

MODEL OF DETERMINANT FACTORS INCREASING PRODUCTIVITY AND SUSTAINABILITY OF POTATO FARMING IN KERINCI REGENCY (WITH SEM-PARTIAL LEAST SQUARE APPROACH)

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Abstract

Potato farming productivity is one indicator of improving the farming business, including its sustainability. Higher farming productivity will be accompanied by increased production. This study aims to analyze the determinants of factors that influence the increase in productivity and sustainability of potato farming. This research was conducted in Kayu Aro Barat District, which was determined purposively. The research locus was Sungai Asam Village, Kebun Baru Village, and GIRI Mulyo Village. The population size of the three villages was 1,100 farmers. Using the Slovin method, a sample size of 76 respondent families was obtained. The sampling method was simple random sampling. The data analysis method used SEM - PLS. The results showed that the description of internal factors, external factors of farmers, and the use of production inputs were in the medium category. The category of productivity and sustainability of potato farming was in the low category. The internal factor that was a determinant of productivity and sustainability of potato farming was the farm income variable. External factors that are determinants of productivity and sustainability of farming are access to credit, access to technology, access to access. This research aims to analyze the impact of internal factors, external factors and technology adoption on productivity and sustainability of potato farming. Meanwhile, the variable of production input use that is a determinant factor of productivity and sustainability of potato farming is land area and fertilizer use. Internal and external factors that need to be considered in modeling increasing productivity and sustainability of potato farming are the use of production inputs by means of assistance with production facilities, working capital assistance and technological assistance. This can be done through policies to increase farmer access to credit, production facilities and potato farming technology.

Keywords: *Internal eksternal Factor, Productivity, Sustainability, Technology Adoption*

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INTRODUCTION

The food agriculture subsector plays a crucial role in the economic structure of Jambi Province, particularly in achieving food security and sustainable agricultural development. Potatoes are a strategic horticultural crop with high economic value, particularly in Kerinci Regency, the main production center. According to the Department of Agriculture, Food, and Horticulture (2023), the average potato area in Jambi Province during the 2015–2022 period averaged 8,960 ha per year, with approximately 68.3% of this area located in Kerinci Regency. Potato production was recorded at 96,888 tons with an average productivity of only 11.5 tons/ha/MT. This figure is still far below the optimal productivity of 22.3 tons/ha as reported by the Central Statistics Agency (2023), indicating a gap in achieving ideal productivity.

The problem of low potato farming productivity is not solely related to technical aspects but also encompasses various internal and external factors affecting farmers. Hasibuan (2019) emphasized that food self-sufficiency and agricultural sustainability are not solely supported by increased farmer capacity but must also be supported by the availability and adequate utilization of production factors. In this context, technology adoption is a key factor in increasing productivity. Differences in technology adoption rates, economic conditions, and institutional access among farmers contribute significantly to disparities in potato farming productivity and sustainability (Nainggolan et al., 2022; Tasman, 2008; Tuwo, 2011).

Previous studies have identified several variables that influence the productivity and sustainability of farming, including land area, input prices, commodity prices, and access to credit, extension services, and production inputs (Nuryana, 2017). Suratiyah (2016) added that farmers' ability to access and manage production inputs and active participation in farmer groups are key determinants of successful adoption of new technologies. This finding is reinforced by the findings of Nainggolan et al. (2019), who stated that technology adoption will be more effective when supported by the availability of local inputs, affordable prices, and intensive extension services.

Although various studies have addressed the relationship between these factors and productivity, most remain partial and have not modeled the interrelationships between factors simultaneously and structurally. Furthermore, few studies have specifically examined the productivity and sustainability of potato farming in Kerinci Regency using a quantitative approach based on Structural Equation Modeling–Partial Least Squares (SEM–PLS), even though this approach can explain latent relationships between variables more comprehensively. This is the main gap in this research.

The novelty of this study lies in the integrative modeling involving internal factors (such as land area, product prices and production facilities), external factors (institutional access: credit, extension, and input), and technology adoption variables as exogenous variables that have a direct impact on the productivity and sustainability of potato farming, both from economic, social, and environmental aspects.

The implications of this research are expected to contribute to agricultural policy development, particularly in designing strategies to increase productivity and sustainability of potato farming through technology-based interventions, economics, and strengthening institutional access. Furthermore, the research findings are also relevant to supporting the achievement of the Sustainable Development Goals (SDGs), particularly SDG 2: Zero Hunger, by improving sustainable agriculture in the Jambi highlands.

This study aims to: (1) analyze the influence of internal and external factors and technology adoption on potato farming productivity, and (2) evaluate how these three factors influence the sustainability of potato farming in Kerinci Regency simultaneously.

