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THE ADOPTION OF AGRICULTURAL TECHNOLOGY AND ITS CONTROLLING FACTORS: A PARTIAL CORRELATION STUDY

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Abstract

This study aims to analyze rice farmers' perceptions of modern agricultural technologies and to examine the relationships among key perception variables while controlling for age and land size. The research was conducted in Kluet Utara and Kluet Selatan Districts, South Aceh Regency, involving 99 rice farmers selected through a stratified random sampling technique. Data were collected using a structured questionnaire covering farming conditions before and after the use of modern technologies, access to machinery, operational skills, perceived welfare improvements, and farmers' intention to continue using technology. Descriptive analysis was employed to compare pre- and post-mechanization conditions, while partial correlation analysis was used to assess the strength of relationships among variables after controlling for age and land size. The results reveal significant differences between farming conditions before and after mechanization, particularly in terms of labor efficiency and time savings. Farmers' operational skills show a strong positive association with perceived welfare improvements, and this relationship remains robust even after controlling for age and land size. In contrast, access to agricultural machinery does not consistently correlate with welfare perceptions when control variables are included. These findings indicate that skills play a central role in maximizing the benefits of modern agricultural technologies, whereas demographic differences do not substantially influence farmers' perception patterns. This study provides important implications for policy formulation, highlighting the need for skill-focused training programs and strengthened machinery service provision to ensure that agricultural mechanization effectively contributes to farmers' welfare in a more equitable manner.

Keywords: *Modern agricultural technology; Farmers' perceptions; Operational skills; Farmers' welfare; Partial correlation*

1. INTRODUCTION

Rice farming constitutes a strategic sector that sustains the economic livelihoods of rural communities, particularly in agrarian regions such as South Aceh Regency. Over the past two decades, national agricultural dynamics have undergone significant transformation through the adoption of modern agricultural technologies aimed at enhancing productivity and improving the

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efficiency of farm operations (Haryono et al., 2021; Noviar et al., 2018). The utilization of agricultural machinery and equipment—including tractors, rice transplanters, water pumps, and combine harvesters—has become an integral component of government strategies to accelerate production processes, reduce labor costs, and maintain regional food security stability (Noviar & Fadhlain, 2025). Nevertheless, the success of mechanization programs is not solely determined by the availability of machinery, but is also strongly influenced by farmers' capacity to access, comprehend, and effectively operate these technologies.

In South Aceh Regency, particularly in Kluet Utara and Kluet Selatan Subdistricts, mechanization programs have encouraged a transformation in farming practices, although their implementation remains uneven. Diverse geographical conditions, limited access to machinery, and variations in farmers' characteristics are among the factors influencing the extent to which modern technologies generate tangible benefits. Some farmers have experienced improvements in efficiency and income following the adoption of agricultural machinery, while others continue to face constraints related to skills, costs, and equipment availability. These disparities indicate heterogeneity in farmers' perceptions and experiences, which warrants deeper examination to ensure that mechanization initiatives are implemented more effectively and inclusively.

Moreover, variables such as age, landholding size, and education level are frequently associated with farmers' capacity to adopt innovations. However, empirical evidence remains limited regarding whether these characteristics truly influence the relationships among farmers' perceptions of modern agricultural technologies (Haryanto et al., 2015; Haryono et al., 2021; Wijaya et al., 2022). Accordingly, more in-depth analysis is required to determine whether factors such as skills, access to machinery, perceived welfare, and intentions to continue using technology are directly interrelated or mediated by specific demographic characteristics.

This study pursues to address this gap through a quantitative approach involving 99 rice farmers in Kluet Utara and Kluet Selatan Subdistricts, selected using a stratified random sampling method. The primary intention is to categorize patterns in farmers' perceptions before and after the adoption of modern agricultural technologies, while simultaneously examining the relationships among perception variables using partial correlation analysis with age and landholding size as control variables. Through this approach, the study aims to provide a clearer understanding of the key factors influencing the success of mechanization at the farm level.

