

# Comparison of the Impact of Production Factors on the Ecological and Economic Efficiency of the Potato Land-Use Type in Vietnam and Russia Based on the Cobb-Douglas Production Function

Pham Quy Giang<sup>1\*</sup>, Vu Thi Thu Huong<sup>2</sup>

<sup>1</sup> Faculty of Environment, Ha Long University, No. 258, Bach Dang Street, Uong Bi City, Quang Ninh 200000, Vietnam

<sup>2</sup> Faculty of Forestry, North East College of Agriculture and Forestry, No. 607, Mac Dang Dung Street, Quang Yen, Quang Ninh 200000, Vietnam

\* Corresponding author's e-mail: [phamquygiang@daihochalong.edu.vn](mailto:phamquygiang@daihochalong.edu.vn)

## ABSTRACT

This study aimed to identify and compare the impact of production factors on the total ecological and economic efficiency of the potato land-use type in the two regions Primorsky Kray, Russia and Red River Delta, Vietnam using the Cobb-Douglas production function. The result of data analysis for the period of 2016–2019 showed that the contribution coefficient of factors such as initial investment, labor cost, expenses of machinery and equipment, and amounts of pesticides and fertilizers used for potato farming per hectare to the total ecological and economic efficiency of the potato land-use type in Primorsky was higher than in the Red River Delta. The results also show that the amounts of pesticides and fertilizers in the Red River Delta were used more than in Primorsky; therefore, they present a higher influence on the total ecological and economic efficiency. On the basis of the analysis of the impact of each factor, this study has proposed the solutions to enhance the influence of the factors that have a proportional effect and minimize the influence of factors that have an inversely proportional effect on the economic-environmental efficiency of potato land use in each study area.

**Keywords:** Cobb-Douglas production function, ecological and economic efficiency, Primorsky Kray, potato, production factors, Red River Delta.

## INTRODUCTION

Nowadays, sustainable, economical, and effective land use has become an important global strategy. The agricultural land use strategy plays an important role, as it governs the creation of agricultural products and has a great impact on local people's livelihoods. An effective and sustainable land use strategy contributes significantly to the development of ecological agriculture and the sustainable development of the country.

Primorsky Kray (Russia) and Red River Delta (Vietnam) are two regions with similar geographical and climatic conditions, and the main crops such as maize, potatoes, rice, soybeans, and vegetables. The agricultural area of Primorsky Kray is 769.9 thousand hectares, accounting for

approximately 11% of the total land area in Primorsky Kray. In Primorsky Kray, the total potato production is the highest, followed by soybean, maize, and wheat. There are about 18.77 thousand hectares of potato cultivation area which provides a total production of about 199 thousand tons with an average yield of 10.5 tons/ha.

In Vietnam, potato is important for local consumption and as a commodity crop. It is used for local consumption and livestock feed. In the Red River Delta, the area of agricultural land is about 935 thousand ha, accounting for 44% of the total area of the delta. The cultivation area of potatoes was about 22.4 thousand ha in 2019, which occupied 3% of the crop cultivation area. In recent years, the development of potato production has intensified in the Red River Delta. Agricultural

development toward sustainability in the Red River Delta has been a topic discussed in many scientific forums and has attracted the interest of Vietnamese and international experts. Therefore, there is a tendency for agricultural restructuring, towards increasing the value of potatoes and other crops and decreasing the area of rice land.

This study was carried out to review the theoretical basis of the Cobb-Douglas production function, systematize previous related studies, and apply it to the case studies of the Red River Delta (Vietnam) and Primorsky Kray (Russia). A research model was built to collect and analyze the data from the Red River Delta as well as Primorsky Kray to estimate and assess parameters in the model. The importance of the factors in the Cobb-Douglas production function model is the basis for considering the possibility of bringing economic equilibrium and suggesting solutions to each region.

Given a data set of 48 potato-producing households and the theoretical background, this study estimated the ecological-economic efficiency in potato production by farming households in Primorsky Kray and the Red River Delta using the Cobb-Douglas function. On the basis of the results obtained, this study proposed solutions to enhance the ecological-economic efficiency in potato production regarding land size, rice selling method, cultivation pattern, input purchase, savings, location, and input usage knowledge.

## METHODOLOGY

### Theoretical basis

The Cobb-Douglas Production Function was developed by Cobb and Douglas, based on their empirical study of the American manufacturing industry (Cobb and Douglas, 1928). It is a linear, homogeneous production function which implies that the factors of production can be substituted for one another up to a certain extent only. In economics, the Cobb-Douglas production function is widely and popularly used in the analysis of growth and productivity. In microeconomics, the production function denotes the quantity of a product by the producer. In macroeconomics, the production function denotes the gross domestic product (GDP) of a country, sector, or region.

