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Increasing Kailan profits using smart farming in the form of a digital water timer

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ABSTRACT

Introduction: Agriculture is no longer facing challenges in the classic way but with modern method called smart farming. Hope this can be a solution to improve agricultural quality and productivity which will lead to increased farming profits. One of them is digital water timer, it helps distributing water in hydroponics. In reality, not many farmers implemented smart farming or greenhouses due to lack of information and costs. This study aims to analysis profit and the factors influencing it. **Methods:** The research was conducted in Jambi City collected with the help of questionnaires and literature study. Primary data was collected from 155 respondents including hydroponics with smart farming in greenhouses, hydroponics non-smart farming in greenhouses, hydroponics only, and conventional farming. The analytical research method used is quantitative descriptive and data processing using the R/C ratio formula, whereas to determine the factors using multiple linear regression with F-test and t-test. **Results:** The results showed that the R/C ratio is 1.74, which means farming is profitable to implement. Hydroponics with smart farming provides the highest profit among other technologies and costs less than non-smart farming. The profit obtained is 18.6% higher than non-smart farming. The higher the technology, the more production will increase. Smart farming affects positively to the Kailan production followed by other factors that is land area. **Conclusion:** This finding provides technology such as smart farming has potential impacts to improve farm profit.

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INTRODUCTION

Rapid population growth, the difficulty of regeneration at the farm level, and limited land require smart farming (Mohamed 2021). Factors that cause defects in hydroponic vegetable products include machine, environmental, and human factors (Novianti et al., 2019). One of the efforts that can be made to avoid this is by implementing smart farming. Smart farming is an illustration of part of the effort to realize advanced, independent and modern agriculture. The goal is to increase production yields and lead to sustainable agriculture which ultimately increases profits, increases land use productivity, and reduces labor use (Knierim et al., 2019). Forms of smart farming technology are available from the simplest to the most complex. Digital water timers are the simplest form of technology and are easy for farmers to implement. The increase in this technological revolution will result in major changes to agricultural cultivation practices. Smart farming is currently not only developing in developed countries, several developing countries including Indonesia have started using the smart farming method although not yet massively. Changes in agricultural practices are not only an opportunity to increase agricultural productivity, but can also be a major challenge considering that many farmers are still unfamiliar with it (Walter et al. 2017).

The concept of smart farming is not entirely new. Since the early 2000s, precision farming technology has been introduced in developed countries such as the United States and Germany in response to the need for efficiency in food production (Fahrurrozi *et al.* 2025). Its development was then expanded with the integration of digital technology such as the Internet of Things (IoT), sensors, and data analytics that can help farmers in making real-time data-based decisions. This technology is the forerunner to the birth of a smart farming system. In Indonesia itself, the idea of smart farming began to be developed along with the industrial revolution 4.0 which encouraged digital transformation in various sectors, including agriculture. So based on this, the implementation of smart farming in Indonesia is currently part of the long journey of adopting technology in the global agricultural sector.

Smart farming can be applied to hydroponic where hydroponic itself has implemented technological advances as a result it can increase crop production by 20%, reduce water use by 30%, reduce the use of human labor by 50%, reduce the use of fertilizers and pesticides by 10% (Rachmawati, 2021). Hydroponic water needs are much more efficient than conventional cultivation techniques because the water containing nutrients is not wasted, the water will always rotate in a cycle (Wibowo *et al.*, 2017; Roidah, 2014). Several previous studies have shown that the implementation of smart farming has a positive impact on agricultural productivity and efficiency. Research by Safitrah *et al*. (2024) proved that the use of soil moisture sensors and irrigation automation increased leafy vegetable yields by up to 25%. Meanwhile a study conducted by Pertiwi *et al*. (2021) found that the integration of a digital temperature and humidity monitoring system in hydroponic cultivation can reduce the number of planting failures. In the field of vegetable hydroponics such as Kailan, there has not been much specific research conducted, but these studies show great potential if smart farming technology is applied more widely. This opens up opportunities for further research to examine the direct relationship between the implementation of smart farming and profit performance in certain commodities such as Kailan in urban areas such as Jambi City.

