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ASSESSING CLIMATE CHANGE AND DETERMINANTS OF RICE PRODUCTION EFFICIENCY IN LAO PDR: THE CASE STUDY OF SAVANNAKHET PROVINCE

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ABSTRACT

Rice is the most essential staple crop in the Lao PDR, accounting for more than 80% of cultivated land and serving as the main source of household food consumption. Despite strong national demand, rice production efficiency remains constrained by several technical, environmental, and socioeconomic factors. This study evaluates the determinants of rice production efficiency in Savannakhet Province using the Cobb–Douglas Stochastic Frontier Production Function. Results show that production factors positively associated with rice yield include cultivated area, rice varieties, fertilizer use, labor input, and production equipment. Conversely, inefficiency is significantly influenced by variables such as education level, technical training, and land-use adaptation, which are negatively correlated with inefficiency levels. Water management practices are found to play a critical role in enhancing productivity, particularly in adapting to climate variability and improving irrigation reliability. The average technical efficiency of households is estimated at approximately 61%, suggesting moderate efficiency with substantial potential for improvement. Strengthening technical training, improving access to appropriate technologies, and developing irrigation systems can significantly enhance production efficiency and support agricultural development in the province.

Keywords: Climate Change, Rice Production Efficiency, Stochastic Frontier Analysis, Lao PDR, Agricultural Productivity.

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1. INTRODUCTION

Rice production covers more than 80% of the total cultivated area and is the most important food crop in Lao PD (1), reported that the per capita domestic rice consumption is 162.6 kg/year of rice, the highest rice consumption in the world. This is particularly evident from the total annual rice production in 2024, which averaged approximately 3,660,060 tons, covering an average annual rice planting area in Lao PDR of approximately 894,416 hectares. Of this, the total harvested area averaged approximately 890,798 hectares, and the national productivity averaged approximately 4 tons/hectare. In general, sticky rice is still the most popular food crop in consumption, making Lao PDR the largest producer and consumer of sticky rice in Asia. Lao agricultural production, in general, and rice production (in particular), depend on weather conditions. (2 pp. 48-52) In years with bad weather, yields are low, while in years with good weather, yields are good. Since the production of rice in many rural areas is more than 80% of the total cultivated area, and the consumption of rice accounts for more than 80% of all the calories consumed, climate change has a great impact on people's lives. The conditions and levels of poverty in many areas are believed to be largely dependent on the level and frequency of natural disasters, particularly droughts and floods.[1]

For research study on "Assessment of water management on efficiency analysis agriculture production in Lao PDR" is expected to be a source of development that will be contributing to sustainable of socio-economic and agribusiness, as the past, the developing countries have used water management in the process of agriculture production in the community[2], This could lead to the development of a comprehensive water management system to support good quality agricultural production that can improve communities or people's lives.

Thus, there is a need to use sustainable development principles in three dimensions: economic, social, and environmental, with the goal of developing and growing economically at an appropriate and stable level. Against such circumstances, in recent years, the agriculture sector has contributed directly to GDP, exports, and the budget of a particular project in agriculture. The contribution to the eradication of poverty in a particular way helps to develop the community and the environment, including local spending in the Lao P.D.R.[3]

2. LITERATURE REVIEW ON WATER MANAGEMENT AND AGRICULTURE PRODUCTION

2.1 Development of water management system in Laos

The National Water, Sanitation and Water Resources Policy sets out the guidelines for implementation to achieve the Sustainable Development Goals (SDGs), particularly SDG number of legislative instruments as tools for macro-management, particularly the Decree on Public-

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Private Partnerships to foster trust and attract private sector investment in water and sanitation development projects. (3 p. 8)

The Laotian government has improved water management through 17 provinces, and the Capital of Vientiane is further divided into districts. (4 p. 28) Water supply is of more importance in Laos[4], especially in the industry sector for the construction of reservoirs to generate electricity, and the agriculture sector for agricultural products [5].Therefore, the Lao government is focusing on making the Water Supply State Enterprise (WSSE),[6] managing water supply implementation in line with provincial plans, and providing piped water supply services to urban and rural areas [7] .So, water management for irrigation in agricultural production is a priority for the Lao government, which has marked an irrigation system at the provincial level for agricultural production in the dry season.[8]

