



Agricultural Digitalization: Can This Transformation Increase Farmers' Income In East Java?

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Abstract. The era of the industrial revolution 4.0 has encouraged various economic sectors to utilize technology and information in their activities, including the agricultural sector. This study provides an overview of the impact of agricultural digitization on farmers' income and examines the characteristics of farmers in East Java who have and have not utilized agricultural digitalization as a first step toward agricultural extension targets. The data comes from the August 2022 National Labor Force Survey in East Java conducted by BPS-Statistics Indonesia with a sample size of 7.852 farmers carrying out agricultural businesses. The t-Student test results show that farmers who utilize agricultural digitization have an average income higher than those who do not utilize it. The binary logistic regression results also show that digitization of agriculture, gender, education, agricultural business field, and business status also affect farmers' income. The results random undersampling analysis and random oversampling classification and regression trees results show that there are two types of characteristics of farmers in East Java who take advantage of agricultural digitization, namely farmers who graduated at least junior high school and farmers who graduated elementary school/equivalent, come from X, Y, or Z generations, and work assisted by permanent workers/paid workers.

1. Introduction

After the Covid-19 pandemic, agriculture has become a sector that needs special attention, especially because of its role in food security issues. The Food and Agriculture Organization (FAO) stated that the Covid-19 pandemic has resulted in the threat of a world food crisis due to the cessation of economic activity, loss of humanitarian aid and a blow to the global food system [1]. The cessation of global economic activity due to the Covid-19 pandemic has also triggered the threat of a world recession. The Indonesian economy itself in 2020 experienced a growth contraction of 2.07 percent and only grew 3.70 percent in 2021 [2]. It is necessary to focus on developing strategic sectors such as the agricultural sector so that it has a more tangible impact, especially on economic recovery and strengthening people's purchasing power.

Agriculture is one of the leading national sectors. This sector ranks as the third main contributor to the Indonesian economy after the Manufacturing Industry and Trade [2]. This sector also always grows positively every year, even during the Covid-19 pandemic. Meanwhile, if we look at labor absorption, in the last ten years this sector has absorbed more than 25 percent of the national workforce. Data from the National Labor Force Survey (SAKERNAS) shows that the agricultural sector was able to absorb more than 29 percent of the national workforce during the Covid-19 pandemic in 2020. Meanwhile, in 2022, more than 28.61 percent of the national workforce is absorbed in this sector. These various data



explain that this sector has the potential to become a buffer when other economic sectors are affected by world turmoil which affects national economic performance.

On a regional scale, the role of this sector is also dominant in several large provinces, including East Java. During 2010-2021, the average contribution of the agricultural sector in East Java was ranked third below the Processing Industry Sector and the Trade Sector, namely 12,62 percent [3]. Meanwhile, in 2022, this sector absorb more than 6,7 million people or more than a third (31.31 percent) of the workforce in East Java [4]. This shows the superiority of the agricultural sector compared to other sectors in the province.

However, the superiority of the agricultural sector in East Java also has the potential to decline. In the last three years, the contribution of the East Java agricultural sector has continued to decrease from 11,88 percent in 2020 to 11,11 percent in 2022. Likewise, the labor absorption in this sector also decreased from 33,01 percent in 2020 to 31.31 percent in 2022 [4]. The trend of decreasing labor absorption in the agricultural sector shows an indication of the aging farmer phenomenon where the majority of East Java farmers are in the old age group. The interest of the productive age population to work in the agricultural sector is increasingly low, especially considering the wages received in this sector. Since 2018 the wages of formal workers working in the agricultural sector have only been around 1,4 – 1,6 million rupiah per month, lower than the average wages of formal workers working in the secondary and tertiary sectors which are around 2,4 – 2,7 million rupiah per month [4]. This also triggers the low level of public interest in doing business in this sector. This also needs to be used as motivation for agricultural policy makers, considering the issue of food security which continues to develop after the Covid-19 pandemic.

Improving and implementing various agricultural sector policies in East Java must be carried out consistently and in an integrated manner. At least by paying attention to the regional development plans contained in the Regional Long Term Development Plan (RPJPD). The East Java Province RPJPD 2005 – 2025 carries the vision of "East Java Province as a leading agribusiness center, globally competitive and sustainable towards a prosperous and moral East Java". Thus, the development of the agricultural sector must be directed towards achieving regional economic development goals, both in terms of community welfare and equitable economic development between districts/cities in East Java [5]. Moreover, we are aware of efforts to improve and recover the economy after the Covid-19 pandemic.

