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The Linkage Between Livelihood Assets and Technical Efficiency of Cocoa Farmer Households in East Java Province, Indonesia

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Abstract

The study aims to investigate the linkage between the livelihood assets of cocoa farming households and the technical efficiency of cocoa farmers in East Java Province. The survey method was used to achieve the research objectives. Analysis data was divided into 3 parts, including the concept of livelihood assets with pentagonal assets used to analyze the level of livelihood assets of cocoa farmer households, stochastic frontier production used to estimate the technical efficiency of cocoa farming, and the linkage between livelihood assets and technical efficiency is analyzed using Rank Spearman correlation. Theresults show that the livelihood assets of cocoa farmer households in both Banyuwangi and Trenggalek Regencies are included in the moderate category with an average score of 3.17 and 3.33. The technical efficiency of cocoa farming in Banyuwangi is 60.74% while Trenggalek is 80.12%. The linkage between livelihood assets and technical efficiency in Banyuwangi is weak, while Trenggalek is moderate.

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Introduction

East Java Province is one of the cocoa commodity development areas on the island of Java. Several districts in East Java Province are developing cocoa as a source of community income, opening new job opportunities, and improving the regional economy such as Banyuwangi and Trenggalek Regency. Banyuwangi Regency is a cocoa-producing center in East Java with a planting area of 9,590 Ha and production of 7,800 tons in 2021 (BPS Jawa Timur, 2023). Banyuwangi is also known for having cocoa beans which are in demand by domestic and international markets. Banyuwangi produces a lot of plantation cocoa and smallholder cocoa. Apart from Banyuwangi, Trenggalek is also one of the cocoa producers in East Java Province with relatively high production. Data for 2021 shows that Trenggalek has a planting area of 1,669 Ha with production of 1,180 tons (BPS Jawa Timur, 2023). This makes Trenggalek ranked fourth as the largest cocoa-producing area in East Java. Trenggalek Regency also produces a lot of smallholder cocoa. Interestingly, the cocoa cultivated by cocoa farmers in Trenggalek, specifically in Suruh village, has switched to organic farming (Fitriyah & Hariyati, 2020).

The condition of cocoa in East Java, both Banyuwangi and Trenggalek, often faces various classic problems, such as: 1) climate change causes unpredictable rainfall and rising temperature (Hutchins *et al*., 2015) so that the rainy season is prolonged which has an impact on increasing pest and disease attacks on cocoa plants (Skendžić *et al*., 2021) thereby reducing productivity and cocoa production (Amfo *et al*., 2021; Wongnaa & Babu, 2020), 2) Land area is getting narrower and decreasing as a result of the shift in commodities from cocoa to other commodities (Asante-Poku & Angelucci, 2013; Asubonteng *et al*., 2018), 3) the use of less superior cocoa seeds led the cocoa plants to produce unhealthy cocoa pods, thereby reducing productivity (Effendy *et al*., 2019), 4) Farmers have old cocoa plants that are easily attacked by pests and disease (Binam *et al*., 2008; Iskandar *et al*., 2020; Kongor *et al*., 2018; Schaad & Fromm, 2017), 5) Farmers have not processed fermented beans or prefer to produce unfermented cocoa beans, this causes the beans produced to be of low quality which has an impact on the low price of cocoa beans (Prihadianto *et al*., 2022; Rifin, 2020), and 6) lack of synergy among institutions at the farmer level causes farmers to have a weak bargaining position (Basri *et al*., 2023; Prihadianto *et al*., 2022).

Those conditions cause cocoa farmers to try to optimize the potential of their resources. Therefore, farmers as drivers in cocoa farming are required to carry out various activities for the survival of their households. Furthermore, the differences in the characteristics of cocoa farming in the two regions, both in Banyuwangi and Trenggalek, can be investigated by

using the concept of livelihood. Through the livelihood concept, farmers' ability to face pressures and shocks in managing resource ownership and other activities that provide income can be known, so that farming households can survive and adapt to environmental change (Scoones, 1998). It helps cocoa farming households in both Banyuwangi and Trenggalek to improve their household welfare.

Furthermore, the problems faced by farming households in cultivating cocoa plants have resulted in a decline in cocoa production, thus requiring farmers to use optimal production inputs. Decreasing cocoa production cannot be separated from the use of inadequate inputs. This is caused by the limited use of fertilizer by farmers due to scarce fertilizer availability and high fertilizer prices, ineffective use of pesticides, and high labor costs. The use of inputs in inappropriate quantities and combinations will affect the output of cocoa farming. The combination of a given input to produce the given output can be determined by measuring the technical efficiency (TE) (Lovell, 1993).

