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DETERMINANTS OF RICE COMMERCIALIZATION LEVEL AMONG SMALLHOLDER FARMERS IN LAOS: A BETA REGRESSION ANALYSIS APPROACH

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Abstract – *The Laos rice sector's transition from subsistence to commercialization, as well as its understanding of the current status of commercialization, technical efficiency, and its relationship to farmer welfare, have the potential to contribute to the literature on agricultural commercialization and serve as a lesson for relevant agencies and policymakers. This study aims to estimate the level of commercialization and identify the factors hindering its level of commercialization. The research was based on cross-sectional data from 408 farm households in Savannakhet Province. Beta regression was applied. The results indicated that the majority of smallholder farmers are semi-commercial rice producers, but they are more commercialized for dry season cultivation. The findings in beta regression revealed that in both seasons, disaster, consumption quantity, and credit accessibility had a statistically significant negative effect on rice commercialization. Meanwhile, land size cultivation had a positive statistically significant effect on rice commercialization in both seasons. In the Wet season, family size and extension accessibility had a positive statistically significant effect on rice commercialization. On the other hand, the dependency ratio had a negative statistically significant. In the dry season, family size had a positive statistically significant effect, and experience in rice cultivation had a negative statistically significant effect. Consequently, technologies that enhance land productivity must be developed and executed. Additionally, land resources in the research region are constrained. Implementing production-oriented education, training, and extension services is essential to enhance land productivity and encourage smallholder farmers' involvement in the output market.*

Keywords: beta regression, commercialization rice, smallholder farmers.

I. INTRODUCTION

The Lao Government has recognized that transitioning from subsistent farming to sustainable commercial farming is necessary. However, Lao PDR's agriculture sector is constrained by subsistent farming and small-scale production with a low level of commercialization, limited processing capacity, underdeveloped supporting infrastructure, and weak public services [1]. In the context of a rapid transition to intensive commercial agriculture in Laos, there are several crucial factors, including new input technology promotion (seed quality improved, fertilizer, mechanization, etc.), market orientation such as market participation, institutional factors like credit accessibility, extension service, farm organization promotion and enhancing technical efficiency via technical assistance. Agricultural commercialization means the change from a subsistence type of production to a market-oriented one with the aim of profit maximization [2].

In 2005, the Lao government launched a new Commercialization of Agriculture and Commodity Production policy. Regarding policy, three main factors influenced the emergence of the

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new commercial crop production system, including farmer organizations, land concessions, and contract farming [3]. In order to meet the commercial agricultural production policy, various areas throughout the country have implemented the tools as stated in the 6^{th} National Socio-economic Development Program (NSEDP) aimed to facilitate marketing and strengthen the bargaining powers of farmers through the production groups [4]. The policy in the 6^{th} NSEDP has also encouraged private enterprises, including foreign investors and traders from both domestic and neighboring countries, to invest in agribusiness, mainly market and credit accesses; this is a 'market pull' [3]. In 2016, the government also sought various solutions to promote agricultural commercialization by requesting a project under the World Bank fund to support agricultural commercialization and improve the sector's performance, especially along the rice value chains[1].

Meanwhile, these projects also aligned with the National Agriculture Sector Plan of 2020 and Strategy to 2025, which improving the commercialization and competitiveness of the agriculture sector are the top priorities [5]. These programs train and build capacity for farmers' organizations, agribusinesses, and public and private service providers. For instance, in the initiative commercialization scheme in Khammuane Province since 2009, to cooperate and coordinate, major mills have established so-called development rice miller groups in each of Khammouane's five districts. These organizations aim to help the province's rice industry grow. For example, the Khammouane Development Rice Miller Group discusses and decides on minimum paddy pricing or export potential. Millers who want to join the group must support at least 200 farm households via contract farming arrangements [6]. Rice farmers are encouraged to engage in high commercialization to boost production and productivity. Rice commercialization was expected to translate into poverty reduction and welfare enhancement in rural localities where most rice is produced [7–9].

Additionally, the commercialization of agriculture could take place on the output side (increased market surplus) or input side (increased use of inputs) [10]. In this study, rice commercialization refers to the sale of a marketable surplus of rice to meet the household expenditure of farmers [11]. Therefore, commercialization implies transitioning from subsistence-oriented rice production to market-oriented production [11]. Additionally, smallholder families require qualified technical assistance to implement new technologies, engage in markets, access input suppliers and service providers, and utilize high-value production crops and related practices for agricultural output to be profitable and commercial [12]. During the 12 years between 1998–1999 and 2010–2011, the agricultural sector has significantly transformed from subsistence farming to becoming more market-oriented [13]. It has been noted that households' indications of the purpose of agriculture have significantly shifted toward commercial production. For instance, whereas only 6% of households stated 'for selling' as their primary reason for farming in 1998–1999, 30% of farming households mentioned producing for the market in 2010–2011 [13]. The percentage of households that sold a portion of their rice produce had increased from 30% in 1998–1999 to 71% in 2010–2011[14]. Market participation of farmers is an essential positive result of economic development. Providing rural people with better income and improving food security is a major pathway to improving their standard of living. A market that is accessible to smallholder farmers is crucial to increasing their participation in the market.