One effort that can be made to improve the agricultural sector in East Java is the application of agricultural digitalization in the industrial revolution 4.0 era so that it can increase business efficiency, including in terms of distribution and marketing of agricultural products. It is believed that the application of agricultural digitalization can encourage the optimization of value chains, food systems and agricultural production [6], [7]. The application of information technology systems as part of agricultural digitalization can help farmers understand the current agricultural system so that farmers can be wiser in determining their agricultural business strategies. [8]. In addition, the application of information technology encourages the transformation of farming techniques that were originally experience-based into data management-based efforts. This indirectly encourages an increase in the efficiency of agricultural businesses which ultimately contributes to an increase in farmers' income [9].

Agricultural digitalization is an inevitability that is slowly becoming more and more real. Moreover, the Covid-19 pandemic has also encouraged changes in societal patterns at all levels [10]. Likewise, the response of the business world is shifting from conventional activities to digital by utilizing digital media to support their business activities [11], [12]. The use of the internet and digital media, which is now increasingly massive in the business world, has not only emerged as a response to the helplessness of entrepreneurs due to the rapid development of technology but also as an alternative to support their business [13]. The BPS survey stated that more than 80 percent of Indonesian entrepreneurs felt the positive influence of using the internet and information technology in marketing and selling their products [14]. This shows that the opportunities for implementing agricultural digitalization are getting bigger. Farmers need to be adaptive and respond to developments in the digital world and information technology in agricultural business processes.



Paying attention to the various problems explained previously, it is necessary to know the role of agricultural digitalization in improving the performance of this sector in East Java. Apart from that, the individual characteristics of farmers also need to be explored, especially in explaining the characteristics of farmers who are adaptive to agricultural digitalization. In this way, policies formulated by the government, such as agricultural extension, can be more implemented and targeted at farmers in accordance with the development plan targets in East Java.

Various studies try to find out the relationship between the implementation of agricultural digitalization and its impact on improving the performance of the sector. However, it is difficult to find research that explains how individual farmer characteristics such as gender, education level, agricultural business field and business status are determinants for a farmer to implement agricultural digitalization. This research explains how the digitalization of agriculture, in this case the use of the internet in agricultural businesses in East Java, encourages increased agricultural performance which is approximated by an increase in farmers' income in the region. This research also explains the individual characteristics of East Java farmers which are determinants of implementing agricultural digitalization. The classification accuracy of a farmer who implements agricultural digitalization is measured by balanced accuracy from testing data. Thus, the results obtained are able to explain the accuracy of individual characteristics which are the determinants of the implementation of agricultural digitalization in East Java. The findings in this research provide valuable policy implications for the government, especially in East Java to encourage agricultural digitalization with the aim of increasing the efficiency of the East Java economy.

2. Literature Review

Digitalization refers to the use of various digital technologies and data. Digitalization in the era of industrial revolution 4.0 can increase the productivity of an activity [15]. Digitalization helps an activity to run effectively and efficiently. Agricultural digitalization means changes in agricultural methods that can be carried out in various aspects of the agricultural process, such as processing to marketing. These changes can be made by utilizing digital technology and information.

Digitalization can increase income in developed and developing countries [16]. Digitalization is also able to increase the income of farmers in rural areas by increasing agricultural productivity due to agricultural digitalization [17]. Agricultural digitalization is also able to increase the income and quality of life of poor people in rural areas [18]. Agricultural digitalization is also able to increase farmers' income by implementing various renewable agricultural technologies [19]. Of course, the characteristics of the farmer such as education level [20] and gender [21] also have an influence in increasing farmer income..

Zhang et al (2023) in their research stated that efficiency of the production process and expansion of the marketing network can help farmers increase their income. Expansion of this marketing network can be achieved by utilizing internet media in marketing agricultural products. Through the internet such as e-commerce websites, farmers can directly market their agricultural products to a wide range of consumers [22]. Ilyas (2022) in his research stated that the use of agricultural digitalization is still minimal. This is reflected in the low number of farmers who use the internet [23].

It is necessary to increase the capacity of farmers to take advantage of agricultural digitalization so that agricultural processes are more efficient [24]. Therefore, the government needs to encourage promotion and support the dissemination of internet use in agricultural businesses among farmers [25]. One way to encourage farmers' awareness of utilizing agricultural digitalization, in this case the use of the internet, is by conducting agricultural outreach related to the use of agricultural digitalization. Several previous studies have studied how to carry out effective and efficient agricultural extension, such as A.F et al. [24] which examines steps to digitize agricultural extension in the new normal era. On the other hand, research that examines the characteristics of farmers who need to be given agricultural counseling regarding agricultural digitalization is still rare. Farmers who need to be given counseling to be able to use the internet are of course farmers who characteristically have not used the internet in their business. Farmer characteristics such as age and education can influence the use of agricultural



digitalization [26]. Gender also influences farmers' perceptions of utilizing agricultural digitalization [27].

Including various characteristics or types of farmers who are the targets of agricultural digitalization extension coming from various generations, education, gender, agricultural business fields, and business status can help increase the efficiency of the extension carried out. In the end, agricultural extension was able to target groups who had not previously utilized digital media in their agricultural businesses so that they were moved to use agricultural digitalization.