Kailan has main consumers that are restaurants, hotels, chinese community and the upper middle class, so the economic value and marketing of Kailan is quite propective (Alhadi *et al.,* 2016). This requires that the Kailan produced must be hygine and free from the use of pesticides. The growth of Kailan is strongly influenced by the water medium which affects the results of its production. Utilizing a digital water timer in Kailan hydroponics can make work more efficient and reduce costs. Hydroponics is a fairly potential agricultural opportunity in Jambi City and still has room for development in the future. However, in terms of implementing smart farming, hydroponic cultivation in Jambi City is still lagging behind other big cities. Hydroponics in Bandung implements smart greenhouses with Internet of Things (IoT) and machine learning for pest detection (Maulana *et al.* 2023). Smart farming is also implemented in educational tourism objects in Tasikmalaya City which offer the concept of integrating the agricultural and fisheries sectors with the application of IoT (Hikmatunnisa *et al.* 2024).

In order for the potential of smart farming to be truly felt by farmers in Jambi City, there needs to be wider adoption based on real evidence. A study by Safitrah *et al.* (2024) showed that the use of irrigation automation can increase water efficiency and leafy vegetable yields by up to 25%, while a 2023 report from the Ministry of Agriculture stated that farmers who implemented IoT-based technology experienced an increase in net profit margins of 15–30%. Therefore, it is important for local governments and educational institutions to not only conduct outreach but also expand technical counseling and in-depth research. Some areas that need to be focused on include research related to the optimal setting of digital water timers for Kailan plants in the local Jambi City climate, and assistance to farmers in accessing government incentives and subsidies for the procurement of smart farming tools.

Not much research has been found related to smart farming in Jambi City. Currently, smart farming in Jambi is still in the experimental stage, which means that this technology has only been tested on a limited scale by government agencies such as the Jambi City Agriculture Service and educational institutions such as Jambi University through research and community service programs. Its implementation is more focused on education, training, and simulation of sensor-based or IoT systems for plant monitoring. The lack of support from a commercial ecosystem such as partnerships with the private sector, limited investment, and low technological literacy among farmers are the main reasons why commercialization has not occurred. Based on a survey in the field, it was found that the Kailan hydroponics implemented greenhouses and smart farming in the form of a digital water timer. In fact, the implementation of smart farming has the potential to significantly increase farmers' profits. Based on the description above, this study aims to analyze the benefits of using smart farming and the factors that influence its production. Specifically, the objectives of this study are: First, to analyze and compare the profitability of kale cultivation using four different methods: hydroponics with smart farming (greenhouse), hydroponics without smart farming (greenhouse), hydroponics alone, and conventional farming. Second, to identify key factors, particularly technology implementation and land area, that significantly influence kale production in Jambi City.

METHODS

The research was conducted on Kailan farms in Jambi City. Location was selected by purposive with the consideration that hydroponic businesses in Jambi City are growing and there is farmer implementing smart farming. data collection was carried out with interviews assisted by questionnaires and information from literature studies. Determination of respondents was taken by census by involving all respondent who farmed Kailan. Primary data were collected from 155 Kailan farmers spread across Jambi City including hydroponics with samrt farming in the greenhouse, non smart farming hIDR oponics in greenhouse, hydroponics only, and conventional farming. The research was carried out from December to January 2023. The analysis method used was descriptive quantitative. To answer the first aim using farming analysis, the second aim using efficiency analysis (R/C ratio), while to see that technology affects profit is analyzed by multiple linear regression analysis.

Analysis of total income

The profit can be calculated using the following formulation (Soekartawi, 1995):

$$\pi = TR - TC$$

$$\pi = (Y \times Py) - (TFC + TVC)$$

Where: π is the profit of Kailan farming (IDR /year); TR is total revenue of Kailan (IDR /year); TC is total cost of Kailan (IDR /year); Y is Kailan production (Kg/year); Py is the price of Kailan (IDR /kg); TFC is total fixed cost (IDR /year); and TVC is total variable cost (IDR /year).