The rainfed lowland system dominates rice production in Laos, and glutinous rice production is still primarily for subsistence, with only a tiny portion marketed and even less exported. However, the cultivated area and especially the yield of rainfed and irrigated rice has been increasing, contributing to rice self-sufficiency at the national level [15]. However, their study did not show evidence of the number related to the level of commercialization and its determinants. In addition to the methodological gaps of pre-

vious studies, several studies have used Tobit regression to assess the commercialization of another primary food crop (wheat, teff) [16–18], and Gari [19] used a multiple linear regression model to analyze determinants of smallholders' wheat commercialization. Nonetheless, the Tobit and multiple linear regression models are unsuitable for analyzing commercialization index scores confined to the interval (0, 1), as the predicted values of the dependent variable go beyond the unit interval (lower and upper limits) [20, 21]. Hence, the appropriate model was the beta regression model. The model in this study was adapted from Endalew et al. [22] and utilized a beta regression model to assess the wheat commercialization index and examine factors that hinder wheat commercialization. However, several explanatory variables do not fit the Laos context and situation, such as the number of oxen and distance to market, because most farmers in the areas no longer use oxen for draft animal power. Most of them sold their products to a collector in their village and sold to the rice group production directly. This study's objective is to identify determinants that influence the level of commercialization. The main question of this study is, 'What are the factors that influence the level of commercialization of rice production?'

II. LITERATURE REVIEW

There has been a lot of research on the factors that affect smallholder farmers' ability to sell their crops in various locations and for different types of crops. Therefore, reviewing these factors helped the researchers choose the study's adequate variables while considering the study site. Recently, practitioners identified several factors influencing agricultural commercialization [23]. These factors can be grouped into long-term or short-term and can either facilitate or impede the commercialization process. The long-term factors are population growth and rural infrastructural development. Certain studies indicate that population expansion may enhance the volume of marketable surplus, while other research suggests that rural infrastructure influences agricultural commercialization by affecting pricing, the dissemination of technology, and the effective integration of inputs and outputs [24]. The factors affecting the market participation decision and marketable supply of agricultural commodities have been identified by different authors using different analytical models based on the nature of the data set. For instance, Bekele et al. [16] used the Tobit estimation method to identify determinants of Haricot bean commercialization in their analysis of farm-level determinants of output commercialization in Haricot bean-based farming systems. They found that the age of household heads, dependency ratio, family size, cultivated land, and livestock ownership were factors influencing the intensity of Haricot bean commercialization.

Tobit regression was used by Lighton et al. [17] to investigate factors influencing the level of commercialization of smallholder farmers in Zimbabwe. They discovered that factors such as household income, draft power availability, cattle ownership, irrigation accessibility, agricultural training, and the distance between the homestead and the town all had a major and favorable impact on commercialization. Conversely, the determinants of community tenure, the number of family members with secondary education, and the location in an agroecological zone considerably and negatively affected commercialization [17]. Additionally, the researchers employed Tobit regression to identify factors affecting crop commercialization intensity and investigated cereal-based dry land farming [18]. The author discovered that agricultural commercialization intensity is significantly and favorably influenced by ox ownership, yield quantity and quality, and training in crop marketing. Increased agricultural commercialization has also been linked to unpaid debt and off-farm income, among other factors. However, factors such as family size, labour shortages among families, irregular rainfall patterns, the expense of agricultural inputs like fertilizer, crop pests and diseases, and distance to markets have a considerably negative impact on the level of crop commercialization. By using Tobit regres-

