



Determinants of Millennial Farmers' Income: The Role of Capital, Education, and Technology

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ABSTRACT

Abstract

Keywords:

Brebes; Capital;
Income;
Millennial;
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This study investigates the factors influencing the income of millennial farmers in Brebes Regency, Indonesia, a region known for its agricultural sector. The objectives are to determine the profile of millennial farmers and analyze the relationship between education level, knowledge of pests and fertilizers, mechanization, access to capital, and infrastructure, with the income level of young farmers. This research employs a mixed-methods approach, combining quantitative and qualitative analyses. Quantitative analysis utilizes correlation and simple linear regression tests on data collected from a representative sample of millennial farmers in the region. Qualitative analysis is based on in-depth interviews with staff from the Brebes Regency Agriculture and Food Security Agency and millennial farmers themselves. Results indicate that education level, knowledge of pests and fertilizers, and the use of agricultural mechanization among Brebes millennial farmers are already at adequate levels. However, access to capital, particularly the size of cultivated land, is a more significant factor influencing farming activities and income among millennial farmers in Brebes Regency. Therefore, policy planning aimed at expanding the agricultural land available to young farmers is crucial for significantly improving the economic well-being of millennial farmers in Brebes Regency.

INTRODUCTION

Central Java holds a comparative advantage in the production of various food commodities, including rice, maize, soybeans, and an assortment of vegetables. Among the regencies/municipalities in Central Java, Brebes Regency plays a strategic role in supporting national food security programs. As part of Central Java Province, Brebes contributes significantly through its agricultural output, which emphasizes a few key commodities that substantially bolster both the local economy and regional food resilience (Febrayanto & Susiyanti, 2024). An analysis of the contribution table of agricultural commodities in Brebes reveals that shallots are the leading commodity, contributing an average of 65% to total agricultural production. This aligns with prior production data indicating that Brebes is the largest producer of shallots in Central Java (Febrayanto & Kurniasih, 2022).

The agricultural sector plays a pivotal role in the economy of Brebes Regency and serves as the backbone of regional development. Contributing approximately 30% to the Gross Regional Domestic Product (GRDP), agriculture acts as a driving force for economic growth and provides livelihoods for the majority of the population. From rice paddies to fruit orchards, Brebes is renowned for its fertile land and diverse agricultural output, making it a major contributor to the national food supply (Febrayanto, 2023). Millennial farmers, in particular, play a critical role in signaling generational renewal in the sector and exemplify the use of digital technologies to foster a modern, productive, and sustainable agricultural environment (Savira et al., 2020).

According to Law No. 19 of 2013, the number of millennial farmers engaged in food crops, horticulture, plantation, and livestock farming in Brebes Regency is recorded at 105,815 individuals (BPS, 2024). These young farmers represent a new generation that drives innovation and sustainability within the agricultural sector of Brebes. Data shows that a significant portion—approximately 41.80%—of millennial farmers in the region actively utilize digital technology in their farming practices. This includes the use of modern agricultural machinery, internet-enabled smartphones, information technologies, drones, and artificial intelligence. In contrast, a smaller percentage—around 9.36%—do not utilize digital technologies, while 7.01% of farmers over the age of 39 are actively engaged in digital farming practices (Savira et al., 2020).

Access to technology and government support are critical factors, though not the only ones. The region's reliance on traditional farming methods, coupled with the predominance of small-scale landholdings, presents both challenges and opportunities (Yunandar et al., 2020). Millennial farmers often inherit land from their families, yet the limited size of these plots may constrain their ability to adopt large-scale mechanization or advanced agricultural techniques. Additionally, the use of pesticides in Brebes remains considerably high, posing potential environmental risks (Handoko et al., 2024).

Thus, knowledge and responsible use of chemical inputs are essential for millennial farmers in Brebes, as these directly affect crop yields, profitability, and environmental sustainability. While chemical fertilizers and pesticides can enhance productivity and protect crops from pests and diseases, misuse may lead to soil degradation, water contamination, and health hazards (Fitriani et al., 2023).

There is an urgent need for research to identify the factors influencing the income of millennial farmers to ensure the sustainability of their agricultural enterprises and support generational renewal within the farming sector (Sukmawati, 2024). Therefore, this study aims to 1) Understand the profile of young farmers in Brebes Regency, focusing on educational background, knowledge base, technology usage (agricultural mechanization), fertilizer and pesticide use, and access to capital and 2) Analyze how these factors affect the income levels of young farmers in the region.

