sell rice to other countries with unique and famous rice seeds. To analyze the factors affecting domestic rice production in Preah Vihear, a statistical model known as ordinary least squares (OLS) will be used to examine the relationship between various input variables (costs) and rice yield. Data were gathered from a sample of 51 rice-farming households across five villages in Preah Vihear province. Additionally, both regression models indicated that herbicide costs were the most significant factor affecting rice yield, demonstrating high significance at the 5% level. This was closely followed by the price for renting rice harvesters and the total land area for rice production (ton). This study provides crucial information that can be used to develop targeted strategies to increase rice production and enhance the livelihoods of rural farmers. This will also empower stakeholders in the agricultural sector to propose campaigns that promote sustainable rice cultivation in local communities.

Keywords: agricultural inputs; agricultural economics; rice yield; domestic rice production; Preah Vihear; Cambodia

1. Introduction

Over the past two decades, Cambodia has achieved remarkable and sustainable economic growth at an average annual rate of 7%. The Royal Government of Cambodia (RGC) is committed to developing Cambodia to be a high-medium income country in 2030 and a high-income country in 2050. To make such progress, the government has been putting efforts into shifting Cambodia from an economy largely depending on traditional agriculture to a modern economy relying on industry, service, and precisely smart agriculture [1]. Despite the industry and service, agriculture has always been the backbone of Cambodia's economy [2,3]. Based on the Ministry of Agriculture, Forestry, and Fisheries (2021), the agricultural sector contributed 24.4% of Cambodia's GDP, while the service and industry sectors contributed 37% and 38.5%, respectively. However, it is the fact that the agricultural sector lowered the contribution to the country's GDP from 24.9%

to 24.4% between 2017 and 2022 [2]. Likewise, the economy is predicted to have a slow recovery, primarily due to the decrease in real estate investment. Although agriculture has shown positive growth, it still faces difficulties that need careful consideration and strategic planning to maintain its progress [4].

The socio-geographic zones in Cambodia are distributed into four main areas, including the Plain Zone, Tonle Sap Lake Zone, the Plateau Zone, and the Coastal Zone, where agriculture holdings represent 43%, 35%, 15%, and 7%, respectively [5,6]. Often referred to as the organic province in Cambodia [7–9], Preah Vihear is in the northern plateau province of Cambodia with a population of 254,827 [10], in which over 80% of the people depend on agriculture, mainly growing rice, which covers the cultivated land of about 70,000 hectares, according to the Cambodia Socio-Economic Survey [11]. The same report mentioned over 2510 thousand households, or 61.2%, planted cereal harvested for grain. It was also found cost production of 13.4% on planting material, 29.2% on chemical fertilizers, pesticides, weedicides, and fungicides, 8.7% on payment for hired draft power, 28.7% on other hired labor charges, and 19.9% on other costs. In the plateau area of Cambodia, including Preah Vihear Province, cultivated 1135 thousand tones in wet season and 78 thousand tones in wet season [5,6].

Preah Vihear is a mountainous province in northern Cambodia, near the borders of Thailand and Laos. It's known for its beautiful scenery, such as the Dangrek Mountains. The province is also home to the famous Preah Vihear Temple, a UNESCO World Heritage site located on a cliff edge [12]. Additionally, The Preah Vihear Temple is a stunning Khmer temple with multiple interconnected sanctuaries arranged in a line. It is famous for its unique architectural style, elaborate decorations, and beautiful natural surroundings [13]. It is undoubtedly one of Southeast Asia's amazing temples and one of the greatest accomplishments of Khmer architecture. Visitors may discover incredible landscapes and live like a true rural Cambodian while the country is still largely undeveloped. Besides, a significant rice-producing area in northern Cambodia is Preah Vihear province as well. While Preah Vihear is an agricultural hub, particularly for rice production, it faces common challenges faced by many such regions. To overcome these hurdles and seize new opportunities, over 4300 small-scale rice farmers, including a significant number of women, have formed 25 cooperatives. This collective effort has resulted in the creation of a unique brand for their rice, with the goal of increasing their income and expanding their market beyond Cambodia [14].

The province of Preah Vihear features a landscape characterized by hilly and plateau-like terrain with over 29,200 hectares of farming land. The vast majority of farms are medium-sized, ranging in size from 1 to 4 hectares, with an average farm size of only 2.7 hectares. Agriculture is the main driver of the province's economy, contributing to 85% of its total economic activity. Rice, cassava, soybeans, cashews, and various vegetables are the primary crops grown in the region. Rice and cassava are particularly important, with large, cultivated areas and significant production volumes. Despite the province's agricultural productivity, a considerable portion of the population lives in poverty, with a poverty rate of 19.4% [15]. **Figure 1** reflects the rice harvesting process in a rice field in Preah Vihear, Cambodia. Across the huge area of rice fields, golden bundles of harvested rice stalks can be observed swaying in the breeze.