sion, factors determining the decision and level of farm output commercialization of smallholder farmers were identified [25]. Results from this study revealed that the age of the household head, household level of education, access to transport, and total cultivated land are the main variables that are statistically significant factors determining household-level of commercialization. Mohammed et al. [26] used an OLS model to find the factors influencing smallholder coffee growers' commercialization. The study discovered that household commercialization is positively influenced by household educational level, farming experience, total harvest, and the proportion of marketable high-value crops. In contrast, the level of commercialization is negatively influenced by family size, land ownership, proximity to the nearest village market, source of fertilizer, and improved seed. Heckman estimation was applied by Abafita et al. [27] to ascertain parameters influencing the commercialization of smallholders. The value of crop production, ownership of oxen, the number of adult family members, availability of all-weather roads, access to credit, fertilizer usage, and involvement in cooperatives within peasant associations positively affected market participation. In contrast, age and family size had a negative effect. The intensity of commercialization was affected by the value of crop produced, ownership of ox, land, all-weather road, access to credit, fertilizer use, market orientation index positively, and by age and family size negatively. Heckman's two-step estimation procedure identifies factors affecting decisions to participate in the crop output market and level of participation [28]. Their findings indicate that the decision of farm families to engage in crop output markets was affected by the gender of the household head, agricultural experience, livestock ownership, area of cultivated land, off-farm or non-farm income, fertilizer application, on-farm revenue, distance to market, and crop diversity. Conversely, the dependence ratio, quantity of farmed land, educational attainment, usage of chemical fertilizers, and proximity to the market were determinants affecting the intensity of agricultural output market involvement among farm families. Another crop investigation of degree of teff commercialization of smallholder farmers was done by using Heckman's two-step estimation procedure [29]. The study found that landholding size, proportion of land allocated for teff production, oxen and donkey ownership, and frequency of agricultural extension contact significantly and positively affect the level of teff commercialization; distance from market and livestock ownership significantly and negatively affects the level of teff commercialization [29]. Truncated regression was employed to identify factors affecting the level of commercialization [9]. The authors found that education, irrigation, farm size, and the number of animals all positively affected the level of commercialization. On the other hand, household size and distance to the nearest market had a negative effect. Moreover, Ele et al. [30] found that the total quantity of food crops produced, farming experience, access to agricultural extension service, the size of land used for cultivation, membership in cooperatives, and household family size are important factors determining the level of commercialization of smallholder farms. The ordered probit model was used to identify determinants of cereal crop commercialization among smallholder farmers [31]. This study determined that the degree of commercialization of cereal crops was significantly influenced by the gender of household heads, ownership of equines, size of cultivated land, frequency of extension contacts, utilization of credit, value of crops produced, and the household's moderate perception of historical crop prices. The degree of commercialization of cereal crops can be enhanced by increasing the frequency of extension contacts, providing low-cost agricultural credit, and implementing strategies that encourage intensive agriculture, such as ensuring the availability of modern agro-inputs at reasonable prices and promoting their adoption among farm households. Another food crop, such as wheat, has been investigated using a beta regression model to analyze factors hindering wheat commercialization [22]. The findings from the Beta

regression revealed that educational attainment, oxen count, land area designated for wheat cultivation, expertise in wheat farming, access to extension services, and distance to market are significant determinants of smallholder farmers' wheat commercialization.

III. RESEARCH METHODS

A. Study design

This research was conducted in Savannakhet Province, which is located in central Laos. The primary data for this study were randomly collected through survey questionnaires among rice farmers in three districts from Savannakhet Province. The total targeted sample size is 408 households. Farmers who responded to this study mainly grow rice for both consumption and sale, practicing both seasons of cultivation, including wet and dry seasons. The information was collected regardless of a farmer's socioeconomic characteristics, production characteristics, farmland characteristics, or institutional characteristics.

B. Sampling techniques, data source, and collection methods

Primary data was obtained from producers in the study area. To select kumb ban (village group), villages, and households, stratified sampling was implemented. In the first stage, three districts were purposively selected from the potential rice commercial of the province. In the second stage, nine villages (three villages per district) were chosen randomly. A proportionate-to-size sampling technique was implemented to ascertain the minimum number of households necessary to conduct survey interviews in the village, resulting in a sample of 408 households. In the three districts of Savannakhet Province, semi-structured questionnaires were developed, pretested, and administered to rice producers. A questionnaire was created to gather information on the characteristics of rice farms and the producers who operate them through in-person interviews.

Secondary data were compiled from relevant publications and government organizations, such as annual reports from nine villages annual report, three districts of Agriculture and Forestry Office, such as Champhone, Songkhone and Xaybouly, Savannakhet Provincial Agriculture and Forestry Office, Provincial Planning and Investment, Ministry of Agriculture and Forestry and Lao National Statistics Centre, during and after the survey. The village head and village committee members were present during the interviews. The data collected included village statistics, cropping systems, non-timber forest products (ntfps) collection, aquaculture activities, and off-farm and non-farm activities; irrigation management; access to capital; access to information and extension; and rice farmer organizations.

Population and sample size

The study was conducted based on data obtained from primary and secondary sources. A two-stage sampling technique was employed to collect primary data. To determine the sample size, the formula given by Kothari [32] was shown in Equation (1).

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} = \frac{(1.96)^2(0.5)(0.5)(45{,}395)}{(0.05)^2(45{,}395) + (1.96)^2(0.5)(0.5)} \approx 380{,}94 = 381 \quad (1)$$

During the village visit for interviewing, we had made, separately with the village headman committee, three people in each village, a total of 27 respondents, so the final sample for this study is 408 samples in total.

