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Factors Affecting the Rice Yield During the Rainy Season Among Farmers in Southeastern Cambodia

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Abstract

A research study utilized the Cobb-Douglas production function to examine the elements influencing paddy production during the wet season in three rural provinces of Cambodia. This analysis was based on data gathered from a survey of farmers' households conducted in 2022. The study discovered that the use of fertilizers and herbicides, the size of the family, and income from off-farm sources significantly impacted the output of wet-season paddy. A one percent increase in the use of fertilizer, herbicide, and family size resulted in an increase in rice output by 0.06 percent, 0.04 percent, and 0.05 percent respectively. Furthermore, a one percent increase in the age of the household head, hired labor, and off-farm income led to an increase in rice yield by 0.08 percent, 0.11 percent, and 0.05 percent respectively. The use of seeds, pesticides, household labor, and the education level of the household heads were found to enhance rice yields in southeastern Cambodia. However, these production relationships varied significantly across different regions. The study concluded that higher yields during the rainy season improved the effectiveness of paddy production, primarily due to the increased responsiveness to fertilizer application.

Keywords: rice production, farmers in south-eastern, Cobb-Douglas production function

1. Introduction

The world's population is expected to reach 9 billion by 2050, up from 6.1 billion in 2000 (FAOSTA, 2015). This rapid increase puts a lot of pressure on food supply and food security, requiring a better understanding of agricultural growth and productivity to meet the growing demand for food. However, agriculture is especially sensitive to the impacts of climate change, making it more vulnerable than other sectors. Climate change could reduce crop yields by more than 25 percent (Sokvibol et al., 2016). Agriculture is the backbone of Cambodia's economy. Most Cambodians live in rural areas and depend largely on subsistence farming for their livelihoods. The government has implemented several reforms in recent years to improve the efficiency and effectiveness of its extension and advisory services (Samoeurn & Suresh, 2018). The agricultural sector contributed 24.4% of the country's GDP in 2022, while the services and industries sectors contributed 37% and 38.5%, respectively. The reason for the lower contribution of the agricultural sector is the growth of the other two major economic sectors, namely industry and services. It is important to note that between 2017 and 2021, the contribution of the agricultural sector decreased from 24.9% to 24.4%, mainly due to the rapid growth of the industry, construction, and service sectors (MAFF, 2021). Rice production is a key component of Cambodia's agricultural sector and plays a crucial role in driving national economic growth, earning it the nickname "white gold" among the Cambodian people (Sokvibol et al., 2016). The Royal Government's strong support, along with the active participation of farmers, has been instrumental in increasing rice production. A notable change has been observed among Cambodian farmers, who have shifted from subsistence farming to commercially oriented production in response to better market demand and higher prices. Wet rice production dominates Cambodian rice production, accounting for 80% of the total rice population and occupying approximately 85% of the harvested land area. Wet-season rice depends heavily on rainfall due to limited irrigation capabilities. Farmers usually start rice production in May and continue harvesting until December or later, depending on the rice variety. The Ministry of Agriculture, Forestry, and Fisheries classified the wet season into five types in 2015: early, medium, late, upland, and floating rice, based on the cultivation-to-harvest timeframe and topographical conditions. Early rice varieties generally have a shorter growing period than medium rice varieties, while late rice varieties require the longest time to mature. Floating rice is typically cultivated in flooded areas surrounding the Tonle Sap Lake and the Mekong River, while upland rice is commonly grown in mountainous regions of the Plateau/Mountain area (Rido 2015). This study aims to analyse the factors influencing rice yield during the wet season among farmers and explore its potential as a policy tool for rural development. The study focuses on farming households operating in the southeastern region of Cambodia, encompassing Takeo, Kandal, and Kampong Speu provinces. The insights gained from this study are intended to benefit both farmers and policymakers, guiding efforts to enhance Cambodian rice production. The rest of this paper is organized into five sections: introduction, research methodology, data and description, results and discussion, and conclusion.

2. Method

2.1 Empirical Model

The study made use of the Cobb-Douglas production function, with the aid of STATA software, to identify the significant factors influencing the input in wet season rice. The Cobb-Douglas function, a widely accepted model for illustrating the relationship between input and output, was originally proposed by Knut Wicksell (1851-1926) and later validated through statistical evidence by Charles Cobb and Paul Douglas (Coelli et al., 1997 as cited Nhat & Tansuchat, 2015).

Several researchers have conducted studies in this field. For example, Pisedh et al. (2011) investigated the challenges of dry season rice production under the irrigation scheme of Tapeing Thmor Water reservoir. Yu and Fan (2009) examined rice production response in Cambodia, while Tun and Kang (2015) analyzed the factors affecting rice production efficiency in Myanmar. Ahmed et al. (2017) conducted a comparative study on factors influencing rice yield in Niger State of Nigeria and Hainan of China, and Koirala et al. (2014) researched the determinant of rice productivity and technical efficiency in the Philippines.

