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Determinants of Millennial Farmers' Decisions in Hydroponic Melon Cultivation: Evidence from Sragen Regency

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ABSTRACT

Melon is one of the fruits that consumers demand and has a relatively high economic value. Melon plants are native to Africa and have many valuable vitamins and minerals for body health. Millennial farmers have recently been involved in the hydroponic melon business because of its high selling value. This study aims to determine the factors that influence the hydroponic cultivation decisions of millennial farmers. The study was conducted in several sub-districts in Sragen Regency, including Gemolong, Plupuh and Masaran. The sampling method was carried out using the Snowball sampling method. This study utilised various data analyses used for SEM-PLS analysis. This study examined factors influencing farmers' decisions to cultivate hydroponic melons, focusing on technical, economic, social, and cultural aspects. Respondents were mostly young men with limited experience but high learning potential. Production outcomes varied widely, reflecting diverse capacities. Validity and reliability tests confirmed robust measurement. Effect size and path analysis revealed that decisions were dominantly shaped by technical ($f^2 = 0.819$, adverse effect) and economic ($f^2 = 0.391$, positive effect) factors, while social and cultural aspects were minor. The study highlights technology complexity and economic constraints as key barriers, suggesting training, accessible facilities, and market support as priority strategies.

1. Introduction

Indonesia is also called an agricultural country, and agricultural and plantation products can be exported to various countries. Indonesia's tropical climate is suitable for growing food crops, industrial crops, and fruits. The exports are in the form of food crops, industrial crops, and fruits, so that they can improve the welfare of farmers (Kuncoro, 2021; Wardhiani, 2019). According to the Health Research and Development Agency stated that vegetables and fruits are very necessary for body health (Hermina & Prihatini, 2016) This is because vegetables and fruits are a source of vitamins, minerals, and fiber. The results of the 2019 Riskesdas showed that 90% of the population aged > 10 years did not consume enough vegetables and fruits (Sari *et al*., 2022).

Melon is a fruit in demand by consumers with a fairly high economic value. Melon plants are native African plants that contain many vitamins and minerals useful for body health

(Larekeng *et al*., 2022). The content of melon fruit includes vitamins C, A, and B6. There are also sources of minerals such as potassium, folic acid, niacin, calcium, iron, magnesium, phosphorus, sodium, and zinc. In Indonesia, the public often consumes three groups of melons, namely C. melo var. Reticulatus, C. melo var. Inodorus, and C. melo var. Cantalupensis (Saparinto & Susiana, 2024). Melon fruit is generally green in color and round or oval in shape. It gives off a fairly distinctive odor. Melon has a sweet taste and thick fruit (Obisi & Chozin, 2022).

The Coordinating Ministry for Economic Affairs of the Republic of Indonesia stated that during the COVID-19 pandemic (January-May 2020), the demand for fresh fruit exports increased significantly to 375.04 tons or an increase of 31.89%. Central Java is one of the provinces where fruit consumption increased in 2020-2021. The average per capita expenditure for fruit consumers from 2017 to 2021 ranged from 21,000 to 25,000 rupiah (Aliudin *et al*., 2024).

Sragen Regency is one of the areas in Central Java Province that produces quite a lot of fruit. One of them is melon, which reaches 15,000 tons per year in Sragen Regency (BPS Sragen, 2020). Recently, many young people have hydroponic melon gardens. They develop premium melons such as Golden Inthanon, Red Aroma and Honey Globe, which have capital-intensive characteristics in their business (Aliudin *et al*., 2024; Nengsi *et al*., 2022). This is interesting because these young people certainly do not have sufficient access to capital.