Analysis of R/C ratio

Farming efficiency is calculated using R/C ratio which is the ratio between profits and total costs incurred during one period. A business is considered profitable or economically efficient if the number is high. The following are the results of R/C ratio which can be interpreted as follows:

1. R/C ratio > 1, the business is considered profitable or economically efficient
2. R/C ratio = 1, the business breaks even.
3. R/C ratio < 1, the business is economically inefficient or unprofit

Multiple linear regression analysis

Factors affecting the profit of kale were analyzed using a multiple regression model. The independent variables that are the estimated factors are land area (X1), nutrition (X2), seeds (X3), and technology dummy (D1), while the dependent variable is kale production (Y). This analysis was carried out using the F test and t test to see the influence of independent variables simultaneously and partially on the dependent variable. The tests used were F-test and t-test at 95% confidence level. Data processing was done with the help of STATA program. The explanatory variables in this study showed on Table 1.

Table 1 Independent variables

Factors that influence	Variables	Description	References
Land area	X_1	Number of planting land use	(Azzura *et al.* 2017)
Nutrients	X_2	Nutrients or fertilizers used	(Azzura *et al.* 2017)
Seeds	X_3	Number of seeds used	(Azzura *et al.* 2017)
Technology dummy	D_1	1 = technology, 0 = conventional	(Bulu *et al.* 2020)

The variables used in this study were determined based on issues related to increasing farm production with the support of previous research and data availability. Technology dummy stands for Kailan cultivation using technology, they are Kailan hydrophonic with smart farming and greenhouse, Kailan hydrophonic with greenhouse non smart farming, and Kailan hyrdroponic only connoted with the number 1. The rest that didn't apply technology conneted with the number 0. These variables need to be tested for their influence on Kailan production. The relationshop between these variables can be formulated in the following equation:

$$\text{Ln } Y = \alpha 0 + \beta 1 \ln X1 + \beta 2 \ln X2 + \beta 3 \ln X3 + \beta 4 \ln D1 + \varepsilon i$$

Where : Y = production (kg); α0 = model constant; β1, β2,.. β7 = coefficient of factors affecting Kailan production; X1 = land area ($220m^2$/year); X2 = nutrients (liters/year); X3 = seeds (grams/year); D1 = technology dummy; ε = error (disturbance term); i = respondent (1, 2,… i).

RESULTS AND DISCUSSION

Application of smart farming in Kailan

The benefits of Kailan can be increased with the addition of greenhouse procurement and smart farming. This technology is the upper version of basic hydroponics. The smart farming applied is a digital water timer, hoping the watering system will be more effective. The timer is used as a tool to set the schedule on and off the hydroponic pump. This timer has the ability to regulate plant watering, so the problems that often occur during manual watering such as delays in watering time can be resolved. This will also keep hydroponic always well maintained and avoid the risk of drought. Another advantage is that the pump machine is not continuosly working so the machine is more durable. The use of time in farming is very important to consider because it will affect the use of labor and cost incurred.

The way this time control works is to control the time of using the machine, every 10 minutes the machine will automatically turn off. At night, the duration is longer for 30 minutes. There is a hose that automatically turns on when the temperature is above 35°C. Time control can save 50% of electricity usage. Based on measurements and calculations carried out at the research site, the water pump in the conventional hydroponic system operates nonstop for a total duration of approximately 64,800 minutes per growing season. Meanwhile hydrophonic using smart farming increase half of it or 32400 minutes per growing season.

In a hydroponic system supported by smart farming technology, the use of a water pump only takes an average of 88.96 seconds and a nutrient pump around 50.39 seconds. This shows a very high working efficiency of the machine. As shown in a study by Syafei & Watiasih (2021), this automatic setting is much more effective than manual settings which require longer operating times and tend to be inconsistent. In conventional hydroponics, watering is usually carried out continuously without considering the actual needs of the plants which causes waste of water and energy. Meanwhile, data from a study by Haq *et al.* (2025) shows that the application of an automatic irrigation system based on smart farming can increase the stability of plant root moisture and result in a 23.5% increase in leafy vegetable productivity compared to conventional methods. Based on this, the efficiency of time and stability of the planting environment conditions provided by smart farming have a direct impact on increasing and stabilizing harvest yields.