A high level of TE indicates that farmers are achieving their potential production. High cocoa production is able to provide higher income for cocoa farming households, so that farming households are able to improve their welfare. On the other hand, farming households with high livelihood assets are able to meet living needs to continue the survival of their household, one of which is through cocoa farming. Studies on livelihood assets (Illu *et al.*, 2021; Lawal *et al.*, 2011; Li *et al.*, 2014; Roslinda *et al.*, 2024; Saleh *et al.*, 2016; Shivakoti & Shrestha, 2005; Tefera *et al.*, 2004; Udoh *et al.*, 2017) focuses on the livelihoods of farming households. Studies on TE (Attipoe *et al.*, 2020; Besseah & Kim, 2014; Binam *et al.*, 2008; Donkor *et al.*, 2023; Ofori-Bah & Asafu-Adjaye, 2011; Rouf *et al.*, 2021) with a focus on cocoa farming have also been widely carried out. High livelihood assets, particularly in the form of human capital such as education level, play a crucial role in enhancing technical efficiency by supporting farmers' managerial abilities, insights, and adaptability to new technologies in managing farm inputs (Asri *et al.*, 2019; Uloh & Abor, 2019). These skills enable more accurate input allocation, allowing farmers to achieve higher technical efficiency and maximize output (Effendy *et al.*, 2019). The resulting increase in output directly boosts income, which in turn strengthens household livelihood assets through the accumulation of productive resources (Bezemer *et al.*, 2005; Eman *et al.*, 2022). Therefore, there is a clear relationship between livelihood assets and technical efficiency. For this study, we analyzed both the livelihood assets of cocoa farming households and the TE of cocoa farming, as well as the linkage between livelihood assets and the technical efficiency of cocoa farming households in East Java Province. This study is an extension of the extant literature and will contribute to the literature on livelihood assets and TE. It will also

provide necessary information for policymakers to improve the productivity of Indonesian cocoa, especially in smallholder cocoa.

1. Materials and Methods

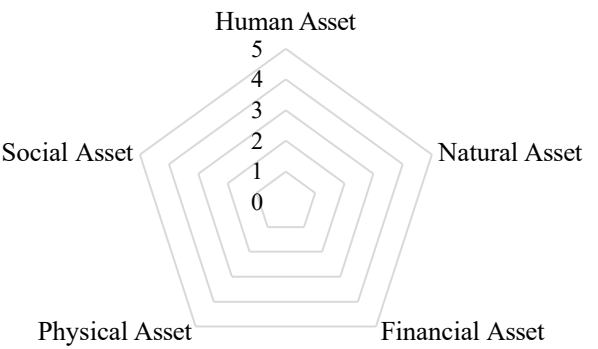
Study Location and Sampling

The study was conducted in Banyuwangi and Trenggalek Regencies, East Java Province, Indonesia. Study location selection was determined using a purposive method. The location was chosen on the basis that those areas are two cocoa commodity centers in East Java Province (BPS Jawa Timur, 2023). The basic method used in this study was a survey. A survey is an investigation carried out to obtain facts from existing phenomena and seek factual information from a group or region and can be carried out by census or using samples (Sugiyono, 2017). The survey was conducted by randomly taking respondents from 100 cocoa farming households. We randomly selected 50 heads of families in each district. The number of respondents was able to produce and describe diverse data according to the research conditions (Sugiyono, 2017). A semi-structured questionnaire was used to collect the data. The field survey was conducted in the period July to December 2023.

Analytical Framework

Analysis of livelihood assets used a livelihood asset pentagon which aims to describe the relationship of the five assets, i.e., human, natural, social, financial, and physical (DFID, 2000; Ellis, 2000), owned by cocoa farming households, which is presented in Figure 1.

Figure 1 - Livelihood Assets Pentagon



Each asset was measured based on asset-measuring variables which consist of several indicators. The measuring variables for each asset are contained in Table 1.

Table 1 - Variables and Indicators of Livelihood Assets

No.	Variables	Indicators
1.	**Human Asset**	1. Education Level 2. Training Participation 3. Health Condition 4. Nutritional Status 5. Involvement of household members in farming 6. Knowledge of healthy plants 7. Knowledge of plant preservation 8. Knowledge of post-harvest processing 9. Knowledge of marketing 10. Activeness in farmer groups
2.	**Natural Asset**	1. Land occupancy status 2. Land use 3. Availability of water 4. Overview of rainfall 5. Water source 6. Opportunity to obtain organic fertilizer 7. Opportunity to obtain inorganic fertilizer 8. Opportunities to obtain labor 9. Overview of the level of erosion 10. Overview of the level of land damage
3.	**Financial Asset**	1. Primary source of income 2. Average primary income in a year 3. Other sources of income 4. Cocoa farming income 5. Adequate household income 6. Ownership of savings 7. Loan involvement for household needs 8. Loan involvement for farming development 9. Sources of loan for household needs 10. Sources of loan for farming development
4.	**Physical Asset**	1. Condition of road facilities 2. Distance to the farming location 3. Condition of residence 4. Home ownership status 5. Overview of farming land 6. Transportation facilities

No.	Variables	Indicators
		7. Communication facilities 8. Information sources 9. Electrical power 10. Access to household necessities
5.	**Social Asset**	1. Communication with neighbors 2. Communication with farmer group administrators 3. Communication with other farmer groups 4. Communication with village officials 5. Communication with farming partners 6. Communication with agricultural extension workers 7. Communication with cooperative institutions 8. Communication with collecting traders

Source: DFID, 2000; Ellis, 2000; Scoones, 1998.

Each indicator was measured by giving a score of 1 to 5. The asset pentagon calculation used the average score of each household's livelihood asset score with a formula:

$$\text{Asset score} = \frac{\sum \text{scores of each asset}}{\sum \text{indicators of each asset}}$$

The average score is used to see the level of livelihood assets of cocoa farming households. The criteria for livelihood asset levels are divided into three categories (Fariz *et al.*, 2022), in the following ranges :

1. Low: $1{,}00 < x \leq 2{,}33$
2. Moderate: $2{,}34 < x \leq 3{,}66$
3. High: $3{,}67 < x \leq 5{,}00$

Factors influencing smallholder cocoa farming in East Java Province in this study were analyzed using the stochastic frontier production function (SFPF). The SFPF estimation model for cocoa farming uses the Cobb-Douglass model with the formula in equation 1 (Bhanumurthy, 2002; Mahaboob *et al.*, 2019).