The findings of this study contribute not only to the academic literature by enhancing theoretical understanding of agricultural technology adoption, but also offer an empirical basis for regional policy formulation. The research recommendations may inform the design of skills training programs, the strengthening of machinery provision services, and the improvement of the effectiveness of sustainable mechanization initiatives in South Aceh. Consequently, this study holds strategic value for efforts to improve farmers' welfare and to facilitate the transformation of the agricultural sector toward a more modern, efficient, and sustainable production system.

2. CONCEPTUAL FRAMEWORK

Modern agricultural technology encompasses the use of tools and machinery such as tractors, cultivators, rice transplanters, irrigation pumps, and combine harvesters to improve the efficiency of production processes. Numerous studies indicate that mechanization is capable of reducing labor

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costs, accelerating land preparation, and enhancing accuracy in planting and harvesting operations (Noviar et al., 2020; Noviar & Yusnandar, 2019; Santoso et al., 2023). In the context of developing countries, mechanization has also been shown to contribute to higher productivity and increased incomes among smallholder farmers, particularly when supported by effective machinery access policies through agricultural machinery service units (UPJA) or farmer groups.

Farmers' perceptions of accessibility, ease of use, and the perceived benefits of technology play a decisive role in determining adoption levels. Empirical studies across various regions in Asia demonstrate that farmers' operational skills in using agricultural machinery constitute a central factor influencing satisfaction, repeated use, and the sustainability of adoption (Schulte et al., 2023; Skorbiansky et al., 2020; Vos et al., 2021). Accordingly, farmers' perceptions are not merely indicators of opinion, but function as critical mediators between technological inputs and farm-level outcomes.

A growing body of research shows that the use of agricultural machinery can enhance cost efficiency, reduce physical labor burdens, and promote increases in farmers' net incomes (Ahmad et al., 2025; Haryono et al., 2021). Mechanization also contributes to reducing production uncertainty and minimizing yield losses during harvest and post-harvest stages. However, these impacts do not occur automatically in the absence of adequate skills and access. Evidence from Indonesia reveals differing outcomes between farmers who are skilled in operating machinery and those who rely solely on rented equipment without sufficient operational competence (Setiajie Anugrah et al., 2022).

Age and landholding size are often considered influential factors in technology adoption. Younger farmers tend to be more receptive to innovation, while farmers with larger landholdings possess greater capacity to absorb the risks associated with technological investment (Nguyen et al., 2022; Noviar & Fadhlain, 2025; Suriani et al., 2023). Nevertheless, several recent studies suggest that once skills and access are evenly distributed, the effects of age and land size tend to diminish (Haryono et al., 2021). This underscores the importance of incorporating control variables when analyzing the strength of relationships among farmers' perceptions.

Based on the literature review and field research findings, several research gaps provide the foundation for this study. Most existing studies focus on the impact of mechanization on productivity or farmers' incomes, while relatively few examine the interrelationships among farmers' internal perceptions themselves. These include, for example, the relationship between skills and perceived welfare, the relationship between access to machinery and perceived benefits, and the relationship between perceived welfare and intentions to continue using technology. This study addresses these gaps by analyzing partial correlations among perception variables.

Studies on mechanization frequently position age and landholding size as dominant factors. However, field evidence from South Aceh indicates that the relationships among farmers' perceptions remain strong even when these variables are controlled, a condition that has received limited attention in both local and national literature. Research on mechanization in Aceh has generally concentrated on institutional aspects (UPJA), rice productivity, and food security. Few studies have systematically examined farmers' perceptions of modern agricultural technology before and after its adoption in Kluet Utara and Kluet Selatan Subdistricts using a quantitative approach based on 99 respondents. Moreover, the application of partial correlation analysis to control for farmer characteristics in agricultural research remains relatively uncommon, despite its capacity to