Millennial farmers are increasingly engaged in hydroponic melon agribusiness because of its high market value. However, this trend raises a critical question: what factors motivate young farmers to adopt hydroponic melon cultivation despite its substantial investment requirements? Previous studies on melon agribusiness and hydroponic systems have largely emphasized economic aspects such as production costs (Alfarda *et al*., 2024), income analysis (Nuha *et al*., 2024), and market opportunities (Fan *et al*., 2025). By contrast, this study adopts a broader perspective by simultaneously examining four dimensions — technical, economic, social, and technological adoption factors (Supriyanta *et al*., 2022). In addition, this study broadens the scope of the study from simply identifying decision-making factors to developing digital marketing strategies and sustainable trade.(Nurul *et al*., 2024; Setyadi *et al*., 2022).

Focusing on millennial farmers, this research has a dual contribution. First, it expands the scope of analysis beyond economics by integrating multidimensional factors that shape adoption decisions. Second, it contextualises the study within Sragen, a regency with strong agricultural potential but limited exploration of high-value commodities like hydroponic melons, focusing specifically on millennial farmers as agents of agricultural transformation. This positioning distinguishes the study from earlier works and provides a fresh contribution to the discourse on agricultural innovation. The findings are expected to identify the key determinants influencing adoption and offer practical insights for designing digital marketing strategies and developing sustainable trade models for premium fruit agribusiness, thereby strengthening the role of millennial farmers in modernising Indonesia’s agricultural sector.

2. Methodology

This study employed a descriptive quantitative method with a survey approach. This approach was chosen to obtain a systematic, factual, and accurate picture of the characteristics of millennial farmers and the factors related to melon cultivation, both hydroponic and non-hydroponic. The study was conducted in several sub-districts in Sragen

Regency, including Gemolong, Plupuh and Masaran. The research respondents were millennial farmers aged 17–35 who cultivate melons with 35 people (Sugiyono, 2017).

The sampling technique was carried out in two stages; first, Purposive sampling was used to identify key informants according to the research criteria, namely melon farmers aged 17–35 years. Then, Snowball sampling was used after the first key informant was identified, followed by additional respondents based on recommendations from previous key informants until the sample size was met (Sugiyono, 2017). Thus, respondent selection was not random but based on specific criteria and an expanded network of informants.

Data collection was conducted using two main techniques. Structured interviews were used in the initial stage to identify potential respondents, validate purposive sampling criteria, and gather basic information on farmer characteristics. Questionnaires with a likert scale used as the primary research instrument to measure the variables studied (Guswita *et al*., 2020; Lolonlun *et al*., 2024). The questionnaire questions include the characteristics of the respondents and are related to the variables studied. The Likert type scale consists of several questions graded from positive to negative (Bagu *et al*., 2022; Effendi *et al*., 2021). The answers are scored from 1 to 5, each of which has the following meaning:

1 = for the answer Strongly Disagree
2 = for the answer Disagree
3 = for the answer Neutral
4 = for the answer Agree
5 = for the answer Strongly Agree

The variables used in this study are operationalised through specific indicators that serve as the basis for measurement. These indicators are then formulated into questions and statements in the questionnaire, which respondents will answer directly (Ibrahim *et al*., 2021). The dependent variable (Y) in this research is the Cultivation Decision, while the independent variables (X) consist of several aspects, namely: X1 = Technical Aspect, X2 = Economic Aspect, X3 = Social Aspect, and X4 = Cultural Aspect. Each of these variables is represented by measurable indicators, so that respondents' answers on the questionnaire using a Likert scale can quantitatively reflect the influence of technical, economic, social, and cultural aspects on cultivation decision-making.

This study utilizes various data analysis, including evaluation of measurement models (outer model) and evaluation of structural models (inner model), as well as hypothesis testing conducted with the SmartPLS 4 application:

2.1 <u>Evaluation of Measurement Models (Outer Model/Measurement model)</u>

PLS testing begins by testing the measurement model to assess instrument reliability and construct validity. The measurement model shows how the manifest or observed variables represent the latent variables to be measured (Ardiyanti *et al*., 2023; Saleh *et al*., 2024).