$$Y = \beta_0 X^{\beta 1} X^{\beta 2} X^{\beta 3} X^{\beta 4} e^{\varepsilon i} \quad (1)$$

Notes:
Y: Production (kgs)
β_0: Intercept
β_i: Coefficient

X_1: Land area (Ha)
X_2: Inorganic or Organic Fertilizer (kgs)
X_3: Chemical or biological pesticides (liter)
X_4: Labor (man-day)
e_i: Error term

Next, the technical efficiency of cocoa farming is estimated using the formula in equation 2 (Coelli *et al*., 2005; Porcelli, 2009).

$$TE_i = \frac{Y_i}{Y_{i^*}} = e^{-ui} = \exp(-u_i) \quad (2)$$

Where:
TE_i: Technically Efficiency of farmer *i*
Y_i: Actual output for farmer *i*
exp(-ui): Estimated output for farmer *i*
u_i: Technical efficiency of farmer *i*

Technical efficiency ranges from $0 < TE_i < 1$. Farmers with a TE of more than 0.70 are classified as technically efficient, while farmers with a TE of less than 0.70 are classified as technically inefficient (Kumbhakar & Lovell, 2000; Sumaryanto, 2001).

The linkage between farming household livelihood assets and the technical efficiency of cocoa farming is analyzed using Rank Spearman correlation in equation 3 (Chen &Popovich, 2002).

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad (3)$$

Description:
r_s: Spearman's rank correlation coefficient
d_i: The difference between the ranks of the i-th pair of observations on the two variables
n: The number of observation

The correlation coefficient ranges from –1 to +1. If the r value is positive, it indicates a positive correlation and the r value is negative, indicating a negative correlation. Correlation coefficient categories include: < 0.20 = very weak; < 0.40 = weak; < 0.60 = moderate; < 0.80 = strong; and < 1.00 = very strong.

2. Results

Livelihood Assets of Cocoa Farming Household in East Java Province, Indonesia

The concept of livelihood is related to household management of the resources and assets they own. Ellis (2000) stated that livelihood comprises the assets (human, natural, financial, physical, and social assets), the activities, and the access to these (institutions and social relations) that determine the living gained by individuals or households simultaneously. Livelihood assets in each region vary depending on the value of each asset owned by cocoa farming households. The variations in value and linkage of assets in livelihood resources are depicted in an asset pentagon. The shape of the pentagon describes schematically variations in ownership levels and community access to assets (DFID, 2000). The wider the pentagon shape to the center point, the higher the score of livelihood assets. In contrast, the closer the pentagon shape is to the center point, the lower the asset pentagon score of a community. The livelihood assets of cocoa farming households in East Java Province can be seen in Figure 2.

Figure 2 - Livelihood Asset Pentagon of Cocoa Farming Household

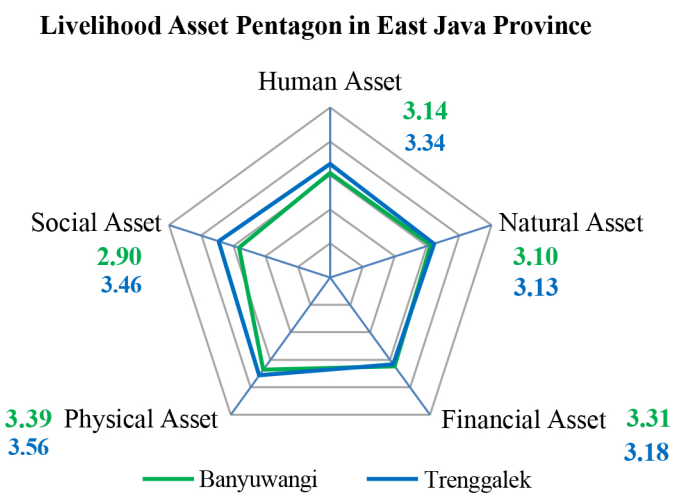


Figure 2 shows that the overall livelihood assets of cocoa farming households in both Banyuwangi and Trenggalek are in the moderate category. The average level of livelihood assets for cocoa farming households in Trenggalek is 3.35

while in Banyuwangi is 3.12. In addition, all livelihood assets, except for the financial assets of cocoa farming households in Trenggalek, are higher than in Banyuwangi. Based on livelihood assets indicators, cocoa farmers in Trenggalek are higher than in Banyuwangi in terms of education and training participation (human asset); opportunity to obtain organic fertilizer (natural assets); condition of road facilities, and overview of farming land (physical asset); and communication with the surrounding community (social asset). Meanwhile, Banyuwangi is superior to Trenggalek based on financial assets, such as indicators of other sources of income and household loans. The lowest livelihood assets score of cocoa farming households in Banyuwangi comes from DFID, (2000) social assets (2.83). This shows that there is a lack of social resource capacity for cocoa farming households in Banyuwangi to adapt to the surrounding community. According to, social resources are generally intangible and not easily measured but it is necessary and beneficial for society. Meanwhile, the lowest score for livelihood assets of cocoa farming households in Trenggalek comes from natural assets (3.13). This is due to the low availability of inorganic fertilizers and labor, most of which only come from within the family. Each indicator of livelihood assets for cocoa farming households in East Java Province is described as follows:

Table 2 - Human Asset of Cocoa Farmer Household

No.	Indicators	Banyuwangi	Criteria	Treanggalek	Criteria
1	Education Level	2.92	Moderate	3.82	High
2	Training Participation	2.20	Low	3.22	Moderate
3	Health Condition	4.84	High	3.52	Moderate
4	Nutritional Status	3.80	High	4.28	High
5	Involvement of household members in farming	1.42	Low	1.92	Low
6	Knowledge of healthy plants	3.64	Moderate	3.64	Moderate
7	Knowledge of plant preservation	3.56	Moderate	3.60	Moderate
8	Knowledge of post-harvest processing	3.72	High	2.80	Moderate
9	Knowledge of marketing	3.04	Moderate	2.92	Moderate
10	Activeness in farmer groups	2.26	Low	3.64	Moderate
	Average score	**3.14**	**Moderate**	**3.34**	**Moderate**

The indicator with the lowest score in human assets in Banyuwangi is the involvement of household members in cocoa farming (Table 2). The same condition also occurs in Trenggalek. It is because the only members of the farming household involved in cocoa farming are the head of the household and/or his wife, while other family members (the children) work in other sectors. Apart from that, in Banyuwangi, indicators of participation in training and activity in farmer groups are in the low category. Cocoa farmers in Banyuwangi are members of farmer groups, but they do not participate in decision-making on farmer group activities and are rarely involved in training activities. In line with (Zulkiflibasri *et al.*, 2022), agricultural institutions tend to be considered just a formality that causes a lack of farmer participation.

Table 3 - Natural Asset of Cocoa Farming Household

No.	Indicators	Banyuwangi	Criteria	Treanggalek	Criteria
1	Land occupancy status	3.36	Moderate	3.22	Moderate
2	Land use	3.52	Moderate	3.36	Moderate
3	Availability of water	4.56	High	4.42	High
4	Overview of rainfall	3.78	High	3.82	High
5	Water source	2.56	Moderate	2.74	Moderate
6	Opportunity to obtain organic fertilizer	1.62	Low	3.32	Moderate
7	Opportunity to obtain inorganic fertilizer	2.12	Low	1.00	Low
8	Opportunities to obtain labor	1.20	Low	1.78	Low
9	Overview of the level of erosion	4.18	High	3.88	High
10	Overview of the level of land damage	4.06	High	3.78	High
	Average score	**3.10**	**Moderate**	**3.13**	**Moderate**

Table 4 - Financial Asset of Cocoa Farming Household

No.	Indicators	Banyuwangi	Criteria	Treanggalek	Criteria
1	Primary source of income	2.62	Moderate	3.62	Moderate
2	Average primary income in a year	2.64	Moderate	2.14	Low
3	Other sources of income	3.06	Moderate	2.26	Low
4	Cocoa farming income	2.12	Low	3.04	Moderate
5	Adequate household income	3.12	Moderate	3.18	Moderate
6	Ownership of savings	1.92	Low	2.24	Low
7	Loan involvement for household needs	4.30	High	3.68	High
8	Loan involvement for farming development	4.34	High	3.84	High
9	Sources of loan for household needs	4.48	High	3.74	High
10	Sources of loan for farming development	4.54	High	4.06	High
	Average score	**3.31**	**Moderate**	**3.18**	**Moderate**

Table 3 shows that opportunities to obtain organic fertilizer, inorganic fertilizer, and labor are indicators in the low category in Banyuwangi. The same conditions, except for the opportunity to obtain organic fertilizer, also occur in Trenggalek. The low opportunity to get fertilizer is caused by scarce fertilizer availability and increasingly high fertilizer prices, so farmers rarely fertilize their cocoa plants. The conditions are different in Trenggalek in obtaining organic fertilizer, where farmers produce organic fertilizer independently to meet the nutrient needs in the soil for cocoa plants. Obtaining labor is also quite limited because the opportunities to obtain labor are relatively small, especially labor from outside the family, so many farmers only use labor from within the family. The overview of the level of erosion and land damage has the opposite meaning, both indicators are classified as high, indicating that the two areas of Banyuwangi and Trenggalek have good land conditions and are suitable for cocoa plants.

While, Table 4 explains that in Banyuwangi, a financial asset in the low category comes from cocoa farming income. It is because cocoa farming is not the primary income in farming households. A few farmers also grow cocoa plants in their yards so the income from cocoa farming is relatively small. Another indicator in the low category is household savings ownership. Farming households in Banyuwangi prefer to use their household income to pursue other activities, such as raising livestock and trading. This aims to increase the income of farmer households apart from cocoa farming. Therefore, the farmers' household savings are relatively low.

In Trenggalek, the lowest financial asset comes from the average primary income in a year. The primary income of farming households comes from cocoa farming which is relatively small, less than IDR 10 million. Households also have savings ownership in the low category. This is because farming households not only use their income for clothing, food and shelter needs, but also for other activities such as raising livestock, trading, and farming other than cocoa. Other sources of income are classified as low because the majority of farming households in Trenggalek rely on cocoa farming as their primary source of income.