METHODS

Kayu Aro Barat District was purposively selected as the research sample area. This area was chosen because it is a major potato-producing center. The villages used as research loci were Sungai Asam Village, Kebun Baru Village, and Giri Mulyo Village. This research was conducted from April to October 2023. Primary data was obtained directly from farmer respondents through direct interviews with potato farmers using a prepared questionnaire based on observational variables and other data deemed necessary for this study.

Secondary data were collected from informants, transcribing, processing, and studying data from related agencies, literature studies, and previous research results related to the study. The number of sample farmers was determined using the Slovin method. The precision level used was 10%. The number of potato farmers was 1,100 farmers, resulting in 76 households of respondents. The sampling method used was Simple Random Sampling. The distribution and number of respondents can be seen in Table 1.

Table 1. Distribution and Number of Respondents from Research Villages

No	Region	Number of Potato Farmers (KK)	Number of Respondents (KK)
1	Sungai Asam Village,	435	30
2	New Garden Village	380	26
3	Giri Mulyo Village	285	20
Amount		1100	76

Source: Batang Asam District Agricultural Extension Center, 2023 (processed data)

Data Analysis Methods

(Saidin Nainggolan, Mirawati Yanita, 2020) (Nainggolan, S et al (2021),(Saidin Nainggolan, 2021) (Saidin Nainggolan, 2022), has conducted research on oil palm plantations and rice paddy farming with the same structural model as this study. Model estimation with Market concentration can be determined from the four largest buyers (CR4) with the following calculation:

Structural Equation Model - Partial least Square (SEM-PLS) was carried out with the following STRUCTURAL MODEL.

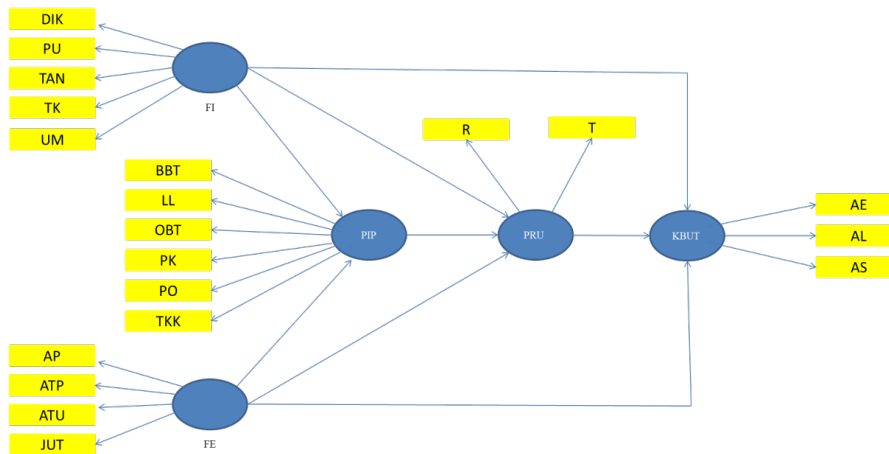


Figure 1. PLS SEM Model

Information:

- | | |
|---------------------------------------|--|
| FE : External Factors | PIP : Procurement of Production Inputs |
| LL : Land area | ATV : Adoption of Business Technology |
| HSP : Price of Production Facilities | KKT : Farmer Group Activity |
| HK : Potato prices | PRDT : Productivity |
| FAK : Institutional Access Factors | domestic worker : Production below average |
| AK : Credit Access | PRR : Above Average Production |
| APT : Access to Technology Counseling | STB : Sustainable |
| FIRE : Input Procurement Access | AE : Economic Aspects |
| US : Social Aspects | AL : Environmental Aspects |

Goodness of Fit Test

Outer Model

- *Convergent validity*{CV}
If $0.5 < CV < 0.6$, the Goodness of Fit is said to be valid (Jaya I Gede NM, 2008)
- *Discriminant validity*{DV}
(Jaya I Gede NM, 2008),(Latan, 2012)And(Gunarto, 2018)that if $DV = AVE > 0.5$ it is said to be Goodness of Fit {reliable}.

$$AVE = \frac{\sum \lambda_i^2}{\sum \lambda_i^2 + \sum_i \text{var}(e_i)}$$

- *Composite reliability*{Pc}
If $CR = pc > 0.7$ it is said to be Goodness of Fit {reliable}

$$pc = \frac{(\sum \lambda_i)^2}{(\sum \lambda_i)^2 + \sum_i \text{var}(e_i)}$$

Inner Model

(Jaya I Gede NM, 2008), Goodness of Fit Model is seen from Q2 predictive relevance. If the Q Square value is closer to one, it means the structural model has a better predictive relevance model value.