2.1.1 *Validity Test*

a. Convergent validity of the measurement model: The aim is to determine the validity of each relationship between the indicator and its construct or latent variable. According to the reflective criteria for convergent validity testing, the filling factor value must be more than 0.70 to be considered reasonable. However, filling factor values between 0.5 and 0.60 are considered reasonable and convergently valid (Melinda *et al*., 2024).

b. The square root average variance extracted (AVE) value can be used to determine discriminant validity. Several methods can be used to evaluate discriminant validity with PLS-SEM. These methods include the Fornell-Lacker criterion, complete collinearity assessment, and the heterotrait-monotrait ratio (HTMT). The discriminant validity test with the Fornell-Lacker table criterion is considered good if the AVE root on the construct is higher than the correlation of the construct with other latent variables (Ardiyanti *et al*., 2023).

2.1.2 *Reliability Test*

The composite reliability value is used to test reliability. According to the Cronbach's Alpha reliability test, data with a composite reliability of more than 0.7 is considered highly reliable. A Cronbach Alpha (α) value between 0.5 and 0.7 indicates that the questionnaire has moderate reliability (Asbari *et al*., 2019).

2.2 Structural Model Evaluation (Inner Model)

The purpose of evaluating the structural model is to determine the relationship between latent variables (Dilasari & Yosita, 2022). The coefficient of determination R-squared (R Square) is a method for calculating how much an endogenous construct can explain an exogenous construct. A coefficient of determination value of 0.75 is considered large, a coefficient of determination value of 0.50 is considered moderate, and a coefficient of determination value of 0.25 is considered low.

Furthermore, the F-squared metric is used to calculate the amount of influence each variable has. The F-squared value is divided into three categories: weak (0.02), medium (0.15), and large (0.35). An F-squared value of 0.02 indicates a weak influence of the exogenous latent variable on the endogenous variable; an F-squared value of 0.15 indicates a medium influence of the exogenous latent variable on the endogenous variable; and an F-squared value of 0.35 indicates a large influence of the exogenous latent variable on the endogenous variable.

2.3 Hypothesis Testing (Resampling Bootstraping)

Hypothesis testing is carried out with t-statistic values, p-values, and confidence levels to determine the influence of cultivation decision factors. The criteria for accepting the hypothesis are that the t-value is more than 1.96 for a 95% confidence level and the p-value is less than 0.05 for a 5% significance level.

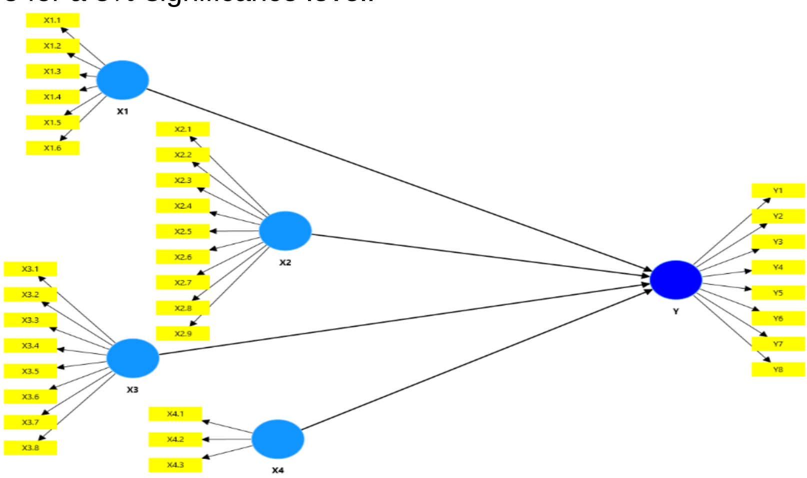

Figure 1. Design of Inner Research Model

3. Results and Discussion

3.1 Results

3.1.1 *Respondent Characteristics*

The respondents' descriptions explain the characteristics of respondents based on gender, age, length of farming, education, and production.

