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The Effect of Agricultural Extension Access on The Performance of Smallholder Sugarcane Farmers in Indonesia

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ABSTRACT

Agricultural extension plays a crucial role in the Indonesian Agricultural Revitalization Program for the 2005-2025 periods, where sugarcane is one of the fourteen priority crops. The provision of an agricultural extension was aimed to increase the income and productivity of sugarcane farmers. This study aimed to evaluate the effect of agricultural extension access on smallholder sugarcane farmers' performance in Indonesia. This study used data from the 2014 Indonesian Sugarcane Farm Household Survey, consisting of 8,831 farmers. This study employed propensity score matching to estimate the effect of access to an agricultural extension on several outcome variables. These variables were gross value-added (GVA), net value added (NVA), labor productivity (LP), land productivity (LDP), net income (NI), and remuneration of family labor (ROFL). The result shows that having access to an agricultural extension increases GVA by 40.5%, NVA by 40.3%, labor productivity by 42.8%, and NI by 40.2%. However, access to agricultural extension insignificantly affects ROFL due to the differences in family working units. Also, farmers with Agricultural Extension access have 13.7% lower land productivity than non-Agricultural Extension farmers since the former has lower input use intensity than the latter. These results suggest that providing agricultural extension service is adequate to improve sugarcane farmers' economic performance.

Keywords: Agricultural extension, farm gross value-added, farm net value-added, net income, remuneration of family labour

INTRODUCTION

Agricultural Extension (AE) plays a crucial role in improving farmers' managerial and technical capacity (MTC) (Bhatta, Ishida, Taniguchi, & Sharma, 2008; Hansson, 2008). An improved farmer's MTC is essential to increase farm production, minimize yield loss due to better pest management, and foster technology adoption that further increases farm productivity (Hansson, 2008). Thus, AE has a strategic role at the macro level to improve agricultural productivity and improve farm performance and farmer welfare at the micro-level. In Indonesia, AE is an integral part of the Agricultural Revitalization Program (ARP)

for the 2005-2025 periods. The government legalized Act 16/2006 to establish the national Agricultural Extension System (AES). The AES establishment aims to achieve the ARP-2025 goals of improving farm performance and farmer welfare for 14 strategic commodities. Sugarcane is a strategic commodity that serves as the primary raw material for the Indonesian sugar industry and livelihood source for 287,099 farm households (BPS-Statistics Indonesia, 2019). However, the lack of high-quality seed plants and the inefficient farm is currently causing the low productivity of sugarcane farmers (Toharisman, Triantarti, & Hasan, 2013). AE plays a crucial role in solving this challenge since it increases farmers' probability of adopting high-quality seeds and improving farming practices (Suwandari *et al.*, 2020). Thus, evaluating how AE improves farm performance and farmer welfare is crucial.

Various studies have identified how AE affects farm performance in different countries, utilizing nationally representative farm data. Ragasa and Mazunda (2018), using a national household panel survey from the Government of Malawi, found that AE is strongly associated with maize and legume farmers' productivity. The BRAC extension program improves farmers' basic cultivation methods in Uganda, increasing productivity gains from the same farm inputs quality (Pan, Smith, & Sulaiman, 2018). Similarly, Cunguara and Moder (2011), utilizing the National Agricultural Survey of 2005 in Mozambique, found that AE increases farm productivity by 11%, but the extension officers tend to choose wealthy farmers, potentially increasing income inequality in the rural area. Also, Emmanuel, Owusu-Sekyere,, Owusu, & Jordaan (2016) used the 2011 Ghana Agricultural Production Survey to estimate the effect of AE on rice farmers' productivity. They found that AE increases rice farm productivity through increased chemical fertilizer application. Finally, a study using the Teagasc National Farm Survey found that AE increases Irish farmers' income. These findings demonstrate that AE significantly improves farm productivity and income (Cawley, O'Donoghue, Heanue, Hilliard, & Sheehan, 2018). However, it potentially increases rural income inequality and environmental damages through increasing chemical inputs use.

To date, few studies evaluate the Indonesian AES policy using appropriate and nationally representative farm data. The majority of AE-related studies in Indonesia is case studies in nature and did not use comprehensive farm performance variables. Examples of those studies are Wardana and Sunaryanto (2019), who studied rice farmers perception toward AE and its impact on their welfare in Semarang, Yunita, Satmoko, & Roessali (2018), who studied the role of AE on the adoption of Integrated Crop Management by rice farmers in Magelang, and Prihatin, Aprolita, & Suratno (2018) who studied the effect of AE on-farm labor productivity in vegetable farming in Muaro Jambi. These studies found that AE positively impacts farm performance. An exception to the previous studies is (Indraningsih, 2015), who conducted an *ethnomethodology* study on Indonesian AES's governing bodies in Java, Sumatra, and Sulawesi. The study found that extension policies increase rice productivity by 29-32.7%.

Based on that background, this study aimed to evaluate the effect of AE on the performance of smallholder sugarcane farmers in Indonesia. The study used data from the

2014 Indonesian Plantation Farm Household Survey, consisting of 8,831 farmers. The study used comprehensive performance variables representing farm value-added (Gross Value-Added and Net Value-Added), farm productivity (labor and land productivity), farm income, and family labor remuneration. These variables effectively measure farm economic performance but are rarely used in AE-evaluation studies, particularly in Indonesia. A comprehensive economic evaluation of AE is needed to understand how AE affects and improves farm performance. The primary contribution of this study is to inform whether and how much AE affects the performance of smallholder sugarcane farmers in Indonesia.