RESULTS AND DISCUSSION

Measurement Model Fit Test (Outer Model)

Measurement model (*outer model*) shows how the indicators manifest in representing the latent constructs measured by testing the validity and reliability of the latent constructs. Validity and reliability tests aim to ensure the measurement model is free from measurement errors. There are three ways to evaluate the outer model: convergent validity, discriminant validity, and composite validity. The following requirements that must be met in the construct validity and reliability test can be seen in Table 2.

Table 2. Requirements to fulfill the Validity and Reliability Test

Validity and Reliability	Parameter	Rule of Thumb
<i>Convergent Validity</i>	<i>Loading factor</i>	• > 0.7
	<i>Average Variance Extracted(AVE)</i>	• > 0.5
<i>Discriminant Validity</i>	<i>Cross loading</i>	• Loading indicator > all cross loading
	<i>Square root of AVE and correlation between latent constructs</i>	• Square root of AVE > correlation between latent constructs
<i>Reliability</i>	<i>Cronbach's Alpha</i>	• > 0.7
	<i>Composite Reliability</i>	• > 0.7

Source: Hengky Latan, 2013

Table 2 explains the requirements that must be met in validity and reliability testing, which is an important stage in evaluating the quality of the measurement model (outer model) in the Partial Least Squares-based Structural Equation Modeling (PLS-SEM) approach. Validity and reliability tests are used to ensure that the indicators used are truly capable of representing the latent constructs appropriately, accurately, and consistently. Convergent validity is evaluated through factor loading and Average Variance Extracted (AVE) values, while discriminant validity is analyzed through cross-loading and a comparison of the square root of AVE with correlations between latent constructs (Hair et al., 2014; Latan & Ghazali, 2012). This test aims to ensure that each indicator has a high correlation with its own construct and a lower correlation with other constructs, thereby minimizing the possibility of overlap between constructs (Kusnendi, 2008).

Meanwhile, reliability testing is conducted to assess internal consistency between indicators within a single latent construct. Commonly used parameters are Cronbach's Alpha and Composite Reliability, with an ideal value >0.7 as the minimum limit indicating good consistency (Ghozali & Latan, 2015). The application of this test is part of quality control in quantitative research that relies on numerical data, to ensure that the research instrument has adequate stability and reliability (Sarwono, 2007). By meeting all validity and reliability criteria, the latent construct can be said to be valid and reliable for use in further analysis. The results of the validity and reliability tests in this study can be seen in Table 3.

Table 3. Results of Validity and Reliability Testing of the Productivity and Sustainability Improvement Model for Potato Farming in the Research Area, 2023

Instrument	Validity		Reliability	
	Loading Factor	AVE	Cronbach's Alpha	Composite Reliability
Internal Factors (FI)				
- Age (UM)	0.799			
- Education (DIK)	0.863			
- Farmer Knowledge (PU)		0.668	0.875	0.909
- Income (TAN)	0.795			
- Labor Supply in the Family (TK)	0.886			
	0.734			
External Factors (FE)				
- Access to Counseling (AP)	0.825			
- Access to Technology (ATP)	0.791	0.647	0.818	0.880
- Adoption of Farming Technology (ATU)	0.806			
- Number of Farms (JUT)	0.795			
Production Input Usage (PIP)				
- Seed (BBT)		0.680	0.905	0.927
- Land Area (LL)	0.879			
- Medications (OBT)	0.914			
- Chemical Fertilizer (PK)	0.758			
- Organic Fertilizer (PO)	0.794			
- Number of Workers (TKK)	0.820			

Farm Business Productivity (PRU)				
- Height (T)	0.921	0.758	0.691	0.862
- Low (R)	0.817			
Sustainable Farming (KBUT)				
- Economic Aspects (AE)	0.906			
- Environmental Aspects(AL)	0.766	0.674	0.764	0.860
- Social Aspects (AS)	0.784			

Source: Smart PLS Processed Data Results Version 3.0, 2023

Table 3 explains the convergent validity test through the outer loading and AVE values by meeting the values above 0.7 and 0.5. The results of the algorithm calculation, all indicator loading values against their latent constructs have a value greater than 0.7, Education, farmer knowledge, income and supply of labor in the family are stronger in reflecting latent internal factors. The average AVE value of the five research variables is above 0.5. Descriptive data from observations explains that internal factors with reflective variables of farmer age are in the productive age range with a range of 28.3 - 67.5 years, farmer education as many as 72.3% are junior high school - high school, farmer knowledge is in the high category score or very knowledgeable aspects of potato farming. Net income from potato farming ranges from Rp. 18.25 - 31.8 million / ha / MT and the supply of labor in the family is sufficient for potato farming without the need for the use of labor outside the family.