Table 1. Respondent Classification

Classification	Description	Number of Respondents	Percentage
Gender	Male	35	100%
Age	< 25 years	18	51%
	25 – 30 years	8	23%
	30 – 35 years	9	26%
Farming experiences	< 3 years	22	63%
	3 – 5 years	7	20%
	>5 years	6	17%
Last education	Elementary School	15	43%
	Junior High School	2	6%
	High School	14	40%
	Diploma / Bachelor's Degree	4	11%
Last production	< 1000 kg	14	40%
	1000-3000 kg	6	17%
	> 3000 kg	15	43%

Source: Primary data analysis, 2025

The respondents of this study were male, namely 100% with an age under twenty-five reaching 51%. Gender has played an important role in the growth of MSME business activities. Currently, female MSME business actors, especially those operating on a micro and small scale, are experiencing growth, although the growth rate does not exceed that of male business actors (Hamid & Lantara, 2024). Male entrepreneurs think more about future business development to advance their businesses. They are also more flexible and anticipate the environment (Sherlywati *et al*., 2017). There is no significant difference between the results of student entrepreneurial practice guidance between men and women (Mubarok *et al*., 2021). Entrepreneurs and business owners need management skills to carry out management functions such as planning, organising, directing, and supervising.

3.1.2 *Evaluation of Measurement Model (Outer Model/Measurement Model)*

The indicators used when evaluating the measurement model for Cultivation Decisions are not entirely valid and reliable, as depicted in Figure 1; therefore, they will be depicted in Figure 2.

Table 2. Output Result for Outer Loading

	Cultural Aspects	Economic Aspects	Social Aspects	Technical Aspects	Cultivation Decisions
X1.1				0.826	
X1.4				0.736	
X1.6				0.911	
X2.2		0.724			
X2.4		0.756			
X2.5		0.866			
X3.2			0.798		
X3.3			0.683		
X3.5			0.615		
X3.6			0.807		
X4.2	0.694				
X4.3	0.887				
Y2					0.648
Y4					0.624
Y6					0.910

Source: Primary data, 2025

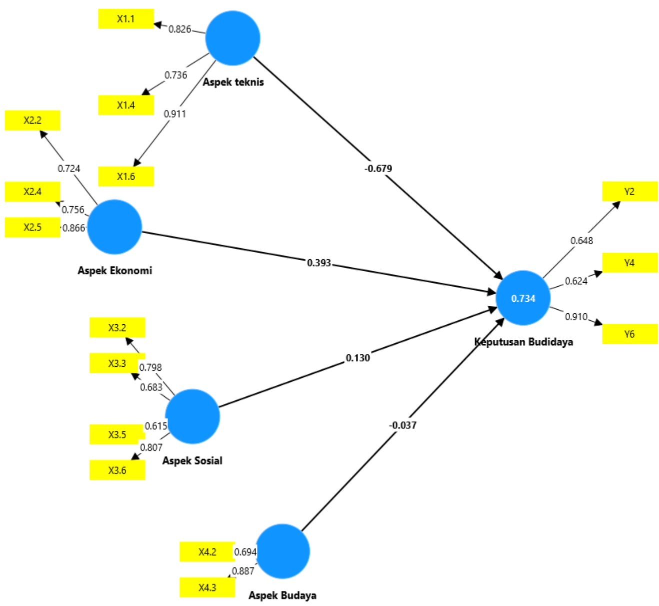

Figure 2. Output Loading Factor Modelling

The validity testing of discriminant variables is carried out using the Fornell-Lacker table criteria and comparing it with each construct's square root value of the Average Variance Extracted (AVE) with the correlation between other constructs. A construct is considered to have good discriminant validity if the square root value of its AVE is greater than its correlation value with other constructs. Heterotrait–Monotrait ratios (HTMT) and the Fornell and Larcker criterion were used to assess discriminant validity. The square roots of AVE values, or diagonal values, can be used to quantify discriminant validity; these should be greater than those that indicate the highest association with other components (off-diagonal values). The results in Table 3 show that the square root of AVE values is greater than the constructs' inter-correlation and that all of the constructs have discriminant validity (Ali *et al.*, 2021), deeming a correlation result satisfactory if it falls below 0.9 (Yoga & Khoirunnisa, 2025).