RESEARCH METHOD

Research Design

This study used a Mixed-Method Sequential Explanatory Approach (M-MSEA) design to estimate the effect of AE access on farmer performance. M-MSEA consists of two analytical stages, the quantitative and qualitative stages (Creswell, 2013). The M-MSEA aims to obtain generalizable findings from the quantitative stage backed with the qualitative stage's explanations. In the quantitative stage, we estimated AE access on smallholder sugarcane farmers' performance using nationally representative data of 8,831 farmers. Figure 1 shows the distribution of farmers. In the qualitative stage, we explored the mechanism by which AE was delivered to farmers. In the second stage, we conducted in-depth interviews with sugarcane farmers, government extension officers, and private enterprise extension officers. The interviews were conducted at Malang regency, East Java, in November 2020.

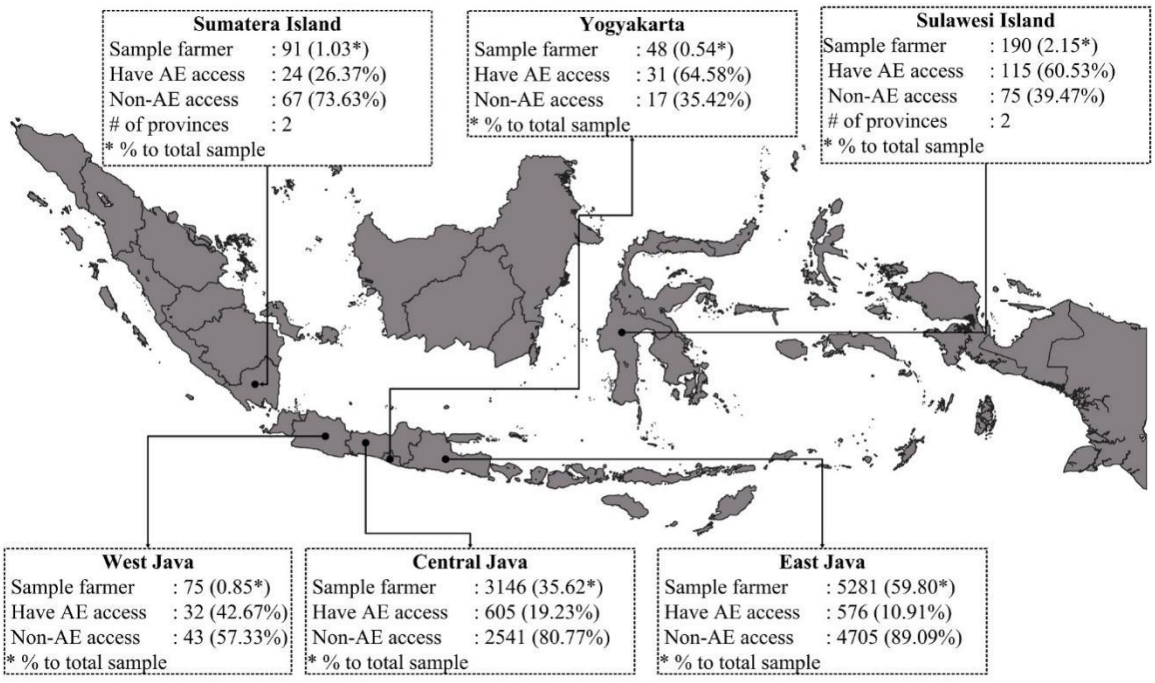

FIGURE 1. THE DISTRIBUTION OF SMALLHOLDER SUGARCANE FARMERS IN INDONESIA

Data

This study used nationally representative data of sugarcane farmers in Indonesia for the quantitative stage. The data was the result of the 2014 Indonesian Plantation Farm Household Survey (IPFHS). The IPFHS data is appropriate for this study for three reasons. First, the survey was conducted in 2014 and can capture the first half of ARP2025. Second, the data has nationwide coverage of sugarcane farmers; thus, it accurately measures the national agricultural extension program's outcome. Third, the data cover comprehensive socio-economic information of sugarcane farmers, making it possible to perform a thorough farm economic assessment. The data consists of 8,831 sugarcane farmers distributed in eight provinces (Figure 1). The figure shows that most sugarcane farmers are located in East Java (59.80%) and Central Java (35.62%). The total number of farmers in both provinces accounts for 95.42% of total sugarcane farmers in Indonesia. The rest of the farmers are located in Sulawesi Island (2.15%), Sumatera Island (1.03%), West Java (0.85%), and Yogyakarta (0.54%).

Estimating the effect of AE access on smallholder sugarcane farmers performance

The estimation of the AE effect on farmer performance consisted of two phases. First, we assessed farm economic performance using the Farm Accountancy Data Network (FADN) framework. The framework provides comprehensive indicators to measure the value-added and profit from farming activity, labour productivity, and family labour remuneration. For that purpose, this study used five indicators: farm gross value-added, farm net value-added, labour productivity, net farm income, and remuneration of family labour. The calculation of these indicators used variables in Table 1 (coded 2). Then, these indicators will be used as outcome variables in the second phase of quantitative analysis. Table 2 shows the formula for each indicator.

