How does entrepreneurial behavior strengthen the sustainability of swamp wetland rice farming systems? a SEM-PLS approach from south sumatra, indonesia

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Abstract. The ecological characteristics of swamp wetlands demand that farmers possess strong adaptability to address various production challenges. This highlights a research gap, particularly the limited studies integrating internal factors, external factors, entrepreneurial behavior, and the sustainability of rice farming in a comprehensive framework. Therefore, this study aims to analyze: (1) internal factors influencing farmers' entrepreneurial behavior, (2) external factors influencing farmers' entrepreneurial behavior, and (3) the influence of entrepreneurial behavior on the sustainability of swamp wetland rice farming. The research was conducted from December 2025 to January 2026 in Pemulutan District, Ogan Ilir Regency, using a survey method with multi-stage random sampling involving 90 respondents. Both primary and secondary data were collected. Data analysis employed Structural Equation Modeling–Partial Least Squares (SEM-PLS) to examine causal relationships among complex latent variables. A quantitative approach was applied using a structured questionnaire with a five-point Likert scale. The findings reveal that internal factors: motivation, experience, education, and land area significantly influence farmers' entrepreneurial behavior ($\beta = 0.588$, $t = 8.534$, $p < 0.001$). External factors, including extension services, access to production inputs, technology, and capital support, also show significant effects ($\beta = 0.370$, $t = 5.169$, $p < 0.001$). Furthermore, entrepreneurial behavior reflected in innovation, risk-taking, and opportunity-seeking positively contributes to the sustainability of swamp wetland rice farming systems ($\beta = 0.608$, $t = 10.277$, $p < 0.001$).

1. Introduction

Entrepreneurial behavior refers to a set of activities grounded in key attributes, including self-confidence, risk-taking, task and result orientation, leadership, and future orientation. Its application enhances business performance, efficiency, and market expansion through innovation, opportunity recognition, and effective resource management [1]. In agriculture, this behavior reflects farmers' capacity to manage farming activities innovatively, independently, and adaptively, thereby improving productivity and sustainability [2]. Entrepreneurial behavior is shaped by internal factors, such as individual characteristics and competencies, and external factors including access to inputs. This concept is particularly relevant in swamp wetland ecosystems, such as lebak areas in South Sumatra, which present high uncertainty due to hydrological variability, soil acidity, and climate change. In regions like Pemulutan District, where rice farming dominates livelihoods, farmers often face constraints including single cropping cycles, unstable productivity, and limited resources. These challenges necessitate adaptive and innovative behavior to enhance efficiency, income, and sustainability.

Although farmer entrepreneurial behavior has been extensively studied, most research is general in nature and has not specifically examined the context of rice farming in swampy areas, which are characterized by high levels of uncertainty. However, the ecological characteristics of swampy areas demand a high level of adaptability from farmers. Therefore, there is a research gap in developing a comprehensive analytical framework that links internal and external factors, entrepreneurial behavior, and farming sustainability [3]. This study aims to fill this gap by analyzing the role of entrepreneurial behavior in strengthening the sustainability of rice farming in swampy areas.

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2. Method

2.1. Place and Time of Research

This research was conducted in Pemulutan Ilir Village, Tanjung Pasir Village, and Ibul Besar 1 Village, Pemulutan District, Ogan Ilir Regency. The location selection was carried out intentionally (purposive sampling) with considerations because the three villages are centers of lowland rice production in Pemulutan District with land characteristics representing shallow, middle, and deep lowland typologies, and the majority of the population is a rice farmer. In addition, the availability of agricultural data from Agricultural Extension Workers (PPL) and village officials as well as easy accessibility of the area supports the smooth observation and data collection. These considerations make the location relevant and appropriate to the research objectives. Field data collection and collection were carried out from December 2025 to January 2026.