Analysis of Kailan revenue

Farm income is calculated from the multiplication of crop production and the price received. The number of Kailan plants is 2320 planting holes on an area of 220 m^2 and tends to remain throughout the year. Kailan is harvested throughout the year with a harvest frequency ranging from 130-180 kg/month. Production and land area affect farm productivity, the better the production, the more productivity will increase. Productivity is obtained from the ratio between the amount of production and the land area of Kailan, in this study the land area uses the number of planting holes. The important thing to note is the productivity of hydroponic Kailan with three different technologies. Both those using smart farming (SGH) and not using smart farming (GH and H) experienced fluctuations within one year (Figure 1). Henceforth, each Kailan farm is written with the following codes; a) SGH is hydroponic Kailan that applies smart farming and greenhouse, b) GH is hydroponic Kailan greenhouse without smart farming, c) H is hydroponic Kailan only without greenhouse and smart farming, and d) C is conventional Kailan.

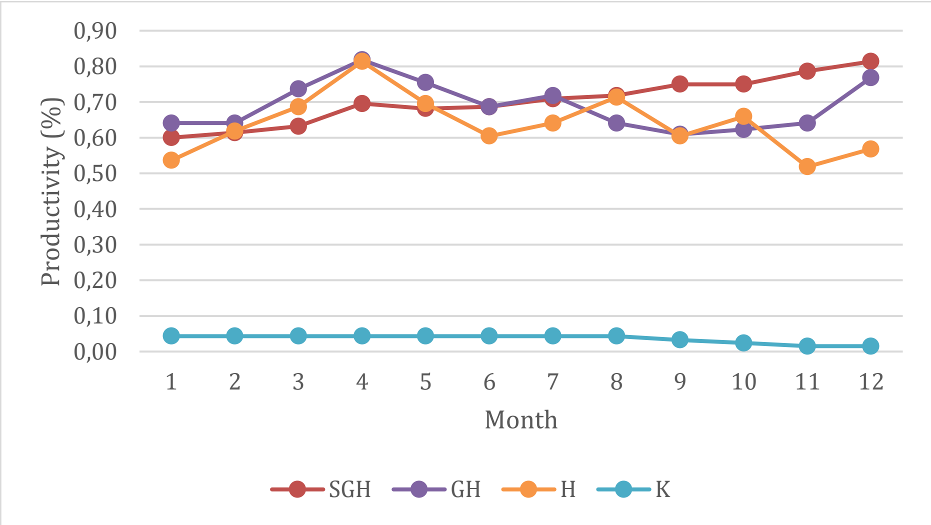

Figure 1. Graph of Kailan productivity in Jambi City 2022

Hydroponic Kailan that applies smart farming has a productivity that tends to stabile and increase compared to other hydroponic Kailan. The average production of smart farming hydroponic Kailan is 1856 kg/year. This indicates that the longer hydroponics is supported by greenhouses and smart farming, the better and more productive hydroponics becomes. This condition is because the water and nutrient needs of Kailan plants are fulfilled and smart farming does not have a negative impact on plants. According to Syafei and Watiasih (2021), there are no problems in the roots and leaves in the sense that there is no decay or damaged leaves from the application of smart farming.

The productivity of non-smart farming hydroponics fluctuates within a year, especially Kailan which only applies hydroponics (H). This is because the production is erratic, one of the factors is because hydroponics is in an open space unlike other hydroponics which is protected by a greenhouse. Hydroponics is only protected by a roof, so if it rains, it is possible for water to enter the module which can affect the pH of the water and the weight of the Kailan vegetables. Hydroponic Kailan in Jambi City has the same market so that the average production also follows the market demand. Likewise, the price range received is uniform following the market. A key finding of this study is that the selling price of kale grown in the hydroponic smart farming system is similar to that of kale grown in the non-smart farming system. This indicates that technological superiority in the production process has not been successfully translated into added value at the market level, possibly due to a lack of strong product differentiation or a lack of consumer awareness of precision farming products in Jambi City. To supermarkets, the Kailan is sold in plastic packaging and labelled with a brand, while to restaurants it is wrapped in ordinary plastic. The price of the Kailan is IDR 35,000/kg, so the revenue received is IDR 64,960,000 per year.

Cost structure of Kailan smart farming

The cost structure presents expenditures for inputs used in farming activities. This research is focuses on smart farming, so the detailed are for Kailan using smart farming. The cost structure is calculated per year and divided into investment costs and operational costs. Operational costs are separated into two, fixed costs and variable costs. Details of Kailan investment costs showed below.