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provide a clearer and more nuanced understanding of relationships among perception variables compared to conventional correlation methods.
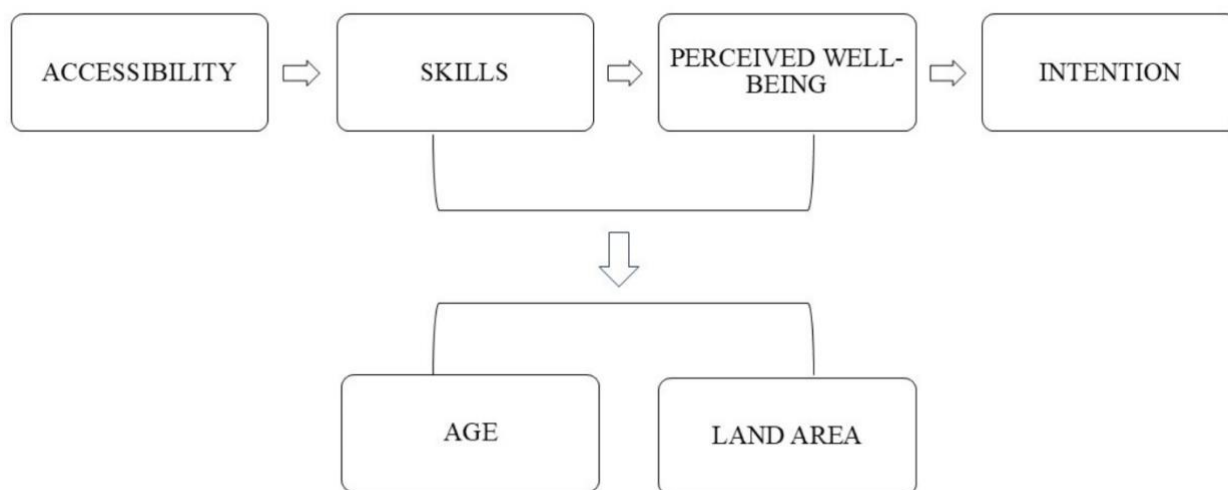

Figure 1. *Research Conceptual Framework*

Hypotheses

The hypotheses were formulated based on theoretical relationships and preliminary results from the processing of questionnaire data.

Main Hypotheses

H_1: Farmers' skills in using modern technology are positively associated with perceived welfare.

H_2: Access to modern technology is positively associated with farmers' perceived welfare.

H_3: Perceived welfare is positively associated with farmers' intention to continue using modern technology.

Partial Correlation Hypotheses (controlling for Landholding Size and Age)

H_4: The relationship between farmers' skills and perceived welfare remains significant after controlling for landholding size.

H_5: The relationship between farmers' skills and perceived welfare remains significant after controlling for age.

H_6: The relationship between perceived welfare and the intention to sustain the use of modern technology remains significant after controlling for both age and landholding size.

3. METHODOLOGY

This study employs a quantitative approach aimed at analyzing farmers' perceptions, experiences, and the impacts of modern agricultural technology use on work efficiency, productivity, and the welfare of rice farmers. The research was conducted in Kluet Utara and Kluet Selatan Subdistricts, South Aceh Regency, which were purposively selected because they are major rice-producing areas

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and are simultaneously experiencing increasing adoption of modern agricultural machinery and equipment.

The study population comprised 5,325 rice farmers in the two subdistricts (BPS, 2023). Respondents were selected using a stratified random sampling technique to ensure proportional representation of farmers from different villages (*gampong*). A total of 99 respondents were chosen as the research sample, a size considered sufficient to provide a representative depiction of the current conditions of technology adoption in the field. Data were collected using a structured questionnaire containing items related to farming conditions before and after the use of modern technology, perceptions of access and operational skills, and farmers' assessments of the technology's impact on their welfare.

The research instrument was developed using a five-point Likert scale, enabling quantitative measurement of respondents' levels of agreement. Prior to deployment, the instrument underwent content validation and a limited pilot test to ensure clarity of the questionnaire items and consistency of measurement.