2.2. Number of Samples

The sampling method used in this study was simple random sampling, a sampling technique that random selection. The first stage involves determining the research locations in stages, starting from South Sumatra Province, then Ogan Ilir Regency, Pemulutan District, and finally selecting three villages as research locations: Pemulutan Ilir Village, Ibul Besar I Village, and Tanjung Pasir Village. This method was used because the research population is geographically dispersed. Next, the sample size was determined using the Slovin formula as follows:

$$n = \frac{N}{1 + N\,(e)^2}$$

Where:

n : Number of samples
N : Number of farmer population
e : Error rate (10%) (4)

$$n = \frac{N}{1 + N\,(e)^2}$$

$$n = 84.20 \approx 90 = \frac{533}{1 + 533\,(0{,}10)^2} \text{ (rounded)}$$

The results of the sample size calculation using the Slovin formula indicate that this study used 84.20 respondents, rounded to 90 respondents from a total population of 533 farmers, obtained from the 2025 data from the Pemulutan District Field Workers (PPL).

2.3. Data Processing Methods

Data obtained from the questionnaire were analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS) to test the causal relationships between complex latent variables, namely the influence of internal and external factors on entrepreneurial behavior and their impact on the sustainability of rice farming. This method was chosen because it can analyze simultaneous relationships in a single model, does not require a normal distribution, and is suitable for small to medium sample sizes.

The SEM-PLS model consists of two main components: a measurement model (outer model) and a structural model (inner model) [5]. The outer model explains the relationship between indicators and latent variables, which can be either reflective or formative. In this study, all latent construct were specified as reflective constructs because the indicators were designed to measure manifestations of their respective latent variables.

This research used a quantitative approach with a closed-ended questionnaire instrument based on a five-point Likert scale (1–5), with a score of "5" indicating a response of strongly agreeing, while a score of "1" indicating strongly disagreeing. The variables analyzed included internal factors, external factors, entrepreneurial behavior, and the sustainability of rice farming. Each variable was measured using indicators that systematically represent aspects of motivation, resources, innovation, and environmental, economic, and social dimensions.

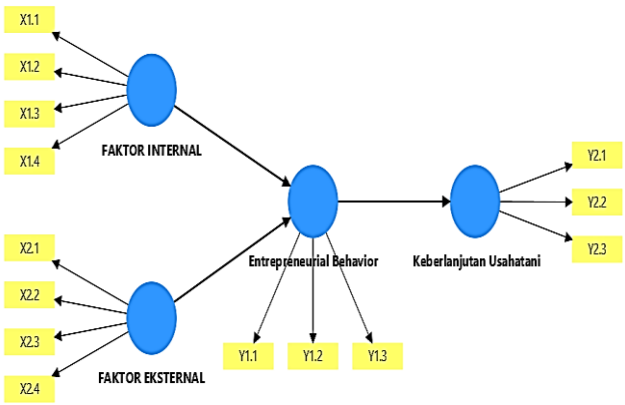

Fig 1. SEM-PLS Model

Based on the Structural Equation Modeling-Partial Least Squares (SEM-PLS) model above, the following is a description of the research variables and the indicators used to measure the

Table 1. Research Variables

Variable	Indicator	Code	Reference
Internal Factors (X1)	1. Motivation	X1.1	(2,6)
	2. Education	X1.2	
	3. Experience	X1.3	
	4. Land area	X1.4	
External Factors (X2)	1. Extension	X2.1	(7,8)
	2. Access to production facilities	X2.2	
	3. Technology	X2.3	
	4. Capital assistance	X2.4	
Entrepreneurial Behavior (Y1)	1. Innovation	Y1.1	(9,10)
	2. Courage to take risks	Y1.2	
	3. Motivation to seek opportunities	Y1.3	
Sustainability of Rice Farming (Y2)	1. Environment	Y2.1	(11,12)
	2. Economy	Y2.2	
	3. Social	Y2.3	

3. Result and Discussion

3.1. Socio-Economic Respondents

Table 2 presents the socio-economic characteristics of the respondents, showing that most farmers were in the productive age category with relatively low to moderate educational backgrounds. The respondents generally had long farming experience, indicating strong practical knowledge and dependence on agriculture as their main livelihood. In addition, most households had a moderate number of family dependents, which may influence labor availability, household economic responsibilities, and farming decisions.