While research on millennial farmers is increasingly common, quantitative studies specifically examining the factors that influence agricultural activities and income among this group remain relatively limited. By conducting a comprehensive investigation, we can gain a

deeper understanding of the elements driving the success of millennial farmers, develop effective strategies to address their challenges, and foster an enabling environment for their sustained engagement in agriculture. Thus, ensuring the sector's continuity and prosperity for future generations.

RESEARCH METHODS

This study was conducted in Brebes Regency from June to December 2024. It employed a mixed-method approach, integrating both quantitative and qualitative methods to gain a comprehensive understanding of the factors influencing the income of millennial farmers in Brebes. Data were collected through the distribution of questionnaires to a representative sample of millennial farmers in the region. A structured questionnaire—previously tested for validity and reliability—was used to measure research variables, which included farmer profiles (education level, land size, number of laborers), independent variables (capital, cultivation knowledge, infrastructure, fertilizer and pesticide use, mechanization), and the dependent variable (income). The data analysis involved descriptive statistics, correlation analysis, and simple linear regression.

Descriptive analysis was employed to address the first research objective: to identify the profiles of millennial farmers in Brebes Regency in terms of education level, capital, knowledge, fertilizer and pesticide usage, and supporting agricultural infrastructure. Correlation and simple linear regression analyses were applied to address the second objective: to determine the influence of education level, capital, knowledge, fertilizer and pesticide use, and infrastructure on the income of millennial farmers.

Quantitative data were collected via a questionnaire developed using Google Forms and distributed to 40 millennial farmers through the Millennial Farmers Forum of Brebes Regency, using random sampling across representative subdistricts. The age range of participating millennial farmers was 20–50 years. The responses, measured on a 5-point Likert scale, provided scores for each respondent corresponding to the questions posed. The key variables captured were education level, capital, knowledge, fertilizer and pesticide use, and supporting infrastructure. The data were then analyzed using correlation tests and simple linear regression to examine the relationships and effects of the independent variables on the income levels of millennial farmers.

The qualitative approach was employed to further explore key influencing factors identified through in-depth interviews with the head of the Millennial Farmers Forum, staff from the Department of Agriculture and Food Security of Brebes Regency, and leaders of millennial farmer groups in the region. These interviews aimed to gain insights into stakeholders' perspectives and experiences regarding the challenges and opportunities facing millennial farmers (Mulyati et al., 2022). The qualitative data highlighted the perceived impacts of current conditions related to education, capital, knowledge, fertilizer and pesticide use, and infrastructure on millennial farmers. These insights served to contextualize and enrich the overall understanding of millennial farmers in Brebes Regency.

RESULTS AND DISCUSSION

1. Profile of Millennial Farmers in Brebes Regency

The study of millennial farmers in Brebes Regency revealed that the majority (40%) possessed a senior high school education, indicating a relatively adequate knowledge and skills base in agriculture. However, 25% had only completed junior high school, and a mere 15% had attained higher education, highlighting the need to enhance access to formal education to strengthen their capacities (Figure 1).

These findings reflect both a promising foundation for the application of knowledge and skills in agricultural practice and a corresponding need for more targeted capacity-building and continuous education programs. With improved educational support, millennial farmers in Brebes will be better equipped to address challenges in the agricultural sector and

contribute to more sustainable agricultural development. Moving forward, millennial farmers must embody the spirit of national agrarian prosperity, positioning Indonesia as a potential global food supplier (Salamah et al., 2021).

Improving farmer welfare is central to sustainable agricultural development, with millennial farmers as the next generation playing a pivotal role in achieving this objective. The emergence of millennial farmers offers an alternative pathway to accelerate agricultural regeneration. They are considered capable of bridging the gap between traditional farmers and younger generations newly entering the sector (Haryanto et al., 2021).