The Cobb-Douglas production function model is in the form of Equation (1).

$$Y = AL^\alpha K^\beta \quad (1)$$

where:  $Y$  – total production or output of good;  
 $A$  – total factor productivity;  
 $K$  – capital input;  
 $L$  – labor;  
 $\alpha$  – output elasticity of capital;  
 $\beta$  – output elasticity of labor.

In Equation 1, when doubling the capital and labor we will obtain:  $Y' = A \cdot (2K)^\alpha \cdot (2L)^\beta = 2^{\alpha+\beta} \cdot (A \cdot K^\alpha \cdot L^\beta)$ , or  $Y' = 2^{\alpha+\beta} \cdot Y$ .

So if  $\alpha + \beta > 1 \rightarrow Y' > 2Y$  and productivity increases by scale, in contrast if  $\alpha + \beta < 1 \rightarrow Y' < 2Y$  and productivity decreases by scale. In case  $\alpha + \beta = 1$ , the yield will not change by scale.

### Research overview

There have been many studies that applied the Cobb-Douglas production function in different aspects. Theodore (1964), Rizzo (1979), Ellis (1993), and Yang (2007) studied the impact of inputs on the efficiency of arable land in agriculture. In regards to the industry or locality in Vietnam, there have been studies such as Idiong (2007), Truong (2007), Bui (2013), Do et al. (2016), and Tran et al. (2021). Notably, Pham (2011) studied how to apply a higher efficiency of agricultural land use throughout the regions of Vietnam. Other studies have developed the Cobb-Douglas production function to analyze the influence of input factors of land use types on the efficiency of agricultural land use, such as Fadejeva and Melihovs (2010), Mai and Nguyen (2011), Dang and Vo (2011), Aydın (2014), Chebil et al. (2015).

There are several studies on the efficiency of agricultural land use relating to this issue. Firstly, Hu and McAleer (2005) used the production function to measure the total factor productivity of China. A data table was established, consisting of data from 30 provinces in China from 2000 to 2005, which was used to evaluate agricultural production efficiency. The results indicated that input variables are labor, capital, fuel costs, materials, and the total maximum output that could be achieved. Orawan and Somporn (2012) studied the efficiency change in rice production in Thailand from 2005 to 2010. The results of the study showed that seeds and better machine technology have the greatest impact on rice yield and production. In addition, the irrigation system, production scale, association of farmers, agricultural

extension programs, supporting policies, access to credit and monitoring mechanisms to ensure that loans were used for production inputs such as chemical fertilizers and seeds were important variables that affected the efficiency of rice production in Thailand. Galawat and Yabe (2012), studied the production efficiency among rice farmers in Brunei using a stochastic profit frontier and inefficiency effects model, analyzed from its three components – technical, allocative, and scale efficiencies. The results of the study show that the mean profit efficiency score is 80.7% and 19.3% of profit is lost due to a combination of technical, allocative, and scale inefficiencies. The factors that are related to profit-loss and profit inefficiency are non-membership of cooperatives, no irrigation, lack of training, and low yield variety. In Vietnam, Vu and Svetlana, (2017) used the Cobb-Douglas production function to perform ecological and economic analysis of agricultural land use in Vietnam under the conditions of innovative development. Nguyen et al. (2018) used the production function to assess the efficiency of five land use types (rice, rice-vegetable, perennial and fruit plants, medicinal plants, and forest) in Con Cuong district, Nghe An province. The studies above have proven the significance of the Cobb-Douglas production function model method if having a good data set.

**Research model**

Agriculture is a material production field so the ecological and economic efficiency of agricultural land use is the most comprehensive indicator to gauge the efficiency of agricultural land use. It is also the contribution of farming households to the total revenue of agricultural production.

Given the theoretical background discussed, the model used to estimate the ecological-economic efficiency in potato production by households in Primorsky Kray and the Red River Delta takes the form of:

$$Y = AK\alpha L\beta \tag{2}$$

where: *Y* – the overall ecological and economic efficiency of using agricultural land created by farming households.

The utilization of the Cobb-Douglas production function analyzes the effects of production factors on the economic-environmental efficiency coefficient of potato cultivation in the study areas; it determines both the influencing factors and the degree of influence of each factor for ecological and economic efficiency (*Eee*) of potato production.

Meanings and expected signs of all  $\alpha_i$  are mentioned in Table 1.

The theoretical background that has just been mentioned enables to establish a model on the determinants of economic efficiency in potato production by farming households as follows:

$$Eee = e^{\alpha_0} \cdot X1^{\alpha_1} \cdot X2^{\alpha_2} \cdot X3^{\alpha_3} \cdot X4^{\alpha_4} \cdot X5^{\alpha_5} \cdot X6^{\alpha_6} \tag{3}$$

For convenience in estimating the parameters in the model, Equation 3 is converted to a linear form in logarithm (Eq. 4).

$$\ln Eee = \alpha_0 + \alpha_1 \ln X1 + \alpha_2 \ln X2 + \alpha_3 \ln X3 + \alpha_4 \ln X4 + \alpha_5 \ln X5 + \alpha_6 \ln X6 \tag{4}$$

where:  $\alpha_0 = \ln(A)$ .