Subsequently, partial correlation analysis (Hong & Reed, 2024; Syazali et al., 2019) was applied to examine the relationships among farmers' perception variables related to modern agricultural technology, including operational skills, perceived welfare, and intentions to sustain technology use. This analysis controlled for age and landholding size to ensure that the observed relationships among perceptions genuinely reflected the influence of technological experience rather than differences in individual characteristics. The application of this technique provides a deeper understanding of the key factors determining the success of modern agricultural technology adoption (Syazali et al., 2019).

$$r_{SW.L} = \frac{r_{SW} - r_{SL}r_{WL}}{\sqrt{(1 - r_{SL}^2)(1 - r_{WL}^2)}}$$

Where r_{SW} = Pearson correlation between S and W, meanwhile r_{SL}, r_{WL} are Pearson correlation coefficient between $S - L$ and $W - L$.

All stages of the analysis were conducted using statistical software commonly employed in social science research. This approach provides a strong empirical foundation for drawing conclusions regarding the effectiveness of modern technology and the key factors determining its sustainability at the farm level.

4. RESULTS AND DISCUSSIONS

Prior to interpretation and further analysis, a reliability test was conducted to ensure the internal consistency of each construct in the questionnaire used (Pramuaji & Loekmono, 2018; Zhang et al., 2022). The results of the Cronbach's Alpha calculation indicate that all variables achieved α values above 0.70, signifying that the instrument falls within the reliable category and is suitable for use in this study. The scales measuring Perceived Skills, Perceived Accessibility, Perceived Welfare, and Intention for Sustained Use demonstrate good levels of consistency, indicating that the items within each construct reliably measure the same underlying dimension.

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Subsequently, construct validity was assessed using exploratory factor analysis (EFA). The Kaiser–Meyer–Olkin (KMO) values were within an acceptable range, and Bartlett's Test of Sphericity was significant at $p < 0.05$, indicating that the data were appropriate for further analysis using factor techniques. The EFA results show that the questionnaire items clustered according to the intended constructs, as evidenced by factor loadings exceeding 0.50. This confirms that each item has a strong capacity to represent the variable being measured.

The results of the reliability and validity tests demonstrate that the research instrument possesses strong measurement quality. Accordingly, the instrument can be used with a high degree of confidence to capture farmers' perceptions and experiences in adopting modern agricultural technology in Kluet Utara and Kluet Selatan Subdistricts.

The following table presents an overview of the respondents' characteristics in this study, including education level, gender, age group, and cultivated land area. This information is essential for understanding the socio-demographic profile of the participating farmers and for ensuring that subsequent analyses appropriately account for variations in respondent characteristics. These basic characteristics also serve as an initial context for assessing how factors such as education, age, and farm size may influence farmers' perceptions and experiences regarding the use of modern agricultural technology.

In terms of gender, the respondent composition is dominated by males, accounting for 70.7%, while females represent 29.3%. This distribution reflects the fact that rice farming activities in the study area are still largely carried out by male farmers as the primary labor force in production activities.

Table 1. Characteristics of Research Respondents (N = 99)

Category	Subcategory	Total (people)	Percentage (%)	Note
Level of Education	SD (Elementary)	30	30,30	
	SMP (Junior High School)	38	38,38	
	SMA (High School)	28	28,28	
	Sarjana (Bachelor's Degree)	3	3,03	
Gender	Male	70	70,70	
	Female	29	29,30	
Age of Group	31–40 years	12	12,12	
	41–50	29	29,29	
	51–60	39	39,39	
	61–79	19	19,19	
Cultivated Land Area	Mean	–	–	34,28 ha
	Minimum	–	–	1,00 ha
	Maximum	–	–	2958,00 ha

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Std. Dev		–	–	296,87

Source: Primary data (processed, 2025).