C. Measurement of rice commercialization

Crop commercialization refers to a shift from subsistence production to market-oriented production [33]. Crop commercialization reflects the extent of smallholder farmers' involvement in the output market as sellers [34]. Equation (2) represents the measurement of smallholder farmers' rice commercialization and indicates the degree of commercialization of each individual

smallholder farmer. For this purpose, the output commercialization formula was used to determine the rice commercialization index at the household level [22, 29, 35, 36].

$$\text{Rice commercialization index} = \frac{\text{Gross Value of rice sales in markets}}{\text{Gross Value of total rice produced}} \quad (2)$$

Sample smallholder farmers were categorized into three levels based on the rice commercialization index score: subsistence (0, 0.3), semi-commercialized (0.31, 0.5), and commercialized above 0.5 [22, 33, 37].

D. Empirical analysis

Practitioners commonly employ multiple linear regression and Tobit models to analyze crop commercialization index scores, which range from zero to one, based on individual features [18, 25, 26, 29, 34]. For instance, even though bounded variables do not support the assumption that error terms are homoscedastic and regularly distributed, multiple linear regression nevertheless makes this assumption [38, 39]. Correspondingly, since commercialization is determined on a scale where index scores cannot exceed the completely commercialized level, the Tobit model is not the appropriate model for the rice commercialization index score [21]. The fitted value of the dependent variable exceeds the unit interval; hence, these models are inappropriate for scenarios where the answer is constrained to the range 0 to 1 [20, 21, 40].

The beta regression model was implemented in this investigation to investigate the relationship between the rice commercialization index score and exogenous variables. The outcome variable follows a beta distribution with the density function given in Equation (3) [41, 42].

$$f(y;\mu,\Phi) = \frac{\Gamma\Phi}{\Gamma(\mu\Phi)\Gamma((1-\mu)\Phi)}\, y^{\mu\Phi-1}(1-y)^{(1-\mu)\Phi-1}, \quad 0<y<1, \quad (3)$$

where μ denotes the expected value of Y, i.e., $E(Y) = \mu$.

The parameter θ fulfills the definition of a precision parameter because the greater the value of θ, the smaller the variance of the dependent variable is defined as Equation (4).

$$Var(Y) = \frac{V(\mu)}{1+\Phi}, \text{ where } V(\mu) = \mu(1-\mu) \quad (4)$$

In the classical beta regression model, only the mean parameter μ of the beta distribution is expressed as a function of covariates, whereas the precision parameter θ is treated as a nuisance and $E(y_i \mid X_i) = \mu_i$, presented in Equation (5).

$$\mu_i = \frac{1}{1+exp(-\eta_i)} = \frac{1}{1+exp(-\chi'\beta)} = g(\chi'_i\beta), \forall i, \quad (5)$$

Where g(•) is a known function with $0 < g(\bullet) < 1$, and the model is respecified as follows using the logit link specification [40, 42], presented in Equation (6).

$$g(\mu_i) = ln(\frac{\mu_i}{1-\mu_i}) = \chi'_i\beta \implies ln(\frac{\mu_i}{1-\mu_i}) = \beta_0 + \sum_{i=1}^{n}\beta_i X_i, \quad (6)$$

Then, the beta regression is defined as Equation (7).

$$g(\mu_i) = \beta_0 + x_{i1}\beta_1 + \ldots\ldots + x_{ik}\beta_k = \eta_i \; i = 1, \ldots\ldots, n \quad (7)$$

where $x_{i1}, \ldots, x_{ip}$ are the covariates, β_0, $\beta_1, \ldots, \beta_k$ are estimated intercept and coefficients corresponding to each covariate, η_i is the linear predictor for the ith observation, and n is the sample size. The model in this study as Equation (8) is specified based on Equation (6).

$$\begin{aligned} Commercialization\ index_i = {} & \beta_0 + \beta_1 Ethnicity_i \\ & + \beta_2 Age_i + \beta_3 Education_i + \beta_4\ FamilyMember_i + \\ & \beta_5 DependencyRatio_i + \beta_6 FarmingExperience_i + \\ & \beta_7 LandSize_i + \beta_8 Remittance_i + \beta_9 Disaster_i + \\ & \beta_{10} Consumption_i + \beta_{11} Extension_i + \\ & \beta_{12} Information_i + \beta_{13} Credit_i + \\ & \beta_{14} Membership_i + U_i \end{aligned} \quad (8)$$

where Z_i represents the commercialization index of two season cultivation (dependent variable); X_1 to X_{14} represent Ethnicity (dummy),

age (years), educational level (years), family members(head), dependency ratio (percentage), farming experience (years), land size(hectares), remittance (dummy), disaster (dummy), amount of consumption (kg), extension accessibility (dummy), information accessibility (dummy), credit accessibility (dummy), and group membership (dummy).