Figure 1. Rice harvesting in Preah Vihear rice field.

Source: Authors, 2024.

Rice production in Preah Vihear Province, Cambodia, is a crucial aspect of the country's agricultural sector. Understanding the factors that affect the domestic rice production output is essential for improving the productivity and income of local farmers. This study aims to analyze the key factors affecting domestic rice production output in Preah Vihear Province using an Ordinary Least Squares (OLS) regression model [16]. The outcomes of the study will be beneficial to farmers, public servants, and agricultural sector stakeholders. This rich data will help in developing specific strategies to enhance domestic rice production and the quality of life for the local population.

2. Methodology

2.1. Data sources and descriptions

Table 1 refers to the descriptive data of the rice yield, which farmers cultivated per season. Six variables were used to conduct the study: labor costs for rice harvest (T_{labor}), transportation costs (T_{transpor}), herbicide prices (T_{weedcid}), price for renting rice harvesters (Tri_{haRen}), land preparation costs (T_{landRiLi}), and price of rice in riel per ton (Tri_{priTon}). The labor costs for rice harvest (T_{labor}) refers to the costs related to labor when harvesting the rice, except the rice harvester. In addition,

transportation costs (T_transpor) refer to all the expenses related to transportation from the production to the harvest stage, while herbicide prices (T_weedcid) represent the costs of herbicide used in rice production throughout the season, and the price for renting a rice harvester (Tri_haRen) means the expense of hiring rice harvesters. The costs to prepare land for rice production are illustrated as land preparation costs (T_landRiLi). The last variable is the price of rice in riel per ton (Tri_priTon), referring to the price of the rice per ton when the farmers sold after the harvest.

The descriptive data summarized input variables (costs) related to rice cultivation from the planting stage to the harvesting stage and output (income) data. According to **Table 1**, the cost to hire rice harvesters significantly represented 763,000 Cambodian Riels (approx. 190.81 USD), which was the highest cost compared to the other categories, followed by the cost of herbicide and the labor cost representing 140,000 Cambodian Riels (approx. 35 USD) and 138,000 Cambodian (approx. 34.69 USD), respectively. The cost of land preparation was 27,000 Cambodian Riels (approx. 6.86 USD), followed by the cost of transportation of 11,000 Cambodian Riels (approx. 2.97 USD), which is the lowest cost category. The farmers harvested 1.63 tons of rice per hectare, or 4.67 tons of the total rice yield per season, on 3.10-hectare rice fields. They earned around 1,171,000 Cambodian Riels (approx. 292.94 USD) by selling rice per ton.

Table 1. Descriptive rice yield with the value of input variables.

Variable	Definition	Value		Group	Obs.	Rice Yield (T/Ha)	Total Yield (T)	Total Land (Ha)
		*1000 Riels	USD					
T_labor	Labor Costs for Rice Harvest	138.74	34.69	> 138.74	20	1.65	5.65	3.70
				≤ 138.74	31	1.81	3.55	2.32
T_transpor	Transportation Costs	11.86	2.97	> 11.86	13	1.38	5.69	4.31
				≤ 11.86	39	1.87	3.92	2.37
T_weedcid	Herbicide Prices	140.00	35.00	> 140	25	1.48	5.88	4.16
				≤ 140	26	2.00	2.92	1.62
TRi_harRen	Price for Renting Rice Harvesters	763.23	190.81	> 763.23	21	1.52	6.14	4.19
				≤ 763.23	30	1.90	3.13	1.93
T_lanRiLi	Land Preparation Costs	27.44	6.86	> 27.44	24	1.67	5.25	3.46
				≤ 27.44	27	1.81	3.59	2.33
TRi_priTon	Price of Rice (Riel per Ton)	1171.7	292.94	> 1171.7	30	1.63	4.67	3.10
				≤ 1171.7	21	1.90	3.95	2.52

Note: The riel is the currency of Cambodia.

2.2. Data collection and research area

Based on **Table 2**, the research used a quantitative approach to collect data. Structured questionnaires were distributed to around 51 rice-farming households in five villages of Preah Vihear province, Cambodia. For the survey, rice farmers were selected using the purposive sample method.

Direct observation was the initial approach to understanding the target area. This method was used to gather information about the overall conditions, including the population, agriculture, and farming systems. By observing the living conditions and

modern rice cultivation practices, researchers were able to determine the specific agricultural methods used in the ecological area. Furthermore, direct observation allowed for comparisons between different villages to identify variations in their cultivating circumstances.