2.2 Factor of rice production in Laos

Factors that affect production efficiency, such as labor costs, machinery, materials, and equipment, are important for production efficiency.[9] Therefore, to increase production efficiency, it is necessary to increase the level of labor costs, materials, equipment, and machinery. At the same time, manure or chemical fertilizers are not important for production efficiency.[10] This shows that some farmers may be using inappropriate techniques in applying chemical fertilizers. In summary, farming requires adding factors (labor, land, chemical fertilizers, education level, production experience, household size, and varieties, etc.) to increase production efficiency. Therefore, farmers with low production efficiency will also have low yields and tend to reduce production inefficiencies. Furthermore, the impact of chemical fertilizers on production has an impact on the environment.[4]

Production efficiency, which is related to services and information, such as technology and crop cultivation techniques, requires improvements in farmers' access to information and technology, production quality, labor, and markets to reduce risks to production efficiency. [11]

2.3 Climate change and factors determining production in Savannakhet Province, Lao PDR

Climate change impacts on agricultural systems are a major challenge for rice production, with most of the production located in Savannakhet province, which has access to large water sources across the country, making rice production very important at the community level. Rice production is largely dependent on rainfall and favorable weather conditions, resulting in increased variability in production. When temperature changes and the impact of the dry season mean that the need for access to water sources increases, this creates a risk to rice production businesses.[12]

Research from many sectors shows that hot, dry weather and changes in rainfall are affecting rice production capacity, especially in lowland rainfed areas, which may lead to losses in rice production as higher temperatures and fluctuating rainfall patterns during the rainy season reduce rice production capacity and pose a threat to food security.[12] In addition to climate, socio-economic factors such as water resources, land resources, access to credit, and education are determinants of rice production efficiency. Several studies have shown that large production areas contribute significantly to production, while access to water resources and the introduction of machinery to assist in production are good contributors to efficiency.[13]

However, climate change remains a major obstacle to rice production in Savannakhet province, while socio-economic factors and land management should be encouraged to develop a mindset to adapt to the changing climate so as not to affect the efficiency and sustainability of rice production in the face of changing climate.[13]

3. METHODOLOGY AND DATA COLLECTION

3.1 Desk research

The research will seek information by reviewing data from websites, books, journals, and summary data from the line's ministry in Laos, especially the Lao Statistics Bureau, the Ministry of Agriculture and Environment, the Faculty of Irrigation, and the Faculty of Agriculture.[14] Therefore, the research has also summarized key informants by line provincials, for instance: the Department of Agriculture and Environment, the Department of Finance, and the Department of Industry and Commerce.

3.2 Field survey

To collect primary data for quantitative analysis. It has three levels:

- **Community Profile Survey**: using Semi-Structured Questionnaires to have focus group discussion with heads of community (village or sub-village), village authorities and teachers residing in the survey area.
- **Household survey*:*** using Semi-Structured Questionnaires to interview heads of selected households using enumerators.
- **Life history** interview: using an Interview Guide to interview Assessment of water management on efficiency analysis agriculture production and collect interesting cases.

To collect primary data for quantitative analysis. It has three levels:

3.3 Sample Selection by cause study in Savannaket province

Task 1: Selection of Province

Savannakhet Province was purposively selected because:

- It is one of the largest rice-producing provinces in Lao PDR.
- It contains both irrigated and rain-fed rice production systems.
- The province is highly exposed to climate variability, including drought and rainfall irregularity.
- It plays an important role in national food security.

The province therefore provides a suitable case for assessing rice production efficiency under climate change conditions

Task 2: Selection of Districts and Villages

Within Savannakhet Province, districts with significant rice production activity were identified in consultation with provincial agricultural authorities.

Village selection followed these steps:

1. A complete list of rice-producing villages in selected districts was obtained from the Provincial Department of Agriculture and Environment.
2. Villages were stratified based on:
    - Irrigation access (irrigated vs. rain-fed)
    - Production intensity
    - Geographic accessibility
3. From this list, **four villages** (Kangyao, Kong, Ladngone, and Nadee) were selected using random sampling within strata.

This approach ensures variation in:

- Water management systems
- Climate exposure
- Production scale

Table 1 will be showed the capture the situation of assessment of water management on efficiency analysis of agricultural production throughout the country, we applied several stages of selection and consulted with the Supervisor Community (SC) and the Technical Team (TT) to make the final selection.