The model's variables were assessed for multicollinearity using the variance inflation factor (VIF). In other words, a multicollinearity issue only happens when the VIF is large enough to drive down the significance levels and change the interpretation of this model. As a rule of thumb, the limit value for VIF is 5; due to the values being less than 3, it is concluded that there is a low multicollinearity among the variables.

Recent empirical investigations have identified the following characteristics as the primary predictors of farmers' level of commercialization including ethnicity, age, educational level, family members, dependency ratio, rice cultivation experience, land size, remittance, disaster, amount of consumption, extension accessibility, information accessibility, credit accessibility, group membership [9, 22, 25, 30, 43]. Ethnicity is a personal factor that can influence farm households' decision-making process in adopting commercial vegetable farming [44]. Ethnicity strongly influences community status relations and may also play an important role in determining commercialization [45]. Age has a positive significant effect on commercialization [25, 46]. Age on market participation has a positive and statistically significant effect, which is attributed to farming experience because older farmers have more experience in farming and are well aware of changes in weather, pesticide use, and production [10]. The younger generation dislikes farming and prefers to work in cities, particularly in the service industry [10]. Agricultural changes are more likely to be influenced by educational levels [47, 48]. Education enables farmers to effectively manage their output, encouraging market participation [11, 49]. Education enables farmers to understand the market and helps them find a better market for production related to higher sales of maize. Education improves farmers' understanding and helps them make informed decisions [50]. Farming experience is expected to positively associate with the level of commercialization. The number of years of the farmers' experience increases, and the probability of commercialization also increases. Experience is considered to bring about excellence in certain endeavors [51]. Family members or household size and the number of people in the household, the greater the possibility of participating in the market [10]. Generally, large household size leads to market participation and household labour can work at a lower cost and reduced transaction cost [52]. This is in line with Adepoju [53], who found that increasing household size will increase commercialization. In contrast, the quantity of persons in the household increases, and the likelihood of selling higher proportions decreases. Similarly, farmers with large households cannot produce marketable surplus mainly due to high domestic demand [51]. A higher dependency ratio is likely to reduce productivity growth [54].This is because a rise in the nonproductive population will reduce productive capacity and may result in lower market orientation indexes for cash and stable crops. The commercialization of poultry products is less, with a dependency ratio [55]. An increase in the household dependent ratio is frequently associated with an increase in household expenditure, and, as a result, a decrease in aggregate farm investment leads to a negative impact on the level of commercialization [56]. The amount of rice that households stock for self-consumption may have a negative impact on the level of commercialization. A larger portion of the output is consumed by the households themselves, and little is left for selling in the output market due to big household size [57]. In contrast, farmers who are focused on commercial agriculture recognize the importance of storing adequate amounts of food on the farm [58]. Rice cultivation experience and having more experience in crop production increases the commercialization level of smallholder farmers [22].

Land is a major and critical production asset that has a direct impact on surplus production in agrarian households [9]. Households that dedicate a sizable amount of land to growing cereal crops are more likely to increase production and, subsequently, their level of commercialization. The marginal effect of cultivated land size for the high commercialization category suggests that increasing the size of cultivated land by one hectare increases the probability of attaining a high level of commercialization by 8.1% [31]. Consistent with Agwu et al. [51] and Martey et al. [11], who pointed out that farm size has a positive significance to commercialization. Remittance refers to the money that is sent or transferred by individuals working abroad to their families or friends in their home country, and it is expected as source income that the recipient can invest in farm operations by purchasing farm inputs. The inflow of remittances to farm households can increase the purchase of farm inputs and assets [59]. Remittances were a lot higher for the non-commercialized group, which shows that most non-commercialized households depend on it [60]. Remittance incomes could be more productive if they were directed towards high-value agriculture [61]. Natural disasters are one of the determinants that negatively affect commercialization since they can reduce competitiveness. For example, a disaster from flooding can affect the competitiveness of rice producers in the market; if a flood-prone area produces rice, farmers may be hesitant to sell rice due to the risk of future floods, which leads to stocking more than bring to market. Extension and credit services are two methods for increasing smallholder farmers' production and productivity. Since smallholder farmers can buy inputs like improved seeds, fertilizer, herbicides, and pesticides, they are dependent on credit services, and farmers who use credit services can reduce their financial constraints and purchase inputs more easily than their counterparts who do not use credit services [22]. Many farmers, especially those who are considered smallholders, struggle to increase their agricultural output due to a lack of finance [51]. Access to information on both market and cultivation information is expected to be critical for farmers considering commercialization. The absence of cooperation among smallholder farmers restricts their capacity to negotiate for elevated pricing and access information and diminishes incentives for commercialization and production growth [50, 62, 63]. Group memberships may assist in providing marketing and production information; thus, it is expected that farmers who belong to formal groups are more likely to commercialize than non-members [64]. In line with other findings, becoming a part of a group or association may lead to better access to resources that might impact marketing and production choices [51, 65].