3. Methodology

This research uses data sourced from the August 2022 East Java National Labor Force Survey (SAKERNAS) sourced from the BPS-Statistics Indonesia. The unit of analysis used in this research is farmers who carry out agricultural businesses in East Java Province. The total sample used is 7,852 farmers. The stages carried out in carrying out the analysis in this research are as follows:

- [1] Select respondents aged 15 years and over who work in the agricultural sector. The scope of work in the agricultural sector here is someone who in the last week carried out activities in the fields of agriculture, fisheries, and forestry to earn income/money or helped with business activities or family/other people's work for at least 1 hour a week. Employment status includes self-employment, employment assisted by temporary workers/family workers/unpaid, and employment assisted by permanent and paid workers. Not included in this research is someone who has a job/business activity but in the last week was not working/not running a business, family workers/unpaid, laborers/employees/employees, working casually in agriculture, and casual workers in non-agriculture.
- [2] Prepare the variables used in the research.
 - a) The agricultural digitalization variable is taken from farmers who use the internet in their work.
 - b) The farmer income variable is taken from the income/earnings received by farmers during the last month (according to the August 2022 SAKERNAS data collection period) from work or agricultural business activities.
 - c) Independent variables that are thought to influence farmer income are agricultural digitalization, farmer gender, farmer education, business field, and business status. The gender of farmers consists of men and women. Farmer education is the highest education completed by farmers, consisting of not completing elementary school, completing elementary school/equivalent, completing junior high school/equivalent, completing high school/equivalent, and completing college. Business fields include all economic activities/business fields, which include crop agriculture (seasonal crops, annual plants, ornamental plants, and plant breeding), animal husbandry, fisheries (capture and aquaculture), and other agricultural activities (agricultural and post-harvest support services, hunting, catching, and breeding plants/animals, and forestry and logging management). Business status includes self-employment, business assisted by temporary workers/family workers/unpaid, and business assisted by permanent and paid workers.
 - d) Independent variables that are thought to influence agricultural digitalization are farmer gender, farmer education, farmer generation, business field, and business status. The scope and explanation of the variables of farmer gender, farmer education, business field, and business status are the same as point c. The agricultural generation consists of the Pre Boomers Generation (born 1922-1945), the Baby Boomers Generation (born 1946-1960), Generation X (born 1961-1980), Generation Y "Millennials" (born 1981-1994), and Generation Z (born 1995-2010).
- [3] Descriptive analysis to describe agricultural digitalization, farmer income, and other variables used in research. Descriptive analysis uses tables and graphs. In this analysis, farmer income was also grouped based on the average income of farmers in East Java.
- [4] The mean difference t test was carried out to test "is the average income of farmers who use the internet (μ_1) greater than those who do not use the internet (μ_2)?" How big the difference in farmer income will be is measured by the difference in the average farmer income from the August 2022



SAKERNAS results. The hypothesis that will be tested in the Student t test for the difference between the means of two populations is as follows:

$$H_0: \mu_1 - \mu_2 \leq 0 \quad (1)$$

$$H_1: \mu_1 - \mu_2 > 0 \quad (2)$$

The test statistics used follow the t-Student distribution which can be seen in the following equation:

$$t_{hit} = \frac{(\bar{x}_1 - \bar{x}_2)}{s_e} \quad (3)$$

Where \bar{x}_1 is the average value of the population sample 1. \bar{x}_2 is the average value of the population sample 2. s_e is the *standard error*. If the variance of the two populations is considered to be the same, then the standard error is obtained using the formula $s \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$ and the degrees of freedom are $n_1 + n_2 - 2$. If the variance of the two populations is considered different, then the standard error is obtained using the formula $\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$ and the degrees of freedom

$\frac{(n_1-1)(n_2-1)}{(1-c)^2(n_1-1)+c^2(n_2-1)}$ where $c = \frac{s_1^2/n_1}{s_1^2/n_1 + s_2^2/n_2}$. Reject H_0 if the t test statistical value is greater than the t table value or if the p value $<$ alpha.