Table 2. Investment cost of Kailan smart farming

Description	Quantity	Price	Total price	Age	Depreciation
	Unit	IDR /unit	IDR	Year	IDR
Greenhouse	1	85,540,000	85,540,000	10	8,554,000
Time control	1	2,500,000	2,500,000	5	500,000
Hydroponic module	12	1,000,000	12,000,000	5	2,400,000
Water pump	2	270,000	540,000	5	108,000
Description	Quantity	Price	Total price	Age	Depreciation
	Unit	IDR /unit	IDR	Year	IDR
Refrigerator	1	3,540,000	3,540,000	5	708,000
TDS & EC meter	1	100,000	100,000	5	20,000
pH meter	1	250,000	250,000	5	50,000
Water tank	1	400,000	400,000	5	80,000
Netpot	2320	400	928,000	4	232,000
Weighing scales	1	150,000	150,000	5	30,000
Trays	11	6,000	66,000	5	13,200
Basket	2	38,000	76,000	5	15,200
Generator	1	1,500,000	1,500,000	10	150,000
Total			107,590,000		12,860,400

Based on the data, total of investment cost to set up a smart farming Kailan farm is IDR 107,590,000. It includes the cost of building, NFT hydroponic modules, hydriponic equipments and machinery, etc. The biggest percentage in investment is greenhouse with a 79.5%. Greenhouse require a large expenditure at the beginning of the construction and then the benefits in protecting plants. The second and third biggest percentage are hydroponic modules and refrigerator. Smart farming in the form of time control costs IDR 2,500,000 per unit or 2.32% of the total investment cost. This tool can be used for approximately 5 years, but farmers still need maintenance costs to anticipate any damage.

The use of smart farming in the form of time control in hydroponics increases investment costs, but can reduce the cost of electricity and water usage. Hydroponic water needs are more efficient because the water containing nutrients used is not wasted, the water will always rotate in a cycle. Table 3 shows the total cost of smart farming hydroponics is IDR 37,378,400

Table 3. Operational cost of Kailan smart farming (IDR /year)

Description	Price	Quantity	Unit	Total price	Percentage (%)
Electricity cost	500,000	12		6,000,000	16.05
Maintenance fee	3,000,000	1		3,000,000	8.03
Depreciation costs	12,860,400	1		12,860,400	34.41
Labor wages	6,000,000	2		12,000,000	32.10
Total fixed cost				33,860,400	
Seeds	15,000	40	Wrap	600,000	1.61
Rockwool	75,000	10	Bal	750,000	2.01
Nutrients	300,000	3	Set	900,000	2.41
Plastic packing	38,000	6	Pack	228,000	0.61
Label packing	200	900	Sheet	180,000	0.48
Yellow trap	1,900	50	Sheet	95,000	0.25
Gasoline	7,650	100	Liters	765,000	2.05
Total variable costs				3,518,000	
Total costs (TFC+TVC)				37,378,400	100.00

Total costs to run Kailan smart farming is IDR 37,378,400. The highest cost is depreciation of investment costs IDR 12,860,400 or 34.41% of total costs followed by labor wages of IDR 12,000,000 (32.10%) and electricity costs of IDR 6,000,000 (16.05%). Depreciation cost is the highest cost because it is a large initial investment for tools and machinery in long term period. The second highest cost is labor, it shows that the addition of technology has not been able to reduce labor dependence because it still requires human labor. The part of the task that requires the labor is to clean the module and control it every day and also to distribute Kailan to consumers. Each worker is paid IDR 500.000/month. The next highest cost is electricity. Hydroponics is very closely related to electricity to be able to keep pumping the machine so the nutrients can be delivered to each plants. The use of time control adds to investments cost but can reduce the cost of electricity use by 50% and the pump machine does not continuously work so it is more efficient than ordinary hydroponics.

