Impact analysis of coffee production in reducing poverty in Aceh Tengah

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Abstract. The plantation is a strategic sector in poverty alleviation. In the Aceh Tengah district, coffee is one of the leading plantation commodities that can increase the pace of the regional economy. Gayo coffee has a distinctive aroma and has a high price. Although generally, the people there are active in producing coffee, there are still poor people. It is necessary to analyse the impact of coffee production in reducing poverty in farming communities in Aceh Tengah district. This study uses a probit regression analysis method to see the characteristics of coffee farmers with significantly different non-coffee farmers. It then uses a Propensity Score Matching (PMS) analysis to see the impact of coffee production in reducing poverty farming communities in Aceh Tengah district. This study indicates that the characteristics significantly differ between coffee farmers and non-coffee farmers are age, education, access to food, eating little food, and assets having a motorbike. The per capita consumption of coffee farmers is not higher than that of non-coffee farmers, but the holdings of coffee farmers are more than those of non-coffee farmers.

1. Introduction
Agriculture is the most strategic sector in poverty alleviation because the agricultural industry can absorb labour, increase the national gross domestic product, and have a vital role in providing raw materials for the industrial sector[1]. Indonesia has made efforts to reduce poverty through several agricultural programs. The efforts that have been made are the intensification of land expansion, technology, irrigation, and extension reform[2]. Agricultural commodities that are commonly used as poverty alleviation projects are rice, corn, and oil palm. The high price of rice does not reduce the poverty rate; only 25% of the poor grow rice; in fact, the high cost of rice makes the poor people grow[3]. Corn production has proven to help reduce poverty when a crisis hits Indonesia. The strategy that needs to be done to increase the number of corn gardens and corn production in Indonesia is to subsidize input costs[4]. Oil palm certification in rural areas requires more resources to affect the socio-economic effects of smallholders[5]. The coffee commodity is also believed to be used as a poverty alleviation project. Coffee is one of the leading commodities in Aceh. Coffee plantations in Aceh Tengah district have considerable potential compared to other communities. In the province of Aceh, coffee plantations are located in 3 districts, namely Aceh Tengah, Bener Meriah, and Gayo Lues Districts.
Table 1. Land area and production of coffee plantations by district/city in Aceh, 2018.

| District     | Production (tons) | Area (ha) |
|--------------|------------------|-----------|
| Aceh Tengah  | 32,039           | 50,408    |
| Bener Meriah | 31,138           | 48,163    |
| Gayo Lues    | 1,545            | 5,083     |

In Table 1, the number of coffee production (tons) in the Aceh highlands. Based on the table, in 2018, Aceh Tengah District produced 32,039 tons of coffee, Bener Meriah District produced 31,138 tons of coffee, and Gayo Lues District had 1,545 tons of coffee [6]. The highest coffee production is found in the Aceh Tengah District. The population in Aceh Tengah, most of whom work as coffee farmers, of course make the production of coffee plants as income to improve the regional economy. So, being a coffee farmer has a significant role in the economy in Aceh Tengah District.

On May 27, 2010, Gayo coffee received a Fair Trade Certified certificate from the International Fair Trade organization. On October 10, 2010, they also received the highest cupping score in the Indonesian Coffee Special auction event in Bali. These certifications and achievements make Gayo coffee the world's best organic coffee. The award received by Gayo Arabica coffee makes Gayo coffee better known in the world's eyes to increase the value of exports and improve the economy of coffee farmers in Aceh Tengah district. With various awards and advantages, Gayo coffee has high value so that by becoming a coffee farmer can reduce poverty in Aceh Tengah District.

Table 2. Percentage of poor population in Aceh Tengah District.

| Year | Percentage (%) |
|------|----------------|
| 2014 | 16.99          |
| 2015 | 17.51          |
| 2016 | 16.64          |
| 2017 | 16.84          |
| 2018 | 15.58          |

Poverty is characterized by low consumption and inadequate standard of living, poor health, limited access to education, knowledge and information [7]. Some solutions to reduce poverty are the equitable distribution of wealth, justice through political and economic democracy, a decentralized economy, the balance between cooperation and competition, constitutional rights based on necessities of life, appropriate education, and agricultural reform [8]. Based on the data in the table above, the poverty rate in Aceh Tengah Regency fluctuates. In 2014 the percentage of poor people in Aceh Tengah Regency was 16.99% and in 2015 increased to 17.51% for poor people, then in 2016, there was a decrease, then in 2017, there was an increase again, and in 2018, the percentage of poor people was 15.58% [9]. It shows that the poverty rate in Aceh Tengah does not tend to decrease from year to year, so efforts are needed to reduce the poverty rate significantly.