- [5] Binary logistic regression analysis is used to determine the effect of digitalization on farmer income. Apart from agricultural digitalization, other independent variables are also used, namely farmer gender, farmer education, business field, and business status. Binary logistic regression analysis is used to model the relationship between response variables consisting of two categories and one or more explanatory variables. The binary logistic regression model used is $g(\mathbf{x}) = \ln \left[\frac{\pi(\mathbf{x})}{1-\pi(\mathbf{x})} \right] = \beta_0 + \boldsymbol{\beta}^T \mathbf{x}$, where $\pi(\mathbf{x}) = \frac{\exp(\boldsymbol{\beta}_0 + \boldsymbol{\beta}^T \mathbf{x})}{1 + \exp(\boldsymbol{\beta}_0 + \boldsymbol{\beta}^T \mathbf{x})}$, $g(\mathbf{x}) = \text{logit } \pi(\mathbf{x})$, $\beta_0 =$ intercept parameter, $\boldsymbol{\beta}^T =$ vector containing parameter values or regression coefficient, and $\mathbf{x} =$ vector containing the values of the independent variables. Estimating the parameters of the binary logistic regression model uses the maximum likelihood method and is completed using Newton Raphson iteration. Model parameter testing is carried out using the likelihood ratio test or G test (simultaneous test) and *Wald* test statistics (partial test). After testing, the odds ratio is interpreted. Odds ratio is a comparison or tendency for an event to occur when compared with other events on the same variable.
- [6] Random oversampling and random undersampling Classification and Regression Trees (CART) analysis is used to determine the characteristics of farmers who utilize digitalization in their businesses. Independent variables that are thought to influence agricultural digitalization are farmer gender, farmer education, farmer generation, business field, and business status. Random oversampling and undersampling is used because the number of farmers who use the internet in their business is much smaller than those who do not use the internet.
- [7] Evaluate the binary logistic regression model using accuracy values. Accuracy is a measure of the classification accuracy of the resulting model. The data used in calculating accuracy values is testing data. In evaluating the CART random undersampling and oversampling models, the balanced accuracy value is used. Balanced accuracy is one of the benchmarks for assessing the goodness of a model on unbalanced data. The data used to calculate balanced accuracy is testing data.

4. Results and Discussion

Based on SAKERNAS sample data from August 2020, the average income of farmers carrying out agricultural businesses in East Java is IDR 1,663,389.-. Farmers who implement agricultural digitalization in terms of using the internet in their agricultural businesses have an average income of



IDR 2,824,182,- while the income of farmers who do not implement agricultural digitalization is IDR 1,531,155,-. The difference in their average income is more than one million rupiah. From the existing sample, farmers who implement agricultural digitalization have an average income of IDR 1,293,027 higher than farmers who do not implement agricultural digitalization. This shows that statistically, farmers who implement agricultural digitalization have higher incomes compared to farmers who do not implement agricultural digitalization. This statement is supported by the results of the Student's t-test for the two populations.

In the Student t-test with the alternative hypothesis, the average income of farmers who implement agricultural digitalization is greater than the average income of farmers who do not implement digitalization, showing a p value of 0.0000. This means rejecting the null hypothesis or accepting the alternative hypothesis, which means that at the five percent alpha level, we have enough evidence to state that the average income of farmers who implement agricultural digitalization is greater than the average income of farmers who do not implement agricultural digitalization.

Farmers who carry out agricultural businesses in East Java mostly (68,33 percent) have incomes below the average (Table 1). For farmers who take advantage of agricultural digitalization, the percentage of farmers whose income is high (above the average) is 55,17 percent, while for farmers who do not take advantage of agricultural digitalization it is only 29,00 percent (Figure 1). It is mean that the percentage of farmers whose income is high (above average) among farmers who utilize agricultural digitalization, in this case the use of the internet, is much greater than those who do not utilize agricultural digitalization.

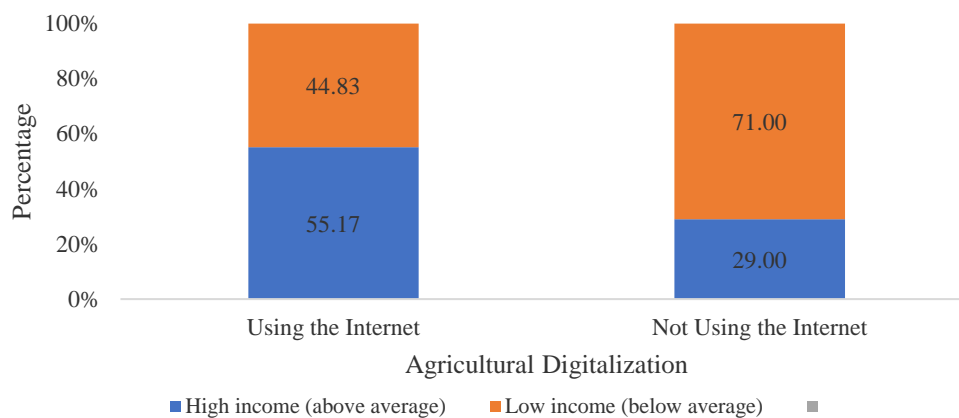


Figure 1. Percentage of Farmers According to Income Group and Internet Use Status in their Agricultural Business in East Java in 2022

The characteristics of the sample of farmers carrying out agricultural business in East Java in 2022 based on the August 2022 SAKERNAS sample data are that the majority are male, have graduated from elementary school/equivalent, are working in the crop farming business field (seasonal crops, annual crops, ornamental plants and plant breeding), trying to be assisted by temporary workers/family workers/unpaid, and come from generation X (born in 1961-1980) (Table 1). Judging from education, the higher the education completed by farmers, the higher the percentage of farmers who have above average income. This means that for farmers who run agricultural businesses, education must continue to be improved because it can affect the income they receive (Figure 2).