TABLE 1. THE FARM PERFORMANCE INDICATORS

Variable	Unit	Description	Formula
FGVA	IDR/yr	Farmer Gross Value Added	Output + Government Support – Intermediate Consumption
FNVA	IDR/yr	Farmer Net Value Added	FGVA – Tax – Depreciation
LP	IDR/AWU	Labour Productivity	FNVA / AWU
LDP	IDR/Ha	Land Productivity	FNVA/UAA
FNI	IDR/yr	Farm Net Income	FNVA – Total External Factors + Balances of Government Support and Taxes Investment
RoFL	IDR/AFWU	Remuneration of Family Labour	FNI – Opportunity Cost of Own Land – Opportunity Cost of Own Capital

Note:

1. FGVA: Farm Gross Value-Added, FNVA: Farm Net Value-Added, LP: Labour Productivity, LDP: Land Productivity, FNI: Farm Net Income, RoFL: Remuneration of Family Labour.
2. AWU is an annual working unit, and AFWU is an annual family working unit

We estimated the average treatment effect on the treated (ATT) of AE access on smallholder sugarcane farmer's performance in the second quantitative analysis phase. The ATT has been widely used to estimate the effect of an intervention using observational data. The ATT is the expected value difference between the outcome variables of the control and

treated group. Since we used observational data, we assumed that the data meet conditional independence and overlapping assumptions. Then, we estimated the ATT using propensity score matching analysis (PSM). Equation 1 denotes the estimation formula in PSM.

$$ATT = E(y_{ij}|D_j = 1, p(x_{ij})) - E(y_{oj}|D_j = 0, p\,(x_{ij})) \quad (1)$$

Where E(●) denotes the expected value of the outcome variables for farmers with AE access (y_{1j}) and farmers with no AE access (y_{0j}).

The PSM estimates the farmers' probability of accessing AE using several observable characteristics (x_{ij}). The probability values were obtained from propensity scores generated using a logistic regression model (LRM). The dependent variable in the LRM is farmer's access to AE, and the independent variables consisted of eight socio-economic variables shown in Table 1 (coded 1). Equation 2 denotes the formula to estimate the LRM.

$$Y_i = \ln\left(\frac{p_i}{1-p_i}\right) = \frac{e^{b_0+\sum_{b=0}^{8} b_i x_i}}{1+e^{b_0+\sum_{b=0}^{8} b_i x_i}}, i = 1,2,K\ ,8 \quad (2)$$

Y_i is farmer access to AE (1=have access, 0=have no access), b_0 is the regression constant, b_i is the parameter to be estimated, and x_i is the independent variable.

The likelihood ratio test and pseudo R^2 were used to check the robustness of the LRM. Before estimating the ATT, a balance test was conducted to test the balance between the control and treated groups. A balance test was performed to make a relevant comparison group and decide the appropriate matching algorithm (Baser, 2006). We estimate the ATT using the radius matching algorithm. This algorithm is appropriate because it matched each observation in the treated group with those in the control group, which propensity scores within a predefined radius (Dehejia & Wahba, 2002). That way, more observations from the control will be used if suitable matches are available, and fewer observations will be used if suitable matches are not available.

RESULTS AND DISCUSSION

Result

Socio-economic characteristics of Indonesian smallholder sugarcane farmers

This study used data from the 2014 Indonesian Plantation Farm Household Survey for sugarcane. The data cover farmers in eight provinces and have a wide range of socio-economic characteristics. The variables cover the social (age, education, gender), economic (utilized agricultural area, farm capital, wealth), and institutional (government support and contract farming) aspect of sugarcane farming. Also, the data cover the farming aspect such as farm production, farm labor, seed plant, fertilizer, and pesticide. Table 2 summarizes the socio-economic characteristics of smallholder sugarcane farmers in Indonesia.

TABLE 2. SOCIO-ECONOMICS CHARACTERISTICS OF INDONESIAN SUGARCANE FARMERS

Code	Variable	Have access to AE			Have no access to AE		
		Mean	SD.	Freq.[1]	Mean	SD.	Freq.
1	Age (yr)	50.7	11.1		51.8	11.9	
1	Education						
	Elementary			872 (63.05)			5,416 (72.72)
	Middle			436 (31.53)			1,815 (24.37)
	High			75 (5.42)			217 (2.91)
1	Gender						
	Female			78 (5.64)			779 (10.46)
	Male			1,305 (94.36)			6,669 (89.54)
1	UAA (ha)	22.48	70.47		0.72	21.04	
1	Capital (IDR)[4]	45,882.9	17,1015.7		10,669.5	39,659	
1	Wealth						
	Poor			360 (26.03)			2,181 (29.28)
	Wealthy			1,023 (73.97)			5,267 (70.72)
1	Government Support						
	Not Receive			765 (55.31)			4,062 (54.54)
	Receive			618 (44.69)			3,386 (45.46)
1	Contract Farming						
	Not Participate			466 (33.70)			5,329 (71.55)
	Participate			917 (66.31)			2,119 (28.45)
2	Production (kg)	78,238.3	28,3027.5		24,764.6	88,857.8	
2	Hired Labour	27.2	70.3		10	70.1	
2	Family Labour	2.8	5.4		1.8	5.5	
2	Seed Plant	31,038.3	59,132.1		14,509	59,272.1	
2	Fertilizer						
	Urea	100	333.6		69.6	334.2	
	TSP/SP36	78.6	395.3		24.7	396.2	
	Za	1,416	2,684.3		487.9	2,689.3	
	KCl	32.2	161		10.4	161.7	
	NPK	719	1,612.2		221	1,614.8	
	Organic	641.8	1,798.3		272.7	1,801.1	
2	Pesticide						
	Solid	0.1	195.3		2.8	195.7	
	Liquid	213.5	2,050.9		51.8	2,054.9	
2	Growth Simulator						
	Solid	0.9	12		0.6	12.1	
	Liquid	31.5	1,144.3		60	1,146.6	
	Sample size (n)			**1,383**			**7,448**

Note:

1. The value represents the number of the farmer for each category in each group for the categorical variable.
2. Household size is the number of household members (including farmers) in a particular farm household.