Table 2. Social Economic Respondent

No	Variable	Percentage (%)	Average	Standard Deviation
1	Age (Years)		55.14	10.67
	15-64	76,67		
	>64	23.33		
2	Education		7.03	2.73
	No School	5.56		
	Elementry School	62.22		
	Junior High School	18.89		
	High School	13.33		
3	Farming Experience (Years)		29.51	15.11
	≤ 10	18.89		
	11-20	20.00		
	21-30	17.78		
	31-40	24.44		
	>40	18.89		
4	Number of Family Dependents (People)			
	1-2	21.11	4	1.80
	3-5	63.33		
	6-8	15.56		

3.2. PLS-SEM Test

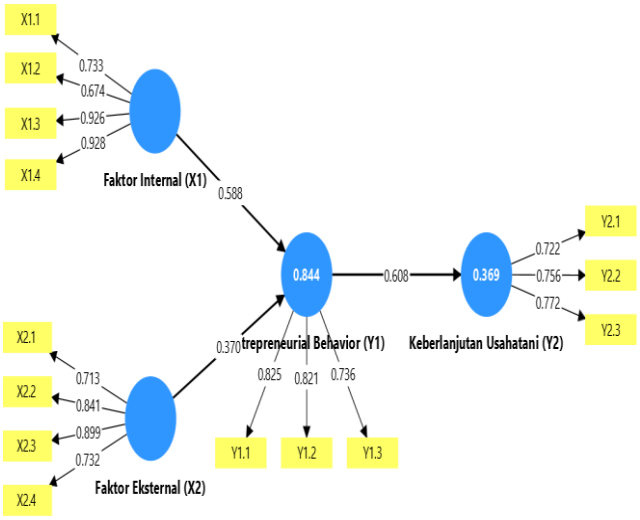

Fig 2. *Partial Least Squares – Structural Equation Modelling*

a. Outer Model

Convergent Validity Test

Based on the results of the Convergent Validity test, it is shown that in general, all indicators have met the validity criteria in representing each latent variable, which is indicated by the majority of the outer loading value is above 0.70. In the internal factor variable, the indicators of farming experience and land area are the most dominant indicators, which indicates that these two aspects have the strongest role in reflecting the internal capacity of farmers. This condition is supported by the characteristics of the respondents, the majority of whom have long farming experience and relatively adequate land tenure in supporting farming management. In the external factor variable, technology indicators and access to production facilities are the most dominant indicators, which shows that easy access to production inputs and the use of agricultural technology play an important role in supporting the effectiveness and development of agriculture. Meanwhile, in the entrepreneurial behavior variable, the innovative indicator and courage to take risks became the strongest indicators in describing farmers' entrepreneurial behavior, which was reflected in farmers' openness to innovation, technology utilization, agricultural information search, and courage in trying new cultivation patterns. As for the sustainability variable of rice farming, the social aspect is the most dominant indicator, which emphasizes that social relations, cooperation, mutual cooperation, and solidarity between farmers have a strategic role in supporting the sustainability of swamp lebak rice farming.

Table 3. Convergent Validity Test

Construct	Indikator	Outer Loading	AVE	Remarks
X1	X1.1	0.733	0.677	Valid
	X1.2	0.674	0.677	Valid
	X1.3	0.926	0.677	Valid
	X1.4	0.928	0.677	Valid
X2	X2.1	0.713	0.640	Valid
	X2.2	0.841	0.640	Valid
	X2.3	0.899	0.640	Valid
	X2.4	0.732	0.640	Valid
Y1	Y1.1	0.825	0.632	Valid
	Y1.2	0.821	0.632	Valid
	Y1.3	0.736	0.632	Valid
Y2	Y2.1	0.722	0.563	Valid
	Y2.2	0.756	0.563	Valid
	Y2.3	0.772	0.563	Valid

Discriminant Validity *Test*

Based on the results of the discriminant validity test in Table 3.13, it can be seen that each indicator has the highest loading factor value in the construct it measured compared to other constructs. Indicators on the internal factor variable show a greater loading value on the construction of internal factors than on external factors, entrepreneurial behavior, and sustainability of rice farming. The same condition is also seen in the variables of external factors, entrepreneurial behavior, and sustainability of rice farming, where all indicators have the strongest correlation to theirespectivee constructs. These findings show that each latent variable is able to accurately represent its indicators and has a clear difference with other latent variables in the research model. Thus, the research model has met the criteria of discriminant validity, so that each construct can be declared valid and able to measure different concepts properly.