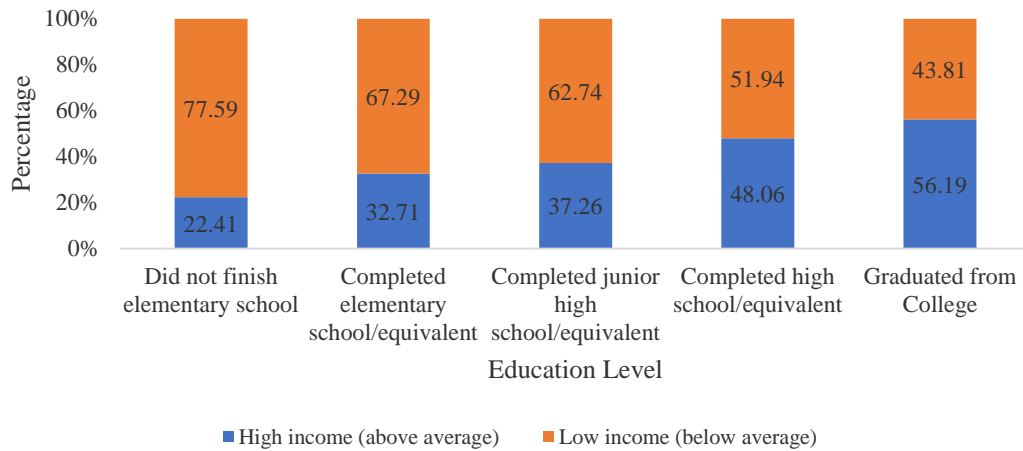


Figure 2. Percentage of Farmers According to Income Group and Education Level in East Java in 2022

Table 1. Characteristics of Farmer Respondents Carrying Out Agricultural Businesses in East Java, August 2022.

Number	Independent Variables	Category	Percentage (%)
1	Income	1. High income (above average)	31,67
		2. Low income (below average)	68,33
2	Agricultural Digitalization	1. Not Using the Internet	89,77
		2. Using the Internet	10,23
3	Genders	1. Male	80,16
		2. Female	19,84
4	Education	1. Did not finish elementary school	33,58
		2. Completed elementary school/equivalent	42,13
		3. Completed junior high school/equivalent	13,09
		4. Completed high school/equivalent	9,86
		5. Graduated from College	1,34
5	Business Fields	1. Plant farming (seasonal plants, annual plants, ornamental plants and plant breeding)	64,47
		2. Livestock	31,10
		3. Fisheries (capture and aquaculture)	2,89
		4. Other agricultural activities (agricultural and post-harvest support services, hunting, catching and breeding plants/animals, and forestry and logging management)	1,54
6	Business Status	1. Self-employed	31,31
		2. Trying to be supported by temporary workers/family workers/unpaid workers	65,98
		3. Trying to be supported by permanent and paid workers	2,71
7	Generations	1. Pre Boomers Generation (born 1922-1945)	3,77
		2. Baby Boomers Generation (born 1946-1960)	30,18
		3. Generation X (born 1961-1980)	50,10
		4. Generation Y "Millennial" (born 1981-1994)	13,96
		5. Generation Z (born 1995-2010)	1,99

The impact of agricultural digitalization, in this case the use of the internet in agricultural businesses, on farmers' income in East Java will also be clarified again through the binary logistic regression



equation. The G test shows significant results at the 5 percent alpha level, meaning that independent variables jointly influence farmer income. Table 2 presents the partial test results of the binary logistic regression model.

Table 2. Results of Binary Logistic Regression Modeling of Farmer Income

Independent Variable	Coefficient Parameter Estimator	<i>p</i> _value	Odds Ratio
<i>Intercept</i>	0,9027	0,0028***	2,4664
Digitalization of Agriculture (Using the Internet vs Not Using the Internet)	0,6927	0,0000***	1,9982
Gender (Male vs Female)	0,5888	0,0000***	1,8018
Education:			
• Didn't finish elementary school vs. finished college	-0,9500	0,0000***	0,3867
• Completed elementary school/equivalent vs completed university	-0,5542	0,0226***	0,5745
• Completed junior high school/equivalent vs completed university	-0,4658	0,0616	0,6276
• High school graduate/equivalent vs College graduate	-0,2369	0,3480	0,7891
Business field:			
• Animal husbandry vs Crop farming	-1,1399	0,0000***	0,3198
• Fisheries vs Crop farming	0,6198	0,0002***	1,8586
• Other agricultural activities vs Crop farming	-0,5720	0,0163***	0,5644
Business status:			
• Self-employed vs. Business assisted by permanent and paid workers	-1,4196	0,0000***	0,2418
• Doing business assisted by temporary workers/family workers/unpaid vs. Doing business assisted by permanent and paid workers	-1,3472	0,0000***	0,2600