The data in Table 2 suggests that young and educated farmers have better access to AE. On average, a farmer with access to AE is one year younger than those with no AE access. Also, the educational attainment of farmers with access to AE is higher than their counterparts. In the former group, 36.95% of farmers attended middle and higher education, higher than that of the latter, 27.29%. Meanwhile, 63.05% of farmers having access to AE have elementary education, lower than those who have no access to AE,

72.72%. But, access to AE seems to be gender-biased since the percentage of female farmers with access to AE is lower than those with no access to AE. 94.36% of farmers with access to AE are male, and only 5.64% are female. Meanwhile, in the no access group, 10.46% of farmers are female.

Furthermore, a cross-tabulation of education, gender, and access to AE (Table 3) provides a clear insight. The educational attainment of female farmers in both groups is lower than that of male farmers. In the access group, female farmers with elementary education are 73.1%, higher than male farmers, 62.5%. Similarly, in the non-access group, the percentage of female farmers with elementary schooling is 85.2%, higher than that of his male counterparts, 71.3%. Then, the percentage of female farmers in the middle and higher education is lower than male farmers in both groups. This data indicates that their low educational attainment might cause females' lower access to AE.

TABLE 3. EDUCATION, GENDER AND ACCESS TO AE OF INDONESIAN SUGARCANE FARMERS

Education	Have access to AE		Have no access to AE	
	Male	Female	Male	Female
Elementary	815 (62.5)	57 (73.1)	4,752 (71.3)	664 (85.2)
Middle	417 (31.9)	19 (24.4)	1,709 (25.6)	106 (13.6)
Higher	73 (5.6)	2 (2.5)	208 (3.1)	9 (1.2)
N	**1,305**	**78**	**6,669**	**779**

Note: The values in the bracket indicate the percentage in each group.

Furthermore, the data strongly suggests that access to AE favors large-scale farmers. On average, farmers' harvest area with access to AE is 18.7 hectares, higher than those with no access to AE, 4.5 hectares. Similarly, farmers' farming capital with access to AE is higher than those with no AE access. The former has annual farming capital of IDR 45,882,900 while the latter has only IDR 10,669,500. Furthermore, 73.97% of farmers with AE access are wealthy households, slightly higher than those with no AE access, 70.72%. On average, farmers with AE access have a larger farm size; thus, they have higher input use. The average hired labor in the farm with AE access is 27.2 per year, higher than that in non-AE access farms, 10. Also, the former group has a larger household size than the latter. Farmers with AE access used more seed plants and fertilizer than those with no AE access. Indonesian smallholder sugarcane farmers commonly use six fertilizer types, and farmers with AE access use each fertilizer in higher quantity than their counterparts. However, farmers with no AE access use higher solid pesticide and liquid growth simulators than farmers with AE access. Farmers with no AE access use 2800% and 190% higher used of solid pesticide and liquid growth simulators than farmers with AE access, respectively. The percentage of farmers who receive government support does not differ significantly between the two groups. The data show that farmers with AE access tend to participate in contract farming (CF). 66.31% of farmers with AE access participate in CF, higher than that of non-AE access group, 28.45%. The data imply that the receiving of agricultural extension is related to farmer participation in CF.

The performance of Indonesian smallholder sugarcane farmers

This study aimed to estimate the impact of agricultural extension access on smallholder sugarcane farmers' performance in Indonesia. To achieve this goal, this study was divided into two analytical phases. In the first phase, we measured the farmers' performance using several performance indicators. These indicators were also used as the outcome variables in the second stage of analysis. Each performance indicator formula is shown in Table 2, and the components of those indicators are shown in Table 4.

The results demonstrate that farmers with AE access operate at a larger scale than farmers with no AE access. The AE farmers have higher values than non-AE farmers in three variables representing the farm size: total output, intermediate consumption, and total external factors. The first variable is the total output representing the agricultural products' value being sold and products for farmers' use and consumption. AE farmers' average total output is IDR 78,793,000/yr, higher than non-AE farmers, IDR 22,231,000/yr. The second variable is the intermediate consumption that represents the direct and overhead costs of farm production. On average, AE farmers spend IDR 24,504,000/yr on intermediate consumption, four times higher than that of non-AE farmers, IDR 6,230,000/yr. Also, AE farmers use higher total external factors, averaging IDR 609,000/yr than non-AE farmers, IDR 56,000/yr.

TABLE 4. THE PERFORMANCE OF SMALLHOLDERS SUGARCANE FARMERS IN INDONESIA

Variables	Pooled		Access to AE		No Access to AE	
	Mean	SD	Mean	SD	Mean	SD
Total output (IDR/year)	31,089	126,252	78,793	283,837	22,231	58,718
Intermediate consumption (IDR/year)	9,092	37,291	24,504	85,087	6,230	16,184
Total external factors (IDR/year)	142	4,113	609	9,615	56	1,690
Annual working unit (person)	15	73	30	175	12	26
Family working unit (person)	5	36	11	86	4	11
Tax (IDR/year)	117	437	234	859	97	306
Depreciation (IDR/year)	319	3,154	1,042	7,922	190	651
OC of land (IDR/year)	(17,096)	83,795	(46,029)	187,274	(11,724)	40,410
OC of capital (IDR/year)	(20,363)	88,326	(49,724)	195,545	(14,911)	44,321

Note:
1. The value is in thousands rupiah.
2. AWU is an annual working unit employed by a farm.
3. FWU is a family working unit.
4. The brackets indicate a negative value.