Here are the details of the process:

Village level: we obtained a list of villages in selected districts prior to the survey and performed village selection using a Random Sampling Method, scoping by time and budget limitations of the research project. We then managed to have a total of 4 villages from the one province:

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Table 1: Data collection

Name of Village	Population	Number of Households	Number of simples
Kangyao	1,062	179	52
Kong	503	134	68
Ladngone	773	159	49
Nadee	348	68	35
Total	2,686	540	204

Source: Tutor analysis, 2025

3.4 The Theory of Heteroskedasticity Test

Although SFA models partially account for composite error structures, testing for heteroskedasticity in the production function residuals strengthens robustness. So, two commonly applied tests include:

(a) Breusch–Pagan / Cook–Weisberg Test

This test examines whether the variance of residuals depends on explanatory variables.

Hypotheses:

- H_0: Homoskedasticity (constant variance)
- H_1: Heteroskedasticity

If the p-value > 0.05, we fail to reject H_0, indicating homoskedasticity.

(b) White's General Test

White's test provides a more general check without assuming a specific functional form.

If heteroskedasticity is detected, robust standard errors (Huber–White correction) can be applied to ensure valid statistical inference.

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3.5 Methodology analysis

The study will be studying the model is the Cobb–Douglas Stochastic Frontier Production Function (SFPF) to estimate household-level rice production efficiency.[15] The model will be showing the relationship between output and key production inputs while separating random errors from inefficiency effects.

The functional form is:

$$LnY_i = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + \beta_5 LnX_{5i} + \beta_6 LnX_{6i} + V_i - U_i$$

Definition:

Y_i = total household output i (kg)

X_1 = Rice cultivation area (ha)

X_2 = Rice variety (kg)

X_3 = Manure(kg)

X_4 = Chemical fertilizer (kg)

X_5 = Laboure (man-days)

X_6 = Equipment (Kip)

β_0 = Constant value

β_s = Coefficient

V_i = Error value

U_i = Inefficiency

This inefficiency model will be showing agricultural production in the case study [16] as well as the research of technical efficiency agriculture in Laos especially maize farmer in north part that be will show the statistic model [17] as below:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + e_i$$

Definition:

Z_1 = Age of interviewer (year)

Z_2 = Number of education (year)

Z_3 = rice planting of experience (year)

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Z_4 = Size of household members (Number)

Z_5 = Technical training

Z_6 = Distance from village to urban (km)

Z_7 = income not agriculture

Z_8 = Organic farming

Z_9 = land adaptation

Z_{10} = Farmer member group

δ_0 = Constant value

δ_s = Coefficient

Table 2 will be discussing study applies a Stochastic Frontier Production Function to assess household rice productivity using key variables such as rice paddy area, rice variety, manure, chemical fertilizer, labour, and equipment. Productivity is expected to increase with larger areas, improved varieties, more labour, and better equipment, while excessive manure and fertilizer may reduce efficiency. The inefficiency model includes household characteristics such as age, education, experience, household size, training, distance to urban areas, non-agricultural income, organic farming, land adaptation, and group membership. Most socioeconomic factors are expected to reduce inefficiency, enhancing productivity through improved skills, experience, and resource accessibility.

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Table 2: Variable analysis Stochastic Frontier Production Function and Inefficiency Model

Variable	**Definition**	**expectation**	**Variable source**
Variable for Stochastic Frontier Production Function			
productivity (Y_i)	Total household production i (kg)	Positive	Benjamin C (2012)
area (X_1)	Rice planting area (ha)	Positive	Benjamin C (2012)
Rice variety (X_2)	variety (rice white, black, red) (kg)	Positive	Boundeth et al (2012)
Manure (X_3)	manure (kg)	Negative	Benjamin C (2012)
Chemical fertilizer (X_4)	Chemical fertilizer (kg)	Negative	Benjamin C (2012)
Laboure (X_5)	Laboure (man-days)	Positive	Boundeth et al (2012)
Equipment (X_6)	Equipment (Kip)	Positive	Boundeth et al (2012)
Variable for Inefficiency Model			
Age (Z_1)	Age of head of household (year)	Negative	Benjamin C (2012)
education (Z_2)	Number of education (year)	Negative	Boundeth et al (2012)
Experience (Z_3)	Rice planting experience (year)	Negative	Boundeth et al (2012)
Size of household member (Z_4)	Size of household member (Number)	Negative	Benjamin C (2012)
training (Z_5)	Variant (if Z_5= 1 technical training, 0 =other)		
Distance (Z_6)	Distance from village to urban (km)	Negative	Benjamin C (2012)
Income not agriculture (Z_7)	Income not agriculture (Off farm)		
Organic farm(Z_8)	Variant (if Z_8= 1 organic farm, 0 =other)		
Land adaptation (Z_9)	Variant (if Z_9= 1 rice planting, 0 =other)		
Group member (Z_{10})	Variant (if Z_{10}= 1 member, 0 =other)		