Table 2. Sample sizes for Preah Vihear province.

Province	District	Commune	Village	Purposive Sample with Domestic Rice Households in Non-Random Sampling Selection		
				H.H Population	H.H Sample	% Sample
Preah Vihear	Rovieng	Reaksa	Doun Ma	270	20	39
			Samraong	39	7	14
			Rumdaoh	54	12	24
			Preal	119	6	12
			Sanlung Chey	67	6	12
01 Province	01 District	01 Commune	05 Villages	549	51	100

The researchers interviewed key local officials, including the chief of district, commune, and village, to gather information about the equipment used in farming, the total amount of land used for rice cultivation, and their interactions with middlemen who provide information about prices and market demand.

The study used face-to-face interviews through the survey-structured with rice farmers in Preah Vihear province to gather information about their farming practices and costs. The data collected included aspects of labor cost for rice harvesting, transportation costs, herbicide costs, price for renting rice harvester, land preparation costs, rice price (Riel per ton), and total land area for rice production (ton). The additional study analyzed this data using statistical methods, specifically OLS and stepwise regression, to determine how agricultural inputs affect rice yield and domestic rice production in Preah Vihear province, Cambodia. The analysis aimed to identify the findings of tendencies that might guide the area's future practices in agriculture.

2.3. Data analysis process

The statistical analysis for this study was carried out using STATA software [17,18] to investigate the relationship between the inputs that affect rice yield, and other various factors. OLS regression was used to estimate how these factors were affecting rice yield. Stepwise regression, a method for selecting important variables, was used to identify the most significant predictors of domestic rice production from a larger pool of potential factors, making the model more efficient and easier to understand [19–21].

The collected data was initially categorized and organized using Microsoft Excel. Subsequently, it was transferred to STATA for data cleaning and the execution of statistical analyses, including regression. By using STATA, several regression models were applied to analyze (*Outputtotal*) considering all the different input factors associated with domestic rice production.

2.4. Model description

This equation indicates the production cost and how each factor contributes to the rice yield of rice production as the dependent variable. The following **Table 3** and developed model clearly convey the economic results [22–24].

$$\text{Outputtotal} = \beta_0 + \beta_1 \ln T_{\text{labor}} + \beta_2 \ln T_{\text{transpor}} + \beta_3 \ln T_{\text{weedcid}} + \beta_4 \ln T_{\text{Ri_harRen}} + \beta_5 T_{\text{lanRiLi}} + \beta_6 \ln T_{\text{Ri_priTon}} + \beta_7 \ln \text{landtotal} + \epsilon_i$$

where: β_0 is the intercept;

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_6, \beta_7$, are the coefficients for each independent variable;

ϵ_i represents the error term.

Table 3. Logarithmic variables, acronyms, and definitions.

Variable	Definition
lnT_labor	The Logarithm of Labor Cost for Rice Harvesting
lnT_transpor	The Logarithm of Transportation Costs
lnT_weedcid	The Logarithm of Herbicide Costs
lnTRi_harRen	The Logarithm of Price for Renting Rice Harvesters
lnT_lanRiLi	The Logarithm of Land Preparation Costs
lnTRi_priTon	The Logarithm of Rice Price (Riel per ton)
Inland_total	The Logarithm of Total Land Area for Rice Production (Ton)

3. Results and discussion

The study employed both ordinary least squares (OLS) and stepwise regression analyses to analyze significantly statistical relationships between input (cost) variables that affect rice yield. Through the transformation of all numerical data into values in **Table 4**, the study offered a thorough examination of the variables by using the asterisks to highlight statistical significance for the coefficient values. Remarkably, the results of both the OLS regression and stepwise significantly demonstrated the herbicide costs (lnT_weedcid) were the most influencing factor affecting the rice yield with a 5% level, compared to a similar finding in the previous research by Sary et al. [2]. In this situation, rice farmers may decide to apply herbicides less frequently or in smaller quantities to save cost when the costs increase in size. Herbicide consumption can be reduced by using alternative weed control methods like crop rotation or human weeding. Reducing the need for herbicides can be achieved by selecting rice types that are more tolerant of weeds [25,26]. The transportation costs (T_transpor), which is the second most affecting factor at 10%. The price of inputs consisting of seeds, fertilizer, and pesticides could increase due to higher transportation costs, which lowers a farmer’s profit margin [27,28]. This might result in less of these inputs being used, which would have an affect on rice yield and quality. Also, rice farmers may find it challenging to sell their produce at prices that are competitive due to limited market access caused by high transportation expenses [29,30]. This may lessen the farmers’ motivation to spend more on improved farming methods or higher-yielding varieties. Furthermore, the total land area for rice production (Inland_total) obtained a positive coefficient as well. This result is likely a result of Sokvibol et al. [31], where the