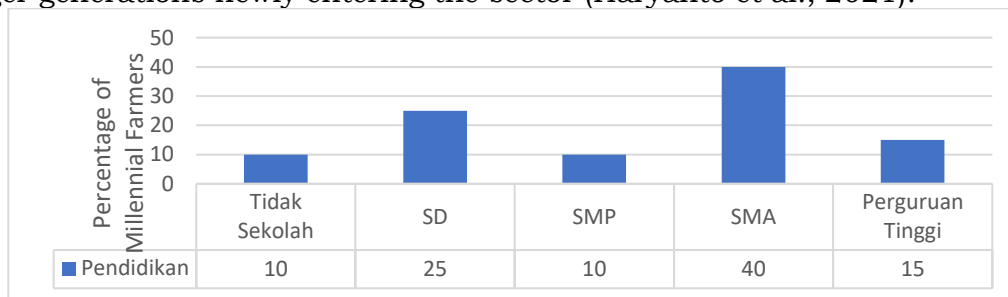


Figure 1. Educational attainment of millennial farmers

Survey results showed that millennial farmers in Brebes Regency possessed strong knowledge of crop cultivation practices, with an average Likert score of 4.3 (on a 1–5 scale). They demonstrated an understanding of proper planting techniques, including the selection of high-yield varieties and crop maintenance, and had participated in training provided by the local agricultural office on modern and environmentally friendly cultivation methods. Knowledge of fertilizers and fertilization practices was also high, with an average score of 4.1, reflecting awareness of the importance of balanced fertilization and the use of organic fertilizers to reduce dependence on chemical inputs. Regarding pests and plant diseases, respondents scored an average of 4.0, indicating good awareness and the implementation of integrated pest management strategies. Furthermore, their understanding of weather impacts on crop growth scored 4.2, underscoring their capacity to manage farming operations effectively and sustainably (Figure 2).

This strong agricultural knowledge positions millennial farmers to contribute meaningfully to regional agricultural development and to ensure the sustainability of the sector (Yunandar et al., 2020). These findings align with research by Dwinarko et al. (2023), which also highlighted the successful development of mangosteen cultivation by millennial farmers utilizing information technology.

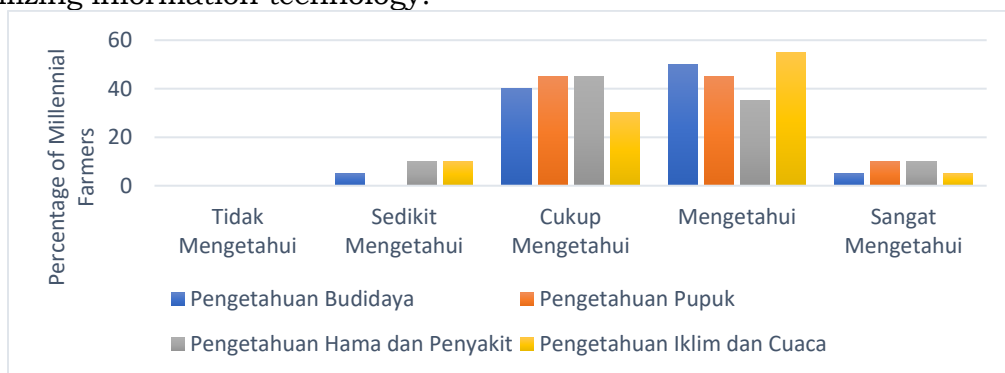


Figure 2. Millennial Farmers' Knowledge

Survey results indicate that the majority of millennial farmers in Brebes Regency operate small-scale farms, with approximately 60% of respondents managing land areas between 1,000–3,000 m². Limited land access is identified as a major constraint in the development of their farming enterprises. Many rely on small plots inherited from family and face difficulties

in acquiring additional land. Farmers managing land exceeding 3,000 m² are generally from established farming families or have gained access through partnerships or land rentals. According to the leaders of farmer groups, land availability remains the primary limiting factor, especially in the context of high population density that intensifies land competition. The Department of Agriculture and Food Security has also acknowledged this challenge and is working to address it through land consolidation programs and vertical farming initiatives. Hence, cultivated land size is a critical factor in improving both productivity and income among millennial farmers.

As illustrated in Figure 3, many young farmers depend on small teams composed of family members or hired labor to manage their farms efficiently (Dalmiyatun et al., 2024; Lakitan, 2019). These findings highlight the challenges millennial farmers face in Brebes Regency, particularly regarding land scarcity and labor availability. The majority of millennial farmers manage plots averaging less than 3,000 m², reflecting relatively small-scale farming operations. This further accentuates the issue of land limitations faced by young farmers and underscores their need to optimize the use of limited resources to remain competitive and productive (Safira & Universitas Islam Syekh-Yusuf, 2022).