IV. RESULTS AND DISCUSSION

A. Descriptive statistics

Continuous variables are represented in Table 1. The average value of rice commercialization index (RCI) for wet season cultivation is 0.45 or 45.7%, and the average value of RCI for dry season cultivation is 0.595 or accounted for 59.5%. The sample households' ages ranged from 35 to 70 years, with an average of 52 years. The average family size of the sample respondents in adult equivalent was 6.67. The average number of schoolings of headed households completed was 5.67 years, with a range of zero (illiterate) to fourteen (university degree) years. The dependency ratio is the proportion of household members under the age of 15 and above 65 years. The average dependency ratio was 0.376, ranging from 0 to 1.25. Rice farming experience, on average, was 32 years, ranging from 15 to 62 years. The land is one of the most critical inputs for those whose primary means of living is farming. The average size of land allocated for rice cultivation in the wet season by sample respondents was 1.29 hectares, and 1.33 hectares for dry season cultivation. The average amount of rice stored for household consumption during the wet season was 2,196 kilograms; during the dry season, it was 1,840 kilograms.

Table 1: Summary continuous variable for the beta regression model

Variable	Description	$\bar{X}$	SD	Min	Max
Dependent variables					
RCI _w	Rice commercialization index in wet season (ratio)	0.457	0.133	0.14	0.86
RCI _d	Rice commercialization index in dry season (ratio)	0.595	0.147	0.23	0.95
Independent variable					
Age	Age of household head (years)	51.958	7.366	35	70
Education	The number of years of formal education the household head received (years)	5.676	3.429	0	14
Family size	The number of family members (people)	5.961	2.061	2	14
Dependency ratio	The ratio of comprising the people of non-working age to the working age group (ratio)	0.376	0.291	0	1.25
Experience	Number of years of rice practices (years)	32.010	7.958	15	62
Land size_w	Total farmland area in the wet season (hectare)	1.297	0.588	0.45	3.7
Land size_d	Total farmland area in the dry season (hectare)	1.330	0.596	0.45	3.7
Consumption_w	Rice stocking for consumption for wet season (Kilogram)	2,196.441	1,098.533	240	7,200
Consumption_d	Rice stocking for consumption for dry season (Kilogram)	1,840.831	1,245.837	100	6,450

Table 2 represents category variables. The majority ethnicity of respondents was Lao-luem, which accounted for 97.3%, and the rest was Phutai. Remittance from family members working abroad is an essential income resource for smallholder farmers. The table shows that 216 respondents (52.94%) did not receive remittances from family members, while 192 respondents (47.06%) received remittances. Over 50% of respondents have experienced a natural disaster in the past few years. 62% of responders had access to extension services provided by the local government. Rice production group membership has been promoted in this area for a decade, and the organizations primarily function as production collectors and seed providers, of which 38% of respondents were members of rice group production. Access to market and cultivation information is critical for farmers planning and preparing for the upcoming season. Around 62% of respondents could access information, while about 37% could not.

Table 2: Summary category variable for the beta regression model

Category variables	Description	Response	Frequency	(%)
Ethnicity	Ethnic of respondents, 1 = Laoluem, 0 = Phutai (Dummy)	Phutai	11	2.7
		Lao-luem	397	97.3
Remittance	Received remittance from family member, D = 1 if yes, 0 = otherwise (Dummy)	No	216	52.94
		Yes	192	47.06
Natural Disaster	Household facing natural disasters, D = 1 if yes, 0 = otherwise (Dummy)	No	195	47.79
		Yes	213	52.21
Access to extension	Access to extension service, D = 1 if yes, 0 = otherwise	No	155	37.99
		Yes	253	62.01
Group memberships	Membership in farm organizations, D = 1 if yes, 0 = otherwise (Dummy)	No	250	61.27
		Yes	158	38.73
Access to information	Access to market and season cultivation information of rice, D = 1 if yes, 0 = otherwise (Dummy)	No	152	37.25
		Yes	256	62.75

B. Determinants of rice commercialization

The beta regression model was used to investigate the factors affecting the rice (paddy) commercialization index score. Thirteen explanatory variables were included in the model to analyze the factors influencing rice commercialization in both seasons. The model is classified into seasons of farmers who cultivate both seasons because of the differentiation of the level of commercialization in each season, and the study only focuses on farmers who benefit from the irrigation scheme. The model result indicated that socioeconomic and institutional factors influence farmers' rice commercialization. Table 3 presents two models of beta regression, in wet and dry seasons, including the significance level, statistical tests, sign, and size of each explanatory variable. For cultivation, in both seasons, land size and family size had a positively statistically significant effect on rice commercialization at $p < 0.01$ significance level. On the other hand, disaster and stocking for self-consumption factors

had a negative statistically significant effect on commercialization at $p < 0.01$ significance level. In addition, access to extension service had a statistically significant effect on rice commercialization at $p < 0.05$ significance level only in the wet season.