The impact of coffee on poverty reduction has attracted the attention of many researchers. Some researchers analyse the effects of selling coffee to cooperatives on poverty reduction [10] [11]. The impact of coffee certification on poverty reduction [12]. The role of coffee as the primary plantation sector that can reduce poverty [13]. And the impact of coffee production on poverty reduction [14]. Based on the above background, the researcher adopts the analytical method Mbow et al. [6]. to analyse whether coffee production activities can help reduce poverty in Aceh Tengah? If coffee farming communities have higher per capita consumption of assets, then coffee-producing actions can prove to be able to help reduce poverty.
2. Methods

2.1. Study area
This research was conducted in the Aceh Tengah district. The research subjects are farmers who cultivate coffee and those who do not. This study uses national socio-economic survey data from the Central Statistics Agency, 2017 - 2019. This study is used to see the impact of agriculture on poverty reduction in farming communities in Aceh Tengah district. The analysis method of this research is to describe the characteristics of coffee farmers and non-coffee farmers. Factors in farming communities consist of age, gender, marital status, education level, and ownership of savings in financial institutions (banks/cooperatives).

2.2. Probit regression analysis
Probit regression analysis is used to see the relationship between the dependent variable, which is categorical (qualitative), and the independent variables, both qualitative and quantitative. The estimated value results for the propensity score method are obtained. The estimated propensity score is a significant characteristic that distinguishes coffee farmers from non-coffee farmers. The form of probit regression is as follows:

\[
Pr(C=1)=\sigma_0+\sum_j \sigma_1 H_j+\sum_r \sigma_2 FIN_r+\sum_d \sigma_3 REGL_d+\sigma_4 Z+\sum_e \sigma_5 ASSET_e+\epsilon
\]  

(1)

Where, C represents the dependent variable (category), \( C_i = 1 \) if the head of the household is a coffee farmer, and \( C_i = 0 \) if the head of the family is a non-coffee farmer. With the variables in it, namely:

\( H \) : Household characteristics which include sex male (1) or female (0), age in units (years), marital status categorized as married (1) or unmarried (0), education level ranging from Elementary School (1) Junior High School (2) Senior High School (3) College (4). Marital status, calculated with a score of (1) if not married (2) if married, (3) divorced alive and (4) divorced dead.

\( FIN \) : Access to financial membership in a savings and loan cooperative (possibly also a social capital proxy), access to credit, health insurance, and other crop or agricultural insurance.

\( REGL \) : Represents the geographical location of the household including urban–rural areas.

\( Z \) : constraints in consumption, namely access to food such as worrying about not having enough food, eating few types of food, skipping one meal on a certain day). With a score of (0) there are no barriers to access to food and (1) have problems with access to food

\( ASSET \) : Ownership of assets, given a score of (1) if you have assets and given (0) if you don't have assets. Assets owned in the form of refrigerator/refrigerator, air conditioner, landline telephone, computer/laptop, motorcycle, car, 30-inch screen television, owns land/land.

2.3. Propensity score matching analysis
Propensity score matching (PSM) analysis is an alternative method for estimating the impact of a treatment on a particular subject. This study analyses the impact of the coffee farming profession in reducing poverty in coffee farming communities using the propensity score matching (PSM) analysis method. Two groups were compared, namely the group that received the treatment (treatment) and the control group. The first step is to estimate the value of the Propensity score using the probit regression method. The propensity score is a value that states the relationship of the subject (coffee producing farmers and non-coffee farmers) to a characteristic that exists in the farming community. After obtaining the propensity score, the second step is to choose a matching algorithm (matching algorithm). In this study, Nearest Neighbor Matching (NNM) was used. Furthermore, in the third step, identify the overlap and joint support between the two groups and, when compared, see the distribution. After that, the Average Treatment of Treated Effect (ATT) value is estimated. The estimated value of the Average Treatment of Treated Effect (ATT) is calculated based on per capita expenditure and total assets, an overview of the Average Treatment of Treated Effect
(ATT) in the group receiving treatment, namely coffee production farmers as follows (Mbowa et al. 2017):

\[ E[Z_1 - Z_0 | X, C = 1] \]  