The average AWU and FWU for AE farmers are 30 and 11 persons, while non-AE farmers are 12 and 4 persons. It suggests that AE farmers employ two times more farm labour than non-AE farmers. Furthermore, the AE farmers have higher value both for the fixed and opportunity costs. There are two fixed-cost in our analysis, farm tax, and depreciation. The average annual farm tax for AE farmers is IDR 234,000, 240% higher than non-AE farmers, IDR 97,000. However, the farm tax represents a small percentage of the total farming costs. The AE farmers have 548% higher depreciation cost than that of non-AE farmers. The annual depreciation cost for each group is IDR 1,042,000 and IDR

190,000, respectively. It demonstrates that AE farmers used more capital goods than non-AE farmers. Finally, the opportunity cost for land and capital of AE farmers is higher than that of non-AE farmers. Still, both groups' value is negative, indicating that sugarcane farming is the optimal economic decision for farmers compared to other alternatives.

TABLE 5. THE PERFORMANCE OF FARMERS WITH ACCESS AND NO ACCESS TO AGRICULTURAL EXTENSION

Indicators	Pooled		Access to AE		No Access to AE	
	Mean	SD	Mean	SD	Mean	SD
Farm Gross Value Added (IDR/yr)	21,997	94,327	54,372	210,967	16,001	46,412
Farm Net Value Added (IDR/yr)	21,931	94,758	54,289	209,773	15,907	46,427
Labour Productivity (IDR/AWU)	2,147	5,700	3,709	12,048	1,857	3,323
Land productivity (Income/hectare)	23,717	23,915	21,415	17,734	24,145	24,872
Farm Net Income (IDR/yr)	21,788	93,857	53,762	208,725	15,850	46,208
Remuneration of Family Labour (IDR/FWU)	16,890	76,114	55,215	248,843	21,407	69,275
Sample size (n)	**8,831**		**1383**		**7,448**	

Note:
1. The value is in thousands rupiah.
2. AWU is annual working unit employed by a farm.
3. FWU is family working unit.

Table 5 shows the value of each performance indicator. The results further demonstrate that AE farmers operate a larger farm than non-AE farmers. Furthermore, the former group records above-average performance while the latter has a below-average performance. AE farmers produce a higher value-added than non-AE farmers. The average gross value-added of AE farmers is IDR 54,372,000/year, higher than that of non-AE farmers, IDR 16,001,000/year. A similar order of comparison is also evident for farm net value-added, where each group has a value of IDR 54,289,000/year and IDR 15,907,000/year, respectively. The productivity measures indicate that AE farmers have higher labor productivity, but non-AE farmers have higher land productivity. The average labor productivity, measured as the net value-added per unit of labor for AE and non-AE farmers, is IDR 3,709,000 and IDR 1,857,000, respectively. The average land productivity for the non-AE farmers is IDR 24,145,000/hectare, higher than that of AE farmers, IDR 21,415,000/hectare.

The last two indicators represent the net income for a farm and the remuneration of each family labour. The results indicate that AE farmers have a higher farm income than non-AE farmers. AE farmers' average farm income is IDR 53,762,000/year, higher than non-AE farmers, IDR 15,850,000/yr. Similarly, the family labour of AE farmers receives higher remuneration than those of non-AE farmers. The average family labour remuneration of AE and non-AE farmers is IDR 55,215,000/yr and IDR 21,407,000/year, respectively. However, the mean value of each group does not provide a relevant group of comparison. Thus, the propensity score analysis is required to create a balanced comparison group.

The Impact of agricultural extension access on the farm performance

The propensity score analysis to estimate the effect of AE on farm performance was divided into three steps: estimating the propensity score, performing a balance test on

covariates, and estimating the ATT (average treatment effect on the treated). A logistic regression model (LRM) was used to estimate the propensity score of access to AE, consisting of eight variables. The estimation results show that the model is robust. The model likelihood ratio is 896.01 and significant at 1% level, and the *pseudo* R^2 is 0.117. Of the eight variables in the model, six variables significantly affect farmer access to AE. Farm capital, farmers' education, gender, contract farming, and farmer's wealth increase the probability of accessing AE. In contrast, being a recipient of government support decreases the probability of a farmer accessing AE. Finally, the size of the utilized agricultural area has no significant effect on farmer access to AE. Table 6 summarises the estimation results of the LRM.