Table 4. The Result of *Discriminant Validity (cross loading) Test*

Indicators	X1	X2	Y1	Y2
X1.1	**0.733**	0.568	0.587	0.331
X1.2	**0.674**	0.430	0.488	0.340
X1.3	**0.926**	0.813	0.868	0.529
X1.4	**0.928**	0.830	0.900	0.608
X2.1	0.542	**0.713**	0.587	0.516
X2.2	0.661	**0.841**	0.659	0.474
X2.3	0.866	**0.899**	0.876	0.591
X2.4	0.526	**0.732**	0.567	0.390
Y1.1	0.735	0.745	**0.825**	0.551
Y1.2	0.780	0.684	**0.821**	0.452
Y1.3	0.611	0.612	**0.736**	0.440
Y2.1	0.451	0.493	0.445	**0.722**
Y2.2	0.380	0.419	0.455	**0.756**
Y2.3	0.450	0.489	0.467	**0.772**

a. Test Inner Model

Path Coeffcient

Based on Table 3.15, all paths of influence between latent constructs show the value of path coefficients with different directions and levels of significance. In the relationship between internal factors and *entrepreneurial behavior*, a path coefficient value of 0.588 with *a t-statistic* of 8.534 and *a p-value* of 0.000 was obtained. The value has met the significance criteria, so the hypothesis that internal factors affect *entrepreneurial behavior* is accepted. The positive coefficient shows that the better the internal factors that farmers have, such as motivation, experience, education, and land area, the more entrepreneurial behavior of farmers will increase. The strength that comes from within farmers plays a significant role in determining the formation of innovative, proactive, and risk-taking attitudes in running farming.

The path of influence of external factors on *entrepreneurial behavior* showed a path coefficient value of 0.370 with *a t-statistic* of 5.169 and *a p-value* of 0.000. The value has met the significance criteria, so that the hypothesis that external factors affect *entrepreneurial behavior* is accepted. The positive coefficient shows that the better the support from outside, such as counseling, access to production facilities, technology, and capital assistance, the more entrepreneurial behavior of farmers will increase. This means that a supportive external environment is able to encourage farmers to be more innovative, more open to change, and more courageous in making decisions in running farming.

Meanwhile, the influence of *entrepreneurial behavior* on the sustainability of rice farming has a path coefficient of 0.608 with *a t-statistic* value of 10.277 and *a p-value* of 0.000. This value has met the significance criteria at the level of 5%, so the hypothesis that there is an influence of *entrepreneurial behavior* on the sustainability of rice farming is accepted. These results show that the relationship between the two variables is positive and statistically significant. This positive and relatively strong coefficient indicates that the better the entrepreneurial behavior of farmers, the higher the level of sustainability of rice farming that is run. This means that farmers who are more innovative, proactive, and daring to take risks tend to be better able to manage resources efficiently, take advantage of market opportunities, and adopt technology or cultivation practices that are in accordance with the conditions of swamp land. Thus, entrepreneurial behavior not only has an impact on increasing production, but also strengthens those who support the sustainability of farming from economic, social, and environmental aspects in the long term.

Table 5. Path *Coefficient Test*

Path	Coefficient	T-Statistic	P-Value
X1 → Y1	0.588	8.534	0.000
X2 → Y1	0.370	5.169	0.000
Y1 → Y2	0.608	10.277	0.000

R- Square *Test (R2)*

R-Square (R^2) is a measure in PLS-SEM that indicates how much the independent variable (X) is able to explain the bound variable (Y). The value of R^2 reflects the proportion of variation of dependent variables that can be explained by independent variables in the model. Based on Table 3.11, the R^2 value in the *entrepreneurial behavior variable* is 0.844 [5]. This means that 84.4% of changes in farmers' entrepreneurial behavior can be explained by Internal Factors and External Factors, while the rest are influenced by other factors outside the study.