Source: data collection and calculator by researcher, 2025

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4. KEY FINDING OF EFFICIENCY ANALYSIS RICE PRODUCTION IN LAOS

4.1 Adaptation climate change in Savannakhet province in Lao PDR

Table 3 will be showed Savannakhed is located in hottest and driest area of Lao PDR; the average mean temperature is about 26.13 °c while the average maximum and minimum temperature are 31.4 °c and 21.8 °c respectively; May is the hottest month with average mean temperature of about 28.4°c; the average rain during last 50 years is estimated to be about 1,478.5 mm, about 23.3% of the rain falls in August. Based on findings from statistical data analysis from nearest weather station, Savannakhed has been experiencing significant climate change, particularly the increasing temperature and declining rainfall. The table below presents more details on climate change during last 40 years, i.e. from 1975 to 2025.

Table 3: Climate change in Savannakhet province, Lao PDR

Items	Unit	Average during 50 years	Changing during last 50 years	Average yearly change
Average mean temperature	°c	26.13	1.90	0.05
Average maximum temperature	°c	31.4	1.40	0.04
Average minimum temperature	°c	21.8	3.10	0.09
Average temperature in march	°c	25.5	3.20	0.09
Average temperature in April	°c	27.6	1.80	0.05
Average temperature in May	°c	28.4	1.80	0.05
Rainfall	mm	1,478.50	-200.00	-5.71
Rainfall in June	mm	228.7	-96.00	-2.74
Rainfall in July	mm	274.3	32.00	0.91
Rainfall in August	mm	344.8	-190.00	-5.43
Rainfall in September	mm	247.9	-60.00	-1.71

Source: Estimated by research team based on data provided by Savannakhet provincial department for agriculture and forestry

Generally, the table 1 above shows increasing temperature and declining rainfall in Savannakhet province during last 40 years. According to the table and figures, the mean temperature has been increasing around 1.9 degree centigrade while rainfall has been declining around 200 mm during the same period. The figures and table show on average the mean temperature has been increasing around 0.05 degree centigrade and rainfall has been declining 5.71mm per year.

All of these indicate that drought and water scarcity problems have been increasing while flooding has been experiencing declining trend in the location during last 40 years. However, it does not mean that the location was not affected by any flooding during the period. In posited direction, based on findings from focus group discussion, flooding is identified as a significant risk associated with climate change; the event has been affecting the location very year during the period and it has been experiencing an increasing trend in term of frequency and severity because of changing of natural resources, particularly the declining forestry cover, shallowing of rivers and ponds, change in rain timing, etc.

In addition, climate data above indicates change in timing of rain during last 40 years; it indicates declining rainfall in May and June 5.71 and 2.74 mm, presenting declining of 0.39% and 1.2% on average per annum respectively while the rainfall in July has been increasing about 0.91 mm, presenting an increasing rain of 0.33% per annum on average, indicating significant and high percentage of change. Sustaining the change over a period July is expected to become wettest month while other months will expect to become dryer. Intensive rain and flood is expected more frequently in July.

Based on findings from focus group discussion, this type of change in rain timing has significant negative impacts on rice production. The change causes frequently water shortage for rice seeding in May and June, particularly for the seeding in fields located in higher attitude and distanced from water body and it causes flooding in July, affecting rice fields located in lower attitude and near from water body.

The increasing temperature, declining rainfall and rain coming not on time mentioned above is expected to affect ecosystem service of wetland and thus affects people livelihood in location. More details on that, the research would like to analyze and talk about in the next section.