Table 1 shows that the respondents are predominantly farmers with a basic level of education, with 30.3% having completed elementary school and 38.4% junior secondary school. Meanwhile, 28.3% are senior secondary school graduates or equivalent, and only 3% have attained tertiary education. These findings indicate that the majority of farmers belong to the lower-to-middle education groups, suggesting that the adoption of modern technology is strongly influenced by relatively limited levels of technical literacy.

The age distribution of respondents shows a relatively balanced pattern across productive and older age groups. Farmers aged 51–60 years constitute the largest group (39.39%), followed by those aged 41–50 years (29.29%), 61–79 years (19.19%), and 31–40 years (12.12%). This condition indicates that most farmers fall within the mature-to-older age range, which may influence their pace of adaptation to modern technology.

Regarding landholding size, the average land ownership among respondents is 34.28 hectares, with a high degree of variation (Std. Dev. = 296.87). The very wide range of land size (minimum of 1.00 ha and a maximum of 2,958.00 ha) highlights substantial inequality in farm scale among respondents. This variation is important for the analysis, as landholding size may affect farmers' needs, capacity, and propensity to adopt modern agricultural technology.

The results of the partial correlation analysis provide deeper insight into how farmers' perceptions of modern agricultural technology are interrelated when age and landholding size are controlled. These findings are crucial as they reveal the factors that truly determine the success of technology implementation in the field and explain why some farmers experience greater benefits than others.

Field data consistently shows that the most important factor is farmers' proficiency with technology, not the ease of access to equipment or individual traits like age and landholding size. This findings supports previous survey data showing that although the majority of farmers believe that modern technology significantly boosts their efficiency, not all of them see consistent increases in yields or income.

Table 2. Correlation Partial Control Variable of Land Area

Variables	Partial Correlation (r)	Sig.	Interpretation
Access to Machinery ↔ Skills	−0.065	0.525	H_0 cannot be rejected; access is not associated with skills.
Access to Machinery ↔ Welfare	−0.212*	0.036	H_0 is rejected with a significant negative relationship; access to machinery does not automatically increase welfare.
Access to Machinery ↔ Niat Menggunakan	−0.146	0.151	H_0 cannot be rejected; access does not encourage the intention to use technology.
Skills ↔ Welfare	0.803	0.000	H_0 is rejected and highly significant; skills strongly enhance perceived welfare.

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Skills ↔ Intention to Use	0.684	0.000	H_0 is rejected at the 1% significance level; higher skills are associated with stronger intentions to use technology.
Welfare ↔ Intention to Use	0.686	0.000	H_0 is rejected at the 1% significance level; perceived welfare increases the sustainability of technology adoption.

Note: *$p < 0.05$ significant
Source: Primary data, (processed in 2025).

Partial correlation analysis with landholding size as a control variable was employed to examine the relationships among farmers' perceptions of modern agricultural technology while removing the influence of differences in farm size. This approach is important because farmers in Kluet Utara and Kluet Selatan Subdistricts operate under varying landholding sizes, and such variation has the potential to affect how they assess the benefits of modern technology. By controlling for landholding size, the analysis ensures that the observed relationships among farmers' perceptions genuinely reflect their experiences in using technology, rather than differences in production scale.

The results indicate that after the effect of landholding size is removed, the relationships among perception variables remain consistent and significant across several indicators. These findings suggest that the impacts of modern agricultural technology are experienced relatively evenly by farmers with different landholding sizes. Consequently, differences in farmers' perceptions are more strongly influenced by aspects of skills and technological experience than by the size of land they own.

Partial correlation analysis with age as a control variable was conducted to examine whether the relationships among farmers' perceptions of modern agricultural technology persist after the influence of age differences is eliminated. This approach is essential given the wide age range of farmers in Kluet Utara and Kluet Selatan Subdistricts, where potential differences in physical capacity, experience, and technological adaptability need to be controlled to avoid biasing the analysis.