The parameters of the formula in Equation 4 are estimated by the Ordinary Least Square (OLS) method of SPSS software.

In Equation 3 *LnEee* is the natural logarithm of standardized profit of farming households, measured by the profit of potato production divided by unit potato price.

**Table 1.** Meanings of variables and expected signs of  $\alpha_i$

1	Variable	Variable symbol	Unit	Expected signs of $\alpha_i$
I	Independent variables			
1	Plot size (cultivated)	X1	Hectares	+ (Positive)
2	Initial investment	X2	Usd/ha	+
3	Labors	X3	Man-days/ha	+
4	Expenses of machine and equipment per ha (potato land)	X4	Usd/ha	+
5	Amounts of pesticides per ha	X5	Kilograms/ha	- (Negative)
6	Amounts of fertilizers per ha	X6	Grams/ha	-
II	Dependent variable			
1	Total ecological and economic efficiency	Eee		

$LnX1$  is the natural logarithm of the standardized land size of households (ha) of farming households.  $LnX1$  is expected to be positive.

Likewise,  $LnX2$  is the natural logarithm of standardized initial investment of farming households, measured by unit initial investment (seed cost,...) divided by unit of potato cultivated.  $LnX2$  is used to test for the relationship between initial investment cost and  $Eee$  of potato production of farming households. As mentioned,  $LnX2$  is expected to be positive.

$LnX3$  is the natural logarithm of standardized labors of farming households, measured by unit Man-days divided by unit ha cultivated.  $LnX3$  is used to test for the relationship between of labors Man-days potato production of farming households. High labor Man-days will raise production costs and lower profit. Therefore,  $LnX3$  should be negative.

Likewise,  $LnX4$  is a natural logarithm of standardized Expenses of Machinery and Equipment of farming households, measured by unit Expenses of Machinery and Equipment divided by unit potato cultivated.  $LnX4$  is used to test for the relationship between Expenses of Machinery and Equipment cost and  $Eee$  of potato production of farming households. As mentioned,  $LnX2$  is expected to be positive.

$LnX5$  is a natural logarithm of a standardized amount of pesticides and is measured by the total of all kinds of pesticides used in potato production divided by the unit of potato cultivated.  $LnX6$  is used to test for a relationship between the amount of pesticides and the  $Eee$  of potato production of farming households. Therefore,  $LnX5$  is supposed to be negative.

$LnX6$  is a natural logarithm of a standardized amount of fertilizers and is measured by the total of all kinds of fertilizers used in potato production divided by the unit of potato cultivated.  $LnX6$  is used to test for the relationship between the number of fertilizers and the  $Eee$  of potato production of farming households. Therefore,  $LnX6$  is supposed to be negative.

## Methods

### Method of measuring the value of variables

Estimation of efficiency in agricultural production in general and in potato production, in particular, using production, cost and profit functions has been done by many studies.

According to previous studies, production is economically and ecologically efficient if it is technically efficient and ecologically efficient at the same time. In this research, the economic efficiency is determined through the calculation of indicators such as: GO (Gross Output); DC (Direct Cost); VA/ha (Value Added); NVA/ha (Net Value Added); and ecological-economic efficiency is determined by the amounts of pesticides used in potato production.

### Measure the total ecological-economic efficiency ( $Eee$ ) of LUT potato

In order to determine the economic-environmental efficiency of potato production in the study area, it is necessary to have appropriate criteria to evaluate synthetically based on the compositional criteria.

The economic-environmental efficiency of potato LUT in the study area is defined in Equation 5:

$$Eee = \left[ \sum_{i=1}^t \frac{Xi}{Xopt(max)} + \sum_{i=t+1}^n \frac{Xopt(min)}{Xi} \right] \frac{1}{n} \quad (5)$$

where:  $Eee$  – the economic-environmental efficiency of potato LUT in the study area;  $Xi$  – the actual value criteria according to the survey data of a comparable indicator (GO, IC, V).

$Xopt$  is the optimal value of a criterion. It consists of two parts: group 1 – the criterion which the largest number is the best (ex GO, VA),  $Xopt(max)$ , group 2 – the criterion which the smallest value is the best (ex GO, VA),  $Xopt(min)$ .

Thus, in the total  $n$  indicators to be calculated, there will be  $t$  indicators in group 1;  $i = 1 - t$  and there will be  $(n-t)$  indicators in group 2, sum  $\sum$  will be taken from  $i = (t + 1$  to  $n)$ .