Table 3. Fornell-Lacker Criterion Value

	Cultural Aspects	Economic Aspects	Social Aspects	Technical Aspects	Cultivation Decisions
Cultural Aspects (X4)	0.796				
Economic Aspects (X2)	-0.317	0.785			
Social Aspects (X3)	0.526	-0.558	0.730		
Technical Aspects (X1)	0.445	-0.481	0.715	0.828	
Cultivation Decisions (Y)	-0.395	0.659	-0.594	-0.791	0.739

Source: Primary data analysis, 2025

The Convergent Validity Test is a correlation between indicator and construct scores that can be used to test the validity of reflective indicators. If other indicators in the exact structure change, the reflective indicator shows that an indicator has changed. The calculation results generated by the innovative PLS 4.0 computer program are shown in Table 2. If the correlation filling value is greater than 0.5, then the correlation meets convergent validity. This is because the filling factor provides a value greater than the recommended value of 0.5. So, the indicators used in this study meet convergent validity. Based on the latest test results shown in Table 3, Fornell-Larcker, all constructs in the model have met these criteria. The Cultural Aspect construct shows an AVE square root value of 0.796, higher than its correlation with other constructs, such as Social Aspect (0.526) and Technical Aspect (0.445). This shows that the Cultural Aspect is unique and does not overlap with other constructs in the model.

Furthermore, the Economic Aspect has an AVE square root value of 0.785, and its highest correlation value with other constructs is 0.659 to Cultivation Decision. Likewise, the Social Aspect, with an AVE square root of 0.730, is still higher than its highest correlation of 0.715 to the Technical Aspect. The same thing also applies to the Technical Aspect construct, which has an AVE square root of 0.828, and its highest correlation is 0.791 to Cultivation Decision, which remains below the threshold. Finally, the Cultivation Decision construct has an AVE square root value of 0.739, which is also higher than all its correlations with other constructs, such as the Economic Aspect (0.659) and Technical Aspect (-0.791). The fact that all AVE square root values are higher than the correlation between constructs proves that each construct can statistically distinguish itself from other constructs. The results of this analysis confirm that the model that has been prepared has met the requirements for discriminant validity based on the Fornell-Larcker approach. This step is crucial before proceeding to further analysis, such as structural testing, because without adequate discriminant validity, the results of estimating the relationships between constructs can be misleading or invalid.

A reliability test in a model indicates the extent to which measurement results using the same object will produce the same data. The following is table four showing the results of the model reliability test.

Table 4. Latent Variable Reliability Test

Variable	Cronbach Alpha	Composite reability	Description
Cultural Aspects (X4)	0.541	0.774	Reliable
Economic Aspects (X2)	0.683	0.827	Reliable
Social Aspects (X3)	0.704	0.819	Reliable
Technical Aspects (X1)	0.768	0.866	Reliable
Cultivation Decisions (Y)	0.569	0.778	Reliable

Source: Primary data analysis, 2025

Table 4 shows that all latent variables measured in this study have a Composite reliability value higher than 0.7, indicating that all latent variables are considered reliable. The Cronbach Alpha (α) value between 0.5 and 0.7 indicates that the questionnaire has moderate reliability (Asbari *et al*., 2019). Based on the reliability test results, all variables have a Composite Reliability value above 0.7, so they are declared reliable. Although the Cronbach's Alpha value for the Cultural Aspect (X4) and Cultivation Decision (Y) is below 0.6, the Composite Reliability values of both still meet the criteria, so reliability remains acceptable. Meanwhile, other variables such as Economic Aspect (X2), Social (X3), and Technical (X1) show good Cronbach's Alpha and Composite Reliability values, indicating high internal consistency. Thus, the instrument used can be trusted to measure each variable in this study.