External factors (FE): Access to extension and technology are highly affordable because the extension workers (PPL) live in the farmers' locality. Adoption of farming technology is quite high, with 86.2% of farmers responding to new technology in potato cultivation. The distance of the farm, although far from the farming village, does not pose a barrier to potato farming management due to excellent access.

The use of production inputs (PIP), seeds, medicines, chemical fertilizers, and organic fertilizers is in accordance with the recommended range of PPL. The area cultivated by farmers is relatively narrow, only around 0.65 - 1.38 ha per farmer. Farm productivity (PRU) with reference to the best potato farming management productivity is 17.5 - 28.7 tons/ha/MT and it turns out that as many as 62.3% of farmers produce productivity in that range or are in the high productivity category. The analysis results show that the income indicator (TAN) is the strongest (can farmer income data be added) in reflecting the internal factor variable (FI) because it has the largest loading value of 0.886. Extension Access (AP) is the strongest indicator in reflecting the external factor variable (FE) because it has the largest loading value of 0.826. The Land Area Indicator (LL) is the strongest indicator in reflecting the Production Input Use (PIP) variable because it has a loading value of 0.919. The High (T) indicator in Farm Business Productivity (PRU) has the largest loading value, namely 0.921. The economic aspect indicator (AE) is the strongest indicator in reflecting the sustainability variable of farming business (KBUT) because it has the largest loading value, namely 0.906. The higher the outer loading value, the more important the indicator is in its latent variable/the strongest measurement ((Latan, 2012),(RA Rozandy, et al, 2013)And(Gunarto, 2018)).

Farming sustainability, particularly price, is rated very high, reflecting farmers' decisions to sustain potato farming. Environmental factors, including technical, geographical, and climatic factors, strongly support potato cultivation techniques. Socially, potato farming can provide a highly profitable source of income for farmers, thus improving their social status.

Structural Model Fit Test (Inner Model)

The inner model test is useful for seeing the relationship between latent variables (constructs) and other latent variables (constructs). Evaluation of model fit (*inner model*) namely through the R-squared (R²) test to measure the level of goodness of fit of a structural model and the path coefficient estimation test to determine how much influence the exogenous (independent) variables have on the endogenous (dependent) variables. The R² value in this study can be seen in Table 4.

Table 4. R² Values of Variables in the Productivity and Sustainability Improvement Model for Potato Farming in the Research Area, 2023

	R Squared
PIP	0.918
PRU	0.730
KBUT	0.750

Source: Smart PLS Processed Data Results Version 3.0, 2023

Table 4 shows that the variable Production Input Use (PIP) has an R² value of 0.918, meaning that the variable Production Input Use (PIP) can be influenced simultaneously by Education (DIK), Age (UM), Farmer Knowledge (PU), Income (TAN) and the Number of Labor Availability (TK) in the latent internal factor (FI), extension aspect (AP), adoption of farming technology (ATP), technological aspect (ATP), and Number of Farms (JUT) in the latent external (FE) which is 91.8%. The farm productivity variable (PRU) has an R² value of 0.730, meaning that the farm productivity variable (PRU) can be influenced simultaneously by Education (DIK), Age (UM), Farmer Knowledge (PU), Income (TAN) and the Number of Labor Availability (TK) on the latent internal factor (FI extension aspect (AP), adoption of farming technology (ATP), technological aspect (ATP), and Farming Distance (JUT) on the latent external (FE) which is 73.0%. And the farm sustainability variable (KBUT) has an R² value of 0.750, meaning that the farm sustainability variable (KBUT) can be influenced simultaneously by Education (DIK), Age (UM), Farmer Knowledge (PU), Income (TAN) and the Number of Labor Availability (TK) on the latent internal factor (FI), extension aspect (AP), adoption of farming technology (ATP), technological aspect (ATP), and Farming Distance (JUT) on the latent external (FE) and Use of Production Inputs (PIP) and farm productivity (PRU) which is 75.0%.

Goodness of fit evaluation

After obtaining the R² value, the next step is evaluation. *goodness of fit* By calculating the Q² value, the goal is to determine the model's ability to predict the relationship between variables. The results of the goodness of fit evaluation are seen from the Q² value as follows:

$$\begin{aligned}
 Q^2 &= 1 - (1 - R^2_{12}) (1 - R^2_{22}) (1 - R^2_{32}) \\
 &= 1 - (1 - 0.918) (1 - 0.750) (1 - 0.730) \\
 &= 1 - (0.082) (0.25) (0.27) \\
 &= 0.994
 \end{aligned}$$

This means that internal factors and external factors have *predictive relevance* which is very high on the sustainability of potato farming.