Condition:  $Eee \leq 1$ ; Mean  $Eee$  close to 1, the best synthesis efficiency will be obtained.

### Measurement of the amount of the economic

Efficiency of potato crops, per 1 ha; consists of criteria (Group of indicators reflecting production efficiency per unit area of land (ha) as GO (Gross output); DC (Direct Cost); VA/ha (Value added); NVA/ha (Net Value Added); and ecological-economic efficiency is determined by the amounts of pesticides used in potato production per ha.



Measurement of the ecological efficiency

Investigating the impact of existing cropping systems on the ecological environment is a problem that requires a long-term analysis of the state and use of agricultural land and agricultural samples. In the present study, only some indicators that affect the ecological environment in land use were considered: the use of fertilizers and the use of chemicals to protect plants grown in the study areas; areas of eroded, contaminated agricultural land; the number of fertilizers, mineral and organic substances applied; costs of fertilizers, etc.

Source of data

Secondary data: The secondary data used in this study were collected from the General Office of Statistics, Primorsky and Delta Red River’s Office of Statistics, the Department of Agriculture and Rural Development, the People’s Committee, and relevant studies.

Primary data: The study randomly selected 48 potato-farming households in Primorsky Kray and Red River Delta to interview.

RESULTS AND DISCUSSION

Potato production in Primorsky Kray and Red River Delta

The data shows that the area of potato cultivation in Primorsky Kray decreased over 20 years from 2000 to 2019. In the Red River Delta, the area of potatoes steadily decreased, especially during the first decade of the 21<sup>st</sup> century. The productivity (total yield output in tons per hectare) of potatoes has gradually increased during the during the investigated period, as shown in Figure 1.

The economic efficiency of potato production of households per unit cultivated area of the two study areas was different during the survey period, the Gross production value of the Primosky region was 188750 while that of the Red River Delta was 225000 thousand VND/ha. However, the total economic-ecological efficiency coefficient of potato production of households in Primorsky Kray (0.759) is slightly higher than that of the Red River Delta (0.748) as shown in Table 2.

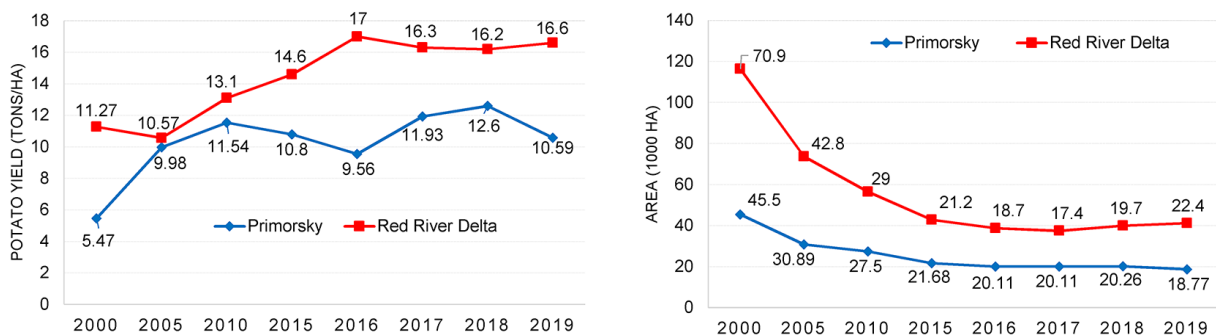


Figure 1. Potato cultivation area and potato yield in Primorsky and Red River Delta

Table 2. Economic efficiency of potato production in Primorsky and Red River Delta

Parameter	Red River Delta, Vietnam	Primorsky Kray, Russia
Gross production value (GO) (1000VND/ha)	225,000	188,750
Cost of production (IC) (1000VND/ha)	74,966	69,206
Value added (VA) (1000VND/ha)	150,034	119,544
MI (Mix income) (1000VND/ha)	137,534	108,964
GO/IC	3.00	2.73
VA/IC	2.00	1.73
MI/IC	1.83	1.57
Fertilizers (kg/ha)	265	225
Pesticides (l/ha)	3.3	2.0
Eee	0.748	0.759

**Estimated parameters and production function model**

The results of the analysis show that the statistic values of 6 variables parameters have  $t \geq 1.98$  and  $\text{Sig.} < 0.05$  for both Primorsky Kray and Red River Delta. The value of the adjusted  $R^2$  in the two cases is about 81% with the values of F-statistic being very small for both two cases. This means that 81% of the data surveyed is accounted for in the regression model for two cases. Hence, the regression models of both study areas can be applied in practice (Table 2).