3.1.3 *Measurement Model Evaluation (Inner Model/Measurement model)*

Structural Model Evaluation (Inner Model) The structural model was tested in SEM with PLS. The R-squared (R2) and significance tests were carried out by estimating the path coefficient. Using the smartPLS 4.0 computer program, the R2 value was tested at 0.734. The R-squared (R^2) value determines how much influence the independent latent variable has on the dependent latent variable. Based on Hair Jr *et al*. (2021), the R^2 values of 0.75, 0.50, and 0.25 are categorized as strong, moderate, and weak, respectively. In this study, the R^2 value was 0.734, which is above 0.50 and close to 0.75, so it can be concluded that the model has strong predictive ability and is categorised as a good model. We looked at the Standardised Root Mean Square Residual (SRMR) to test for a good model fit. For an acceptable model fit, SRMR should have been lower than 0.08 (de Lauwere *et al*., 2022). Result showed that SRMR are 0.076 lower than 0.08, it can be concluded that the model was a good model
The results of the F test are shown in Table 5.

Table 5. F test

	X1	X2	X3	X4	Y
Cultural Aspects (X4)	-	-	-	-	0.023
Economic Aspects (X2)	-	-	-	-	0.391
Social Aspects (X3)	-	-	-	-	0.025
Technical Aspects (X1)	-	-	-	-	0.819
Cultivation Decisions (Y)	-	-	-	-	-

Source: Primary data analysis, 2025.

The results of the effect size analysis (F/f^2 Test) confirmed that technical and economic factors mainly influenced cultivation decisions. The technical aspect recorded an f^2 of 0.819, far above the threshold of 0.35, so it is categorised as a considerable influence and is the primary determinant in the modelling. The economic aspect has an f^2 of 0.391, also quite large, indicating that cost conditions, market access, and profitability play an important role in driving farmer decisions. In contrast, the social and cultural aspects show an f^2 of 0.025 and 0.023; although significant, their contribution is only small, so factors such as community support or social networks play a secondary role. This finding complements the R^2 value of 0.734, which indicates the model's ability to explain cultivation decisions strongly; overall, the model highlights the importance of improving technical aspects and economic support as priority strategies, while social and cultural interventions can be positioned as supporters.

The purpose of the significance test in the SEM PLS model is to determine the relationship between endogenous and exogenous variables. The bootstrapping process with the smartPLS 4.0 computer program is used to test the SEM PLS hypothesis. The results are as follows:

Table 6. Results of Hypothesis Testing

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Cultural Aspects (X4) -> Cultivation Decisions	-0.037	-0.032	0.119	0.311	0.756
Economic Aspects (X2) -> Cultivation Decisions	0.393	0.413	0.142	2.771	0.006
Social Aspects (X3) -> Cultivation Decisions	0.130	0.078	0.134	0.971	0.331
Technical Aspects (X1) -> Cultivation Decisions	-0.679	-0.629	0.157	4.329	0.000

Source: Primary data analysis, 2025

3.2 Discussion

The respondents' last education was mostly elementary and high school graduates, with a percentage of 43% and 40%, respectively. Education affects the speed of innovation adoption and the application of new technologies (Cahyani *et al*., 2024). Hydroponic melon cultivation requires the adoption of sufficient technology to carry out the cultivation process compared to cultivation activities carried out on conventional land. The length of melon farming also affects the skill level in the cultivation process. Respondents with less than three years of experience in hydroponic melon cultivation reached 63%. Little experience makes the business more vulnerable to sustainability due to low knowledge and cultivation risks (Wiwoho & Prasada, 2024). However, this is balanced by a young age, full of high melon cultivation learning abilities. The last percentage of respondents who produced more than 3000 kg was 43%, and those who produced less than 1000 kg were 40%. Production above 3000 kg is among the respondents who still produce conventional melon and have started hydroponic melon cultivation (conversion). Respondent farmers who produce hydroponic melons below 1000 kg are farmers who have decided to cultivate using hydroponics.