The findings show that even after controlling for age, the patterns of relationships among perception variables remain stable and consistent. The strong relationships between skills in operating agricultural machinery, perceived welfare, and the intention to continue using technology do not change significantly. These results underscore that age differences do not determine how farmers evaluate the effectiveness and benefits of modern technology, indicating that the impacts of technology are relatively uniform across different age groups.

Table 3. Partial Correlation Control Variable of Age

Variabel Korelasi	Partial Correlation (r)	Sig.	Interpretasi Singkat
Access to Machinery ↔ Skills	–0.061	0.552	H_0 cannot be rejected; not significant, similar to the landholding size control.
Access to Machinery ↔ Welfare	–0.215*	0.034	H_0 is rejected with a negative relationship significant at the 5% level;

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			the pattern is consistent with the landholding size control.
Access to Machinery ↔ Niat Menggunakan	–0.148	0.147	H_0 cannot be rejected; not significant.
Skills ↔ Welfare	0.797	0.000	H_0 is rejected at the 1% significance level; the results are consistent.
Skills ↔ Intention to Use	0.672	0.000	H_0 is rejected at the 1% significance level.
Welfare ↔ Intention to Use	0.670	0.000	H_0 is rejected and significant; higher perceived welfare is associated with a stronger intention to continue using technology.i.

Source: Primary data, (processed in 2025).

Correlation Analysis of Research Variables

The results of the partial correlation analysis provide deeper insight into how farmers' perceptions of modern agricultural technology are interrelated when age and landholding size are controlled. These findings are important because they reveal the factors that truly determine the success of technology implementation in the field and explain why some farmers experience greater benefits than others.

The empirical evidence reveals a consistent pattern: farmers' skills in operating technology constitute the most influential factor, rather than ease of access to machinery or personal characteristics such as age and landholding size. This finding reinforces earlier questionnaire results showing that while most farmers perceive substantial efficiency gains from modern equipment, not all experience uniform increases in income or crop yields. The results of this study indicate that farmers' operational skills are the primary determinant of the effectiveness of modern agricultural technology adoption. These findings differ from those of Ahmad A. et al., who emphasize the efficiency potential of mechanization without examining in depth farmers' technical capacity as a prerequisite for success.

This study also finds that age and landholding size do not exert significant effects, suggesting that demographic variables are not differentiating factors in technology utilization. Furthermore, although time and labor efficiency gains are perceived by most farmers, increases in income and crop yields do not occur evenly, contrary to the optimistic assumptions presented in the referenced article. Accordingly, the findings underscore that the benefits of mechanization are not determined solely by the availability of machinery, but depend critically on users' technical competence and their broader socio-economic context.

1. Modern equipment hasn't had a direct impact on well-being for the people.

One important finding is the presence of a weak but statistically significant negative correlation between ease of access to machinery and perceived improvements in welfare. This indicates that access to modern agricultural equipment alone is insufficient to make farmers feel more prosperous.

In the context of Kluet Utara and Kluet Selatan, many farmers have relatively easy access to agricultural machinery such as hand tractors, harvesting machines, or modern spraying equipment. However, such access does not necessarily translate into higher incomes or improved household

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welfare. This finding is consistent with earlier questionnaire results, in which some farmers reported that although they were able to use modern technology, their net income did not always increase significantly. In other words, technology reduces labor burdens and accelerates production processes, but it does not automatically lead to higher financial returns.

2. Skills in Using Technology as the Primary Determinant of Economic Benefits

The strongest finding of this analysis is the very high correlation between farmers' skills in operating modern agricultural machinery and their perceived welfare, as well as their intention to continue using technology in the future. Correlation coefficients approaching 0.80 indicate a very strong and consistent relationship, even after controlling for age and landholding size.

The implication of this finding is clear: farmers who genuinely master the use of modern equipment are those who experience the greatest economic benefits, including higher yields, cost efficiency, and improved household welfare. This also answers a key question raised in earlier questionnaires regarding why some farmers remain neutral or uncertain about whether technology improves their yields or incomes. Uneven skill levels lead to uneven technological impacts.