Table 6. R^2 Test

Construct	R-Square	R-Square Adjusted	Remarks
Y1	0.844	0.840	Strong
Y2	0.369	0.362	Moderate

Effect size (f^2)

The f^2 value is used to see how much influence each variable individually has in the PLS-SEM model. The results of the study show that internal factors have the greatest influence on entrepreneurial behavior with a large effect size category, which means that farmers' entrepreneurial behavior is more influenced by factors from within farmers, such as experience, ability, and personal readiness. External factors also affect entrepreneurial behavior, but their contribution is in the medium category so the influence is not as strong as internal factors. In addition, entrepreneurial behavior has a great influence on the sustainability of rice farming, which shows that farmer entrepreneurial behavior plays an important role in supporting the sustainability of farming.

Table 7. Effect size f^2 Test

Construct	X1	X2	Y1	Y2	Remarks
X1			0.680		Large
X2			0.269		Medium
Y1				0.585	Large
Y2					

Mathematical Equations in SEM

The mathematical equations used in the SEM model of this study are as follows.

a) Structural model equations
   $\eta1 = 0{,}588\xi1 + 0{,}370\xi2 + \zeta1$
   $\eta2 = 0{,}608\eta1 + \zeta2$
b) Equation of exogenous variable measurement model
   $X1.1 = 0.733\xi1 + \delta11$
   $X1.2 = 0.674\xi1 + \delta12$
   $X1.3 = 0.926\xi1 + \delta13$
   $X1.4 = 0.928\xi1 + \delta14$
   $X2.1 = 0.713\xi2 + \delta21$
   $X2.2 = 0.841\xi2 + \delta22$
   $X2.3 = 0.899\xi2 + \delta23$
   $X2.4 = 0.732\xi2 + \delta24$
c) Equation of endogenous variable measurement model.
   $Y1.1 = 0.825\eta1 + \varepsilon11$
   $Y1.2 = 0.821\ \eta1 + \varepsilon12$
   $Y1.3 = 0.736\eta1 + \varepsilon13$
   $Y2.1 = 0.722\ \eta2 + \varepsilon21$
   $Y2.2 = 0.756\eta2 + \varepsilon22$
   $Y2.3 = 0.772\eta2 + \varepsilon23$

3.3. The Influence of Internal Factors on Entrepreneurial Behavior (X1 Y)

The results of the study show that the internal factors of farmers have a positive and significant effect on the entrepreneurial behavior of swamp rice farmers. These findings indicate that the internal capacity of farmers is an important determinant in shaping adaptive skills, decision-making, and orientation for sustainable farming development. In this study, land area and farming experience are the most dominant indicators in representing the internal factors of farmers. Land area reflects the capacity to control resources that allow farmers to have greater flexibility in business management, diversify production, and implement more efficient and productive farming strategies. Meanwhile, farming experience plays a role in shaping the accumulation of tacit knowledge, managerial skills, and resilience of farmers in facing risks and dynamics of the agricultural business environment. Farmers with longer experience tend to have better ability to identify opportunities, manage uncertainty, and make strategic decisions in

farming. Thus, internal factors not only function as individual characteristics of farmers, but also as capacity capital that is able to strengthen entrepreneurial behavior in supporting the sustainability of swamp rice farming.