Profit analysis of Kailan smart farming

Profit was calculated by multiplying the total Kailan production by the price received. There are 2,320 planting holes in a 220 m² area, which remained stable throughout the year. This indicates that hydroponic systems supported by greenhouses and smart farming become more productive over time. The reason is because the water and nutrient needs of Kailan are fulfilled and smart farming does not give bad impact on plant. According to Syafei & Watiasih (2021), there are no problems in the roots and leaves, there is no decay or damaged leaves from the application of smart farming. Kailan is harvested throughout the year with a harvest frequency around 130-180 kg/month. The amount of production and physically, there is no significant difference between Kailan hydroponic smart farming and Kailan non smart farming. The profitabilies of Kailan is presented in Table 4 below so that it is known which technology is the most profitable.

Tabel 4. Annual profit of kailan farming based on cultivation technology

No.	Description	Unit	SGH	GH	H	C
A	Production	Kg	1856	1821	1685	1000
B	Price	IDR	35,000	35,000	30,000	15,000
C	Revenue (AxB)	IDR	64,960,000	63,735,000	50,550,000	15,000,000
D	Cost	IDR	37,378,400	40,477,600	37,136,400	12,591,650
E	Profit (C-D)	IDR	27,581,600	23,257,400	13,413,600	2,408,350
F	R/C ratio (C/D)	IDR	1.74	1.57	1.36	1.19

Description: SGH = smart farming, greenhouse, hydroponic; GH = greenhouse, hydroponic; H = hydroponic; C = conventional.

The production of kailan using smart farming (SGH) showed an advantage over other methods. Specifically, SGH production was recorded as 1.9% higher than non-smart farming hydroponics in a greenhouse (GH) and 10.1% higher than the hydroponics-only method without a greenhouse (H). Based on the data above, the higher the technology the higher the production. Hydroponics that does not apply both technologies (H) is only protected with a roof. If it rains, water might still get into hydroponic module. It affects the pH of water or nutrient and then impact to Kailan weigh. In addition, Kailan with conventional technology is smaller which is one ton/year because the possibility of plant damage is bigger in open soil. There is no different between price of Kailan smart farming and non smart farming, which is IDR 35.000. This is because the public and market do not really understand about smart farming and the look of Kailan smart farming and non smart farming are same. So, farmers follow the price of Kailan on the market. When Kailan in conventional scarce, the price of Kailan smart farming can be higher. This profit advantage was primarily driven by lower production costs for smart farming (SGH), amounting to IDR 37,378,400, compared to IDR 40,477,600 for non-smart farming (GH). These cost savings, particularly on electrical components from the use of digital water timers, were a key factor in increasing profitability. The application of smart farming increases investment costs it will reduce input costs in the long run. Kailan using smart farming and greenhouse provides the highest acceptance and followed by higher profits among another Kailan farming with various different technologies. Smart farming influences cost savings which have an impact on increasing profits.

The profit obtained was IDR 27.581.600 per year or 18,6% greater than non smart farming Kailan. Followed by an R/C ratio of 1.74, the highest among other Kailan farms. Every additional cost of IDR 1 spent on or invested in this farm will generate a return of IDR 1.74. These results show that applying smart farming in greenhouse-based hydroponic kailan cultivation is both efficient and profitable. This finding is consistent with Kakamoukas et al. (2021) that smart farming provides benefits in increasing revenue, and on the other hand, reducing operational costs. Hydroponic farming saves costs and encourages sustainable green leaf crop production (Ferguson et al. 2014). All costs incurred in the production process can be covered (Ismail *et al.* 2019). According to Mamilianti (2017), the imbalance in the difference in costs, revenues, and profits can be caused by 3 things, (a) the management of farming is more intensive than the management of conventional farming, or (b) there is a wasteful use of production costs, especially labour costs, or (c) the management of farming is not efficient.

Classical assumption test

Classical assumptions test on the model needs to be done to ensure that the model is not biased and produces a valid regression model. The assumptions that need to be met by the model are having a normal error distribution, no multicollinearity and no heteroscedasticity (homoscedasticity) problems. The assumption of normality of errors in the model was tested using the Skewness-Kurtosis Test. Based on the test results on STATA software, the Prob> chi2 value was obtained at 0.3740. This value is greater than α = 0.05 so it can be concluded that the residuals are normally distributed or accept H_0 at a real level of 5%.