Furthermore, Sokbibol et al. (2017) compared Cambodian rice production technical efficiency at the national and household level. Rido (2014) studied factors affecting the cost efficiency of Cambodian rice farming households, and Sokchea and Richard (2013) researched ways to improve rice productivity and farmers' income in Cambodia. Rada et al. (2016) studied the profit efficiency of rice farmers in Cambodia. Rohmad and Praptiningsih (2016) analyzed the efficiency of production factors utilization in upland rice farming, and Hossain and Majumder (2015) measured the efficiency of the Cobb-Douglas production function with additive and multiplicative errors.

Despite extensive research in this field, no study has specifically focused on the factors affecting rice yield in the wet season. Therefore, this study aims to fill this gap and contribute to increasing rice production in Cambodian farming. In the study, the Cobb-Douglas production function was applied as follows:

$$Y = AK^{\beta1}L^{\beta2} \tag{1}$$

where,

Y = the total output; L = labor input; K = capital input; A = is constant; β1 and β2 are the coefficients to be estimated for labor and capital, respectively.

Equation (1) is nearly always treated as a linear relationship by making a logarithm transformation, which yields:

$$\ln Y = \ln A + \beta_1 \ln K + \beta_2 \ln L \tag{2}$$

According to Equation (2) with independent variables L and K to *i* become:

$$\ln Y = \beta_0 + \beta_1 \ln K + \beta_2 \ln L + \dots + \beta_i \ln X_i \tag{3}$$

And decoding Equation (3) according to this study we have:

$$\ln Y = \beta_0 + \beta_1 \text{lnseed} + \beta_2 \text{lnfert} + \beta_3 \text{lnpest} + \beta_4 \text{lnweed} + \beta_5 \text{lnhom} + \beta_6 \text{lnhired} + \beta_7 \text{lnage} + \beta_8 \text{lnfamily} + \beta_9 \text{lnedu} + \beta_{10} \text{lnincome} + \varepsilon_i \tag{4}$$

where,

lnseed: logarithm of seed; lnfert: logarithm of fertilizer; lnpest: logarithm of pesticide; lnweed: logarithm of weedicide; lnhom: logarithm of household labor; lnhired: logarithm of hired labor; lnage: logarithm of the age of household head; lnfamily: logarithm of family size; lnedu: logarithm of education of household head; lnincome: logarithm of income off-farm job.

The coefficient β_1, β_2, β_3, … β_i are the elasticity yield to input L, K,… and *i*. The sum of elasticity $\beta_1 + \beta_2 + \beta_3 + \ldots + \beta_i$ provides the returns to scale of the farms in question. It means if: $\beta_1 + \beta_2 + \beta_3 + \ldots + \beta_i = 1$, the production operates under constant returns to scale.

$\beta_1 + \beta_2 + \beta_3 + \ldots + \beta_i > 1$, the production operates under increasing returns to scale.

$\beta_1 + \beta_2 + \beta_3 + \ldots + \beta_i < 1$, the production operates under decreasing returns to scale.

2.2 Data Description

This study involved the examination of data collected from a household survey carried out in 2022 across three provinces in Cambodia. A total of 240 farmer households were selected for the study using a random sampling technique. The data collection process was spearheaded by the authors, who were assisted by postgraduate students from AII-CAAS and graduate students from the National Polytechnics Institute of Cambodia (NPIC). The data collected covered various aspects of rural farmers, including household conditions, farming income, daily expenditure, inputs for rice production, and information on agricultural technology. To facilitate face-to-face interviews with household farmers and stakeholders, the authors reached out to local authorities, such as the chief of wards and chief of communes. The inputs for wet season rice included seeds, pesticides, herbicides, fertilizer, irrigation, household labor, hired labor, and transportation, among others. The increase in rice inputs positively impacted wet-season rice production, leading to a yield increase of about 7.637 million tons and 2.315 million tons for dry-season rice production in 2016. This surge in rice production was largely attributed to the support provided by the Royal Government of Cambodia, relevant ministries and institutions, development partners, national and international organizations, sub-national authorities, and the participation of farmers.

To reduce bias in sample selection, the study only included farming households, while mixed farmers, paddy producers, and other crops were excluded from the data analysis. Data modification and filtering were carried out to ensure that the unit of measure of each variable was consistent with the academic goals and that the data quality was satisfactory.