TABLE 6. ESTIMATES OF FACTORS AFFECTING FARMERS ACCESS TO AGRICULTURAL EXTENSION

Variable	β	SE.	Sig.
Utilized agricultural area (ha)	0.01	0.02	0.446
Capital (million rupiah)	0.004	0.009	0.000*
Age (yr)	-0.001	0.003	0.825
Education (higher education)	0.237	0.059	0.000*
Gender (man)	0.543	0.128	0.000*
Government Support (receive support)	-0.177	0.063	0.005*
Contract Farming (participate)	1.510	0.064	0.000*
Wealth (wealthy)	0.155	0.071	0.029**
Constanta	-3.324	0.233	0.000*
Number of obs	8.831		
LR chi^2	896.01		
Prob > chi^2	0.000*		
Pseudo R^2	0.117		

Note: *Significant at 10%, **Significant at 5%, ***Significant at 1%, ^{ns}not significant

TABLE 7. THE BALANCE TEST OF COVARIATES IN PROPENSITY SCORE MATCHING

Variable	Unmatched			Matched			Bias reduction
	AE	NAE	Sig.	AE	NAE	Sig.	
UAA	22489	7220.4	0.000***	19638	18246	0.524 ^{ns}	90.6
Capital	45883	10670	0.000***	39693	36418	0.563 ^{ns}	90.7
Age	50.665	51.767	0.001***	50.723	50.609	0.792 ^{ns}	89.6
Education	1.4237	1.302	0.000***	1.4141	1.4315	0.442 ^{ns}	85.7
Gender	0.9436	0.89541	0.000***	.94273	.94366	0.916 ^{ns}	98.1
Government Support	0.44685	0.45462	0.594^{ns}	0.44493	0.4402	0.804 ^{ns}	39.0
Contract Farming	.66305	0.28451	0.000***	.65786	0.65518	0.252 ^{ns}	99.3
Wealth	.7397	0 .70717	0.014	.73568	0.747	0.315 ^{ns}	65.2
Pseudo R^2			0.115			0.000*	
Mean bias			24.7			1.7	
Median bias			19.8			1.8	

Note: *Significant at 10%, **Significant at 5%, ***Significant at 1%, ^{ns}not significant

The second step is the balance test. The purpose of the balance test is to create a relevant group of comparison between the treated (AE farmers) and the control group (non-AE farmers). We employed a radius matching algorithm to perform the balance test. The balance test reduces the selection bias by improving the balance between the treated and

control groups' explanatory variables. The balance test results demonstrate that all explanatory variables in the control and treated group do not differ significantly after matching. Six out of eight explanatory variables were statistically different in the unmatched panel at the 1% level. After matching, all explanatory variables do not differ significantly and produce an average of 92.33% bias reduction. Also, the mean and median bias after matching is only 1.7 and 1.8%. This result indicates that the matching algorithm produces a relevant comparison group and is suitable for the ATT estimation. Table 7 summaries the balance test results.

Table 8 shows the ATT estimation results. The ATT estimation results show that AE farmers have higher gross value-added, net value-added, labor productivity, and farm income than non-AE farmers. But, the non-AE farmers have significantly higher land productivity than AE farmers. In contrast, the remuneration of family labour for both groups does not differ significantly. But, the results indicate that AE farmers remunerate more family labour than non-AE farmers. The ATT estimation compares AE and non-AE farmers with statistically indifferent explanatory variables. Thus, the estimation procedure compares farmers with the same size of land and capital, similar age and level of education, and equal access to government support and contract farming. Also, both groups have a similar composition of male and female farmers.

TABLE 8 THE IMPACT OF AE ON THE PERFORMANCE OF SMALLHOLDERS SUGARCANE FARMERS

Variable	AE	NAE	ATT	S.E.	t-stat
Gross Value-Added	54,372	38,696	15,675	5,731	2.73
Net Value-Added	54,289	38,675	15,613	5,700	2.74
Labour Productivity	3,709	2,595	1,113	329	3.38
Land Productivity	21,278	24,680	-3,401	649	-5.24
Net Income	53,762	38,322	15,440	5,671	2.72
Remuneration of Family Labour	55,215	55,704	-488	6,997	-0.07
Hired Labour	18	11	7	2	2.86
Family Labour	11	5	6	2	2.35

1. The values presented are the average value after matching.
2. The matching algorithm used was Radius Matching.

The results demonstrate that AE farmers produce 40.5% or IDR 15,675,000/year higher gross value-added (GVA) than non-AE farmers. The average GVA of AE and non-AE farmers is IDR 54,372,000/year and IDR 38,696,000/year, respectively. Similarly, the net value-added of AE farmers is 40.3% higher than that of non-AE farmers. The average net value-added of AE farmers is IDR 54,289,000/year, higher than that of non-AE farmers, IDR 38,675,000/yr.

Discussions

Access to agricultural extension improves farm performance

The primary purpose of this study is to identify the effect of AE on the performance of smallholder sugarcane farmers in Indonesia. This study used farm value-added to capture the added value from sugarcane farming. Farm value-added is crucial in measuring economic

sustainability since it can measure whether labor, land, and resources used in agricultural production are optimally remunerated (Thomassen, Dolma, van Calker, & de Boer, 2009). This study demonstrates that AE increases both the gross and net farm value-added. The value of FGVA and FNVA is quite similar. This value indicates that the tax and depreciation costs are relatively small compared to other costs. This study's findings indicate that AE is a crucial policy instrument to improve smallholder farmers' economic sustainability. The primary purpose of the Indonesian AES, especially in the sugarcane sector, is to increase farm productivity (micro-level) to increase aggregate production (macro-level) to support the national sugar industry.

