

An analysis of the Factors Affecting the Rice Yield in the Dry Season in Households Farming Cambodia

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Abstract

This study attempts to determine the factors affecting the dry rice output in rural farming in Cambodia. Data applied in this study was obtained from the household survey conducted in 2023. It was conducted in three provinces of Cambodia namely, Takeo, Kandal, and Kampong Speu from which, 240 households are randomly selected based on the regulation and sample distribution. According to the estimation of parameters, the Cobb-Douglas production function for dry season revealed that a 1% increase in the input of seeds would increase the total outputs by approximately 0.6961% and a 1% increase in the input of household labor will increase the total rice output by around 0.0940%. Additionally, there is an increase in the output of dry season rice by roughly 0.0447% if there is a 1% increase in the input of hired labor. Furthermore, if there is a 1% increase in the input of transportation, there will be an increase in the rice output by the amount of 0.7674%, and a 1% increase in the input of income for the farming job will increase the output by roughly 0.4188%. The variables seed, fertilizer, pesticide, household labor, hired labor, transportation, age of household head, family size, and income from an off-farm job are calculated to give more effective rice output. Moreover, increased rice yields during the dry season depend heavily on seed quality and the increased use of irrigation infrastructure. However, the availability of high-quality varieties and other inputs is minimal among families of farmers, and lacking research and development institutions to improve rice production efficiency and market information in Cambodia is a significant constraint for farmers.

Keywords

Rice production, farming households Cambodia, Cobb-Douglas production function

1. Introduction

Rice is Cambodia's staple food, the leading crop, and a valuable source of income for 85 percent of rural households. It contributes to approximately 4.5% of the GDP, and 20% of the total family income, and the rice revenue accounts for more than 50% of the gross domestic product [1]. Income from crops has increased annually as a result of yield increase, and due to increased yields, crop costs are high. The rapid poverty reduction in rural areas, from 59% in 2004 to 24% in

2011, was driven by higher rice prices, high rice production, high returns from non-farm businesses, high rural salaries, and job growth in urban areas. Almost half of the poverty reduction is directly attributable to high prices (24 percent) and rice production (23 percent) [2]. Rice production alone accounted for half of the total crop production and grew significantly from about 1.7 million tons in 1980 to 9.3 million tons in 2015. Cultivated varieties include traditional non-aromatic rice, IR rice (mostly dry season paddy), and fragrant rice (wet season paddy). Official statistics are scarce. However, it is currently estimated that the IR varieties account for about one-quarter to one-third of the total output. From 1980 to 1992, most agriculture fields were rice fields. Dry season rice production began to increase in 1994, up from just 0.4 million tons in 1980 to 2.2 million tons in 2015, equivalent to 23% of total paddy production [3]. Furthermore, the key inputs of rice production are seeds, fertilizers, pesticides, insecticides, farmland, and hired labor, and some may include irrigation infrastructure and machinery rentals. Early rice varieties are demanded the most in kilogram per hectare, while the late maturing rice is requested at the lowest demand. Similarly, those farmers used the highest amounts of basal fertilizer. The use of fertilizers is remarkably high in short-term farming compared to medium- and long-term agriculture. Farmers cannot estimate the exact number of agricultural pesticides they have applied to their fields. However, they were reminded of the higher spending on short-term rice by CDRI (2017).