The marginal effect in the model revealed that having more family members increases rice commercialization in dry and wet season cultivation by 3.4% and 5.4%, respectively. This meant that the greater the likelihood of a household being involved in commercialization as a result of increased labour supply that may be required for cultivation due to the agriculture society in Laos still being based on physically intensive labour rather than fully machinery cultivation. As a result, family labour is essential for cultivation. This result is in line with the study of Lighton et al. [17], who revealed that household members increase the probability of commercialization by 1.8%.

Furthermore, a large family is viewed as an economic asset, and everyone desires a large family so that they can work and bring money home. Having a large family is especially advantageous in agriculture, as there is a labour shortage during planting and harvesting seasons, and if labour is available, it is costly; therefore, family labour can be beneficial in such circumstances [10, 53]. However, family size also negatively affects commercialization [9, 18, 26, 27].

According to the model, there was a positive correlation between the amount of land used for rice production and the amount of area used for rice commercialization. The marginal effect analysis reveals that a one-hectare expansion in land designated for rice cultivation will enhance rice commercialization by 23.2% during the dry season and 22.5% during the rainy season. This demonstrates that the larger the land size is allocated to rice production, the higher the output, increasing the volume of rice supplied to the market. The larger land size allows for higher rice production, enabling farmers to sell a greater volume of rice in the market. Therefore, land size is considered a crucial variable in determining farmers' involvement in commercial agricultural practices. This result suggests that the Laos government could focus on ensuring farmers have sufficient land access for rice production. This could involve implementing land reform measures, providing secure land tenure, and promoting equitable distribution of agricultural land. This study is consistent with the study of Endalew et al. [22], who found that increasing the land size allocated for wheat could increase wheat commercialization by 16.88%. Additionally, several researchers who studied the commercialization of other types of crops found similar results [9, 16, 25, 28, 29, 31, 66].

Extension service accessibility will increase the level of commercialization for wet season production by 2.4% but is not statistically significant in dry season production. This indicates that farmers with more access to extension services, which give knowledge, training, and support on agricultural methods and market prospects, are more likely to engage in commercial activities and sell their rice on the market. According to the findings, increasing the accessibility of extension services can lead to increasing the commercialization of rice production. The explanation for insignificant extension service in the dry season might be due to wet season cultivation typically involving higher rainfall, which may result in increased disease and pest pressures, as well as challenges in water management. Farmers may require specialized knowledge and guidance from extension services to address these specific challenges in such conditions. In contrast, the dry season may provide other goals and concerns, such as irrigation management and drought resilience, where extension services may have less effect. Relevant authorities can focus on extending and improving extension services, ensuring farmers have easy access to agricultural methods, market opportunities, and business development knowledge, training, and assistance. This can be accomplished by establishing extension centres, farmer field schools, mobile technology platforms, and other means of knowledge dissemination. This result aligns with the study of Endalew et al. [22],

Table 3: Parameter estimates of the beta regression model

Variable	Dry season				Wet season			
	Coef. (S.E)	P > z	dy/dx (S.E)	P > z	Coef. (S.E)	P > z	dy/dx (S.E)	P > z
Ethnicity	0.038	0.720	0.008	0.720	0.175	0.100	0.040	0.100
	(0.106)		(0.023)		(0.107)		(0.025)	
Age	0.001	0.838	0.009	0.838	-0.003	0.374	-0.039	0.374
	(0.004)		(0.042)		(0.004)		(0.044)	
Education	-0.003	0.526	-0.004	0.526	0.003	0.575	0.004	0.576
	(0.005)		(0.007)		(0.005)		(0.007)	
Family size	0.026**	0.018	0.034**	0.018	0.039***	0.001	0.054***	0.001
	(0.011)		(0.015)		(0.012)		(0.016)	
Dependency ratio	0.001	0.988	0.000	0.988	-0.097	0.154	-0.009	0.153
	(0.069)		(0.006)		(0.068)		(0.006)	
Farming experience	-0.005	0.119	-0.039	0.119	-0.001	0.750	-0.008	0.750
	(0.003)		(0.025)		(0.003)		(0.026)	
Land size	0.779***	0.000	0.232***	0.000	0.741***	0.000	0.225***	0.000
	(0.050)		(0.014)		(0.048)		(0.014)	
Remittance(dummy)	0.018	0.638	0.002	0.637	0.055	0.139	0.006	0.140
	(0.038)		(0.004)		(0.037)		(0.004)	
Disaster (dummy)	-0.148***	0.000	-0.018***	0.000	-0.170***	0.000	-0.021***	0.000
	(0.035)		(0.004)		(0.035)		(0.004)	
Consumption	-0.001***	0.000	-0.277***	0.000	-0.001***	0.000	-0.274***	0.000
	(0.000)		(0.009)		(0.000)		(0.013)	
Access to extension (dummy)	0.060	0.372	0.008	0.371	0.163**	0.015	0.024**	0.016
	(0.067)		(0.009)		(0.067)		(0.010)	
Access to information (dummy)	-0.008	0.904	-0.001	0.904	0.037	0.569	0.006	0.569
	(0.065)		(0.009)		(0.066)		(0.010)	
Group membership (dummy)	0.045	0.250	0.004	0.248	0.008	0.836	0.001	0.836
	(0.039)		(0.003)		(0.039)		(0.004)	
Constant	0.558	0.004			-0.205	0.291		
	(0.194)				(1.94)			
LR $Chi^2(13)$				513.61***				400.77***
Log-Likelihood				465.13				446.88
Observations				408				408