However, the Indonesian AES covers only 15.16% of farmers. The LRM estimation of farmer access to AE (Table 1) demonstrates a tendency for extension officers to select only large-scale farmers. Farmer with higher capital is more likely to gain access to AE. Also, farmer with a higher household wealth is more likely to have access to AE than those with lower household wealth. According to Arias, Leguía, & Sy (2013), farm size increases farmer access to AE since large economies of scale implement feasible new technologies. Farmer education increases the likelihood of farmer access to AE. This finding conforms to previous studies in Ghana, where education increases the probability of a farmer accessing AE (Anang, Bäckman, & Sipiläinen, 2020). Participation in contract farming and government support increases the probability of access to AE. At the field level, the government uses AE as a channel to deliver the content of agricultural policy (Bhatta, Ishida, Taniguchi, & Sharma, 2008). In addition, the result demonstrates that female farmer is less likely to receive AE than male farmers. Meanwhile, utilized agricultural area and farmer age have no significant effect on farmer access to AE. Our in-depth interview found that sugarcane farmers receive extension services mainly from private extension officers. This service is a feature of contract farming between farmers and sugar mill companies. The companies used AE as a channel to distribute farm credit and inputs to farmers. This arrangement is typical in the Indonesian sugarcane sector, where AE is the channel to distribute farm credit to farmers (Rondhi *et al.*, 2020). Also, AE access is closely related to farmer participation in contract farming (Rokhani *et al.,* 2020) and adopting a certified seed plant that increases farm productivity (Suwandari *et al.*, 2020).

Access to AE also increases farm labor productivity by 42.8%; however, it decreases land productivity by 13.7%. AE farmers' labor productivity is IDR 3,709,000/AWU, higher than non-AE farmers IDR 2,595,000/AWU. But non-AE farmers have higher land productivity of IDR 24,680,000/ha than AE farmers, IDR 21,278,000/ha. This finding aligns with previous literature (Cunguara & Moder, 2011; Emmanuel *et al.*, 2016; Pan *et al.*, 2018; Ragasa & Mazunda, 2018). However, unlike previous studies, which measure farm productivity in yield per unit of land, we measured farm productivity as the value-added created by one unit of labor (labor productivity) and utilized agricultural area (land productivity). The purpose of using these indicators is to identify whether AE increases farm productivity through labor or land. The results show that AE significantly increases labor productivity. It signifies the role of AE as an institution that delivers training to farmers and

improves their managerial and technical capability. Furthermore, previous studies associated AE access with technology adoption (Lambrecht, Vanlauwe, & Maertens, 2016; Ogutu *et al.*, 2020; Pan *et al.*, 2018). It is evident that these technologies, especially farm machinery, increase labor productivity (Paudel, KC, Rahut, Justice, & McDonald, 2019). However, our study indicates that AE farmers have lower land productivity than non-AE farmers. The possible explanation for this finding is that AE farmers, on average, utilized a larger land area; thus, the input use intensity is lower than those of non-AE farmers. We define input use intensity as the farm inputs used for each hectare of utilized agricultural area. The data in Table 9 demonstrate that farmers with no access to AE have higher input use intensity for all types of inputs. Farmers with access to AE have lower labor, seed, fertilizer, pesticide, and growth simulator use intensity for each hectare of land. Input use intensity is crucial for farm productivity. Table 9 shows the average input use intensity between farmers with access to AE and no AE access.

TABLE 9. ACCESS TO AE AND INPUT USE INTENSITY OF SUGARCANE FARMERS

Variable	Have access to AE		Have no access to AE	
	Mean	SD.	Mean	SD.
Hired Labor (labor/ha)	1.21	3.13	13.89	97.36
Family Labor (labor/ha)	0.12	0.24	2.50	7.64
Seed Plant (seed/ha)	1380.71	2630.43	20151.39	82322.36
Fertilizer	0.00	0.00	0.00	0.00
Urea (kg/ha)	4.45	14.84	96.67	464.17
TSP/SP36 (kg/ha)	3.50	17.58	34.31	550.28
Za (kg/ha)	62.99	119.41	677.64	3735.14
KCl (kg/ha)	1.43	7.16	14.44	224.58
NPK (kg/ha)	31.98	71.72	306.94	2242.78
Organic (kg/ha)	28.55	80.00	378.75	2501.53
Pesticide	0.00	0.00	0.00	0.00
Solid (kg/ha)	0.00	8.69	3.89	271.81
Liquid (l/ha)	9.50	91.23	71.94	2854.03
Growth Simulator	0.00	0.00	0.00	0.00
Solid (kg/ha)	0.04	0.53	0.83	16.81
Liquid (l/ha)	1.40	50.90	83.33	1592.50

Furthermore, access to AE significantly increases farm income by 40.2%. AE farmers' net farm income is IDR 53,762,000/year, higher than non-AE farmers, IDR 38,322,000/yr. However, both groups have statistically insignificant remuneration of family labour (ROFL). The ROFL of AE and non-AE farmers is IDR 55,215,000/year and IDR 55,704,000/yr, respectively. The ROFL value is higher than that of farm income because the opportunity cost of land and capital is negative. Previous studies have confirmed the income-increasing effect of AE (Baiyegunhi, Majokweni, & Ferrer, 2019; Cawley *et al.*, 2018; Danso-Abbeam,, Ehiakpor, & Aidoo, 2018), but these studies measure only farm income and not the remuneration of family labour. Measuring the effect of AE on family labour remuneration is crucial to identify whether AE increases farmer welfare and contributes to poverty alleviation

of the farm household. Thus, we compare family labour remuneration and regional minimum wages to see whether farm family labour is optimally incentivized.

Does the benefit of AE access equally distributed across the region?