3. Perceived Welfare as a Key Factor in Technology Sustainability

The strong relationship between perceived welfare and the intention to continue using technology indicates that farmers are willing to sustain technology adoption when they perceive tangible improvements in their livelihoods—whether in the form of time efficiency, labor savings, or increased output.

This finding closely reflects field realities: although technology significantly reduces time and labor requirements (as indicated by nearly universal agreement in earlier questionnaires), farmers continue to weigh operational costs, crop yields, and grain prices before deciding whether technology is truly beneficial. Thus, the sustainability of technology adoption depends not merely on the presence of equipment, but on the economic benefits perceived by farmers.

4. Age and Landholding Size Are Not Differentiating Factors

The partial correlation results show that when age and landholding size are controlled, the relationships among perception variables remain equally strong and consistent. This implies that both younger and older farmers hold similar perceptions of technology, and that farmers with small or large landholdings experience comparable impacts on welfare and intentions to use technology.

These findings suggest that the modern technologies used in Kluet Utara and Kluet Selatan are inclusive in nature and can be utilized by farmers across demographic groups. They are also consistent with earlier crosstabulation results showing no significant relationships between gender, education, and technology perceptions.

Overall, the success of modern agricultural technology does not depend solely on the availability of equipment, but rather on farmers' capacity to operate it effectively. While modern technology clearly delivers substantial gains in labor and time efficiency, as evidenced in earlier questionnaires, economic impacts such as increased income and improved welfare are largely determined by the level of farmers' operational skills.

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Accordingly, modern agricultural technology can be considered successful only when supported by adequate capacity-building and training initiatives. Skilled farmers are able to capture the full range of technological benefits, whereas less-skilled farmers tend to experience only partial benefits—primarily in the form of labor efficiency rather than increased income or welfare.

Discussions

The results of the partial correlation analysis provide a deeper understanding of how farmers interpret the use of modern agricultural technology after accounting for individual factors such as age and landholding size. When these variables are controlled, the relationships among farmers' perceptions remain strong and consistent, particularly with respect to skills, perceived welfare, and the intention to continue using technology. This finding underscores that the benefits of technology do not depend on farmers' basic characteristics, but are instead shaped primarily by their capacity to utilize the technology effectively.

First, the relationship between ease of access to modern agricultural equipment and perceived household welfare exhibits a significant negative correlation. This result indicates that easy access to technology does not automatically lead to improved welfare among farmers. Greater accessibility does not necessarily translate into higher profitability or increased income. This finding is consistent with the questionnaire results, which show that although most farmers agree that technology saves time and labor, not all experience increases in net income. In other words, access to technology alone is insufficient; the ability to use and operate it effectively is the critical determinant of the economic benefits received by farmers.

Second, skills in operating modern agricultural machinery emerge as the most dominant factor shaping positive perceptions of technology. Skills show a very strong correlation with perceived welfare and the intention to continue using technology, even after adjusting for age and landholding size. This indicates that farmers who are proficient in operating agricultural machinery not only experience technical benefits such as time efficiency, but also enjoy more tangible economic gains. Accordingly, skill enhancement can be viewed as the primary key to the successful adoption of technology at the farm level.

Furthermore, the strong relationship between perceived improvements in welfare and the intention to sustain technology use demonstrates that the continuity of technology utilization is largely driven by perceived economic benefits. Farmers tend to maintain technology use when they observe direct impacts on their household economic conditions. This finding aligns with broader patterns in agricultural innovation, where long-term adoption is influenced more by perceived benefits than by technical efficiency alone.

Interestingly, the analysis also shows that age and landholding size do not exert a meaningful influence on the relationships among perception variables. Both younger and older farmers, as well as those with smaller and larger landholdings, display similar perception patterns toward modern agricultural technology. This suggests that the technologies employed in Kluet Utara and Kluet Selatan Subdistricts are inclusive in nature and capable of delivering benefits across different farmer groups, regardless of demographic differences or farm scale. This finding reinforces earlier crosstabulation results indicating that education level and gender likewise do not affect farmers' perceptions of technology effectiveness.