Table 5 - Physical Asset of Cocoa Farming Household

No.	Indicators	Banyuwangi	Criteria	Treanggalek	Criteria
1	Condition of road facilities	2.88	Moderate	3.56	Moderate
2	Distance to the farming location	3.60	Moderate	3.42	Moderate
3	Condition of residence	3.16	Moderate	3.56	Moderate
4	Homeownership status	4.48	High	4.70	High
5	Overview of farming land	2.12	Low	3.72	High
6	Transportation facilities	3.62	Moderate	3.24	Moderate
7	Communication facilities	3.70	High	3.58	Moderate
8	Information sources	3.28	Moderate	3.16	Moderate
9	Electrical power	3.18	Moderate	3.26	Moderate
10	Access to household necessities	3.92	High	3.44	Moderate
	Average score	**3.39**	**Moderate**	**3.56**	**Moderate**

Table 4 also shows that loan involvement for households and farming has the opposite meaning from other indicators. A high score indicates that the household has never been involved in loans for household or farming needs. In both regions, both indicators are classified as high, showing that cocoa farming households rarely or never engage in loans. This indicates that cocoa farming households in both regions are mostly able to meet their household and farming needs from cocoa farming as the primary source of income. The same thing also applies to indicators of loan sources for both household consumption and farming business development. In both regions, both indicators are classified as high, indicating that cocoa farming households have access to loans from official institutions such as cooperatives and banks. A few farmers prefer to borrow money from neighbors or moneylenders to meet their household needs. These conditions were aligned with the study of (Saleh *et al.*, 2016).

In Table 5 we know that the overview of cocoa farming land in Banyuwangi Regency is in the low category. This is because most farmers perform cocoa farming in the yard or cultivation rights on land (HGU). Cocoa plants, whether in the forest (cultivation rights on land) or yard, are planted without paying attention to effective spacing, the presence of shade trees, and plant treatment. Meanwhile, in Trenggalek, the condition of cocoa farming land is organized by adjusting the planting distance even for plants in the yard. Farmers in Trenggalek also make *rorak* (a burrow for storing water) for their cocoa plants to overcome water shortages during the dry season.

Table 6 - Social Asset of Cocoa Farming Household

No.	Indicators	Banyuwangi	Criteria	Treanggalek	Criteria
1	Communication with neighbors	4.70	High	5.00	High
2	Communication with farmer group administrators	2.58	Moderate	3.78	High
3	Communication with other farmer groups	2.54	Moderate	2.88	Moderate
4	Communication with village officials	2.72	Moderate	2.58	Moderate
5	Communication with farming partners	2.30	Low	2.82	Moderate
6	Communication with agricultural extension workers	1.86	Low	3.34	Moderate

No.	Indicators	Banyuwangi	Criteria	Treanggalek	Criteria
7	Communication with cooperative institutions	1.92	Low	3.28	Moderate
8	Communication with collecting traders	4.52	High	3.98	High
	Average score	**2.90**	**Moderate**	**3.46**	**Moderate**

Table 6 explains that in Banyuwangi, communication with farming partners, agricultural extension workers, and cooperative institutions are low. Communication with farming partners is only carried out by the farmer group leader, so farmer members rarely communicate directly with farming partners. The limited number of agricultural extension workers means that extension services are rarely carried out to farmers so communication with agricultural extension workers is limited. Even though farmers have access to cooperative institutions, only a few farmers make loans to cooperatives so communication with cooperative institutions is minimal. On the other hand, all social assets in Trenggalek are classified as moderate or high. It shows that farming households in Trenggalek have good social resource capabilities. However, farming households still need to improve communication with village officials to obtain information regarding the presence of aids, such as basic food supplies and other social aids. Likewise, communication with other partner groups and farming partners so that farmers can exchange information regarding the effective and efficient implementation of cocoa farming, both from on-farm to off-farm activities, both on-farm and off-farm activities. DFID (2000) conluded that social capital is considered to enhance mutual trust and lower the cost of working simultaneously. Furthermore, it also helps to increase people's income and savings (financial assets), is more effective in improving the management of common resources (natural assets), maintains shared infrastructure (physical assets), and facilitates the development of knowledge (DFID, 2000).

Technical Efficiency of Cocoa Farming in East Java Province, Indonesia

Cocoa farming in East Java province is influenced by land area, organic or inorganic fertilizer, biological or chemical pesticides, and labor. Farming in Banyuwnagi tends to use chemicals such as inorganic fertilizers and chemical pesticides, while Trenggalek has implemented the use of organic materials in cocoa farming such as organic fertilizers and pesticides.

Table 7 - Estimation Result of Cocoa Production Function in East Java Province

Variable	Banyuwangi		Trenggalek	
	Coeff.	**t-ratio**	**Coeff.**	**t-ratio**
Intercept	5.5468	6.4007	6.8529	27.0781
Land area	0.3758**	4.5811	0.8893**	50.0085
Inorganic/Organic Fertilizers	0.0045 ^{ns}	0.1455	0.0303^{ns}	1.1119
Biological/Chemical Pesticides	0.1413 ^{ns}	1.2701	0.0243^{ns}	0.5642
Labor	0.4823 ^{ns}	1.5674	0.2514**	3.3394
Sigma-squared (σ^2)	0.9763		0.0185	
Gamma (γ)	0.9355		0.9999	
Log-likehood function MLE	–37.8266		37.0650	
LR test of the one-side error	1.8563		3.2820	

Notes: ** significant at α 1%; * significant at α 5%; ^{ns} not significant.