In Primorsky Kray, the variable  $\text{LnX1}$  (plot size) has the value  $\text{Sig.} = 0.312$ , (however, condition  $\text{Sig.} \leq 0.05$ ), so this variable has no statistical significance with the dependent variable. Hence, these hypotheses are rejected and variable  $\text{LnX1}$  (plot size) has not indeed an impact on the value added of the dependent variable  $E_{ee}$ , so this variable is excluded from the model. The remaining variables include initial investment ( $\text{LnX2}$ ), expenses of machine and equipment ( $\text{LnX3}$ ), labor ( $\text{LnX4}$ ), amounts of pesticides ( $\text{LnX5}$ ), and fertilizers ( $\text{LnX6}$ ) have indeed an impact on the  $E_{ee}$  the total ecological-economic efficiency of potato production.

In Red River Delta, The variable  $\text{LnX1}$  (plot size) and the variable Labors ( $\text{LnX4}$ ) have the value  $\text{Sig.} = 0.312$  and  $\text{Sig.} = 0.266$ , (however, condition  $\text{Sig.} \leq 0.05$ ), so these variables have no statistical significance with the dependent variable  $E_{ee}$ . Hence, these hypotheses are rejected

and variable  $\text{LnX1}$  (plot size) as well as labors ( $\text{LnX4}$ ) have not made an impact on the value added of the dependent variable  $E_{ee}$ , so this variable is excluded from the model. The remaining variables—initial investment ( $\text{LnX2}$ ), expenses of machine and equipment ( $\text{LnX3}$ ), amounts of pesticides ( $\text{LnX5}$ ), and fertilizers ( $\text{LnX6}$ )—have an impact on the  $E_{ee}$ , the total ecological-economic efficiency of potato production (Table 3).

The results of testing hypothesis of the parameters in the Wald-Test model give  $\text{Sig.}$  having probability  $\leq 0.05$  for both the Red River Delta and Primorsky region (Table 3).

From the analysis results shown in Table 3, the Cobb-Douglas production function model with data from Red River Delta and Primorsky are as follows:

Model of Primorsky:

$$\text{Ln}E_{ee1} = 0.118\text{LnX2} + 0.086\text{LnX3} - 0.159\text{LnX4} - 0.062\text{LnX5} + 0.29\text{LnX6} - 1.470 \quad (6)$$

Model of the Red River Delta:

$$\text{Ln}E_{ee2} = 0.214\text{LnX2} - 0.078\text{LnX4} - 0.214\text{LnX5} - 0.219\text{LnX6} + 1.781 \quad (7)$$

**Assessment of the hypothesis of the parameters in the model**

The results of the analysis show that the value of adjusted  $R^2$  in the case of Red River Delta is 81% and in the case of Primorsky Kray it is nearly 81.4%. This means that 81% of the data

**Table 3.** Estimated results of parameters

n	Independent variable	Symbol	Primorsky Kray			Red River Delta		
			B	T	Sig.	B	T	Sig.
		Constant	-1.470	-1.024	0.312	1.781	1.458	0.153
1	Cultivated area	$L_nX_1$	-0.008	-0.983	0.331	-0.002	-0.201	0.841
2	Initial investment	$L_nX_2$	0.118	7.748	0.000	0.214	4.403	0.000
3	Labors	$L_nX_3$	0.086	2.470	0.018	0.093	1.128	0.266
4	Expenses of machine and equipment	$L_nX_4$	-0.159	-2.949	0.005	-0.078	-1.982	0.046
5	Amounts of pesticides /ha	$L_nX_5$	-0.062	-1.997	0.046	-0.214	-2.939	0.005
6	Amounts of fertilizers/ha	$L_nX_6$	0.290	2.563	0.014	-0.219	-3.997	0.000

**Table 4.** Model summary

Model	R	$R^2$	Adjusted $R^2$	Std. Error of the estimate	Change Statistics					Durbin-Watson
					$R^2$ Change	F Change	df1	df2	Sig. F Change	
Primorsky Kray	0.915 <sup>a</sup>	0.838	0.814	0.03286	0.838	3.340	6	41	0.000	2.316
Red River Delta	0.914 <sup>a</sup>	0.835	0.810	0.03189	0.835	33.737	6	40	0.000	1.573

**Note:** a – predictors: (Constant),  $\text{LnX6}$ ,  $\text{LnX5}$ ,  $\text{LnX4}$ ,  $\text{LnX2}$ ,  $\text{LnX1}$ ,  $\text{LnX3}$ ; b – dependent variable:  $E_{ee}$ .

surveyed is accounted for in the regression model of the Red River Delta and it is almost 81.4% in the case of Primorsky Kray. Hence, the regression models of both regions can be applied in practice (Table 4).

The value of the Correlation coefficient adjusted  $R^2$  (Adjusted R Square) for Primorsky Kray and Red River Delta are 0.814 and 0.810, which means that 81.4% and 81% of the change of the dependent variable Y (the overall economic-environmental efficiency of potatoes) is explained by the variables included in the model (condition is to be above 50%).