Direct Influence

The direct effect is the effect of the relationship between the independent (exogenous) variable and the dependent (endogenous) variable. The results of the effect are presented in the following table.5.

Table 5. Relationship between Latent Variables in the Productivity and Sustainability Improvement Model Potato Farming in the Research Area, 2023.

Relationship between Variables	Path Coefficient	Sample mean	Standard Deviation	t-statistic	P Value	Information
FI -> PIP	0.510	0.513	0.075	6,780	0,000	Positive and Significant
FI -> PRU	1,081	1,057	0.215	5,027	0,000	Positive and Insignificant
FE -> PIP	0.489	0.485	0.074	6,616	0,000	Positive and Insignificant
FE -> PRU	0.488	0.533	0.208	2,341	0.020	Positive and Significant
PIP -> PRU	-0.722	-0.744	0.263	2,750	0.006	Positive and Insignificant
PRU -> KBUT	0.866	0.874	0.016	55,086	0,000	Positive and Significant

Source: Smart PLS Processed Data Results Version 3.0, 2020

Table 5 shows that internal factors (FI) have a direct positive and significant effect on the use of production inputs (PIP) and a positive and highly significant effect on farm productivity (PRU). This means that every 10% increase in internal factors directly strengthens the use of production inputs (PIP) by 5.10% and farm productivity by 10.8%, significantly ($p\text{-value} = 0.000 < \alpha = 0.01$).

External factors have a direct, positive and significant impact on the use of production inputs (PIP) but also have a positive and significant impact on farm productivity. This means that whenever external factors strengthen, by 10% will strengthen the use of production inputs by 4.89% and is very significant ($p\text{-value} = 0.000 < \alpha = 0.01$) and strengthen farm productivity by 4.88%. The use of production inputs directly has a positive and significant effect on farm productivity. It can be interpreted that every 10% increase in the use of production inputs will result in a -7.22% increase in farm productivity. Farm productivity has a direct positive and very significant effect on farm sustainability. It can be interpreted that every 10% increase in farm productivity will result in a 8.66% increase in farm sustainability.

Consistent with Rozandy and Santoso (2013), the use of production inputs significantly influences farm productivity. Furthermore, Nainggolan and Yanuar (2022) stated that productivity is a determining factor in the sustainability of potato farming. Tasman, A (2008) found that strengthening the implementation of cultivation techniques that prioritize the application of production inputs according to recommended doses will be a determining factor in determining the level of farm productivity.

Indirect Influence

In this study, internal and external factors not only directly influence farm productivity but also play an indirect role through moderating variables such as the use of production inputs and farm productivity. This means that farm sustainability is influenced by the interaction between these factors, mediated by how farmers manage their inputs and farm output. As explained in Table 6, the indirect influence value can be analyzed quantitatively to determine the extent to which these intermediary variables contribute to strengthening the causal relationship. This finding aligns with a study by Rahman et al. (2023), which showed that the introduction of technology and management in agricultural processing can strengthen farmers' production effectiveness through an indirect pathway based on input mastery and technical knowledge. Furthermore, a study by Amrullah and Syifa (2023) emphasized that skills and innovation are important intermediary variables in driving the success of small and medium enterprises, which can be analogous to the conditions in small-scale farming. Therefore, understanding the role of moderating variables is crucial for developing more effective and sustainable farmer empowerment strategies. The indirect influence values of internal and external factors on farm sustainability are shown in Table 6.

Table 6. Indirect Effect of Variables on Potato Farming Productivity and Sustainability in the Research Area, 2023

Relationship between Variables	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistic	P-Value
FI->PIP -> PRU->KBUT	-0.319	-0.332	0.127	2,522	0.012
FI->PIP->PRU	-0.369	-0.380	0.146	2,531	0.012
FI-> PRU->KBUT	0.936	0.924	0.187	5,016	0,000
FE->PIP -> PRU->KBUT	-0.306	-0.316	0.123	2,488	0.013
FE->PIP->PRU	-0.535	-0.363	0.143	2,470	0.014
FE-> PRU->KBUT	0.422	0.465	0.180	2,341	0.020
PIP->PRU ->KBUT	-0.625	-0.649	0.227	2,760	0.006
Total Indirect Impact					
FI->PRU	0.713	0.677	0.165	4,327	0,000
FI->KBUT	0.617	0.592	0.145	4,268	0,000
FE->PRU	0.135	0.170	0.190	0.707	0.480
FE->KBUT	0.117	0.149	0.167	0.699	0.485
PIP->KBUT	-0.625	-0.649	0.227	2,760	0.006