4.2 Analysis Overall rice production and water supply system in Laos

Figure 1 is explanting the rice production from 2019 to 2024. In 2019, production was about 3.53 million tons, followed by a slight decrease in 2020 to 3.50 million tons. However, production began to increase steadily afterward, reaching around 3.65 million tons in 2021 and continuing to rise to 3.78 million tons in 2022. The highest level was recorded in 2023 at approximately 3.90 million tons, showing strong growth in rice output. In 2024, production slightly declined to about 3.75 million tons. Overall, the trend line indicates a gradual upward movement in rice production over the six-year period, despite minor fluctuations. The overall increase suggests improved agricultural practices, favorable weather, or policy support that boosted production levels.

Nonetheless, the drop in 2024 implies that external factors such as climate conditions or input costs may have temporarily affected yield. The general trend remains positive toward sustainable rice production growth.

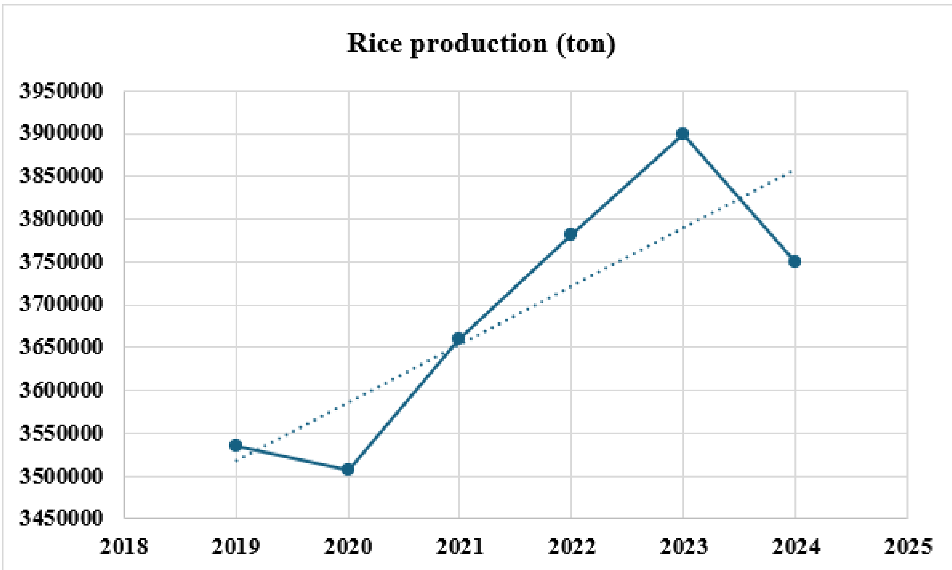

Figure 1: rice production in Laos 2019 – 2024 (Source: Laos Statistic Bureau, 2024)

The graph illustrates the trend of the water supply area (in hectares) from 2022 to 2024. In 2022, the total water supply area was approximately 420,000 hectares. This figure increased significantly in 2023, reaching around 480,000 hectares, showing strong progress in expanding irrigation and water management infrastructure. By 2024, the water supply area further rose to about 500,000 hectares, although the growth rate slowed compared to the previous year. Overall, the data demonstrate a consistent upward trend over the three-year period, indicating continued improvement in water resource development and availability. The expansion of the water supply area contributes positively to agricultural productivity, food security, and sustainable water management. This steady increase suggests effective implementation of water-related programs and investments in irrigation systems, ensuring better access to water for farming and other uses. The gradual growth from 2022 to 2024 reflects the country's ongoing commitment to enhancing water infrastructure and supporting rural development. (Detail is show in figure 2)