In addition, the total agricultural land has grown over the past 10 years. Cultivated rice expanded from 3.052 million hectares in 2013 to 3.055 million hectares in 2014. The cultivation of dry season rice amplified from 0.485 million to 0.491 million hectares. Nevertheless, it diminished from 2,568 to 2,565 million hectares during the wet season. Between 2004 and 2014, the average rice output increased from 2.0 tons/hectare to 3.1 tons/hectare. The average yield in 2014 is seasonally adjusted and the output in the wet season decreases from 2.9 to 2.8 tons/ha, but it had amplified from 2.3 tons/ha in 2011 and 2013 from 4.38 to 4.44 tons/ha during the dry season [4]. Agricultural crop in the dry season is very productive depending on irrigation, the use of high-yield varieties, fertilizers, and a high commitment to management [5]. According to the Ministry of Agriculture, Forestry and Fisheries in 2015b, the decline is due to climate change, especially drought. Drought-damaged areas have been calculated to be approximately 20.06 hectares, the highest in five years [6]. Rice output in the rainy season has increased every year from 2004 to 2013, but in 2014, it declined to 7.1 million tons from 7.27 million tons in 2013. The rice production in the dry season augmented from 1.04 million tons in 2004 to 2.18 million tons in 2014 due to expanding the cultured region and improved output. Floating rice yield, surged in 2008 (98,116 tons), but dwindled for six years (2009-2014). In 2014, only 52,539 tons of floating rice were produced. The reduction by half is due to changes in natural floods and the construction of hydropower dams and reservoirs [4].

In this study, we attempt to contribute to analyzing the rice inputs in the dry season to improve rice yields in farming households of Cambodia as a policy instrument to develop rural areas. Amongst the farming households operating in the southeast region of Cambodia are Takeo, Kandal, and Kampong Speu provinces. This study aims to analyze inputs of dry season rice production and to determine the main factors influencing the growth in rice yield and productivity. The information gathered might be useful to rice farmers as well as for policymakers of the government and related parties for improving Cambodian rice production. The rest of this paper is divided into five sections. Following the introduction are the research methodology, data description, results and discussion, and conclusion.

2. Research Methodology

The study carried out the Cobb-Douglas production function, using STATA software to analyze the significant factors of input in dry season rice yield. The research used Cobb-Douglas production function including the study of new production function with technological innovation in China by [7, 8] analysis of the factors affecting rice production efficiency in Myanmar, the study of analysis of rice production and contributions to Cambodian economic growth by [9], the study on comparative study on factors influencing rice yield in Niger State of Nigeria and Hainan of China by [10], [11] researched on does input quality drive measured differences in firm productivity, the study on determinants of rice productivity and technical efficiency in the Philippines by [12], [13] researched on efficiency analysis of production factors utilization in upland rice farming in Indonesia, the study on analysis of technical efficiency for household's rice production in Cambodia by [14], the study on measurement of efficiency of Cobb-Douglas production function with additive and multiplicative errors in Bangladesh by [15], [16] the study on technical efficiency analysis of rice production in Vietnam, the study on the influences of production factors with profit on agricultural heritage system in China by [17], the study on use of Cobb-Douglas production function model on some selected manufacturing industries in Oman by [18]. There has been no study on the factors affecting dry season rice yield yet. Therefore, the study will contribute to increasing rice production in Cambodia.

In the study, the Cobb-Douglas production function was applied as follows:

$$Y = AK^{\beta_1}L^{\beta_2} \quad (1)$$

Where:

- Y = the total output of a certain crop at the time
- L= labor input (the total number of person-hours worked at the time)

- K = capital input (seed, fertilizer, pesticide, weedicide, irrigation, transportation at time)
- A = is constant
- β_1 & β_2 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:

$$\ln Y = \ln A + \beta_1 \ln K + \beta_2 \ln L \quad (2)$$

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

$$\ln Y = \beta_0 + \beta_1 \ln K + \beta_2 \ln L + \dots + \beta_i \ln i \quad (3)$$

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

$$\ln Y = \beta_0 + \beta_1 \ln \text{seed} + \beta_2 \ln \text{fertil} + \beta_3 \ln \text{pest} + \beta_4 \ln \text{weed} + \beta_5 \ln \text{irri} + \beta_6 \ln \text{hom} + \beta_7 \ln \text{hired} + \beta_8 \ln \text{tran} + \beta_9 \ln \text{age} + \beta_{10} \ln \text{family} + \beta_{11} \ln \text{edu} + \beta_{12} \ln \text{income} \quad (4)$$