### Comparison of the factors affecting the ecological and economic efficiency of household's potato productivity

Potato is produced mostly for local consumption and local markets in Primorsky Kray and Delta Red River. It is an important crop in these regions and accounts for per capita production values.

Agricultural production in the Red River Delta beheld new developments with increasing values of agricultural production, diversified types of plants, and a shift in agricultural structure towards increasing plant products with high economic value. However, agricultural production still has the characteristics of small,

fragmented, and inefficient production leading to waste of agricultural land.

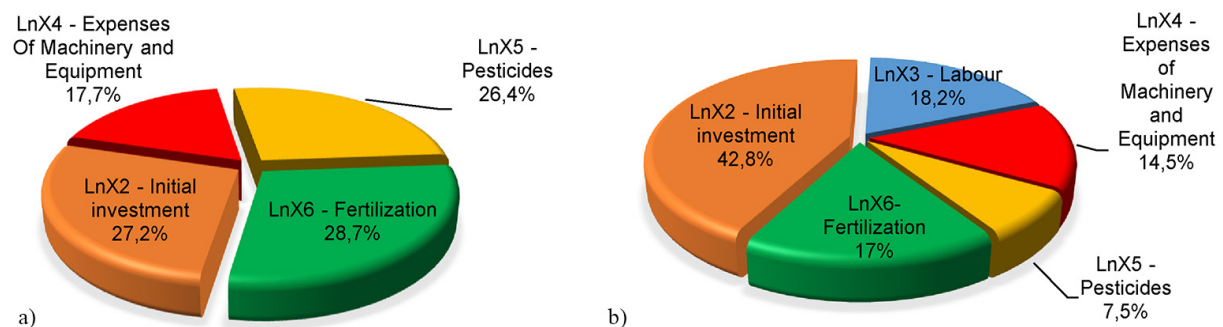
The models above show that the contribution including initial investment (LnX2) and labor (LnX4) to the total factor Economics–ecological efficiency of potato production in Primorsky Kray is higher than the Eee in Red River Delta in the period surveyed. Apart from these two factors, the potato production in Red River Delta also relies on Eee factors of expenses of machinery and equipment(LnX4), labor (LnX3), amounts of pesticides (LnX5), and fertilizes (LnX6) (Table 5 and Figure 2).

According to Table 5, in Primorsky Kray, variable LnX2 (initial investment) has the strongest influence, contributing over 42% of the change to Eee, the lowest influence is variable LnX5 (amounts of pesticides per ha); and in Red River Delta, variable LnX6 (fertilizers) has the strongest effect (28.72%) on Eee, the lowest effect is expenses of machine and equipment (LnX4).

Table 5 and Figure 2 show that to increase the ecological and economic efficiency of potato production, 3 factors should be increased: the cost of initial investment per 1 ha of crops (LnX2), labors (LnX3), and fertilizers (LnX6) into production in the models used. To reduce the level of environmental pollution of agricultural land, additional expenditures should not be made on

**Table 5.** Comparison of the model of the Delta Red River and Primorsky Kray

Variable	Red River Delta		Primorsky Kray	
	Coefficient B	%	Coefficient B	%
LnX2	0.306	27.16	0.732	42.82
LnX3			0.311	18.16
LnX4	0.200	17.75	0.248	14.50
LnX5	0.297	26.36	0.129	7.53
LnX6	0.324	28.72	0.291	17.00
Sum	1.127	100	1.710	100



**Figure 2.** Contribution of each factor to the total factor Economicsecological efficiency of potato production in (a) Primorsky Kray, and (b) Red River Delta

funds for the protection of potatoes in these regions. To increase the ecological and economic efficiency of land use, it is necessary to reduce the cost of machinery and technology per ha in agricultural production (LnX4).

Similar to the result of the analysis for Primorsky territory, a study conducted for the Krasnaya Delta region on the production factors affecting environmental and economic efficiency also yielded the results that allow making proposals, using the degree of importance of factors influencing the overall efficiency of the land use model for potatoes. It was found that when analyzing the influence of each factor on the ecological and economic efficiency of potato production, the most optimal solution for the use of agricultural land was determined.

Thus, the results of the study showed that the role and degree of effect of production factors that individually affect the indicators Eee of the model of land use for potatoes in the Primorsky Kray and Red River Delta are not the same, but if one or all of the factors are changed for the better, this will significantly increase the income of peasant farms, increase the ecological and economic efficiency (Eee) of the use of agricultural land.

## Discussion

According to the results, the ecological-economic efficiency in potato production by farming households in the study area is affected by production factors such as initial investment, expenses of machinery and equipment, labors, amounts of pesticides, and fertilizers.