The technical aspect has a coefficient of -0.679, a P value of 0.000, and a T-statistic of 4.329; it has a negative but significant influence. This shows that the higher the technical challenges or technological limitations, the lower the tendency to make cultivation decisions. This can be explained by the fact that hydroponic melon cultivation requires mastery of complex technologies such as nutrient solution management, pH and EC control, and greenhouse microclimate regulation. Such complexity is in line with Valizadeh *et al*., (2025), the findings align with the complex relationship in the absorption of innovation adoption. In complex innovation adoption, interpersonal relationships between business actors have been shown to strengthen the influence of attitudes and innovation attributes (trialability, visibility) on adoption intentions. In contrast, positive attitudes are the primary foundation in the adoption process. Hydroponic melon farmers must build social relationships and form positive attitudes before focusing on technical aspects. Socialising with more advanced farmers and a willingness to learn will rapidly increase technical knowledge. Although limited to a specific context, the results guide the development of better agricultural technology adoption. Meanwhile, according to (Nafar *et al*., 2025), the decision to adopt is determined not only by the technical superiority of the innovation itself, but also by its users' psychological, social, and economic readiness. Thus, innovation adoption is an interaction between the potential of the technology and the user context, which determines how quickly and widely the innovation can be effectively implemented. Thus, technical limitations become a dominant obstacle even when potential profits exist. These findings are also reinforced by (Ramadan *et al*., 2025), which emphasizes the importance of institutional support, transparent communication, and aligning technology with local cultural practices in technical aspects. These findings are relevant for policies accelerating the diffusion of sustainable agricultural technologies in dry areas.

The coefficient of 0.393 and the P value of 0.006 indicate that the influence of the economic aspect is statistically significant ($P < 0.05$) with a T-statistic of 2.771. Economic conditions such as costs, profits, and market access influence cultivation decisions. Significant barriers include high investment requirements (greenhouse construction, hydroponic installations, skilled labour) and limited access to affordable production facilities. According to agribusiness decision-making theory Yazdani *et al*., (2019), farmers are generally risk averse and weigh costs, risks, and expected returns before deciding. Therefore, when capital access and market certainty are available, the likelihood of adoption significantly increases. Agribusiness decision-making results from the interaction between individual considerations and institutional structures that shape opportunities and constraints for farmers (Kusnandar *et al*., 2024). For millennial farmers, economic considerations naturally play a central role in decision-making (Mankhin *et al*., 2024; Theodorou & Tzovenis, 2023). This research also supports Salam *et al*., (2025) findings, which state that IoT integration in hydroponics increases efficiency, sustainability, and attracts young people to modern agriculture. While beneficial for productivity and reduced manual labor, adoption remains hampered by high initial costs, limited internet infrastructure, and low technological literacy. Support from the government, education, and the private sector is key to accelerating adoption and developing a generation of innovative young farmers.

The social aspect has a coefficient of 0.130 with a P value of 0.331 and a T-statistic of 0.971, indicating that the social aspect has no significant influence. Social support, community networks, or social influence have not been proven to influence cultivation decisions in this model strongly. This can be interpreted as a result of the individualistic nature of hydroponic farming, which contrasts with traditional farming systems that rely more on collective action. Even though farmer groups and community support exist, they are not strong enough to drive adoption because technical and financial readiness are the decisive factors. Within Valizadeh *et al*., (2025), the role of the social system weakens when an innovation is perceived as costly and complex. Meanwhile, Torma & Aschemann-Witzel, (2023) added that social acceptance can strengthen or weaken the adoption of innovation at the micro (individual), meso (organization/community) and macro (society/government) levels. Meanwhile, Kusumastuti *et* *al*., (2023) shows that the majority of farmers of productive age (25-38 years) with supportive social conditions show a fairly high level of adoption of innovation in new technology.