Where,

- $\ln \text{seed}$: logarithm of seed
- $\ln \text{fertil}$: logarithm of fertilizer
- $\ln \text{pest}$: logarithm of pesticide
- $\ln \text{weed}$: logarithm of weedicide
- $\ln \text{irri}$: logarithm of irrigation
- $\ln \text{hom}$: logarithm of household labor
- $\ln \text{hired}$: logarithm of hired labor
- $\ln \text{tran}$: logarithm of transportation
- $\ln \text{age}$: logarithm of the age of household head
- $\ln \text{family}$: logarithm of family size
- $\ln \text{edu}$: logarithm of education of household head
- $\ln \text{income}$: logarithm of income off-farm job

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

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

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

3. Data Description

The data analyzed in this study was obtained through a household survey conducted in 2023 from the three stated provinces in Cambodia. Random sampling was done through which 240 farmer households were randomly selected. The authors lead data collection and were accompanied by some postgraduate students from AII-CAAS, graduate students from Regional Polytechnics Institute Techo Sen Takeo (RPITT), and the University of Management and Economics (UME). The data collection has covered several aspects of the rural farmers encompassing households condition, income from farming, daily expenditure, inputs of rice production, and agricultural technology information. The data collection was preceded by contacting the local authorities (chiefs of the ward, commune, and village) and then conducting a face-to-face interview with farming households and stakeholders. The rice inputs of dry season rice included seeds, pesticides, herbicides, fertilizer, irrigation, household labor, hired labor, transportation, and others. Because the increased rice inputs affected the wet season rice, the dry season rice production had increased yield to about 7.637 million tons and 2.315 million tons respectively in 2016. The increase in rice production is mainly due to the support offered by the Royal Government of Cambodia, relevant ministries and institutions, development partners, national and international organizations, sub-national authorities, and farmer participation.

In this study, only farming households were selected for analysis. Mixed farmers, paddy producers, and other crops are not included in the data to be analyzed to ensure bias in sample options is minimized. Data modification and filtering are performed to ensure that the unit of measure of each variable is consistent with the academic goals and the quality of the data is satisfactory.

4. Results and Discussions

The statistics summary of variables in rice inputs and outputs used in estimating the regression model (refer to Table 1). The table includes; seeds, pesticides, weedicides, fertilizer, irrigation, household labor, hired labor, and transportation. The household characteristics encompass; the age of the household head, family size, education of the household

head, and income off-farm job of a head household. The mean, standard deviation, minimum, and maximum value of each variable are shown in the table as followed; on average, the yield of dry season rice was about 4977 kilograms per hectare, the maximum and minimum were around 6374 kilograms, and 2080 kilogram respectively. The estimated yield of 3996 kilograms of dry season rice is needed for standard deviation. According to Yu and Fan (2007) research on rice production response in Cambodia, it showed that the average paddy yield of the dry season was about 3600 kilograms per hectare, so from 2007 to 2017 paddy yield of dry season rice increased to around 1377 kilograms.

On average around 234 kilograms per hectare of seeds were used, the maximum is 420 kilograms of seed per hectare and the minimum is roughly 250 kilograms of seed per hectare. Reference from Cambodia Agriculture Value Chain Program [19], showed that Cambodian farmers used an average of 230 kilograms of seeds per hectare for the dry season and 134 kilograms of seeds per hectare for the wet season and other farmers used up to 400 kilograms of seed per hectare. Moreover, according to Sothy et al. (2017), the early rice varieties required 322.1 kilograms of seeds per hectare and 122.2 kilograms of seeds for late rice. Looking at the average of pesticides applied is around 4472 ml/ha, the maximum application is 6500 ml/ha in dry season rice, and the average of weedicides used is 2165 ml/ha, while the maximum approximates 2400ml/ha in the output of dry season rice. According to World Bank (2015) and Dary et al. (2017), showed that most Cambodian farmer use of pesticides on crops and vegetables is surging. Peasants used more pesticides on vegetables than rice. In 2013, the cost of farmers' expenditure on pesticides was 12 dollars per hectare for dry season rice and the use of weedicides was also increasing. Weed destruction is a significant obstacle to large-scale farming, especially in the upland regions. The farmers that produce cassava and maize use higher application of weedicides compared to rice production.