The primary advantage of a nationally representative study is its ability to capture spatial inequality in the effect of agricultural extension access. The primary purpose of AES is to improve farm productivity and farmer income in all regions. However, the data shows a spatial inequality in the AES coverage and AE effect on farmer income. First, the data in Figure 1 suggest an un-proportionate distribution of extension officials in each province. For example, farmers with access to AE in East Java and Central Java are only 10.91% and 19.23%, respectively, even though 95.42% of sugarcane farmers are situated in these provinces. On the other hand, the percentage of farmers with AE access in other provinces is higher than 20%, such as Sumatera (26.37%), Yogyakarta (64.58%), Sulawesi (60.53%), and West Java (42.67%). This result indicates that the current distribution of extension officials is disproportionate to the number of farmers in each province. Thus, a reallocation of extension officials, especially to the province with the highest number of farmers, will increase AES coverage. Addressing inequality in agricultural extension is crucial since it contributed to agricultural productivity (Tsikata, 2015).

Second, the result demonstrates a spatial inequality in income. Figure 2 compares the family labour remuneration of AE and non-AE farmers to each province's minimum wages. Family labour remuneration is higher than minimum wages in West Java and East Java, both for AE and non-AE farmers. These provinces accounted for 60.65% of Indonesian smallholder sugarcane farmers. The average ROFL of AE farmers in West Java is lower than that of non-AE farmers. In contrast, AE farmers' average ROFL is higher than that of non-AE farmers in East Java. Furthermore, only 19% of AE farmers in East Java whose ROFL is lower than the minimum wages, compared to 21% for the non-AE farmers. A contrasting situation is found in Central Java, whose farmers account for 35.62% of Indonesian sugarcane farmers. The average ROFL for AE farmers is lower than that of non-AE farmers and minimum wages. However, the percentage of AE farmers whose ROFL is lower than minimum wages is 76%, lower than non-AE farmers, 82%. The ROFL of AE and non-AE farmers is lower than minimum wages in Yogyakarta, Lampung and North Sumatera. But, the farmers in these three provinces are only 1.57% of total farmers.

This finding provides essential information on the Indonesian Agricultural Revitalization Program (ARP) evaluation, especially on the Indonesian Agricultural Extension System (AES). In general, the Indonesian AES effectively increases both the productivity and income of smallholders of sugarcane farmers. However, there are two situations worthy of consideration. First, the data imply that there is a tendency for the extension officers tends to select larger farmers. This tendency makes the AES less inclusive since the majority of farmers are small-scale farmers. Second, the coverage of extension services must be increased proportionally to the population in each province. For example, the AES coverage in East Java, whose farmers account for 59.80% of total farmers, is only

10.91%. Meanwhile, the AES coverage in Sulawesi, whose farmers are only 2.15% of total farmers, is 60.53%. In this case, the government should allocate AES's coverage proportionately to the number of farmers, which can be achieved by equating AES's percent coverage in each province.

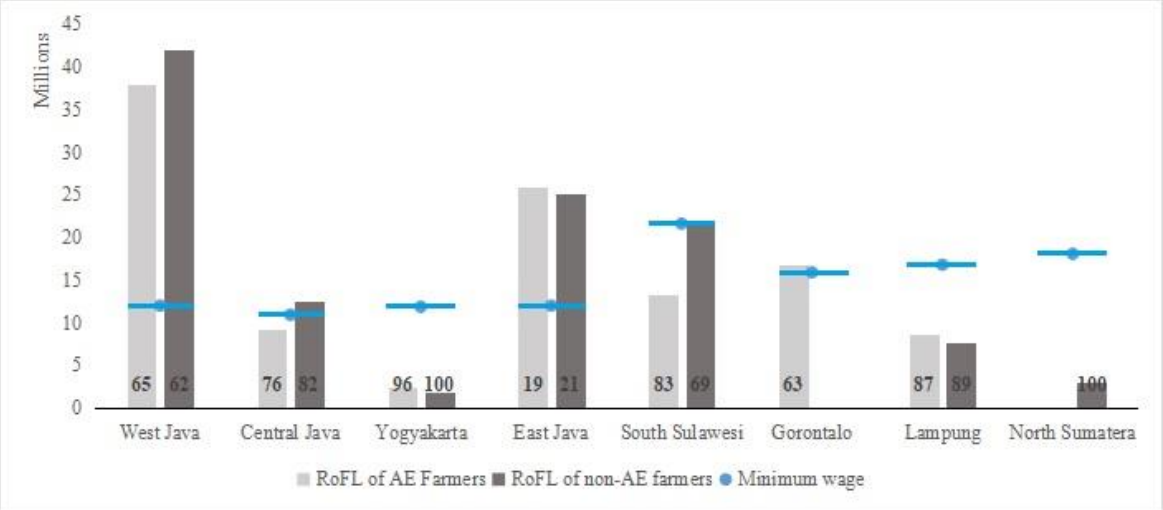

FIGURE 2. FAMILY LABOUR REMUNERATION AND REGIONAL MINIMUM WAGES BETWEEN AE AND NON-AE FARMERS

CONCLUSIONS

This study aimed to estimate the impact of agricultural extension access on smallholder sugarcane farmers' performance in Indonesia. The results of this study show that AE access significantly improves farm performance. First, farmers with access to AE produce 40.5% (gross) and 40.3% (net) higher value-added than those with no AE access. Second, access to AE increases labor productivity by 42.8%, but it decreases land productivity by 13.7%. Third, agricultural extension access increases farm income by 40.2%. The remuneration of family labour doesn't differ significantly between AE and non-AE farmers, but the former remunerates more family labour than the latter. However, the study found that the Indonesian AES prioritizes larger farmers than small-scale farmers, making it less inclusive since most farmers are small-scale farmers. Therefore, the study recommends that the government should increase the coverage of AES and prioritize small-scale farmers to enhance the benefits of AE.

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