The cultural aspect does not have a significant effect on cultivation decisions. The path coefficient value is -0.037 with a P value of 0.756 and a T-statistic of 0.311. This value is far below the significance threshold of 1.96 (for α of 0.05). This result indicates that hydroponic melon farming does not strongly relate to traditional values or cultural practices, so cultural factors serve only as symbolic support rather than determinants. Farmers base their choices more on technical feasibility and economic rationality.

Based on the construct of the variables analysed in this study, it can be explained that the decision to cultivate hydroponic melons is influenced by farmers' perceptions of technical, economic, social, and cultural aspects, which align with the indicators of the related variables. Variables Y2, Y4, and Y6 indicate challenges in cultivating hydroponic melons, especially related to difficult results marketing, high costs, and complex technical management compared to conventional cultivation. These three indicators reflect farmers' perceptions that hydroponic melons require greater expertise and resources.

In the technical aspect, variables such as X11 (mastery of cultivation techniques), X14, and X16 (pest and disease control) indicate that although some farmers have technical capabilities, the complexity of hydroponic technology remains a significant obstacle in decision-making. This is reinforced by the results of the structural model analysis and bootstrapping, which show that technical aspects have a large and significant influence on cultivation decisions (p-value = 0.000, f^2 = 0.819), indicating that mastery or limitations of technology are dominant factors.

Economic aspects, such as X22 (limited production facilities), X24 (complex procedures), and X25 (high greenhouse costs), make it clear that affordability and economic access are the main barriers for most farmers. This is in line with the results of the path analysis, where economic aspects also have a significant effect ($p = 0.006$, f^2 = 0.391), indicating that cost factors and availability of inputs greatly determine farmers' decisions. Meanwhile, social (X32–X36) and cultural (X42, X43) aspects have not shown a significant effect. Although social indicators show support from groups and communities, and cultural indicators show belief in the benefits of hydroponics, this is not strong enough to drive cultivation decisions. The small f^2 value and p value > 0.05 indicate that the influence of these two aspects is still complementary or supporting, not the primary determinant.

This confirms that technical and economic aspects are the main determinants of hydroponic melon adoption, while social and cultural aspects act as peripheral supports. These findings highlight the importance of technical training (capacity building) and economic policy support (subsidised inputs, access to finance, market guarantees) to accelerate agribusiness innovation adoption.

4. Conclusion

Respondents were mainly men under 25 with elementary to high school education and less than three years of hydroponic melon experience, yet their young age offers strong learning potential. Education plays a key role in technology adoption, while 43% achieved yields above 3000 kg, mainly those transitioning from conventional to hydroponics. No significant gender differences were observed in adoption outcomes. Farmers face marketing difficulties, high production costs, and technical management complexity. The technical aspect has a negative but significant influence, showing that higher technological complexity and limited mastery reduce the likelihood of adoption. Technical constraints such as nutrient solution management, pH–EC control, pest and disease handling, and greenhouse microclimate regulation remain dominant barriers. The economic aspect has a positive and significant influence, where access to capital, affordable production facilities, and market certainty substantially increase the likelihood of adoption. Although high investment requirements and limited input access remain obstacles, these can be mitigated by institutional and policy support.

Meanwhile, the social and cultural aspects do not show significant influence, functioning more as complementary factors rather than decisive determinants. This reflects the relatively individualistic nature of hydroponic farming compared to traditional collective farming systems. Efforts to accelerate adoption should focus on strengthening farmers' technical skills through intensive training and providing economic support such as subsidised inputs, financing schemes, and market guarantees. These interventions are essential to overcome barriers, encourage adoption among young farmers, and ensure the sustainable diffusion of hydroponic technology.

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