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Overall, the analysis reveals that skills constitute the most critical factor in the success of modern agricultural technology, while access to equipment, age, and landholding size are not the primary differentiating factors. Although technology is able to generate positive impacts on work efficiency, economic benefits will only be realized when farmers are able to operate the technology effectively. Therefore, strengthening farmers' capacity through training and extension support is an integral component of efforts to enhance productivity and welfare in the rice farming sector.

Research Implications

The findings of this study indicate that the success of modern agricultural technology adoption in South Aceh is highly dependent on farmers' technical capacity. Therefore, local governments need to strengthen practice-based training programs and provide continuous technical assistance to ensure more optimal use of agricultural machinery and equipment. While equitable access to machinery remains important—particularly through the strengthening of Agricultural Machinery Service Units (UPJA) to enable smallholders to access technology at affordable costs—access alone is insufficient.

Moreover, increases in production do not automatically translate into higher incomes; thus, policies must be integrated with post-harvest support, price stabilization measures, and strengthened market access. Given that demographic differences do not influence perceptions of technological benefits, it is essential to ensure that all farmer groups have equal opportunities to access technical services and training. Finally, local governments should develop field-based, data-driven systems for monitoring the impacts of technology as a foundation for continuous policy evaluation and improvement.

5. CONCLUSIONS

Research on farmers' perceptions and the impacts of modern agricultural technology use reveals three main findings that are consistent and mutually reinforcing. First, modern agricultural technology has been shown to significantly improve farmers' work efficiency, particularly in terms of time and labor savings. Nearly all respondents reported experiencing direct benefits from mechanization, indicating that technology is able to substantially and broadly enhance production processes at the farm level.

Second, the impacts on production outcomes and farmers' net income are heterogeneous. Some farmers reported increases in yields and income after adopting technology, while others remained neutral. This finding suggests that the effectiveness of technology is not determined solely by the availability of equipment, but is strongly influenced by farmers' skill levels in operating the technology. Partial correlation analysis confirms that skills have the strongest relationship with perceived welfare and the intention to continue using technology, whereas access to equipment alone does not exert a meaningful positive effect on welfare improvement.

Third, differences in demographic characteristics—such as age, gender, education level, and landholding size—do not affect farmers' perceptions of technology. This result indicates that modern technology has an inclusive impact and is acceptable across all farmer groups. Accordingly, the success of modern agricultural transformation in South Aceh is more strongly determined by internal factors related to technology use itself rather than by farmers' characteristics.

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6. RECOMMENDATIONS

Based on the study of farmers' perceptions of modern agricultural technology use in Kluet Utara and Kluet Selatan, several concise recommendations can be drawn. Farmers' skills emerge as the most critical factor in improving welfare and sustaining technology adoption. Therefore, capacity-building programs should prioritize intensive, field-based training on agricultural machinery to ensure that technology use enhances not only labor efficiency but also farmers' incomes.

Continuous technical assistance is also essential. Support through UPJA, extension agents, or village operators is needed to address operational constraints and ensure proper and consistent use of machinery. At the same time, equitable access to agricultural equipment must be strengthened, particularly for smallholders, through affordable rental schemes and the expansion of machinery units at the subdistrict and village levels.

To ensure that productivity gains translate into higher incomes, policies should integrate post-harvest and marketing support, including drying facilities, grain storage, and improved market access. As demographic differences do not affect farmers' perceptions of technology, mechanization policies should be designed inclusively to reach all farmer groups.

Future research should focus on identifying key determinants of net income improvement using advanced quantitative methods, such as regression or SEM, and on evaluating the effectiveness of UPJA. Incorporating social and psychological factors would also provide a more comprehensive understanding of technology adoption.

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