Table 1. Summary statistics on the inputs of rice in the dry season per hectare

Variable	Units	Obs	Mean	Std. Dev.	Min	Max
Rice outputs	Kg/ha	240	4977	3996	2080	6374
Seed	Kg/ha	240	234	117	250	420
Pesticides	ml/ha	240	4472	3934	-	6500
Weedicides	ml/ha	240	2165	1922	-	2400
Fertilizer	Kg/ha	240	269	206	100	500
Irrigation	mm ³ /ha	240	6316	5824	3800	17000
Household labor	person/ha	240	8	2	2	13
Hired labor	person/ha	240	8	5	-	17
Transportation	ton/ha	240	5	1	2	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	2886000	2897000	-	4000000

Note: education; 0=illiterate, 1=literate, 2=primary, 3=secondary, 4=high school, 5=university

The average application of fertilizer was around 269 kilograms per hectare of dry season rice; the maximum is approximately 500 kilograms per hectare, and the minimum is 100 kilograms per hectare. The result illustrated that the farmers used more fertilizer compared to the research of [20, 9] (in 2013, farmers used 153kg/ha during the dry season and only 66kg/ha during the wet season). However, in the upland areas, the rice cultivation of the wet season is shifting cultivation, so farmers use small quantities of fertilizer during the dry season and the use of fertilizer varies depending on its price. The kind of crops farmed along the Mekong region uses more fertilizer than the other areas. The average irrigation approximates 6316 mm³/ha, and the maximum and minimum are around 17000 mm³/ha and 3800 mm³/ha of early rice, respectively. According to the Cambodia Development Research Institute [22] showed that most of the rice cultivation in Cambodia relies more heavily on rainfall than the irrigation system and lacks proper technology, which limits productivity. Furthermore, supplemental irrigation for both seasons is essential for food security.

The average household labor was about 8 persons per hectare in dry season rice, while the maximum and minimum are around 13 and 2 persons, respectively. From 2005 to 2013, the number of working days decline to 34% for wet-season rice and 52% for dry-season rice but increased working days for vegetables. Therefore, mixed crops, rainy season, and dry season rice need to have more workdays than other crops. In addition, the average hired labor is about the same as that of household labor, but the maximum of hired labor is higher compared to household labor. The aver-

age transportation was around 5 tons/per hectare and, the maximum and minimum are about 13 tons and 2 tons for dry season rice, respectively.

Furthermore, the summary statistics reveal that the average age of the household head was 49 years old and ranged from 22 to 88 years old. In other words, the results displayed for age are similar to the research of Sokvibolet al. (2016) in the technical efficiency analysis of Cambodian households' rice production. Moreover, 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 result obtained is lower than analyses of technical efficiency for household rice production in Cambodia, which showed that most of the farmers' household heads gained an education up to secondary school. The results also displayed that the average family size of peasant households in Takeo, Kampong Speu, and Kandal is around 5 persons per household and ranges from 2 to 9 persons per household. The average income from the off-farm job approximated 2886 thousand riels, and the maximum was 4,000 thousand riels of rice in the dry season.

The (refer to Table 2) illustrates that all independent variable's estimation parameters are in conformity with the prior expectation, but except for the input of weedicides, the age of the household head and education of the household head is not significant with the rice output of the dry season. The coefficient of the irrigation, age of household head, and education of household head are negative, implying that all these variables are missing contributions to the rice yield.

The Cobb-Douglas production function was applied to estimate the number of inputs that affected rice in the dry season. Therefore, the results of the farming households in Cambodia's dry season rice reveal that, if there is a 1% increase in the input of seed it will consequently increase the total outputs of the dry season rice by approximately 0.6961%, and if 1% increases in the input of fertilizer would increase the rice output of about 0.1752%. A 1% increase in the input of pesticides will increase the total output by approximately 0.5136%. The total rice output will increase by around 0.0940% if a 1% increase in the input of household labor. An increase of 1% in the input of hired labor will increase the rice output by about 0.0447%. A 1% increase in the input of transportation will increase the rice output in the dry season by approximately 0.7674%. A 1% increase in the input of the age of household heads will decrease the rice output by about 0.0569%. An increase of 1% in the families' size will increase the rice output by an amount of 0.2174%. A 1% increase in the input of income from an off-farm job will increase the rice output by roughly 0.4188%.