Table 7 summarizes the results of estimating the production function in Equation 1. The results show that one of the four factors significantly influences the technical efficiency of cocoa farming in Banyuwangi and two factors significantly influence the technical efficiency of cocoa farming in Trenggalek. In Banyuwangi, land area has a positive and significant effect, whereas inorganic fertilizers, chemical pesticides, and labor do not have a significant effect. Meanwhile, in Trenggalek, land area and labor are factors that have a positive and significant influence on technical efficiency, on the other hand, organic fertilizers and pesticides do not have a significant influence. The sigma squared, gamma, and log-likelihood MLE values show strong estimation results. Gamma values of 0.9355 and 0.9999 mean that the model is influenced by technical inefficiency effects of 93.55% and 99.99%, while the rest is influenced by stochastic effects or random factors. Factors estimated to cause technical inefficiency in cocoa farming include age, education, number of family members, cocoa farming experience, land ownership status, gender, etc. (Attipoe *et al*., 2020; Besseah & Kim, 2014; Danso-Abbeam *et al*., 2020; Donkor *et al*., 2023; Rouf *et al*., 2021). Attipoe *et al*., (2020) added that technical inefficiency has a fundamental role in explaining output levels among cocoa farmers in a region. In our analysis, we did not include tree age as a variable due to the unavailability of this specific data during field collection. However, based on field information and interviews with local agricultural officers and farmers, we learned that cocoa planting in both Trenggalek and Banyuwangi districts was carried

out simultaneously as part of government-supported seedling assistance programs. In Trenggalek, the cocoa seedling distribution program was implemented approximately 20 years ago, while in Banyuwangi, a similar program was conducted around 15 years ago. As a result, the age of cocoa trees in each region tends to be relatively homogeneous around 20 years in Trenggalek and 15 years in Banyuwangi. While we acknowledge that tree age can influence the responsiveness of fertilizer use and yield over time in perennial crops, we believe that the relatively uniform planting time within each region helps to minimize the variability caused by tree age in this particular case. Nonetheless, we recognize this as a limitation of the study.

The land area has a positive and significant effect on cocoa production, while inorganic fertilizers, chemical pesticides, and labor have a positive and insignificant effect on cocoa production in Banyuwangi. The land area has a coefficient value of 0.3758. This value means that every 1% increase in land area will increase cocoa production by 0.3758%. On average, cocoa farmers have a land area of less than 0.5 Ha. This shows that even though cocoa farming is small-scale (smallholder cocoa), farmers have the potential to increase land area through the use of yard land and cultivation rights on land that have not been managed optimally. If cocoa production is to be increased, the area of land cultivated by farmers must also be increased. This result is similar to (Effendy *et al*., 2019; Rahman & Hariyati, 2023; Rouf *et al*., 2021). Inorganic fertilizers and chemical pesticides do not have a significant effect on cocoa production. This is because the older cocoa plants (in Banyuwangi, the cocoa plants are about 22 years old) make the use of fertilizers and pesticides less effective in increasing cocoa production. Furthermore, a few farmers do not treat their cocoa plants properly, including using fertilizers and pesticides in cocoa farming. Farmers assume that cocoa plants will still produce fruit even if the cocoa plants are not treated properly (Rahman & Hariyati, 2023). Labor also does not have a significant effect on cocoa production. Older cocoa plants and the density of plants in the cocoa plantation area cause the use of labor to preserve and treat cocoa plants to be less effective in increasing cocoa production. Farmers should replace new cocoa plants so that the use of production inputs such as inorganic fertilizers, pesticides, and labor can increase cocoa production in Banyuwangi. Binam *et al*., (2008) concluded that the cocoa tree becomes productive after four years of planting with the yields increasing annually until about 18 years, then the yields gradually begin to decline. (Binam *et al*., 2008) added that after 20-30 years of cocoa tree planting, farmers need to reinvest in uprooting, replanting, soil improvement, and future pest reduction, or migrate to a fresh area.

In Trenggalek, land area and labor have a positive and significant influence on cocoa production. Meanwhile, organic fertilizers and pesticides have a positive and insignificant effect on production. The land area has a coefficient value of 0.8893, meaning that every 1% increase in land area will increase

cocoa production by 0.8893%. Similar to farmers in Banyuwangi, cocoa farmers cultivate cocoa plants on a small scale with a land area of less than 0.5 Ha. Cocoa farmers have the potential to increase the area of cocoa through the use of yard land to increase cocoa production. These results are in line with the studies from (Effendy *et al.*, 2019; Rouf *et al.*, 2021). Labor with a coefficient value of 0.2514 means that every additional 1% of labor will increase cocoa production by 0.2514%. Increasing the use of labor will improve the efforts of cocoa plant treatment. Farmers tend to be more intensive in performing biological control, fertilization, land clearing, post-harvest handling, and others, thus it will optimize their cocoa production. This result is similar to (Attipoe *et al.*, 2020; Donkor *et al.*, 2023; Rouf *et al.*, 2021). Organic fertilizers and pesticides do not have a significant effect on cocoa production. The use of organic fertilizers and pesticides requires a longer process and time for cocoa plants to absorb nutrients and other chemical compounds contained in organic fertilizers and pesticides, therefore it takes longer for cocoa plants to produce fruit. These conditions were aligned with the findings of (Febriani *et al.*, 2021; Jatsiyah *et al.*, 2020; Sharma & Chetani, 2017). Furthermore, similar to Banyuwangi, the cocoa plants in Trenggalek are old plants, about 28 years old. Farmers need to replant their cocoa plants.