Source: Analysis Data, 2023

Table 6 shows that the magnitude of the coefficient of the internal factor variable through the moderating variable of the use of production inputs and the moderating variable of farm productivity on the sustainability of farming, internal factors through the moderating variable of the use of production inputs on farm productivity and internal factors through the moderating variable of farm productivity on the sustainability of farming, have a positive and significant effect. It can be interpreted that indirectly every strengthening of the internal factor by 10% through the moderating variable of the use of production inputs and farm productivity will strengthen the farm sustainability variable by -3.19% and is significant ($p\text{-value} = 0.012 < \alpha = 0.05$), through the moderating variable of the use of production inputs will strengthen the farm productivity variable by -3.69% and is significant ($p\text{-value} = 0.012 > \alpha = 0.05$), and through the moderating variable of farm productivity will strengthen the farm sustainability variable by 9.36% and is significant ($p\text{-value} = 0.000 < \alpha = 0.01$).

The coefficient of external factor variables through the moderating variables of production input use and farm productivity moderation variables on farm business sustainability and external factors through the moderating variable of farm technology adoption on productivity have a positive and significant effect. It can be interpreted that indirectly every 10% strengthening of external factors through the moderating variables of production input use and farm productivity will strengthen the farm business sustainability variable by -3.06% and is significant ($p\text{-value} = 0.013 < \alpha = 0.05$), through the moderating variable of production input use will strengthen the farm productivity variable by 5.35% and is significant ($p\text{-value} = 0.014 < \alpha = 0.05$). Meanwhile, the external factor variable through the moderating variable of farm productivity on farm sustainability has a positive and significant effect. It can be interpreted that indirectly every 10% strengthening of external factors through the moderating variable of farm productivity will strengthen the farm sustainability variable by 4.22%.

The use of production inputs with the moderating variable of farm productivity on the sustainability of farming businesses has a positive and significant effect. This means that indirectly, every 10% increase in the use of production inputs through the moderating variable of farm productivity will strengthen the sustainability variable of farming businesses by 6.25% and is significant ($p\text{-value} = 0.006 < \alpha = 0.01$).

The path diagram of the indicator variables of internal and external factors that influence the sustainability of potato farming businesses generated through the PLS algorithm can be seen in Figure 2.

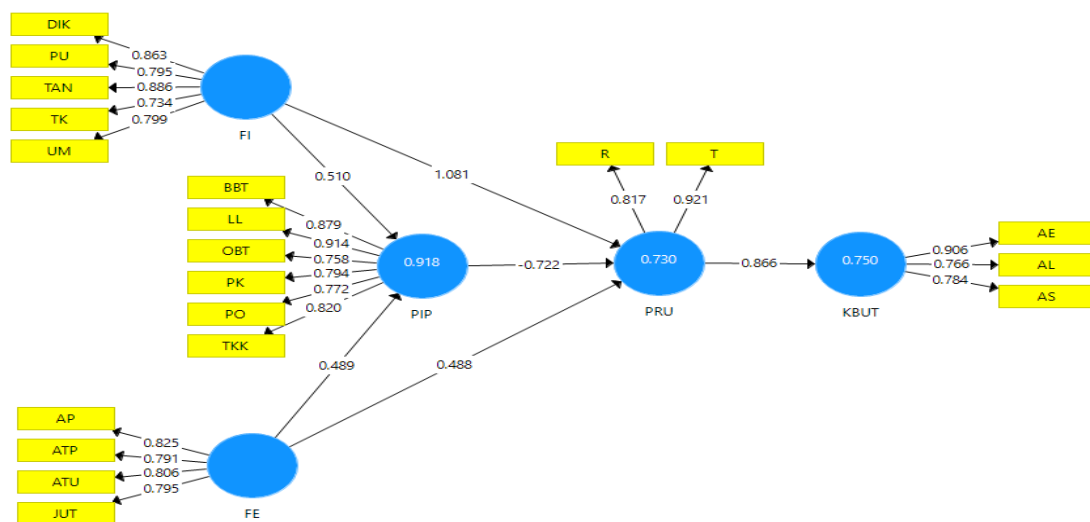


Figure 2. Path Diagram of Variable Indicators in the Model for Increasing Productivity and Sustainability of Potato Farming in the Research Area, 2023

Analysis of the Influence of Indicators on Latent Variables

The latent variables in this study consist of 5 variables, namely internal factor variables, external factor variables, external factors, adoption of farming technology, farming productivity, and farming sustainability. The influence of manifest variables on latent variables can be seen in Table 7.