Where,

E : Estimated value

\( Z_1 \): Per capita expenditure (Rp/month) and total treatment assets

\( Z_0 \): Per capita expenditure (Rp/month) and total control assets

X: Influencing characteristics

C=1: Group of farmers who produce coffee

\( E[Z_{(1)} | X,C=1] \) is the estimation result of the treatment group. Overall household consumption expenditure is obtained by aggregating expenditure per item from various sub-components. Then \( E[Z_{(0)} | X,C=1] \) is the factual control and X is the observed characteristic. The term right-hand side is used in the invoice control estimation equation as follows:

\[ E[Z_0 | X, C = 1] = E[Z_0 | X, C = 0] \]  

Then to estimate the impact of coffee production on per capita expenditure and total assets owned as follows:

\[ ATT = \frac{1}{n_1} \sum_{j \in I_1 \cap S_p} (Z_{1j} - E[Z_{0j}|C = 1, Pr]) \]  

Where,

\( I_1 \) : Population of coffee farmers.

\( I_0 \) : Population of non-coffee farmers.

\( S_p \) : Area of residence.

\( n_1 \) : Total population collected based on \( I_1 \cap S_p \)

\( W_{ij} \) : The weight for each observation in the comparison group according to the distance between the propensity scores of these observations and their comparative propensity scores in the treatment group.

\[ E[Z_{0j}|C = 1, Pr] = \sum_{j \in I_0} W_{ij} Z_{0j} \]  

Equation 5 is an accurate control estimate.

3. Results and discussion

Before entering the Propensity Score Matching (PSM) equation, first determine the covariate variables. Covariate variables were obtained by analysing the close relationship between the independent variables, namely the characteristics and level of welfare of the dependent variable, namely coffee farmers and non-coffee producing farmers. The analysis used the probit equation. The results of the probit analysis obtained are as follows:

In this study using data in 2019, the characteristics that compare coffee farmers with non-coffee farmers in seeing how the coffee farmer's profession in reducing poverty consists of characteristic probit results data in 2019 as shown in Table 3.

The age variable in the probit regression results can be seen that the p-value is 0.004, so it can be said that there is a significant difference between the age of the farmer and the farmer's profession in growing coffee with a significant level of 1%. The value of the variable coefficient of coffee farmers' age is 0.0387903, the value of the coefficient is positive, it can be seen that coffee farmers are older than non-coffee farmers.
Table 3. Probit regression from the comparison of characteristics of coffee and non-coffee farmers.

| Variables                                      | Coefficient | Std. err | z    | P >|z|
|------------------------------------------------|-------------|----------|------|-----|
| Constant                                      | -2.052.069  | 1.632646 | 1.26 | 0.209|
| Age                                           | 0.0387903   | 0.0135226| 2.87 | 0.004*|
| Male gender                                   | 0.2393925   | 0.5344664| 0.45 | 0.654|
| Status                                        | -0.2297844  | 0.3181014| 0.72 | 0.470|
| Not married yet                               |             |          |      |      |
| Marry                                         |             |          |      |      |
| divorced                                      |             |          |      |      |
| death divorce                                 |             |          |      |      |
| Region classification – rural                 | -0.0700749  | 0.8568669| 0.08 | 0.935|
| last education                                | 0.9854827   | 0.2920827| 3.37 | 0.001*|
| Junior high school                            |             |          |      |      |
| Senior High School                            |             |          |      |      |
| College                                       |             |          |      |      |
| Have savings in a banking/cooperative financial institution | 0.6255954   | 0.4350688| 1.44 | 0.150|
| Access to food                                |             |          |      |      |
| Worried about not having enough food          | 0.1864611   | 0.2880392| 0.65 | 0.517|
| Eat a few kinds of food                       | -0.9952396  | 0.4377272| 2.27 | 0.023*|
| Skipping one meal on any given day            | 0           |          |      |      |
| Asset                                         |             |          |      |      |
| Refrigerator / refrigerator                   | -0.3446656  | .3712724 | 0.93 | 0.353|
| Air conditioning                              | 0           |          |      |      |
| Home phone                                    | 0           |          |      |      |
| computer / laptop                             | 0.3014581   | 0.6164868| 0.49 | 0.625|
| Motorcycle                                    | 0.6238833   | 0.3352786| 1.86 | 0.063**|
| Car                                           | 0.0937609   | 0.6632585| 0.14 | 0.888|
| Television (30 in screen)                     | 0.7512237   | 0.6645882| 1.13 | 0.258|
| Own land / land                               | 0.7272187   | 0.5159111| 1.41 | 0.159|
| Expenditure per capita                         | 7.79e-07    | 4.50e-07 | 1.73 | 0.083**|

Description: ** = significant 0.1. * = significant 0.05

The education variable has a p-value of 0.001, so it can be said that the education variable is significant with a significance level of 1%. The coefficient value obtained by the last education variable is 0.2920827; the coefficient value is positive. It is known that coffee farmers take a higher level of education than non-coffee farmers.