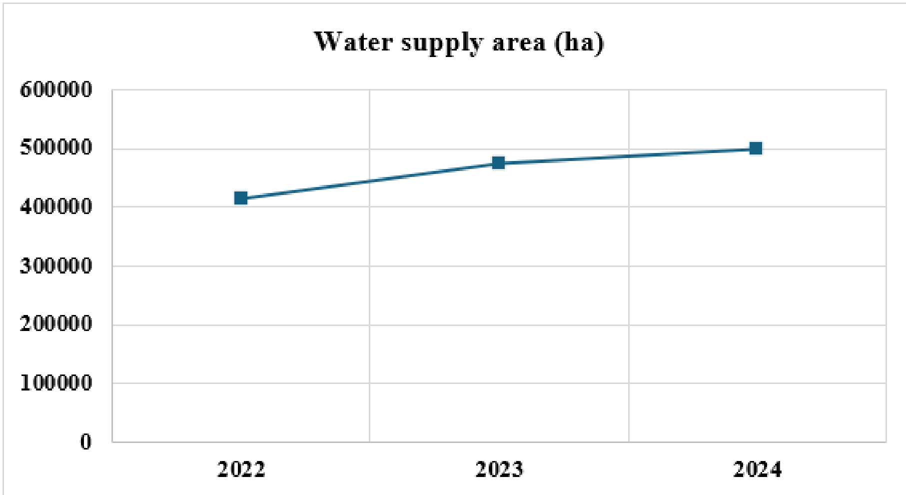

Figure 2: Laos water supply area 2022-2024 (Source: Laos Statistic Bureau, 2024)

Figure 3 will be showed from 2019 to 2024, the plant and harvest areas showed opposite overall trends. The planted area fluctuated, peaking in 2023 at around 1,005,000 ha before sharply declining to about 912,000 ha in 2024, indicating a downward trend. In contrast, the harvest area generally increased from 840,000 ha in 2019 to a peak of 990,000 ha in 2023, then slightly decreased to 915,000 ha in 2024. The overall rise in harvest area suggests improved crop management and efficiency, while the decline in planted area may reflect land-use changes or environmental constraints affecting cultivation practices in the final year.

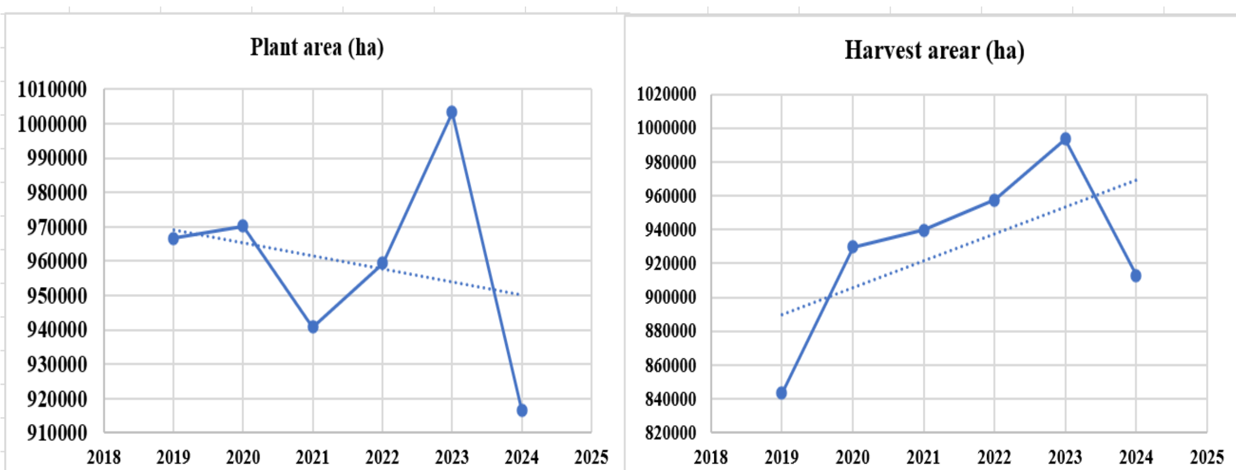

Figure 3: Plant and harvest areas (Source: Laos Statistic Bureau, 2024)

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4.3 Key finding rice production by cause study Savannakhed province

Table 4 explanted the result evaluation of rice production efficiency showed that the average rice yield of each household was about 3,919 (kg), the average area for rice production by household was about 1.06 (ha), the average variety used for rice production in one season was 114 (kg), the average amount of manure used in production was about 2,393 (kg) and the average amount of chemical fertilizer used was about 110 (kg) per production season, and the average labor used in rice production in one season was about 204 person-days. The average cost of purchasing equipment for production was 1,403,038 (Kip) per family, and the average Age of households producing rice was 43 years. The average level of education of interviewees was about 7 years. The average experience in rice production by households was about 12 years. The average Number of household members was about 5 per family. Of these, about 18% had received technical training. The average distance from Mueang Paek to the village where rice is produced was about 19 km. The average non-agricultural income of households was about 35,800,000 (Kip)/family. About 27% of households cultivated organic rice. There was a pattern of land use changed before planting rice. Farmers had previously grown rice before, with an average of about 94% of households surveyed. Of these, only 6% of households interviewed participated in the chicken rice production group.