Table 7. Effect of Indicators on Latent Variables in the Model of Increasing Productivity and Sustainability of Potato Farming in the Research Area, 2023

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T-Statistics (O/STDEV)	P-Value
DIK <- FI	0.863	0.863	0.056	15,427	0,000
UM <- FI	0.799	0.798	0.051	15,724	0,000
PU <- FI	0.795	0.787	0.058	13,608	0,000
TAN <- FI	0.886	0.888	0.035	25,361	0,000
Kindergarten <- FI	0.734	0.721	0.098	7,525	0,000
AP <- FE	0.825	0.825	0.065	12,736	0,000
ATU <- FE	0.806	0.806	0.064	12,582	0,000
ATP <- FE	0.791	0.785	0.070	11,273	0,000
JUT <- FE	0.795	0.799	0.049	16,301	0,000
BBT <- PIP	0.879	0.877	0.035	25,311	0,000
LL <- PIP	0.914	0.911	0.026	35,459	0,000
OBT <- PIP	0.758	0.760	0.070	10,839	0,000
PK <- PIP	0.794	0.797	0.086	9,187	0,000
PO <- PIP	0.772	0.773	0.058	13,324	0,000
TKK <- PIP	0.820	0.816	0.052	15,756	0,000
T <- PRU	0.921	0.925	0.011	85,852	0,000
R <- PRU	0.817	0.802	0.081	10,042	0,000
AE<-KBUT	0.906	0.911	0.014	65,946	0,000
AL<- KBUT	0.766	0.758	0.094	8,140	0,000
AS <- KBUT	0.784	0.776	0.069	11,428	0,000

Source: Smart PLS Data Processing Results, 2023

Table 7 shows the manifest effect on the latent variables. All manifest variables in the study have a p-value of $0.000 < 0.010$, meaning they have a very significant effect. First, education, age, farmer knowledge, income, and labor availability are collectively able to measure and explain the latent variables, namely internal factors. Where the coefficients of each of the internal factor manifests are 0.863, age 0.799, farmer knowledge 0.795, income 0.886, and labor availability 0.734. This means that every 10% increase in the manifest of the internal factor variable will, respectively, strengthen the internal factor variable by 8.63%, 7.99%, 7.95%, and 8.86%.

Second, accessExtension, adoption of farming technology, access to technology, and the number of farming businesses together are able to measure and explain external factor variables. Where the coefficients of each of the external factor manifests are access to extension of 0.825, adoption of farming technology of 0.806, access to technology of 0.791, and the number of farming businesses of 0.795. This means that every 10% increase in the manifest variables of price access, market access, extension access, and technology access will strengthen the external variables by 8.25%, 8.06%, 7.91%, and 7.95%.

Third, the economic, environmental, and social aspects collectively measure and explain the sustainability variables of farming. The coefficients for each of the sustainability manifests for farming are 0.906 for the economic aspect, 0.766 for the environmental aspect, and 0.784 for the social aspect. This means that every 10% increase in the economic, environmental, and social manifests will increase the sustainability variables for farming by 9.06%, 7.66%, and 7.84%, respectively.

Efforts to Increase Productivity and Sustainability of Potato Farming

The productivity and sustainability of farming businesses are determined by internal and external factors. The internal factor that significantly influences productivity and sustainability is income. This income factor is a key factor as the main economic aspect in farming sustainability. External factors that determine productivity and sustainability of farming businesses include access to credit, access to inputs, access to technology, and irrigation. These determinants are key factors in the use of production inputs and production. In turn, these factors are key factors in productivity, economic aspects, and environmental aspects. (Nainggolan, et al, 2019). The model for increasing productivity and sustainability of potato farming is based on influential variables (determinant factors on productivity and sustainability of potato farming can be seen in the following chart).

Increasing the productivity and sustainability of potato farming is also influenced by farmers' adaptation strategies to climate change, the adoption of appropriate technology, and the diversification of their farming operations. Several international studies have shown that farmers' access to modern agricultural technology, training, and land management innovations plays a significant role in increasing productivity and maintaining the sustainability of farming systems. For example, the implementation of sustainable agricultural practices such as Integrated Crop Management (ICM) has been shown to increase input efficiency and potato crop productivity in various countries (Abhayapala 2015). Furthermore, community-based extension services and institutional support are key in strengthening farmers' resilience to production risks (Wright, 2017). Other research has shown that the combination of superior varieties and soil conservation strategies can simultaneously increase yields and soil quality sustainably (Stagnari, 2009). Finally, government policy support in the form of environmentally friendly input subsidies and access to financing contributes to the development of a productive and sustainable potato farming system (Setiyo, 2017).