The variable access to food in the probit results also showed a significant p-value with a p-value of 0.023. The coefficient value obtained is -0.9952396. The value of the coefficient is negative, and it is said that non-coffee farmers tend to eat less food than coffee farmers.

In the asset variable, motorcycle ownership shows a significant value with a p-value of 0.063 at a level of 5%. The coefficient value obtained is 0.6238833. If the coefficient value is positive, it can be said that most coffee farmers have motorbikes.
The variables used as covariates in matching are significant differences between coffee farmers and non-coffee farmers in poverty levels. The covariates used are age, last education, access to food, eating few types of food, and having motorbike assets. Outcome is a variable that will change its value due to changes in the value of the Independent/Predictor. The outcomes used to compare the treatment group and the control group are the total assets owned (refrigerator/refrigerator, air conditioner, home telephone, computer/laptop, motorbike, car, 30-inch screen television, owns land/land) and per capita expenditure. Then to determine the value of the propensity score, regression was carried out in the treatment group and the control group on the covariate variables. Regression using probit regression, the results are as in Table 3.

| Variables                                    | Coefficient | Std. err | z      | P >|z| |
|----------------------------------------------|-------------|----------|--------|-----|
| Constant                                     | –1.711.414  | 0.7787509| 2.20   | 0.028|
| Age                                          | 0.0293083   | 0.0112931| 2.60   | 0.009*|
| last education                               | 0.9253745   | 0.2520984| 3.67   | 0.000*|
| Eat a few kinds of food                      | 0.4394981   | 0.3233196| –      | 0.174 |
| Owning a motorbike                           | 0.5373298   | 0.2928882| 1.83   | 0.067**|

The impact of coffee production was calculated using Propensity Score Matching (PSM). By using the nearest neighbour (NN) method, which compares the nearest propensity value of each of the treatment group (coffee farmers) with the control group (non-coffee farmers) with one comparison. From this comparison can produce the average treatment effect or Average Treatment Effect on The Treated (ATT). The ATT value was used as the difference value between the treatment group and the control group.

There are several variables that are not used as covariates in calculating the propensity score. If these variables are not significant to distinguish coffee farmers from non-coffee farmers, such as relationship status, regional classification, having savings and access to food and some assets owned. Table 5 shows the value of the Average Treatment Effect on the Treated (ATT) of the covariate variables, namely the characteristics that affect the difference in total assets owned and per capita expenditures issued by farmers between the treatment group and the control group.

| Variable                    | Sample                  | Coffee farmers | Non- Coffee farmers | Difference | S,E | T–stat |
|-----------------------------|-------------------------|----------------|---------------------|------------|-----|--------|
| Total assets owned          | Before matching         | 2.34798535     | 1.76                | 0.587985348| 0.247867266| 2.37 |
|                             | After matching (ATT)    | 2.34798535     | 1.92307692          | 0.424908425| 0.313780579| 1.35 |
| Expenditure per capita      | Before matching         | 1,136,235.19   | 919,945.16          | 216,290.034| 120,637.413| 1.79 |
|                             | After matching (ATT)    | 1,136,235.19   | 869,4632.09         | 266,771.985| 125,840.394| 2.12 |

In Table 5, it can be seen the value of the total asset analysis (refrigerator/refrigerator, air conditioner, landline telephone, computer/laptop, motorcycle, car, 30-inch television screen, owns land/land) coffee farmers non-coffee farmers, namely 0.587985348. After the matching aimed at the ATT, the total assets

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**Table 4. Probit regression to get a propensity score.**

**Table 5. Results of measuring the impact of coffee production with Propensity Score Matching (PSM) using the nearest neighbour method.**
of coffee farmers with non-coffee farmers have a coffee difference of 0.424908425. And the per capita expenditure shows a difference of IDR 216,290. After a match aimed at the ATT, the coffee farmers’ per capita expenditure costs differ from IDR 266,771. Based on the measurement of the impact of coffee production farmers using the psmatch2 method and the nearest neighbor (NN) method, coffee production farmers can increase their per capita expenditure. Results of measuring the impact of coffee production with Propensity Score Matching (PSM) using the nearest neighbor method.