### In Primorsky Kray

Variable LnX2 (initial investment) and LnX3 (labors) have the strongest influence, contributing 42% and 18.2% of the change to Eee and in Red River Delta, variable LnX6 (fertilization), LnX2 (initial investment) and pesticides LnX5 have the strongest effect on Eee.

Specifically, in Primorsky Kray, variable LnX2 (initial investment cost) has an elasticity coefficient 0.118, is supposed to be positive with Eee, meaning that if the potato production's households increased by the initial investment cost of 1%, the Eee would increase by 0.118%.

Variable LnX3 (labors) has an elasticity coefficient of 0.086, which is supposed to be positive with Eee, meaning that if the case of potato

production's households increased by the initial investment cost by 1%, the Eee would increase by 0.086%.

Variable LnX4 (expenses of machine and equipment cost) has an elasticity coefficient of -0.159, and is supposed to be negative with Eee, meaning that if potato production's households increased by expenses of machine and equipment cost 1%, the Eee would decrease by -0.159%.

Variable LnX5 (pesticides) has an elasticity coefficient of -0.062, which should be negative with Eee, meaning that if potato production's households increased by amounts of pesticides 1%, the Ecological-economic efficiency (Eee) would decrease by -0.062 %.

Variable LnX6 (fertilizers) has an elasticity coefficient of -0.219 which should be positive with Eee, meaning that if the case of potato production's households increased by amounts of fertilizers of 1%, the Ecological-economic efficiency (Eee) would increase by 0.214%.

### In the Red River Delta

Variable LnX2 (Initial investment cost) has an elasticity coefficient of 0.306, which should be positive with Eee, meaning that if the case of potato production of households increased by the initial investment cost by 1%, the Eee would increase by 0.306%.

Variable LnX4 (expenses of machine and equipment cost) has an elasticity coefficient of -0.078, which should be negative with Eee, meaning that if the potato production's households increased by expenses of machine and equipment cost 1%, the Eee would decrease by 0.078%.

Variable LnX5 (pesticides) has an elasticity coefficient of -0.214, which should be negative with Eee, meaning that if potato production households increased the amount of pesticides by 1%, the Eee would decrease by 0.214%.

Variable LnX6 (fertilizers) has an elasticity coefficient of -0.219 which should be negative with Eee, meaning that if potato production households increased the amount of fertilizer by 1%, the Eee would decrease by 0.214%.

Specifically, in the case of potato production of households in Primorsky Kray, the elasticity coefficient of Ecological-economic efficiency by initial investment is 0.732, by labors is 0.311, by expenses of machine and equipment cost is -0.248, by fertilizer is 0.291, and by pesticides is -0.129. The corresponding figures in the case of



potato production of households in the Red River Delta are 0.306; 0; -0.324; -0.200 and -0.297.

This means that when other factors remain unchanged, if the case of potato production of households in Primorsky Krai increased by 1% in initial investment, in labors, and in fertilizes, the ecological-economic efficiency would increase by 0.732%, 0.311%, and 0.291%, respectively. If the potato production of households in Primorsky Krai increased by 1% in expenses of machinery and equipment cost and pesticides, the ecological-economic efficiency of potato production of households in Primorsky Krai would decrease by 0.248% and 0.129%.

There are similar figures for the Red River Delta. If potato production of households in the Red River Delta increased by 1% in initial investment then the Eee would increase by 0.306%. If the case of potato production households in Red River Delta increased by 1% in expenses of machinery and equipment cost, pesticides, and fertilizes, the Eee of potato production of Red River Delta would decrease by 0.324%, 0.200%, and 0.297%, respectively.

## CONCLUSIONS

This study aimed to identify and compare the impact of production factors on the total ecological and economic efficiency of the potato land-use type in the two regions Primorsky Krai, Russia and Red River Delta, Vietnam using the Cobb-Douglas production function. The results show that the ecological-economic efficiency in potato production by farming households in the study area is affected by production factors such as initial investment, expenses of machinery and equipment, labors, amounts of pesticides, and fertilizers. These research findings suggest that the potato production of households in the study areas should consider the following directions:

Firstly, to improve ecological-economic efficiency, the potato production households in the study areas must focus on productivity factors as well as the impact of ecological factors.

In particular, it is essential to invest in the assets of initial investment, labor, and fertilizer for potato production farms because they are important factors in increasing the ecological-economic efficiency of potato production in Red River Delta farming. Similarly, Primorsky Krai should continue to focus on in-depth development of total

factor productivity such as initial investment, labor, and fertilizer.

Secondly, In the Red River Delta, amounts of pesticides and fertilizers have a negative influence on the dependent variable Eee, which is the composite efficiency coefficient, so the proposal for this area is as follows: It is necessary to adjust farming techniques in the direction of controlling and reducing the use of these variables. The reality in the Red River Delta also shows that the abuse of fertilizers and pesticides in agricultural cultivation is at an alarming level.