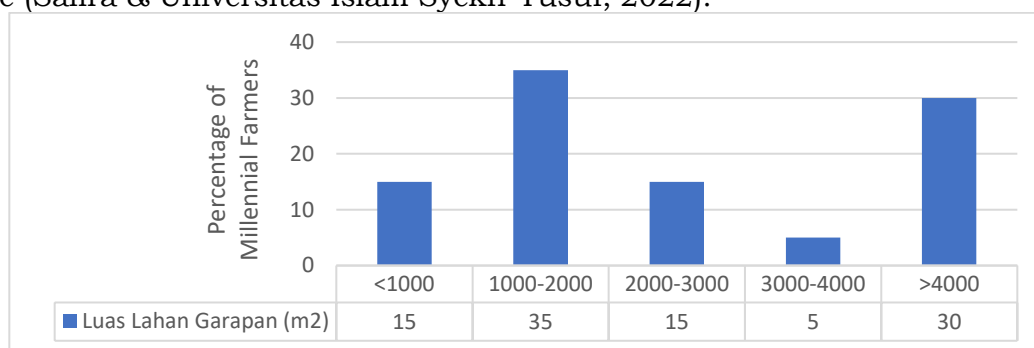


Figure 3. Average Cultivated Land Area of Millennial Farmers

A survey of the labor variable revealed that most millennial farmers in Brebes Regency rely on relatively limited human resources. The small operational scale (1,000–3,000 m²) influences the labor demand. Around 80% of respondents reported utilizing only 1–2 workers, most of whom are immediate family members. The remaining 20% employed additional laborers, though still in relatively small numbers (an average of 3–4 workers) (Figure 4). In-depth interviews revealed that additional labor is often seasonal, mainly during peak periods such as planting and harvesting, and prioritized for labor-intensive tasks. Permanent labor employment is relatively rare, as it is deemed economically inefficient due to limited land size. This indicates a strong dependence on family labor and the need for efficient, cost-effective labor management strategies.

Farmers with smaller plots (less than 2,000 m²) generally rely solely on family labor or, at most, one additional worker. A significant increase in land area correlates with an increased demand for labor (Pratama et al., 2022). Farmers with land holdings above 3,000 m² are more likely to employ a higher number of both permanent and seasonal workers to meet their larger operational needs. Interviews with farmers and farmer group leaders confirmed that labor quantity is a key determinant of farm productivity and efficiency. Labor constraints on small plots often become a major obstacle to optimal land management and the adoption of more advanced agricultural technologies.

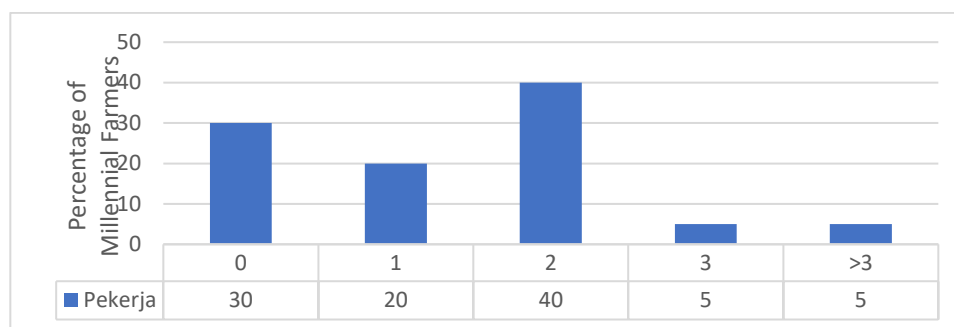


Figure 4. Average Number of Workers Assisting Millennial Farmers

The irrigation conditions on land managed by millennial farmers in Brebes Regency demonstrate significant disparities. Only 20% of respondents reported having adequate irrigation, while 70% experienced water availability limited to the rainy season. Unreliable water access, particularly during the dry season, presents a major challenge to agricultural productivity, with farmers who have good irrigation access reporting more stable yields. On the other hand, the level of agricultural mechanization adoption is relatively high, with 35% of respondents using machinery at every stage of cultivation, although high initial investment costs remain a barrier. The condition of farm access roads (JUT) is also concerning; only 30% of respondents reported good road conditions, while 15% reported severe damage, leading to increased transportation costs and difficulties in distributing harvests.

This shift toward mechanization indicates their willingness to adapt and embrace modern solutions to address the challenges they face (Sudarma et al., 2024). The existing infrastructure gap highlights the need for targeted interventions to enhance access and transportation reliability for all millennial farmers (Juantero et al., 2020). These findings underscore the importance of investing in transportation infrastructure to ensure the efficient movement of agricultural goods and resources. Addressing transportation challenges, particularly during harvest seasons, can improve productivity, enhance livelihoods, and enable young farmers to contribute significantly to the agricultural sector (Prabowo et al., 2023). Furthermore, sustained support for mechanization adoption can further empower millennial farmers to optimize their farming practices and adapt to the evolving agricultural landscape (Pramesti et al., 2024).