3.4. The Influence of External Factors on Entrepreneurial Behavior (X2 Y)

The findings of the study indicate that the entrepreneurial behavior of swamp rice farmers is significantly influenced by external factors that develop in the farming environment. These external conditions play an important role in shaping farmers' capacity to adapt, innovate, and develop more productive and opportunity-oriented farming strategies. In this study, technology emerged as the most dominant indicator in representing external factors, followed by access to means of production. The dominant role of technology shows that the transformation of agricultural mechanization that has occurred in the research area has encouraged changes in farming management patterns to become more modern, efficient, and productivity-oriented. The use of various agricultural technologies, such as combine harvesters, hand tractors, water pumps, and rice transplanters, not only increases labor efficiency and production effectiveness, but also strengthens the entrepreneurial behavior character of farmers through increasing innovation skills, courage to make business decisions, and orientation to farming business development opportunities. This condition indicates that technology adoption is an important instrument in strengthening farmers' adaptive capacity to the increasingly complex and competitive dynamics of the agricultural sector. In addition to technology, access to production facilities is also an external factor that contributes strongly to shaping farmers' entrepreneurial behavior. The ease of obtaining seeds, fertilizers, and production input subsidy support provides space for farmers to maintain the sustainability of farming and improve production efficiency. The availability of adequate inputs allows farmers to be more flexible in determining cultivation strategies and developing farming businesses based on productivity and added value. However, this study also found that the indicators of counseling and capital assistance have a relatively lower contribution compared to other indicators. The low contribution of counseling is suspected to be related to the limited intensity of the implementation of counseling and the uneven distribution of information to all members of farmer groups, so that knowledge transfer and innovation have not run optimally. Meanwhile, capital assistance has not been the main determinant because most farmers tend to rely on personal capital in running farming. Thus, the results of this study show that external factors, especially technology and access to production facilities, are strategic determinants in strengthening the entrepreneurial behavior of swamp lebak rice farmers and supporting the transformation of farming towards a more adaptive, innovative, and sustainable agricultural system.

3.5. The Influence of Entrepreneurial Behavior on Rice Farming Sustainability (Y1 Y2)

The results of the PLS-SEM analysis indicate that entrepreneurial behavior has a positive and significant effect on the sustainability of rice farming (path coefficient = 0.608; t-statistic = 10.277; $p<0.05$). This confirms that the higher the farmers' entrepreneurial behavior, reflected in innovation, risk-taking, and opportunity orientation, the stronger their ability to maintain farming sustainability, especially in the uncertain conditions of swampy areas. Entrepreneurial behavior plays a crucial role in encouraging more adaptive and sustainable agricultural practices. Farmers who are innovative, proactive, and risk-taking tend to be more responsive to environmental changes and more open to technology adoption. This finding is further supported by Barman & Singh (2025), who emphasize that farmer-based innovation is a key factor in improving farming sustainability through the integration of local knowledge and modern technology.

Empirically, the innovation indicator is the most dominant dimension in shaping entrepreneurial behavior (loading factor = 0.825). Farmers demonstrated active efforts in seeking information, adopting technology, and adapting cultivation techniques to land conditions, such as using flood-resistant varieties and efficient input management. Meanwhile, the risk-taking indicator (0.732) also played a significant role, particularly in encouraging farmers to try more intensive cropping patterns despite the potential for failure. This finding is consistent with [14], who stated that the risk-taking dimension is a key factor in the adoption of climate change adaptation strategies.

Conversely, the opportunity-seeking motivation indicator had the lowest contribution (0.713), indicating that farmers' orientation toward business diversification and market exploration is still limited. This condition aligns with the findings of [15] who stated that conventional farming patterns focused on a single commodity result in low incentives to develop new business opportunities.

In the context of sustainability, the social dimension is the most dominant indicator, supported by strong social capital such as cooperation, information exchange, and participation in farmer groups. The importance of social capital in increasing the efficiency and sustainability of farming. Meanwhile, economic and environmental aspects also showed relatively good conditions through efficient input use and the adoption of more environmentally

friendly cultivation practices. Overall, these results confirm that entrepreneurial behavior plays a strategic role in strengthening the sustainability of rice farming.

4. Conclusion

The findings of this study demonstrate that internal factors, encompassing motivation, farming experience, educational attainment, and landholding size, exert a significant influence on the entrepreneurial behavior of rice farmers. In addition, external factors, including agricultural extension services, access to production inputs, technological support, and capital assistance, were also found to significantly shape farmers' entrepreneurial behavior. These results indicate that the development of entrepreneurial behavior is not solely determined by farmers' individual capacities and intrinsic readiness, but is also strongly influenced by the availability of external support systems that enhance agricultural productivity and adaptability. Furthermore, entrepreneurial behavior, characterized by innovativeness, risk-taking orientation, and opportunity-seeking capacity, was found to have a positive and significant effect on the sustainability of swamp rice farming. This finding underscores the strategic role of entrepreneurial behavior in strengthening farmers' ability to manage resources efficiently, respond adaptively to environmental and market dynamics, and sustain farming activities from economic, social, and environmental dimensions.

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