## Acknowledgments

The authors would like to express their gratefulness to the Ministry of Natural Resources and Environment of Vietnam, Vietnam National University of Agriculture, and the State University of Management of Russia for their support and data supply for this study.

## REFERENCES

1. Aydın B. 2014. Determining the structural characteristics and productive efficiency of farms in Thrace Region. Ph.D. Thesis, Namık Kemal University, Tekirdağ, Turkey.
2. Bui N.H.A. 2013. Solutions to improve economic efficiency in agricultural land use in Yen Bai in the period of 2012–2020. Ph.D. Thesis, Thai Nguyen University, Vietnam.
3. Chebil A., Fija A., Thabet C. 2015. Economic efficiency measures and its determinants for irrigated wheat farms in Tunisia: a DEA approach. *New Medit*, 14, 32–39.
4. Cobb C.W., Douglas P.H. 1928. A Theory of Production". *American Economic Review*. 18 (Supplement), 139–165. JSTOR, 1811556.
5. Do V.N., Nguyen T.A., Nguyen K.V.B. 2016. Assessing Efficiency of agricultural land use models for commodity production in Luong Tai District, Bac Ninh Province. *Vietnam J. Agri. Sci.* 2016, 14(9), 1418–1427.
6. Dang H.T., Vo T.D. 2011. Analysis of factors affecting the growth of Can Tho City: The approach to total factor productivity. *Journal of Science*, 17b, 120–129.
7. Ellis F. 1993. *Peasant Economics: Farm Households and Agrarian Development*. Cambridge University Press, Cambridge.
8. Fadejeva L., Melihovs A. 2010. Measuring total factor productivity and variable factor utilization:

- Sector approach, the case of Latvia. *Eastern European Economics*, 48(5), 63–101.
9. Idong I.C. 2007. Estimation of farm level technical efficiency in smallscale swamp rice production in Cross River State of Nigeria: A stochastic frontier approach. *World Journal of Agricultural Sciences*, 3(5), 653–658.
  10. Galawat F., Yabe M. 2012. Profit efficiency in rice production in Brunei Darussalam: A stochastic frontier approach. *Journal of International Society for Southeast Asian Agricultural Sciences*, 18, 100–112.
  11. Hu B., McAleer M. 2005. Estimation of Chinese agricultural production efficiencies with panel data. 68, 475–484. <https://doi.org/10.1016/j.matcom.2005.02.002>
  12. Lamers M., Anyusheva M., La N., Nguyen V. V., Streck T. 2011. Pesticide pollution in surface-and groundwater by paddy rice cultivation: A case study from Northern Vietnam. *Clean-Soil, Air, Water*, 39, 356–361.
  13. Nguyen M.T., Nguyen T.B.P., Bui N.H. 2018. Efficiency assessment of agricultural land use in Con Cuong District, Nghe An Province. *Journal of Forestry Science and Technology*, 2018 (2), 65–74
  14. Pham V.D. 2011. GAP for Rice in the Mekong Delta, progress and plans. *Proc. of Workshop on Good Agricultural Practices (GAP) for Rice in Southeast Asia*.
  15. Rizzo M. 1979. The cost of crime victimization: An empirical analysis. *The Journal of Legal Studies*, 8, 177–205. <http://dx.doi.org/10.1086/467606>.
  16. Orawan S., Somporn I. 2012. Efficiency change in Thailand rice production: Evidence from panel data analysis. *Journal of Development and Agricultural Economics*, 4(4), 101–108.
  17. Theodore S. 1964. *Transforming traditional agriculture*. Yale University Press, New Haven,.
  18. Tran T.A.T., Ho V.H., Ho N.L., Nguyen V.B., Nguyen T.P. 2021. Efficiency of agricultural land use of ethnic communities in A Luoi District, Thua Thien Hue Province. *Hue University Journal of Science: Agriculture and Rural Development*, 130(3B), 105–118. <https://doi.org/10.26459/hueunijard.v130i3B.6025>
  19. Truong V.T. 2007. Evaluating the economic efficiency of land use in Dak Lak Province. *Journal of Science and Technology*, University of Da Nang, 19, 1–4.
  20. Vu T.T.H., Svetlana P.K. 2017. Ecological and economic analysis of agricultural land use in Vietnam in conditions of innovative development. *State University of Management Bulletin*. 12, 106–112. [http://vestnik-old.guu.ru/?page\\_id=910](http://vestnik-old.guu.ru/?page_id=910). Accessed 10 Dec 2022.
  21. Yang C.H. 2007. What factors inspire the high entry flow in Taiwan’s manufacturing industries-A count entry model approach. *Applied Economics*, 39(14), 1817–1831. <https://doi.org/10.1080/00036840600690181>