The average VIF (Variance Inflation Factor) value on the variable is 5.02 and the tolerance value is greater than 0.1 (Table 5). The requirements for a model to be free from multicollinearity symptoms are a VIF value less than 10 and tolerance greater than 0.1. The model meets both of these requirements, so the model is free from multicollinearity symptoms. The next assumption is the absence of heteroscedasticity, namely the condition of inconsistent error variance values. This problem can cause the results of 155 statistical tests to be less reliable. The Glejser test is used to detect this problem, obtaining a probability value of 0.1279 or greater than α = 0.05. This indicates that the regression model is free from heteroscedasticity symptoms or the heteroscedasticity test has been met.

All tests carried out on the model have been met because there is no heteroscedasticity and multicollinearity. This shows that the model used is not biased and can be used as an appropriate analysis tool to estimate the factors that affect the profitability of kale farming in Jambi City. The regression model that meets the assumptions is known as the best, linear, unbiased, efficient of estimation (BLUE).

Factors affecting Kailan production

The independent variables are land area (X_1), nutrients (X_2), seeds (X_3), and dummy of technology which is including the three different technologies in hydroponic (smart farming greenhouse hydroponic, greenhouse hydroponic, and hydroponic). The dependent variable is Kailan production (Y). This anylisis was conducted using the F-test and t-test to see the effect of independet variables simultaneously and partially on the dependent variable. Table 5 presents the regression results of the determinants of Kailan farming production in Jambi City.

Table 5. Results of multiple regression

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Constant	2.062	0.535	3.85	
Land area	0.417	0.021	19.59	0.000*
Nutrients	-0.0118	0.079	-0.15	0.881
Seeds	-0.0017	0.020	-0.09	0.932
Technology dummy	0.8390	0.211	3.97	0.000*
R^2	0.811	* : significant at 5% error rate		
Adjusted R-square	0.806			
T table	1.98			
Prob>F (F-statistic)	0.000			

The adjusted R-square value of 0.806 means that the effect of all independent variables on Kailan production is 80.6%. This value is in the storng category because it is more than 0.67 (Chin, 1998). This shows that it can be explained by the independent variables in the model. The remaining approximately around 19.4% is explained by other factors outside the model. Probability value (F-statistic) in the model is 0.000 < (0.05). This value is smaller than the rate level of 5% so that H_0 is rejected and H_1 is accepted. It means all the independent variables land area, nutrients, seeds, and technology simultaneously have a signifincant influence on Kailan production. Based on the data processed, the regression model can be formulated as follows:

$$\hat{Y}= 2.062 + 0.417X_1 – 0.011X_2 – 0.001X_3 + 0.839D_1$$

The t-statistic test was conducted to prove that technology affects the production of Kailan farming in Jambi City. Based on the test, information was obtained that there were two significant independent variables, they are land area and technology dummy. The value is smaller than 5% (0.000 < 0.05), so it can be conluded that reject H_0 and accept H_1, which means that the technology (D_1) has a significant and positive effect on Kailan production. It shows that partially hydroponics with smart farming and greenhouse has a real effect on Kailan production. Based on the log-linear regression model, the coefficient for the technology dummy (0.839) indicates that, ceteris paribus, the adoption of technology (hydroponics) is, on average, associated with 131.4% higher production compared to conventional farming. This large effect is understandable as the model compares all hydroponic-based systems against soil-based farming. This model finding is consistent with the observational data, where the most advanced farming system (SGH) yields 85.6% higher production (1856 kg/year) than conventional farming (1000 kg/year), confirming that the regression model successfully captures the significant impact of technology adoption. The choice of technology has a significant effect on production which then affects the income and profits of kale farming. This study provides results that are in accordance with the research conducted by Ragavi et al. (2019) which states that implementing smart farming can increase production. The decision of Kailan farmers to implement smart farming affects the increasing profits of farming businesses.

Other variables beside technology that affect production partially is land area (X_1). The sign obtained is 0.000 < 0.05 means land area has a significant effect on Kailan production. If there is an addition od 1% of land area, production will increase 0.417%. This finding is in line with previous research by Lubis *et al.* (2019) that state land area has a significant effect on production. Furthermore, according to Yuliani *et al.* (2023), a positive relationship was found between increasing land area and hydroponic pak choy production in Jambi City. If farmers have sufficient planting area, the probability of improving agricultural yields and profits will be higher. The wider the hydroponic farming land, the higher the value of hydroponic vegetable production.