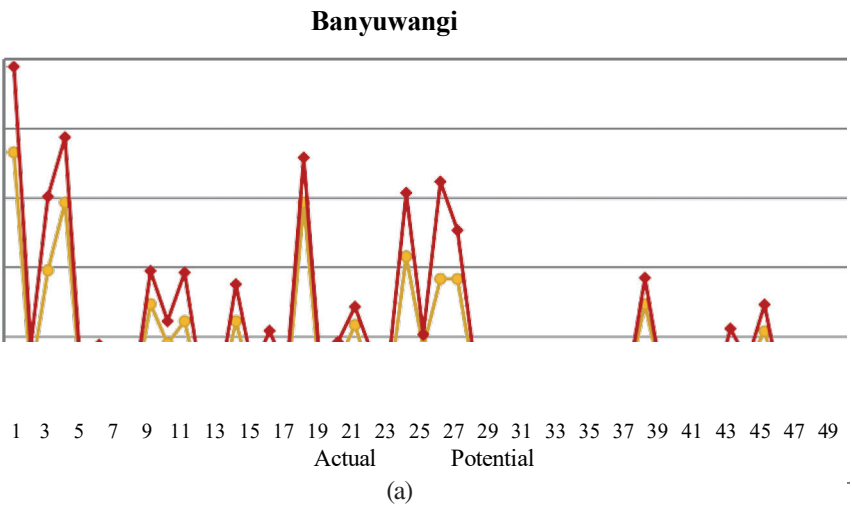
Table 8 - The Distribution of Technical Efficiency of Smallholder Cocoa Farmers

Technical Efficiency	**Banyuwangi**		**Trenggalek**	
	Number of Farmers	**%**	**Number of Farmers**	**%**
< 50	17	34	0	0
50 ≤ ET ≤ 70	12	24	9	18
70 < ET ≤ 90	20	40	33	66
> 90	1	2	8	16
N	50	100	50	100
Mean		**60.74**		**80.12**
Maximum		**91.20**		**99.94**
Minimum		**12.88**		**61.16**

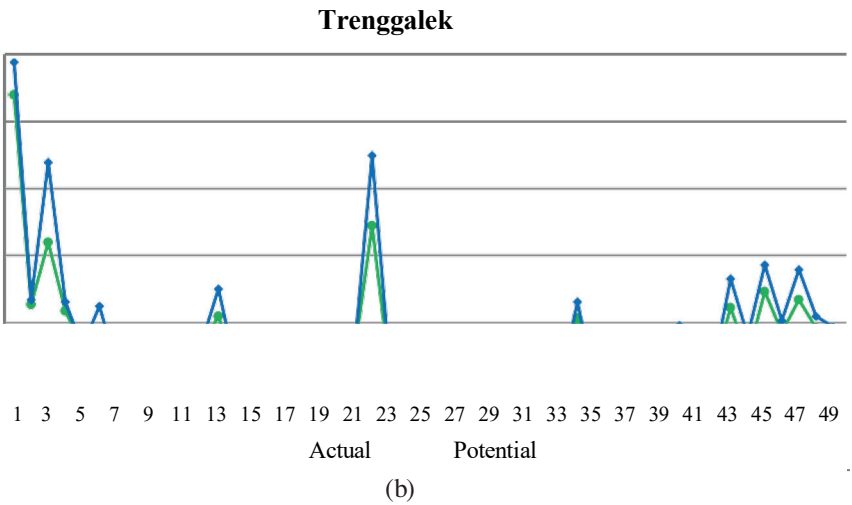
Table 8 shows that the average technical efficiency of cocoa farming in Trenggalek is 80.12% and 60.74% for Banyuwangi. The highest technical efficiency in Trenggalek and Banyuwangi are 99.94% and 91.20%, while the lowest are 61.16% and 12.88%. The majority of farmers in Banyuwangi are at a lower-level efficiency with a percentage of farmers below 70% efficiency

level of 58%. At the same level, the percentage of farmers in Trenggalek is only 18%. Farmers in Trenggalek dominate with a high level of efficiency with the percentage of farmers at a 70-90% efficiency level of 66% and 16% of farmers operating at an efficiency level higher than 90%. The percentage of farmers in Banyuwangi who operate at an efficiency level of 70-90% is 40%, and the remaining 2% of them operate at an efficiency level higher than 90%. It indicates that farmers in Trenggalek have higher technical efficiency than Banyuwangi.

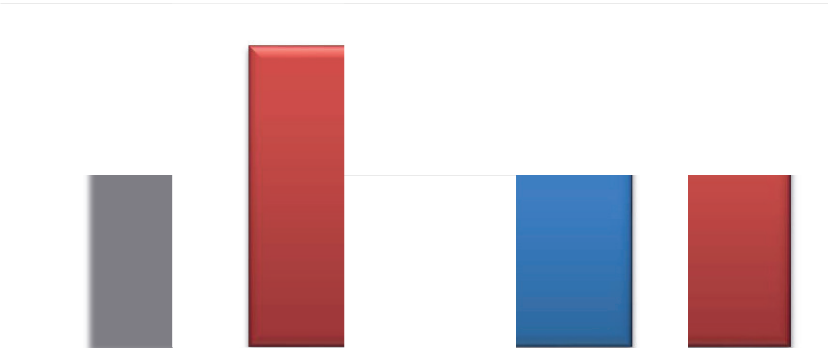
Figure 3 - Comparison of Actual and Potential Production of Cocoa Farming: (a) Banyuwangi (b) Trenggalek (c) Average Production



(a)



(b)



(c)

Figure 3 shows that the actual production of both regions is below potential production. It indicates that the level of technical efficiency of cocoa farming in both regions has not been able to reach ideal potential production. The gap between actual production and potential production can be seen from the level of technical efficiency of cocoa farming which is less than one (TE ≠ 1). The gap between actual production and potential production in Trenggalek is lower than in Banyuwangi. It is proven by the technical efficiency level of Trenggalek (80.12%) which is higher than Banyuwangi (60.74%). The higher the technical efficiency, the lower the gap between actual and potential production. Even though the technical efficiency value in Trenggalek is higher than in Banyuwangi, the actual production in Banyuwangi is still higher than in Trenggalek. This is because the land area of cocoa farmers in Banyuwangi is higher than in Trenggalek, so cocoa production in Banyuwangi remains higher than in Trenggalek. (BPS Jawa Timur, 2023) data show that the area of cocoa plantations in 2022 in Banyuwangi of 9,824 Ha with cocoa production of 8,017 tons, while Trenggalek has a land area of 4,201 Ha with cocoa production of 2,821 tons.