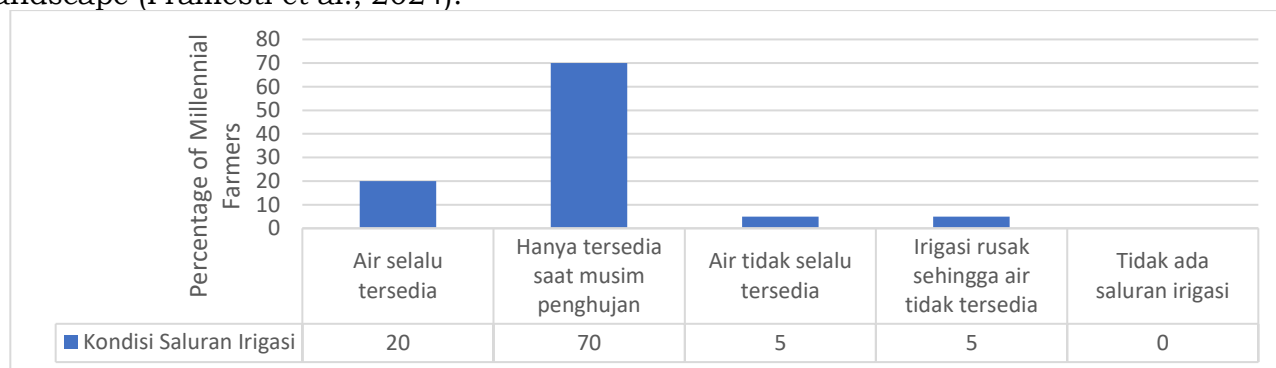


Figure 5. Irrigation Status of Millennial Farmers' Land

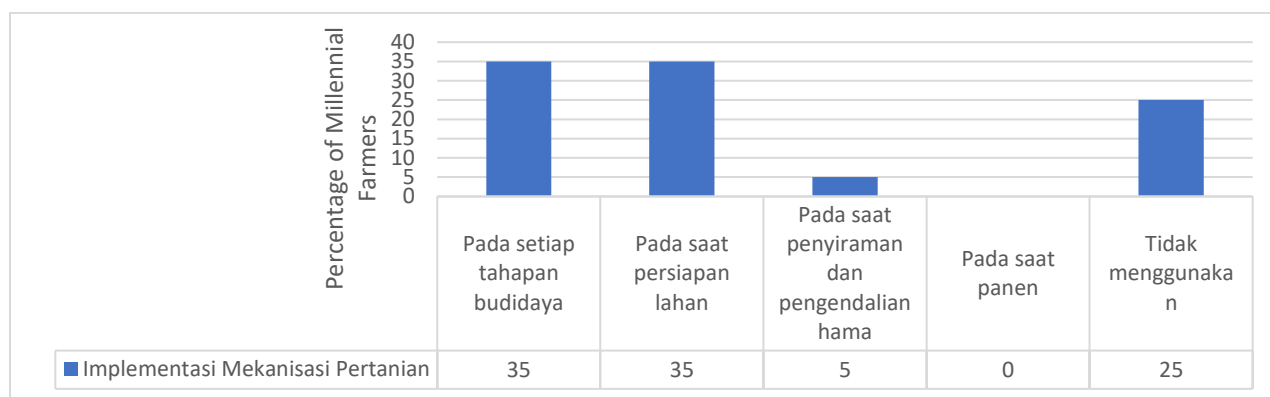


Figure 6. Implementation of Agricultural Mechanization

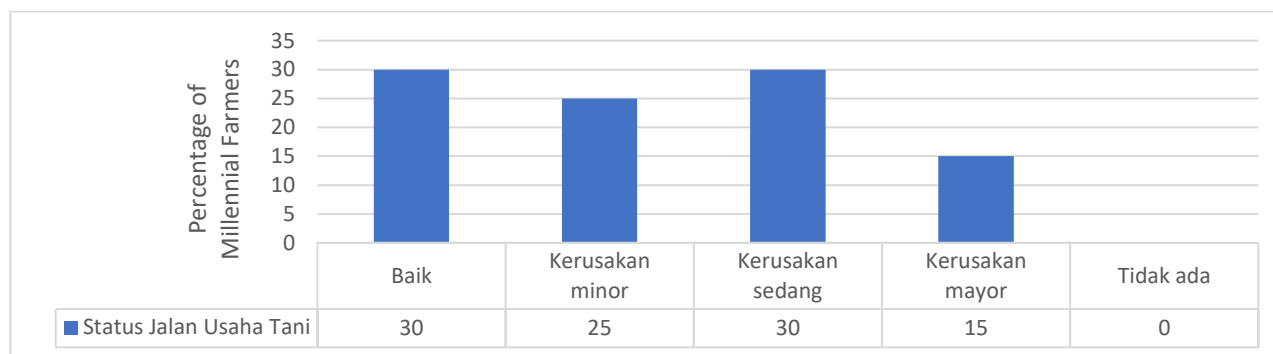


Figure 7. Condition of Farm Access Roads

The use of chemical fertilizers among millennial farmers in Brebes Regency varies. Approximately 5% of respondents reported using large and diverse quantities of fertilizer, while 65% applied fertilizer according to the specific needs of their crops, reflecting a sound understanding of nutrient management. However, 20% relied solely on subsidized fertilizers, and 5% used fertilizer in limited quantities due to financial constraints. Factors such as price, availability, and knowledge of proper fertilizer use influenced these usage patterns. In terms of pesticide use, 75% of farmers reported applying pesticides only in response to pest outbreaks, while 5% used them with high frequency, indicating potential environmental risks. Meanwhile, 5% of respondents refrained from using pesticides altogether, reflecting a commitment to organic farming practices. Increasing awareness of the harmful effects of pesticides has prompted some farmers to shift toward integrated pest management (IPM) and the use of organic pesticides, although dependence on chemical pesticides remains due to their effectiveness.

The majority of surveyed millennial farmers demonstrated a commitment to using chemical fertilizers by the specific nutritional needs of their crops. This reflects their understanding of balanced nutrient application to support optimal crop growth while minimizing environmental impact (Nursyamsi et al., 2023). Furthermore, the study revealed that most millennial farmers only use pesticides when actual pest or disease outbreaks occur, indicating a proactive approach to pest management consistent with sustainable agricultural practices. This responsible use of fertilizers and pesticides underscores their commitment to sustainable agriculture and their potential to contribute to a more resilient and environmentally friendly agricultural sector (Febrayanto et al., 2025).