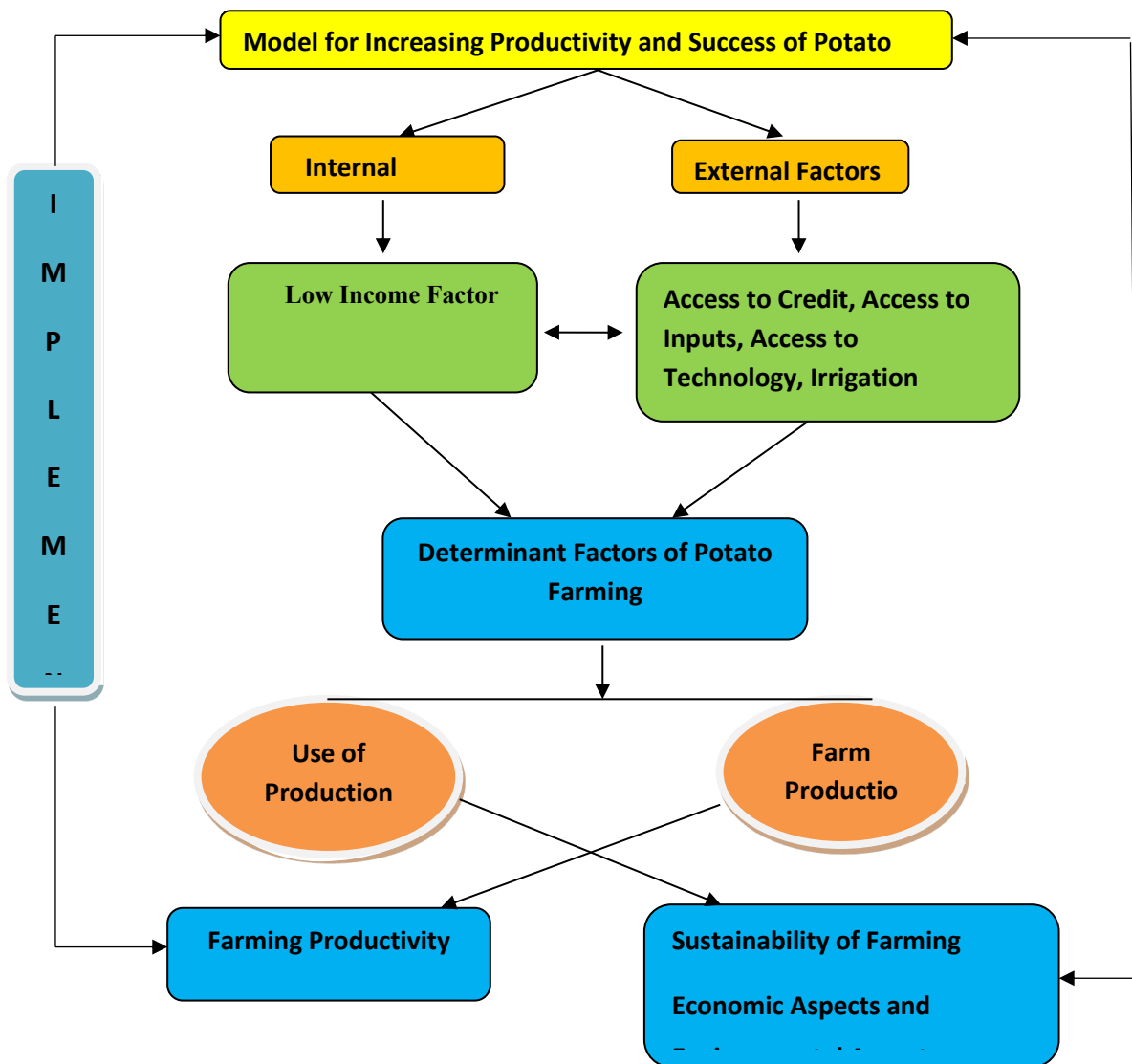


Figure 3. Frame Work Research

CONCLUSION

The description of internal factors, external factors of farmers, and the use of production inputs are in the moderate category. The productivity and sustainability categories of potato farming are in the low category. The internal factor that is a determinant of productivity and sustainability of potato farming is the farm income variable. External factors that are determinants of productivity and sustainability of farming are access to technology and access to inputs. The use of production inputs that are determinants of productivity and sustainability of potato farming are land area and fertilizer use. Modeling for increasing productivity and sustainability of potato farming that must be a priority to pay attention to is the use of production inputs. The main policy needed is to increase farmer access to address fertilizer availability in the farming locality. Guidance on the use of production inputs and guidance on economic and environmental aspects of farming sustainability.

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