| Treatment          | Covariates used | Covariates discarded | Total |
|--------------------|-----------------|----------------------|-------|
| Coffee farmers     | 273             | 0                    | 273   |
| Non-coffee farmers | 25              | 0                    | 25    |
| Total covariates   | 298             | 0                    | 298   |

The standard support area represents the similarity of characteristics between the two groups based on the similarity of the distribution of their propensity values. In the PSM method, observations that have different propensity scores will be excluded. The process of matching the Propensity Score Matching scores seen in table 12 shows the propensity value of coffee farmers with non-coffee farmers getting a matching pair or a total of 298 units of standard support consisting of 273 units from the treatment group and 25 controls. Thus no observations are discarded during the comparison process.

Moreover, the balancing test was carried out to determine the existence of a bias between each of the variables used in the matching process or a balancing test between variables from the treatment group and the control group to see possible biases (Sinaga, 2019). To determine the existence of a bias between the coffee farmer group and the non-coffee farmer group, a balancing test must be carried out on each covariate variable. The results after the balancing test can be seen in table 6.

| Variable          | Sample               | Coffee farmers | Non-coffee farmers | Difference | S.E.    | T-stat |
|-------------------|---------------------|----------------|--------------------|------------|---------|--------|
| Total assets owned| Before matching      | 2.3498535      | 1.76               | 0.587985348| 0.247867266| 2.37   |
|                   | After matching (ATT)| 2.34798535    | 0.534798535        | 1.81318681 | 0.506341237| 3.58   |
|                   | Before matching (ATT)| 1.136.235.19  | 919.945.16         | 216.290.034| 120.637.413| 1.79   |
|                   | After matching (ATT)| 1.136.235.19  | 1.180.038.75       | –          | 567.782.345| 0.08   |

The results of the t-test showed a significant effect on total assets (refrigerator/refrigerator, air conditioner, landline telephone, computer/laptop, motorcycle, car, 30-inch television screen) where t-test (3.58) was greater than t-table (3.11) with a significant level of 0.001. In contrast, the per capita expenditure showed insignificant results. After matching, there is a difference of 1.81318681 where the total assets of coffee farmers are 2.34798535, and non-coffee farmers are 0.534798535. Coffee farmers can reduce poverty because the assets owned by coffee farmers are more than non-coffee farmers.

The results of the t-test showed a significant effect on total assets (refrigerator/refrigerator, air conditioner, landline telephone, computer/laptop, motorcycle, car, 30-inch television screen) where t-test (3.58) was greater than t-table (3.11) with a significant level of 0.001. In contrast, the per capita expenditure showed insignificant results. After matching, the difference is equal to expenditure per capita in the study. The results are not significant, where the t table value is greater than the t value of
the results. The difference after matching is Rp–43,803, where the per capita expenditure of coffee farmers is Rp. 1,136,235, and the per capita expenditure of non-coffee farmers is Rp. 1,180,038. Per capita expenditure is a cost incurred for the consumption of all household members for a month divided by the number of household members. This reveals that there is no impact of the coffee farming profession in reducing poverty in farming communities in Aceh Tengah district. Based on the per capita expenditure of coffee farmers, it is less than the per capita expenditure of non-coffee farmers, only Rp43,803.

4. Conclusions
Characteristics of farming communities that significantly differentiate between coffee and non-coffee farmers (farmers of rice and secondary crops, horticultural farmers, and forestry) in Aceh Tengah district are age, education, access to food, eating little food, and assets own a motorcycle. Coffee farmers have higher education than non-coffee farmers. Coffee farmers do not have problems with access to food, and coffee farmers have more motorcycle assets than non-coffee farmers. The impact of the coffee farming profession in reducing poverty is positive. Coffee farmers have total assets (refrigerators/refrigerators, air conditioners, home telephones, computers/laptops, motorcycles, cars, 30-inch television screens) more than non-coffee farmers—compared to non-coffee farmers. However, seen from the comparison of per capita expenditure, it does not show a significant difference. The per capita expenditure of coffee farmers and non-coffee farmers is not much different. The per capita expenditure of non-coffee farmers is Rp. 43,804, more than coffee farmers. Judging from the average per capita spending of farmers in Aceh Tengah District, coffee farmers above the poverty line.

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