Table 4: Evaluation of efficiency production in Laos

Variable	**Unite**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Variable of Stochastic Frontier Production Function					
Productivity (Y_i)	(kg)	3919.686	2146.098	400	11000
Area (X_1)	(ha)	1.065521	0.5638356	0.15	3.5
Rice variety (X_2)	(kg)	114.0294	56.77984	20	315
Manure (X_3)	(kg)	2393.985	2981.762	0	16000
Chemical fertilizer (X_4)	(kg)	110.1012	249.195	0	3290.4
Laboure (X_5)	(man-days)	204.45	112.9469	15	601
Experient (X_6)	(Kip)	1,403,038	1,151,215	4375	7,577,500
Variable for Inefficiency Model					
Age (Z_1)	(year)	43.33824	13.97071	20	73
Education (Z_2	(year)	7.058824	3.130412	0	18
Experient (Z_3)	(year)	12.06863	6.179993	1	34
Household member size (Z_4)	(people)	5.254902	1.449894	2	10

Training (Z_5)	(if Z_5= 1 yes, 0 =other)	0.1813725	0.3862745	0	1
Distance (Z_6)	(km)	19.03431	10.02577	10	33
Income non agriculture (Z_7)	(Kip)	35,800,007	61,800,000	0	543,000,000
Organic planting(Z_8)	Variant (if Z_8= 1 organic farm, 0 =other)	0.2745098	0.4473648	0	1
Land adaptation (Z_9)	Variant (if Z_9= 1 rice planting, 0 =other)	0.9411765	0.2358729	0	1
Framer group member (Z_{10})	Variant (if Z_{10}= 1 member, 0 =other)	0.0637255	0.2448642	0	1

Source: data collection and calculator by researcher, 2025

Table 5 will be shows the result the factors affecting rice production efficiency. The area of production is positively correlated with yield. At the 1% confidence level, if the interviewed households increase their area of production by 1 unit, they will increase their yield by 0.06 units. This finding is consistent with the findings of Benjamin C (2012). For rice varieties, there is a positive correlation with yield, and with a confidence level of 1%, if a household adds 1 unit of rice variety to its production, it can effectively increase the yield of small rice by 0.14 units. This research result is the same as the research of Boundeth et al (2012). Tools (knives, sickles, rakes, shovels, axes, harvesting equipment, spray protection equipment, water pumps, sprayers, tractors, and buffaloes) are another factor that has a positive relationship with yield, which can also increase the efficiency of rice production. With a confidence level of 1%, if a household adds 1 unit of tools to its production, it can increase rice production efficiency by 0.05 units. Labor is another factor that has a positive relationship with productivity, which can also increase the efficiency of rice production. With a confidence level of 5%, if a household adds 1 unit of labor to production, it can increase the efficiency of rice production by 0.0723 units. For the use of manure, another factor that has a positive correlation with the efficiency of rice production, which can increase the yield with a confidence level of 10%. If a household adds 1 unit of manure to its production, it will increase the yield by 0.0009 units because: Rice production requires the addition of manure to increase the quantity and efficiency of rice production. However, for the results of this research, the use of chemical fertilizers is a factor that does not affect the yield because people still use natural cultivation, and the techniques for using chemical fertilizers are not yet consistent in growing small chicken rice. And because manure is not enough for production, households use chemical fertilizers in production to increase production efficiency.

Table 5: Factor effecting efficiency rice production in Lao

Variables	Cobb-Douglas production function		
	Coefficient	t-ratio	
Stochastic Frontier Production Function			
constant Value	6.9227	20.1635	***
area(X_1)	0.6087	18.1443	***
Rice variety (X_2)	0.1491	5.0589	***
Manure (X_3)	0.0009	1.6697	*
Chemical fertilizer (X_4)	0.0063	1.3935	
Laboure (X_5)	0.0723	2.5564	**
Experient (X_6)	0.0505	3.6537	***
Inefficiency Model			
constant Value	1.7062	5.6436	**
Age (Z_1)	-0.0040	-1.2904	
Education (Z_2)	-0.0040	-2.5449	**
Experient (Z_3)	-0.0093	-1.44708	
Household member size (Z_4)	-0.0581	-1.57823	
training (Z_5)	-0.1421	-1.9270	*
Distance (Z_6)	0.0009	0.3040	
Income non agriculture (Z_7)	-1.0330	-1.0154	
Organic planting (Z_8)	0.2171	4.1644	***
Land adaptation (Z_9)	-0.2630	-1.7909	*
Framer group member (Z_{10})	0.0273	0.1659	
Sigma-squared	0.1559	20.11269	***
Gamma	0.9999	1805.44	***
log likelihood function	34.6752		
(Efficiency)	0.6162		