3. Results and Discussion

3.1 Statistical Summary

The statistical summary of variables in rice inputs and rice yield was estimated using multiple regression analysis. Table 1 includes variables such as seeds, pesticides, weedicides, fertilizer, household labor, and hired labor. Household characteristics such as the age of the family head, education level of the household head, family size, and off-farm income of the household head were also considered.

The table displays the average, standard deviation, minimum, and maximum value of each variable. On average, the output of wet rice was about 1.7 tons, with a minimum and maximum of approximately one ton and 2.5 tons, respectively. According to MAFF (2015), the rice yield in the wet season was around 3.21 tons per hectare, which is larger than the result of this study. This discrepancy could be because the MAFF report covered the whole country, while this study focused only on three provinces.

Farmers used an average of about 175 kg/ha of variety in the wet season, with a minimum and maximum of approximately 42 kg/ha and 400 kg/ha, respectively. According to the Cambodian Agriculture Value Chain Program CAVAC (2016), farmers typically used an average of 134 kg for wet season varieties, or up to 400 kg/ha. Furthermore, Sothy et al. (2017) showed that dry-season rice varieties required 322.1 kg, while wet-season varieties required 122.2 kg.

Table 1. The statistical Summary inputs of the wet rice per hectare

Variables	Units	Obs	Mean	Std. Dev.	Min	Max
Rice outputs	Kg/ha	240	1,699	274	1,000	2,500
Seed	Kg/ha	240	175	88	42	400
Pesticides	ml/ha	240	2,149	1,012	500	6,600
Weedicides	ml/ha	240	1,184	659	480	3,500
Fertilizer	Kg/ha	240	201	71	100	450
Household labor	person/ha	240	8	3	3	17
Hired labor	person/ha	240	7	2	1	13
Age_HHhead	year	240	49	12	22	88
Education_HHhead	level (0-5)	240	2	1	0	5
Family size	person	240	5	1	2	9
Income off-farm	KHR/ha	240	2,886	2,897	-	4,000

The study utilized multiple regression analysis to estimate the variables in rice inputs and rice yield. The average application of pesticide was approximately 2,149 ml/ha, with a range of about 500 to 6,600 ml/ha for the wet season rice. The average application of weedicide was roughly 1,184 ml/ha, with a range of around 480 to 3,500 ml/ha. When compared, the average usage of pesticides and weedicides in the wet season was lower than that applied in the dry season rice.

The average application of fertilizer was around 201 kg/ha, with a range of about 100 kg to 450 kg/ha. Our results showed that farmers used more fertilizer compared to the research of Dary et al. (2016), which revealed that farmers apply about 153 kg/ha of chemical fertilizer for dry season rice, while only 66 kg/ha in the wet season.

During the study period, the average household labor was nearly 8 people per hectare, with a range of about 3 to 17 people. Sok Vibol et al. (2016) demonstrated that the average adult working day per year of family members was around 108 days in 2013, increased to 110.5 days in 2014, and then decreased by 106.7 days in 2015.

The statistics summary revealed that the average age of the household's head was 49 years old, ranging from 22 to 88 years old. The average education level was 2, implying that most of the farmers' household heads obtained education at primary school (grades 1-6 in the Cambodian education system). The results also displayed that the average family size of peasant households in Takeo, Kampong Speu, and Kandal is around 5 persons per household, ranging from 2 to 9 persons per household. The average income from the off-farm job is approximately 2,886 thousand riels, with a maximum of 4,000 thousand riels. Based on research, farmers with small land cultivated l are not able to support family members throughout the year. Consequently, most farmers take different actions to generate income to support their household family. It is not just farming activities. The peasants find various works to increase their household income.

3.2 The Estimated Parameters of Rice in the Wet Season

Table 2 shows that all estimated parameters of the variables align with expectations. Fertilizer had a positive coefficient and was significant at the one percent level. Weedicides, irrigation systems, family size, and off-farm income also had positive coefficients but were significant at the five percent level. Hired labor and the age of the household head were significant at the ten percent level.

The seed input had a negative coefficient but was significant at the ten percent level, implying a contrasting relationship between varieties and rice output during the research period. The study also showed no significant correlation between pesticide input and wet-season paddy output. Similarly, the education level of the household head had a negative coefficient and showed no significance at any level, indicating no correlation between the education of the household head and rice yield during the study.

The Cobb-Douglas production function was used to estimate the parameters of inputs affecting the wet season paddy. The results showed that increasing the quantity used of fertilizer, weedicides, hired household labor, age of the household head, and off-farm income could lead to an increase in household farming rice output.