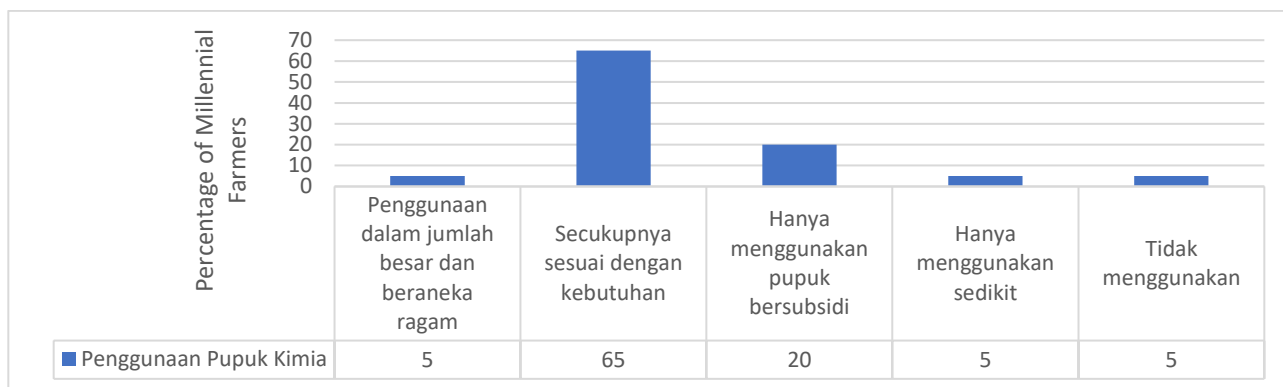


Figure 8. Fertilizer Usage Practices

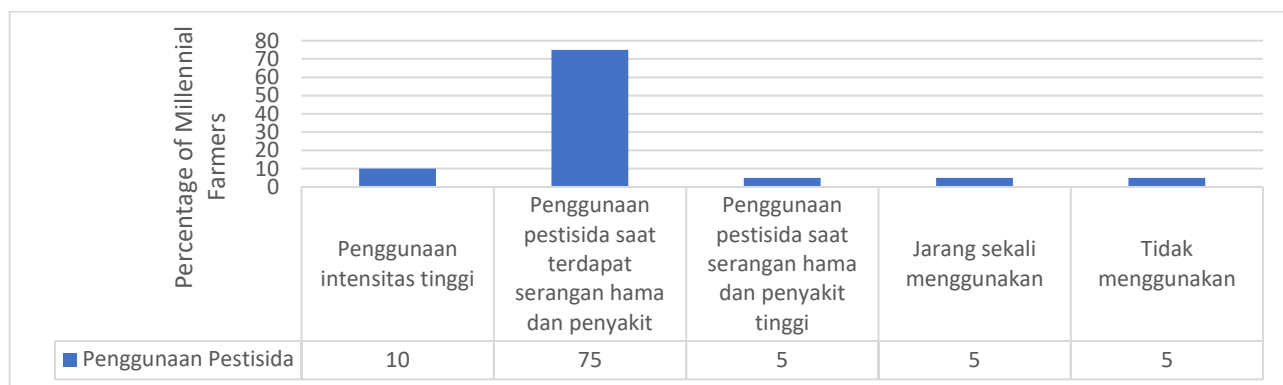


Figure 9. Pesticide Usage Practices

An analysis of monthly income data among millennial farmers in Brebes Regency reveals an uneven distribution, reflecting notable economic disparities. A majority of respondents (approximately 35%) fall within the income range of IDR 1,000,000 to IDR 2,000,000 per month (scale 2), indicating that most millennial farmers are still within a relatively low-income bracket. Around 10% fall in the IDR 2,000,000 to IDR 3,000,000 category (scale 3), suggesting modest income improvements that remain below a decent living standard. Only about 35% of respondents earn above IDR 3,000,000 per month (scales 4 and 5), indicating that only a minority of millennial farmers attain relatively high incomes. Approximately 20% earn less than IDR 1,000,000 per month (scale 1), revealing a highly vulnerable economic segment (Figure 10).

This distribution illustrates a significant economic gap that requires attention. Factors previously discussed—such as land size, access to technology, market access, and managerial skills—likely contribute to this income disparity. Further analysis is needed to identify more specific correlations between these variables and income levels. These findings highlight the need for well-targeted policy interventions aimed at increasing the income of millennial farmers, particularly as many remain below the poverty line or earn significantly low incomes. Capacity-building programs, access to capital assistance, and market development should be prioritized to address these economic disparities. While some farmers may struggle to meet basic needs, the majority can maintain a decent standard of living through their agricultural activities (Ariyanto, 2024).



Figure 10. Average Income of Millennial Farmers

2. Analysis of the Relationship Between Independent Variables and Their Influence on Millennial Farmers’ Income

The correlation analysis in this study revealed a strong relationship between education level and fertilizer use among millennial farmers (Table 1). This indicates that farmers with higher levels of education are more likely to adopt nuanced and informed approaches to fertilizer application (Savira et al., 2020). The analysis also showed a strong positive correlation between knowledge and the adoption of agricultural mechanization among millennial farmers. This suggests that farmers with deeper understanding of agricultural technology are more likely to embrace and utilize mechanical equipment in their farming practices (Zalukhu et al., 2022).