Note: The symbols ***, **, and * indicate the significance of the variable at the 1%, 5%, and 10% levels.

4.4 Key finding Comparison with Similar Rice Efficiency Studies in Southeast Asia

To contextualize the results of this study on rice production efficiency in Savannakhet Province, it is essential to compare them with findings from related research across Southeast Asia. This

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broader comparative analysis highlights both common regional patterns and contextual differences shaped by agro-ecological and socio-economic factors.

1. Technical Efficiency Levels

Several studies in Southeast Asia report technical efficiency scores for rice farmers within ranges comparable to those found in this analysis.

In Vietnam's Mekong Delta, studies using Stochastic Frontier Analysis (SFA) often find technical efficiency scores between 0.60 and 0.80, indicating considerable room for productivity improvement comparable to the moderate efficiency levels observed in Savannakhet.[18]

Research in Thailand's central plains showed slightly higher average technical efficiency (>0.80), which authors attribute to greater mechanization and better access to irrigation infrastructure.[19]

These similarities suggest that rice producers across the region commonly operate below full efficiency, and gaps are frequently linked to constraints such as limited capital, sub-optimal input use, and climatic risks.

2. Input Use and Resource Constraints

Studies across Southeast Asia similarly identify key determinants of inefficiency related to resource use:

Vietnam and Cambodia: Studies emphasize that inefficient use of seeds and fertilizers, along with poor access to credit, are significant contributors to low technical efficiency.

Philippines: Rice farmers facing high fertilizer cost variability and inconsistent extension services also show reduced productivity outcomes.

In comparison, the present study in Lao PDR finding that fertilizer use, labor allocation, and irrigation access significantly influence output is consistent with the regional evidence.

5. CONCLUSION AND DISCUSSION

By analyzing statistical data and the Stochastic Frontier Analysis model. Therefore, in this research paper, it is shown that: The evaluation of the efficiency (Efficiency) in rice production is about 61% on average, which shows that: The efficiency of rice production in Savannakhet province is moderately efficient in rice production. However, we also evaluated the factors that affect the efficiency of rice production that have a positive relationship with yield, such as area, variety, equipment, labor, and fertilizer at a confidence level of 1%, 1%, 1%, 5% and 10% respectively.

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In this study, we also analyzed other factors that affect rice production inefficiency that are negatively correlated, such as education level, technical training, and land conversion at 5%, 10%, and 10% confidence levels, respectively.

As a result of this study, we also have some suggestions for improving the efficiency of chicken rice production. For example, the use of manure in production is not sufficient for actual production. Therefore, households turn to using chemical fertilizers instead of manure. The more manure households use in production, the greater the increase in the quantity and efficiency of chicken rice production. Therefore, the government should be supported more attention to technical training, especially on the correct and appropriate use of chemical fertilizers, rice cultivation techniques that increase production efficiency, methods for storing rice varieties for a long time, methods for eliminating insects or pests, making organic fertilizers that can be used in actual production to replace manure, or providing additional advice on knowledge and understanding of rice cultivation that can increase efficiency.

The research also shows that the level of education is a factor that the government should support with more attention in order to provide households with a deeper understanding, along with increased technical training, which could increase the efficiency of small rice production, which is constantly increasing. In addition, the government should be supported to focus more attention on creating a comprehensive irrigation system, finding new markets, and controlling domestic prices, including exports.

Competing Interest declaration

The authors declare that there is no duplication with any other author's paper and no financial or personal relationships that could have influenced the work presented in this paper.

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Authors contribution

The contribution of authors for working paper Vongphachanh XAYALATH: Data collection, Stata software installation, design questionnaire, selected simple, and writing draft paper preparation. For, Zhang Yang is: Literature review by journal, website, and find secondary data.

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