In an overall view, the variables seed, fertilizer, pesticide, household labor, hired labor, transportation, age of head household, family size and income from the off-farm job are more effective in the output of dry season rice.

Table 2. Estimated Parameters of the Cobb-Douglas production for rice in the dry season

Variable	Coefficient	Std. Err.	t	P>t	[95% Conf.	Interval]	
Constants	β_0	6.8814	0.2070	33.25	0.0000***	6.4706	7.2922
Inseed	β_1	0.6961	0.0237	8.52	0.0001***	-0.0110	0.0831
Infertilizer	β_2	0.1752	0.0208	3.73	0.0303**	-0.0262	0.0566
Inpest	β_3	0.5136	0.0197	4.69	0.0010***	-0.0255	0.0527
Inweed	β_4	-0.0158	0.0203	-0.78	0.4370	-0.0560	0.0244
Inirri	β_5	-0.0230	0.0183	-1.26	0.2120	-0.0593	0.0133
Inhomlabor	β_6	0.0940	0.0385	1.14	0.0460**	-0.0325	0.1204
Inhired	β_7	0.0447	0.0239	1.87	0.0640*	-0.0026	0.0921
Intran	β_8	0.7674	0.0416	18.45	0.0000***	0.6848	0.8499
Inage	β_9	0.0569	0.0365	3.46	0.0450**	-0.0894	0.0556
Infamily	β_{10}	0.2174	0.0290	3.68	0.0205**	-0.0402	0.0749
Inedu	β_{11}	-0.0095	0.0188	-0.5	0.6150	-0.0468	0.0278
Inincome	β_{12}	0.4188	0.0113	1.65	0.0020***	-0.0038	0.0413
Prob>F	=	0.0000					
R-squared	=	0.8645					
Adj R-squared	=	0.8478					
Root MSE	=	0.0819					

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

Source: Author

5. Conclusions

This study employs the Cobb-Douglas production function to examine the input of rice farming households in Cambodia and to explore the input factors affecting the rice output in the dry season. The estimated parameters of all inputs are conformism with the prior expectancy, but the input of weedicides, irrigation infrastructure, and education of household heads are not much effective with the output yield in the dry season.

Based on our research, we found some constraints and challenges. The first constraint is the seed; farmers can increase their yields in the dry season by 0.6961% if recommended seeds are used increasing by 1%. But unfortunately, the recommended seeds are still limited and most farmers use previously harvested seeds in the next season of farming. Most Cambodian farmers use their seeds. The second is fertilizer; farmers cannot afford proper fertilizer because of rising costs even though the use of fertilizers is essential. The problems of using chemical fertilizers include licensing that encourages renting and promoting illegal imports and restricting imports. Approximately 10% of farmers face problems with counterfeit fertilizers. Thirdly is that most irrigation infrastructures are designed and built only for the wet season crops. Moreover, CEDAC (2009) found that over 2,400 technical infrastructures needed rehabilitation or reconstruction. Operations and small maintenance have been emphasized as weak points of irrigation systems in Cambodia. The technical limitations and institutional barriers are major obstacles to improving the irrigation system. In addition, irrigation system management and enlargement in many schemes do not encourage paying farmers' irrigation costs or fully contributing to irrigation. Until now, farmers use irrigation systems based on natural sources such as rainfall. Most farmers do not have access to irrigate the fields for the dry season crop. Moving on, rice is one of the most basic crops produced in Cambodia. It also creates jobs for key populations living in remote areas as a major source of income. Therefore, the Royal Government of Cambodia and other stakeholders need to work closely with farmer households to increase the productivity of the rice sector.

All in all, according to the results of the rice studies, increasing rice yields during the dry season depends heavily on seed quality and the increased use of irrigation infrastructure. The availability of high-quality varieties and other inputs is minimal among families of farmers. The lack of research and development institutions working to improve rice production efficiency and market information in Cambodia is a significant constraint for farmers.

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