Additionally, the correlation analysis revealed a strong connection between infrastructure, particularly well-maintained road access, and the adoption of agricultural mechanization among millennial farmers (Table 1). Farmers with reliable road access suitable for transporting heavy machinery, such as tractors and harvesters, are more likely to invest in and utilize mechanization (Simarmata, 2019). Ensuring smooth and efficient transportation of machinery enables farmers to fully leverage the benefits of mechanization, leading to increased productivity, reduced labor costs, and ultimately, a more sustainable and profitable agricultural sector (Pratama et al., 2022).

The analysis further indicated a strong positive correlation between capital investment and income among millennial farmers (Table 1). This suggests that farmers with greater access to financial resources can invest more in their farming operations, resulting in increased productivity and, consequently, higher income (Ibrahim et al., 2024; Novisma & Iskandar, 2023).

Table 1. Correlation Analysis

	Education	Capital	Knowledge	Infrastructure	Fertilizer & Pesticide Use	Income	Mechanization
Education	1						
Capital	0,06	1					
Knowledge	0,01	-0,01	1				
Infrastructure	-0,28	-0,07	0,50 **	1			
Fertilizer & Pesticide Use	0,53 **	0.12	0,07	-0,06	1		
Income	0.30	0,53 **	-0,06	-0,05	-0,01	1	
Mechanization	-0,15	-0,13	0,39*	0,44**	-0,03	-0,09	1

Source: Processed Primary Data

The linearity test is a prerequisite for conducting regression analysis. It aims to determine whether the relationship between independent and dependent variables is linear. The results of the linearity test between the independent variables and the dependent variable (millennial farmers' income) varied. Education level and capital variables yielded linearity values of < 0.05 , indicating a linear relationship. Meanwhile, infrastructure, knowledge, and fertilizer/pesticide use variables had linearity values > 0.05 , suggesting that the relationships with income are not linear (Table 2).