significance level was also placed at 1%. In several similar study by Jourdain et al., Yu and Diao, and Smith and Hornbuckle [32–34], and the Asian Development Bank [35–37], farmers who cultivated additional lands could maintain reasonable levels of the necessary inputs. The final variable of the price for renting rice harvesters (lnTRi_harRen) was also found to be one of the affecting factors of the rice yield. This affect highlighted the significance of delayed harvesting, like rice losses from overripening, animal harm, or bad weather that can result if a farmer is unable to pay for a harvester when the rice is ripe [38]. Beyond that, rice farmers' capacity to spend on equipment may be limited by higher renting rice harvesters, particularly for smaller-scale farmers. Notably, hiring labor costs were shown to be significant at the 10% level based on the study conducted by Sary et al. [35].

Table 4. The regression results of rice yield as dependence variable for rice production function.

Variable	Mean	OLS Model			Stepwise Model		
		Coeff.	T-statistic	P-value	Coeff.	T-statistic	P-value
lnT_labor	12.36	0.252	1.01	0.329	-	-	-
lnT_transpor	9.09	0.286*	1.95	0.069	0.264*	2.01	0.06
lnT_weedcid	11.65	-4.816**	-2.34	0.032	-4.417**	-2.40	0.03
lnTRi_harRen	13.78	0.567*	1.69	0.111	0.650**	2.09	0.05
lnT_lanRiLi	10.74	-0.189	-0.76	0.456	-	-	-
lnTRi_priTon	13.97	-0.906	-0.45	0.657	-	-	-
Inland_total	0.88	3.683*	1.78	0.095	3.188*	1.72	0.10
cons		54.87	1.59	0.131	38.16	1.92	0.07
No.of obs.		24			24		
Prob > F		0.073			0.013		
R-squared		0.508			0.470		
Adj R-squared		0.293			0.359		
Root MSE		0.339			0.323		

Note: *10% Significance Level; **5% Significance Level; ***1% Significance Level.

4. Conclusions and recommendations

This study emphasizes the key factors affecting domestic rice production in Preah Vihear Province, Cambodia. It examines the significant variables and explores the reasons behind these influences. The OLS regression model fundamentally provides a robust framework for analyzing these factors and identifying areas for improvement. The findings revealed that herbicide costs were the most significant factor affecting the rice yield from both regression models analysis, compared to a similar finding in the previous research. It also highlighted the crucial aspect of Cambodia's agricultural sector, like common challenges in the region as well. In summary, the study offered valuable insights to rice farmers in Preah Vihear Province, equipping them to design techniques for increasing rice yield, improving profits, and promoting the socioeconomic growth of the area. To mitigate the significant challenges affecting domestic rice production, rice farmers in Preah Vihear province should consider implementing strategies to enhance land area, labor, fertilizer, seed, and machinery

usage. Local farmers can increase their rice yields and improve their livelihood with the following five recommendations:

Firstly, investing in agricultural machinery would provide access to modern agricultural machinery that can improve efficiency and timeliness of operations, leading to higher yields. The rice farmers should invest in more modern agricultural machinery. Multiple benefits provided by modern agricultural machinery may significantly improve farming operations' productivity, sustainability, and efficiency. Rice farmers can reduce their environmental impact while fulfilling the increasing demand for food by adopting these innovations. Secondly, ensuring proper fertilizer application is crucial for preserving the health of rice crops, increasing rice production, and saving the environment. Moreover, it can support healthy and strong root systems, which help plants absorb water and nutrients more effectively and enhance crop growth by preserving soil fertility. Thirdly, improving seed quality is key to producing profitable rice crops. It can result in a more related canopy, improved use of resources, and a significant rise in yields and health of the rice crop. To reduce the need for herbicides, many quality seed types have also been created to be resistant to particular diseases and pests. Fourthly, increasing labor efficiency through training and mechanization can significantly boost rice yields, benefiting both individual farmers and the agricultural sector as a whole. Efficient labor practices can lead to higher yields per unit of land, increasing farmers' revenue and reducing their environmental footprint. Lastly, expanding cultivated land generally helps encourage farmers to expand their cultivated land area, which can increase total rice output. The increase in rice cultivation can enhance food security by boosting production, creating jobs in related industries, and generating foreign exchange through exports. This has the potential to significantly boost both Preah Vihear Province's and Cambodia's entire economic growth.

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Abbreviations

Approx.	Approximately
H.H	Household
Ha	Hectare
OLS	Ordinary Least Squares
Riels (KHR)	The official currency of Cambodia
T	Tone
USD (US Dollar)	The currency of the United States

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