For instance, a one percent increase in the input of seed would decrease the rice yield of the wet season by approximately 0.07 percent. A one percent increase in the input of weedicides will increase the rice yield by about 0.04 percent. The rice yield will increase by approximately 0.06 percent if there is a one percent increase in the input of fertilizer. A one percent increase in the input of hired labor will increase the rice output by about

0.11 percent. An increase of one percent in the input of the age of the household head will increase the rice output by roughly 0.08 percent. A one percent increase in family size would result in a 0.05 percent increase in wet paddy production. The rice output will increase by approximately 0.05 percent if there is a one percent increase in off-farm job income.

Table 2. The parameter of Cobb-Douglas for wet-season paddy

Variable		Coefficient	Standard Error	t-ratio	P > t
Constants	β_0	6.5708	0.5095	12.9000	0.000***
lnseed	β_1	-0.0720	0.0394	-1.8300	0.074*
lnpesticides	β_2	-0.0281	0.0585	-0.4800	0.633
lnherbicides	β_3	0.0434	0.0845	4.5100	0.031**
lnfertilizer	β_4	0.0587	0.0865	8.6800	0.002***
lnhousehold_labor	β_5	-0.0503	0.0778	-0.6500	0.521
lnhired_labor	β_6	0.1114	0.0724	1.5400	0.053*
lnage_household_head	β_7	0.0797	0.0677	1.1800	0.065*
lnfamily_size	β_8	0.0485	0.0601	2.8100	0.024**
lneducation	β_9	-0.0248	0.0436	-0.5700	0.571
lnincome_off	β_{10}	0.0469	0.0196	4.3600	0.024**
Prob > F	= 0.0355				
R-squared	= 0.3284				
Adj R-squared	= 0.1745				
Root MSE	= 0.1386				

Note. ***, ** and * indicate significance at 1%, 5% and 10% respectively.

The majority of Cambodian farmers can grow rice just once a year due to insufficient irrigation and effective water management practices. The rainy season is the primary period for rice cultivation, accounting for 80 percent of the total crop. Irrigation facilities are primarily utilized for the dry season rice and to supplement the wet season paddy if necessary (Smith & Hombuckle, 2013). Yu and Diao (2011) argued that Cambodia has tremendous potential to boost rice production given its abundant agricultural land and water resources. If the rice fields are irrigated, production will increase.

Regarding fertilizer application, Yu and Fan (2009) demonstrated that the percentage of farming households using fertilizers rose for both seasons of rice production. On average, about 78 percent of rice in the wet season plots used fertilizers, and this percentage increased to 88 percent in 2007.

In summary, the use of fertilizer has the most significant impact on paddy rice production, followed by herbicides, household size, non-farm income, seed, hired labor force, and the age of the household head. The production of wet-season rice is affected when farmers use higher volumes of these inputs.

4. Conclusions

The findings above indicate that factors such as fertilizers, herbicides, family size, and off-farm job income significantly influence the output of wet-season paddy. A one percent uptick in the use of fertilizers, herbicides, and family size could enhance rice production by 0.06, 0.04, and 0.05 percent respectively. Similarly, a one percent rise in the age of the household head, hired labor, and off-farm job income could boost rice yield by 0.08, 0.11, and 0.05 percent respectively. Elements like seeds, pesticides, household labor, and the education level of the household head also contribute to rice production in Cambodia, although the relationships vary by region. Simulations show that high yields in the rainy season, even when doubled due to high fertilizer responsiveness, enhance the efficiency of paddy production.

These insights have significant implications for boosting rice production in Cambodia. Farmers stand to gain the most from improvements in agricultural productivity and technology. Cambodian farmers need to concentrate on the agricultural sector to drive growth in rice production and alleviate poverty in rural areas. Given that most of Cambodia's poor reside in rural areas and depend on agriculture, high agricultural growth will ensure food security by increasing supply, reducing prices, and raising the incomes of poorer farm households. To facilitate this response and achieve food security, agriculture, which has been neglected, has been included on the political agenda.

Firstly, there is considerable potential for enhancing rice production in Cambodia. If appropriate resources (like fertilizer and irrigation) and infrastructure (like electricity markets, agricultural extension, and education) are provided, it is possible to elevate Cambodian rice output to match that of its neighboring countries. Given the high awareness of fertilizer, farmers could significantly increase their yield and revenue from more market sales.

Secondly, the introduction of advanced technologies and crop diversification should be tailored to local conditions. However, poor road and market conditions hinder local producers from capitalizing on the comparative advantage of rice production. Greater investment in infrastructure would enable farmers to access the latest market information and transport their produce to Phnom Penh and other regional markets. Investments in rural roads have been shown to yield high returns in terms of poverty reduction in developing countries. Improving rural roads will enable rural people to access essential services.

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Data Sharing Statement

No additional data are available.