Note: ***Significant at 5 Percent Alpha Level

Table 2 shows that agricultural digitalization, in this case the use of the internet in agricultural businesses, affects farmers' income in East Java. All other variables also influence farmer income, namely farmer gender, farmer education, agricultural business field, and business status. From the odds ratio results, it can be seen that the odds or tendency for farmers to have a high income (above average) if they use the internet in their business is almost double compared to farmers who do not use the internet. This shows that agricultural digitalization is actually helping farmers increase their income.

Male farmers also have almost twice the odds or tendency to have a high income (above the average) compared to female farmers. In terms of education, it appears that farmers who have lower education



have a lower tendency to earn high incomes compared to farmers who have higher education. Therefore, awareness of continuing education for farmers needs to continue to be increased because education can significantly influence farmers' income.

Judging from the agricultural business field, farmers who work in the fisheries business field have the odds or tendency to earn a high income (above the average) almost twice compared to farmers who work in the crop farming business field (seasonal crops, annual plants, ornamental plants, and plant breeding). Meanwhile, farmers who work on livestock and other agricultural activities have lower odds or tendencies to earn a high income (above the average) compared to farmers who work in crop farming (seasonal crops, annual crops, ornamental plants, and plant breeding).

The odds or tendency for farmers whose business status is self-employed to be assisted by permanent workers and paid to earn a high income (above the average) is four times compared to farmers whose business status is self-employed ($1/0.2418=4.1356$). Meanwhile, the odds or tendency for farmers whose business status is being supported by permanent and paid workers to obtain a high income (above the average) is almost four times compared to farmers whose business status is being supported by temporary workers/family workers/unpaid ($1/0.2600=3.8462$).

The results of the binary logistic regression analysis previously explained show that agricultural digitalization can play a role in increasing farmers' income. Next, what strategies does the government need to implement to encourage farmers to take advantage of agricultural digitalization? To answer this question, it is necessary to classify which farmers use the internet in their agricultural business and which farmers do not use the internet. The factors that influence internet use and determining the characteristics of farmers who use the internet as a form of agricultural digitalization are explained through the results of CART random undersampling and random oversampling.

Figure 3 is a classification tree obtained from data using a random undersampling process. The variable level of farmer education is the main determining variable and most determines the classification of farmers who utilize agricultural digitalization, in this case using the internet in their business. Variables that also play a role in determining the classification of farmers who utilize agricultural digitalization are farmer generation and business status.