Table 2. Linearity Test Results

No	Independent Variable	Linearity Value
1.	Education	0.04
2.	Capital	0.01
3.	Knowledge	0.67
4.	Infrastructure	0.73
5.	Fertilizer & Pesticide Use	0.94

Source: Processed Primary Data

The simple linear regression analysis conducted in this study reveals a significant effect of education level and capital investment on the income of millennial farmers (Table 3). These findings emphasize the critical role of human capital and financial resources in shaping the economic success of young farmers. The positive t-values associated with these variables indicate a consistent and direct relationship, suggesting that as education and capital investment increase, so does farmers' income.

The resulting regression model for the relationship between education level and the income of millennial farmers is as follows:

$$Y = 0,98 + 0,46X$$

Meanwhile, the regression model for the relationship between capital and income is:

$$Y = 0,39 + 0,54X$$

Table 3. Simple Linear Regression Analysis of Independent Variables and Millennial Farmers' Income

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.08	1.83		-0.59	0.56
	Education	0.98	0.34	0.46	2.91	0.01**
	Capital	0.39	0.09	0.54	4.14	0.00**
	Knowledge	-0.06	0.09	-0.11	-0.71	0.48
	Infrastructure	0.09	0.09	0.15	0.95	0.35
	Fertilizer & Pesticide Use	-0.33	0.17	-0.30	-1.96	0.06

Source: Processed Primary Data

The findings of this study underscore the critical role of capital resources, particularly land size and labor availability, in determining the income levels of millennial farmers in Brebes Regency. This emphasizes the need for strategies that empower young farmers to effectively access and utilize these resources. Expanding land ownership opportunities and facilitating access to skilled labor could significantly enhance their farming operations, leading to increased productivity and profitability (Mulyati et al., 2022).

Furthermore, the development of an enabling environment that supports knowledge acquisition and skill enhancement related to modern agricultural practices, including efficient use of fertilizers and pesticides, and the adoption of mechanization, can contribute to long-term sustainability and economic resilience (Pratama et al., 2022). Through investments in education, training programs, and infrastructure development, policymakers and

stakeholders can equip millennial farmers with the tools and resources necessary to navigate the challenges and opportunities of the modern agricultural landscape (Surachmanto & Nabiha, 2023).

CONCLUSION

This study provides a comprehensive overview of the profile of millennial farmers in Brebes Regency, revealing that most of them possess a moderate level of education and fall within a relatively low-income bracket. A majority earn between IDR 1,000,000 and IDR 2,000,000 per month, highlighting significant economic challenges. Additionally, the study identifies the use of chemical fertilizers and pesticides, adoption of mechanization, and access to infrastructure as critical factors influencing their agricultural practices. On the other hand, land limitations and restricted access to capital pose considerable barriers to increasing productivity and income.

Correlation analysis reveals a significant positive relationship between education level and capital with the income of millennial farmers. These findings affirm that improvements in education and access to financial resources can contribute to income growth. Other variables—such as knowledge, infrastructure, technology, and the use of fertilizers and pesticides—do not demonstrate a statistically significant linear relationship with income but still play an essential role in supporting sustainable agricultural practices. Therefore, the study recommends targeted interventions focused on improving access to education, training, and financial support, enabling millennial farmers to optimize their agricultural practices and sustainably enhance their economic welfare.

RECOMMENDATIONS

Future research is encouraged to employ multiple linear regression analysis to examine the simultaneous effects of the independent variables (education level, capital access, agricultural knowledge, infrastructure, fertilizer and pesticide usage, and mechanization) on the income of millennial farmers. This modeling approach will provide a more comprehensive understanding of variable interactions and help identify the most influential factors affecting income.

To enhance the validity and generalizability of the results, an increased sample size is also recommended. Sample size should be calculated accurately using statistical formulas, considering the desired confidence level and margin of error. The use of stratified random sampling is recommended to ensure balanced representation across various farmer subgroups based on relevant characteristics. A larger and more representative sample will yield more accurate parameter estimates and increase the statistical power of the analysis.

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