The nutrient variable (X_2) has a significance level of 0.881 > (0.05), so H_0 is accepted and H_1 is rejected. This shows that partially nutrients do not have a significant effect on Kailan production because they have a probability value greater than a real level of five percent. Nutrients show a negative and insignificant effect which can be caused by incorrect calculations of the concentration between nutrients and water. Nutrients are given in the main water tank and based on the ppm of nutrients. Water then flows throughout the hydroponic installation of plants with varying ages, even though the nutrients for newly transplanted seedlings are certainly different from the nutrients needed by mature plants. This is supported by Bojtor *et al.* (2023) that the nutritional needs of plants in the vegetative phase are different from the generative phase. The two phases do not run alone. When the generative phase takes place, the vegetative phase continues and the processes that occur in the generative phase are more dominant.

The seed variable (X_3) has a significance level of 0.875 > (0.05), so H_0 is accepted and H_1 is rejected. This shows that partially the seeds do not have a significant effect on kale production because they have a probability value greater than a real level of five percent. Seeds show a negative and insignificant effect which can be caused by several factors such as varieties that are not in accordance with environmental conditions, the use of expired seeds, or their use is already maximized. This is supported by the findings of Wang *et al*. (2023) and Taryana *et al.* (2025) that increasing the number of seeds and inserting them into existing installations means making new planting holes will reduce the distance between each plant. There will be plant competition in absorbing nutrients, water, and sunlight so that plant growth is less than optimal which has an impact on decreasing production capacity and causing thin and tall plants.

Based on the analysis that has been done, the results show that Kailan farming is profitable. Kailan hydroponics with smart farming requires large investment costs which will be followed by greater additional profits. This is due to the higher price of kale because it has a market share of the middle to upper class. The advantages of hydroponics include easy to work on so that it is more energy efficient, no need to cultivate the land, more efficient water use, does not depend on the season, can be done on narrow land and protected from rain and direct sunlight, in addition to that the price is stable. It is not enough just with the existing hydroponics, the production of kale hydroponics can be increased by adding greenhouse procurement and smart farming technology. Farming in the form of a digital water timer encourages greater profit because it saves electricity costs. Other production pump machines do not work continuously so they are more durable. Smart farming affects cost savings which have an impact on increasing the amount of production, but this study did not see its direct effect on the quality and quantity of kale production. The core of implementing smart farming is actually focusing on how artificial intelligence can help overcome challenges in agriculture and simultaneously reduce negative impacts on the environment.

Smart farming influences cost savings that result in increased production but not many farmers have implemented it. The main reason why many hydroponic actors do not implement smart farming is because of cost issues, in addition to the perception of farmers who feel that the hydroponic business they are running is not yet large-scale so they feel there is no urgency to implement smart farming. The price of Kailan also the same in the market, making farmers feel that there is no difference with the ordinary hydroponics that they have been cultivating. In fact, if a cost to profit analysis is carried out, the profit is greater if using smart farming. This is in line with the research of Tinaprilla *et al.* (2024) which states that smart fertigation reduces input usage and increases profits higher than farmers who do not implement it. Technology and land area are important factors for kale production and this amount can still be continued, on the other hand, nutrients and seeds can be reduced. According to Caffaro and Cavallo (2019), smart farming contributes to providing great benefits through the use of natural resources such as more efficient water use, and reduced nutrient input.

CONCLUSIONS

The study concludes that Kailan farming using smart farming technology is the most profitable, with an annual profit of IDR 27,581,600 or 18.6% higher than non-smart farming. The R/C ratio of 1.74 indicates that the business is economically feasible, as every additional IDR 1 invested generates an average return of IDR 1.74. Regression analysis confirmed that both technology (smart farming) and land area significantly influence Kailan production, where higher technology adoption leads to increased productivity.

Further dissemination and training for farmers are needed to encourage wider adoption of smart farming technologies. Future research should investigate the effects of digital water timers on the quality and quantity of Kailan production, as well as explore appropriate product pricing and business development strategies for hydroponic farmers who have adopted smart farming systems.

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