*Note: ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.*

who found that extension services had a positive relationship with the degree of commercialization. In contrast with this result, households with access to extension services commercialize maize at 3% lower than those without access to extension services [11]. This outcome could be attributed to inadequate monitoring to ensure the efficacy of new technologies transferred to farmers.

Conversely, facing natural disasters negatively and significantly affected rice commercialization. The model result revealed that natural disasters will decrease rice commercialization of dry and wet season cultivation by 1.8% and 2.1%, respectively. This result implied that farmers who faced natural disasters are more likely to have a lower level of rice commercialization than those who did not face natural disasters. This result suggests natural disasters can impact rice production, availability, and marketability, resulting in lower commercial agriculture activity. Natural disasters, such as floods, droughts, storms, or pest outbreaks, can result in crop damage and yield losses. These adverse consequences make it more difficult for farmers to cultivate, harvest, and sell their rice in the market. The result highlights the importance of policies and measures to reduce the impact of natural disasters on rice production and commercialization by improving disaster preparedness, early warning systems, agricultural

insurance programs, and post-disaster assistance for farmers might all be implemented.

Meanwhile, the model also revealed that higher stocking for own consumption in the family decreases rice commercialization in dry and wet seasons by 27.7% and 27.4%, respectively. This result implied that farmers who allocate a more significant portion of their harvest for family consumption are more likely to have lower levels of commercialization, as they prioritize meeting their own food needs rather than selling the surplus on the market. They may prefer to rely on their stored rice for family consumption rather than engaging in commercial activities. This decision could influence food security concerns, personal preferences, or cultural factors. The implication is that local authorities should strengthen awareness and know how to store an adequate proportion of household self-consumption.

V. CONCLUSION AND RECOMMENDATIONS

Motivated by the gaps of previous studies and the rice potential of Savannakhet plain, the largest contributor to the nation's rice sector, this study was undertaken to measure the level of rice commercialization and examine factors that hinder rice (paddy) commercialization using the output commercialization index and the beta regression model to assist Laos to depart from LDC status in a couple of years by fulfilling the indicator for agricultural production instability. In general, smallholder farmers in the study area have a massive potential for rice commercialization compared to other rice-producing areas because the result of the mean values of dry and wet seasons are 0.59 and 0.46 (over 0.5 is equal to the commercial practices category), respectively. Consequently, smallholder rice producers should be incentivized to engage effectively in the rice market to enhance their living conditions. Moreover, intervention techniques aimed at enhancing rice yield should empower smallholder farmers to generate a marketable surplus that meets the input requirements of large-scale milling operations developed in Savannakhet Province, which have been purposely exported. Moreover, the econometric model result indicated that land size cultivation, consumption quantity, access to extension service, facing natural disasters, and family size had a statistically significant effect on rice commercialization. The study's findings suggest that efforts to enhance smallholder farmers' engagement in the output market must prioritize key explanatory variables. Laos should start an insurance program and post-disaster assistance for rice farmers that covers losses from natural disasters. Additionally, land size allocated to rice production positively affected rice commercialization. Consequently, innovations that enhance land productivity must be devised and executed. Land resources are also constrained in the research region. The implementation of production-oriented education, training, and extension services is essential to enhance land productivity, engage smallholder farmers' participation in the output market, and strengthen farmer awareness about the right decision to stock for self-consumption and supply. In long-term support, policymakers should be concerned about implementing land reform measures, providing secure land tenure, and promoting equitable distribution of agricultural land.

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