The Linkage of Livelihood Assets and Technical Efficiency of Cocoa Farming Households in East Java Province, Indonesia

The link between livelihood assets and the technical efficiency of cocoa farming households aims to examine the relationship between those two. Higher livelihood assets will be followed by farmers' ability to achieve higher potential production (or technical efficiency) of cocoa farming, vice versa.

The analysis results of the linkage between livelihood assets and technical efficiency of cocoa farming households in East Java province are presented in Table 8. Analysis of the relationship between livelihood and TE using Rank Spearman correlation because this analysis examines a relationship between two variables in a population as an inferential statistic (Chen & Popovich, 2002). This analysis is in line with the research of (Anandari, 2022).

Tabel 8 - The Correlation Result of Livelihood Assets and Technical Efficiency

Correlation	Banyuwangi	Trenggalek
Sig. (2-tailed)	0.032*	0.000**
Rank Spearman Correlation	0.303	0.514

Notes: ** significant at α 1%, * significant at α 5%

Table 8 explains that the correlation between livelihood assets and the technical efficiency of cocoa farmer households in both Banyuwangi and Trenggalek Regencies has a positive and significant correlation. The Rank Spearman correlation value for Banyuwangiis 0.303 meaning the correlation between the two variables is in the weak category, while Trenggalek is 0.514 meaning the moderate category. The positive sign indicates that the higher the livelihood assets of cocoa farming households, the higher the level of technical efficiency of cocoa farming, vice versa. The high livelihood assets condition of cocoa farming households shows that the household has adequate assets to meet household needs (clothing, food, shelter) as well as cocoa farming as a primary source of household income. Farming households with adequate assets will utilize the resources they have to increase their cocoa farming production. In Trenggalek, farmers have been able to independently provide production inputs such as organic fertilizers and pesticides. Meanwhile, in Banyuwangi, farmers still rely on inorganic fertilizers and chemical pesticides as input for their cocoa farming production. These efforts are performed by cocoa farmers to achieve potential production or technical efficiency. On the other hand, technically efficient cocoa farming (such as in Trenggalek) means that production resulting from cocoa farming reaches potential levels. Potential production generates sufficient household income for cocoa farmers to support the compliance of livelihood assets to meet living needs, manage existing resources, and adapt to changes.

The results of the correlation analysis between farmer household livelihood assets and the technical efficiency of cocoa farming are in the weak category.

This is because the use of livelihood assets by cocoa farming households does not focus on cocoa farming. The majority of farming households cultivate cocoa plants not as the main commodity. Farmers choose to switch to cultivating dragon fruit or durian plants, raising livestock, and trading, because the income earned is relatively higher, so households pay less attention to their cocoa farming business, especially the fulfillment of production inputs for cocoa plants such as providing fertilizers and pesticides becomes less fulfilled. It causes cocoa farming in Banyuwangi to be technically inefficient. On the other hand, inefficient cocoa farming means that farmers' cocoa production is still far from reaching production potential so that farmer household income from cocoa farming is relatively low. The low income from cocoa farming does not fully help farmers in increasing the level of livelihood assets of cocoa farming households, especially on indicators in natural, social, and human assets. Roslinda *et al*., (2024) stated that farming is a business that depends on natural conditions which are always changing and often face uncertainty, thereby affecting the condition of natural assets. Roslinda *et al*., (2024) continued that for human assets, the age and education of the head of the family greatly influence his behavior toward technology adoption and greatly determine workability and productivity (Roslinda *et al*., 2024). Younger farmers tend to be more innovative and open to new technology. Likewise, farmers with higher education tend to be more accepting and appreciative as well as implement innovations (Kongor *et al*., 2018).

Meanwhile, in Trenggalek, the results of the correlation analysis between livelihood assets and the technical efficiency of cocoa farming households are classified as moderate. This is because the livelihood assets of cocoa farming households are not fully utilized to achieve maximum production in cocoa farming, but also to undertake other activities, such as raising livestock (chickens and goats) and trading. Likewise, the high level of technical efficiency of cocoa farming does not necessarily mean that farmers can use it to increase the overall livelihood assets of farming households. This is because not all household livelihood assets can be increased by farmer household income, such as several indicators of natural assets and social assets which cannot be directly influenced by farmer household income.

Conclusions

This study aims to examine the level of livelihood of cocoa farming households, the technical efficiency of cocoa farming, and the relationship between the two in East Java. This research found that the livelihood assets of cocoa farmer households in both regions, Banyuwangi and Trenggalek

Regencies, were classified as moderate. Cocoa farming in Banyuwangi is not yet technically efficient, while in Trenggalek it is technically efficient. Furthermore, the linkage between livelihood assets and technical efficiency in Banyuwangi and Trenggalek has a positive correlation which is classified as weak and moderate. This proves that the higher the livelihood assets of cocoa farming households, the higher the technical efficiency of cocoa farming, and vice versa.

This study has limitations. This study did not analyze technical inefficiency factors that could influence TE. Further research needs to be carried out in this field, particularly by considering technical inefficiency factors and the possibility of significant differences in efficiency by farmers from different regions.

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