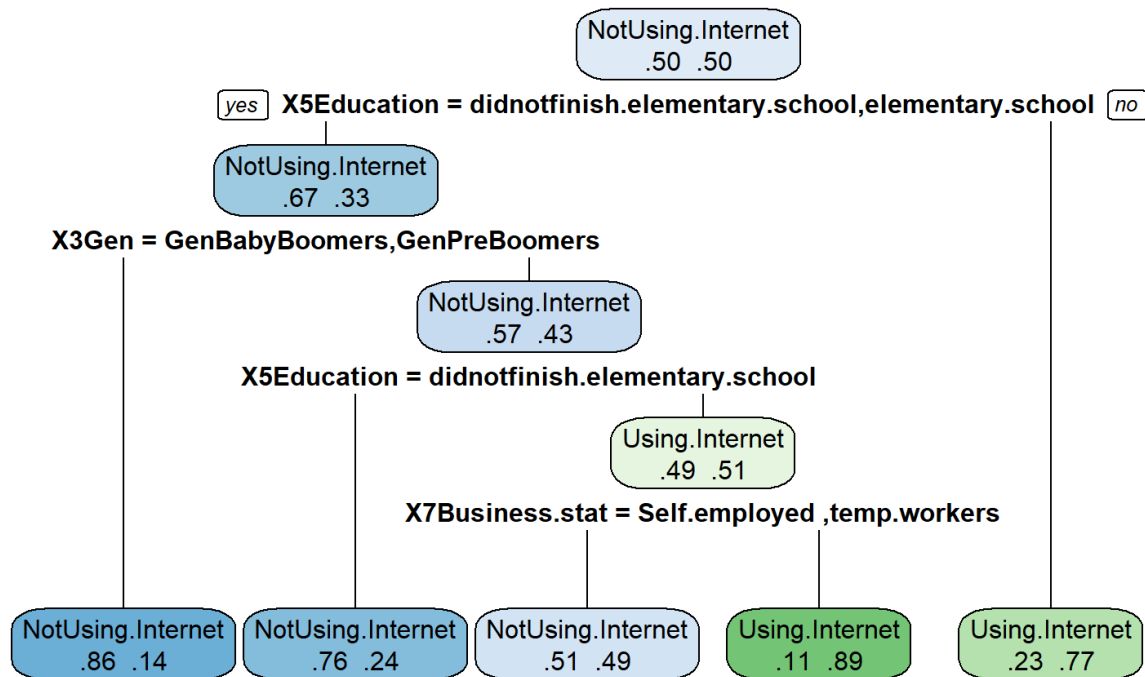


Figure 3. Random Undersampling Classification Tree of Farmers Using the Internet



The characteristics of farmers who utilize agricultural digitalization, in this case using the internet in their business, are as follows:

- 1) Farmers whose highest level of education is at least junior high school.
- 2) Farmers whose highest level of education is elementary school/equivalent, come from generation X, Y, or Z, and are working with the help of permanent/paid workers.

The characteristics of farmers who do not take advantage of agricultural digitalization, in this case using the internet in their business, are as follows:

- 1) Farmers whose highest level of education has been completed elementary school/equivalent or not completed elementary school/equivalent and come from the pre-boomers or baby boomers generation.
- 2) Farmers whose highest level of education is elementary school/equivalent, come from generation X, Y, or Z, and are self-employed or self-employed with the help of temporary/unpaid workers.
- 3) Farmers who have not completed elementary school and come from generation X, Y, or Z.

Figure 4 is a classification tree obtained from data using a random oversampling process. The farmer's education level variable is the main determining variable and most determines the classification of farmers who utilize agricultural digitalization, in this case using the internet in their business. Variables that also play a role in determining the classification of farmers who utilize agricultural digitalization are farmer generation and business field.

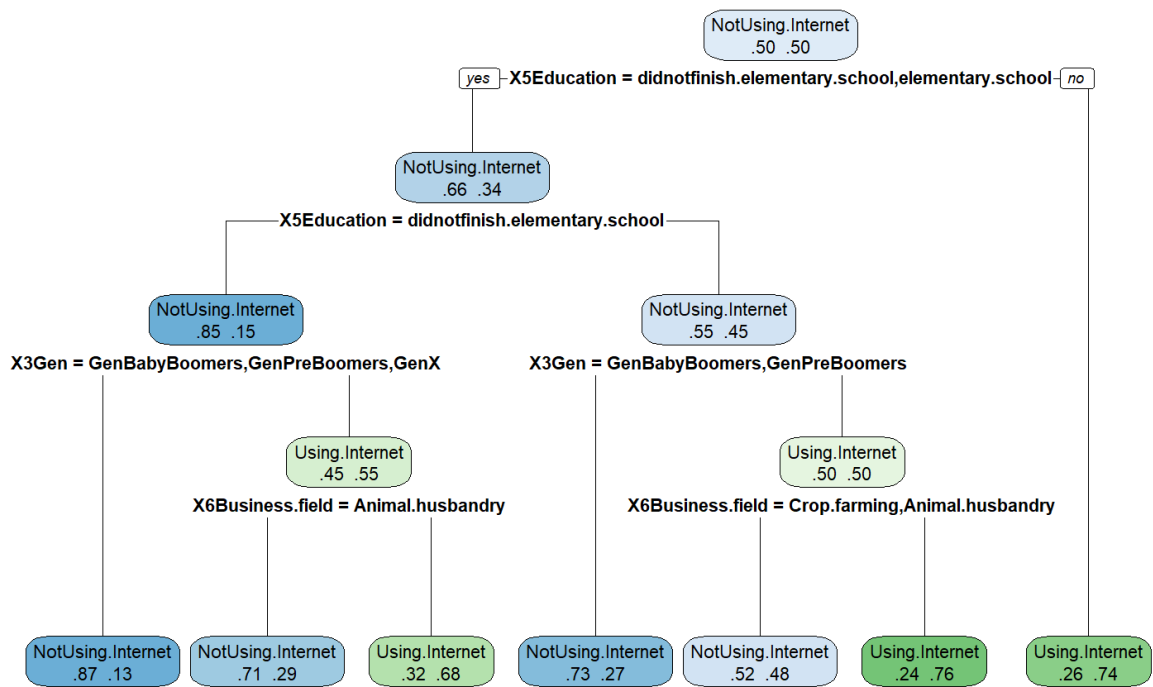


Figure 4. Random Oversampling Classification Tree of Farmers Using the Internet

The characteristics of farmers who utilize agricultural digitalization, in this case using the internet in their business, are as follows:

- 1) Farmers with the highest level of education completed at least junior high school.
- 2) Farmers whose highest level of education is elementary school/equivalent, come from generation and plant/animal breeding, and forestry and logging management).
- 3) Farmers who have not completed elementary school/equivalent, come from generation Y, or Z, and work in the field of crop farming (seasonal crops, annual crops, ornamental plants and plant breeding or fisheries (capture and aquaculture) or other agricultural activities (agricultural and post-harvest support services, hunting, catching and breeding plants/animals, and forestry and logging management).



The characteristics of farmers who do not take advantage of agricultural digitalization, in this case using the internet in their business, are as follows:

- 1) Farmers whose highest level of education is elementary school/equivalent and come from the pre-boomer or baby boomer generation.
- 2) Farmers whose highest level of education is elementary school/equivalent, come from generation X, Y, or Z, and work in crop farming (seasonal crops, annual crops, ornamental plants and plant breeding) or animal husbandry.
- 3) Farmers who have not finished elementary school and come from the pre-boomers or baby boomers or generation X generation.
- 4) Farmers who have not completed elementary school, come from generation Y or Z and work in the livestock business field.

Evaluation of binary logistic regression models using accuracy values. The data used in calculating accuracy values is testing data. The accuracy of the prediction results of the binary logistic regression equation in predicting farmer income categories was 71.85 percent.

Evaluation of the CART random undersampling and oversampling model using balanced accuracy values. The data used to calculate balanced accuracy is testing data. The balanced accuracy value of CART random undersampling in predicting farmers' agricultural digitalization category is 72.04 percent. The Balanced Accuracy value of CART random oversampling in predicting the farmer's agricultural digitalization category was 70.77 percent. This balanced accuracy value is smaller than the balanced accuracy value of CART random undersampling.

5. Conclusions and Recommendations

The majority of farmers carrying out agricultural business in East Java in 2022 from this research sample data have incomes below the average income of farmers in East Java. The majority of them do not take advantage of agricultural digitalization (the internet). Most of the farmers are male, have graduated from elementary school/equivalent, work in crop farming (seasonal crops, perennial plants, ornamental plants and plant breeding), work with the help of temporary/family/unpaid workers, and come from generation X (born 1961-1980).

Agricultural digitalization plays an important role in increasing farmers' income in East Java. This is shown by the results of the Student's t-test which states that the average income of farmers who implement digitalization is higher than those who do not implement agricultural digitalization. The results of binary logistic regression also show that agricultural digitalization (use of the internet in agricultural businesses) affects farmers' income in East Java. The odds or tendency for farmers to have a high income (above average) if they use the internet in their business is almost double compared to farmers who do not use the internet. Other variables that also influence farmer income are farmer gender, farmer education, agricultural business field, and business status.

The variable that most determines the characteristics of farmers who use the internet as a form of agricultural digitalization is the farmer's education level. Another variable that also plays a role in determining the characteristics of farmers who use the internet using the CART random undersampling and CART random oversampling methods is the generation of farmers. In the CART random undersampling method, there is an additional variable that plays a role in determining the characteristics of farmers who utilize agricultural digitalization, namely the variable agricultural business status. In the CART random oversampling method, there is an additional variable that plays a role in determining the characteristics of farmers who utilize agricultural digitalization, namely the agricultural business field variable.

CART random undersampling has a balanced accuracy value of 72.04 percent. This value is greater than the balanced accuracy value of the CART random oversampling method, which is 70.77 percent. There are two types of characteristics of farmers who utilize agricultural digitalization based on methods that provide the greatest balanced accuracy, namely farmers whose highest education is at least junior high school and farmers whose highest education is elementary school/equivalent, come from generation X, Y, or Z, and trying to be assisted by permanent workers/paid workers.



Based on the results of the binary logistic regression discussed previously, the recommendation for farmers is to implement the use of agricultural digitalization in their business because it can help increase income. The recommendation for the government based on the CART results is to prepare agricultural extension services so that farmers utilize agricultural digitalization in their businesses by paying attention to the characteristics of individual farmers, especially East Java farmers, as obtained from this research. The results of the research show that farmers in East Java who belong to generations Thus, agricultural counseling related to internet use for farmers of generations Meanwhile, for farmers who come from generations For farmers who come from the pre-boomer or baby boomer generation, the target of agricultural extension regarding internet use in this group is farmers with education less than junior high school/equivalent.

Bank Indonesia through its representative office in East Java can also collaborate with the East Java regional government (in this case the East Java Bappeda, East Java Education Service, East Java Statistics Communication and Information Service, and East Java Province Agriculture and Food Security Service) in designing mechanisms for promotion, outreach and education on the use of the internet in agricultural businesses for farmers. This program can be provided from the start, even at the basic education level so that farmers in East Java can understand the benefits of implementing agricultural digitalization. In the end, every farmer can implement agricultural digitalization and increase his income.

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