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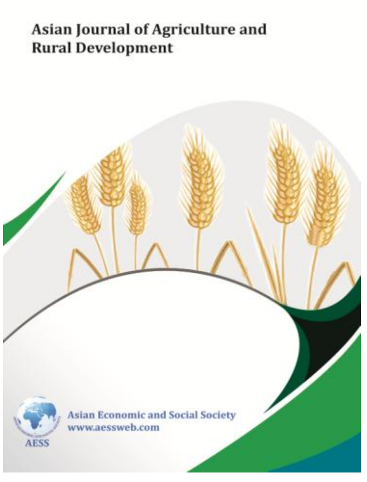


# Socioeconomic and Ecological Dimension of Certified and Conventional Arabica Coffee Production in North Sumatra, Indonesia

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# Socioeconomic and Ecological Dimension of Certified and Conventional Arabica Coffee Production in North Sumatra, Indonesia

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## Abstract

The study was conducted in six subdistricts of Simalungun district, North Sumatra, Indonesia. The research objective is knowing the influence of socioeconomic and ecological factors on production of specialty Arabica coffee. Determination of the households sample was using Probability Proportional to Size and Simple Random Sampling for 79 units certified coffee farms and 210 units conventional coffee farms. Farmer's data was analyzed with multiple linear regression model. Benefit of coffee certification compared to conventional coffee was analyzed by independen t-test. Increased production of arabica coffee could be achieved by intensification strategy through: increased application of suitable fertilizer recommendations, facilitation of coffee farm credit, optimization of land use (intercropping or multistrata coffee), optimization of family labour used, and application of GAPs (shade tree, organic fertilizer, coffee pruning, land conservation, and control of CBB). Ecological dimensions have important role in the development of specialty arabica coffee in the Simalungun highland; i.e. enhance productivity, improve coffee quality and support sustainability of coffee production. Productivity of certified arabica coffee is lower (8%) than conventional coffee, meanwhile premium price of certified coffee is only slightly higher (3.57%) than conventional coffee.

**Keywords:** Production, Coffee, Certification, Conventional, Socioeconomic, Ecology

## Introduction

Coffee is the second most important export commodities in global trade, after petroleum (Gregory and Featherstone, 2008; ICO, 2010; Amsalu and Ludi, 2010). Coffee is an agricultural commodity traded most widespread in the world, mostly managed by small scale farmers with the significant role of woman (ITC, 2011). Coffee produced by more than 70 countries where 45 developing countries are supply 97% of world coffee production. Coffee is an important commodity as agent of development which gives income, because production process and harvest are much laborious, capable of being a source of important employment in rural areas, good labor opportunity to man and woman (ICO, 2009; Marsh, 2005; Roldán-Pérez *et al.*, 2009).

In 2010, Indonesia became the third major coffee producer country in the world after Brazil and Vietnam, while the fourth position is Colombia. The four countries produce 63,48% coffee production (ICO, 2012). Indonesia and Vietnam's coffee production are still dominated by Robusta coffee; while the largest producers (Brazil) and fourth (Colombia) more dominantly produce Arabica coffee.

Coffee as one of main plantation commodities has real contributed in Indonesian economy as a foreign exchange, source of farmer's income, producer of raw materials to industry, job creation and regional development. The government has prioritized main agricultural commodities and one of them is coffee while four others are cocoa, rubber oil palm, and shrimp (Soemarno *et al.*, 2009). Coffee is a national leading commodity (Ministry of Agriculture/MoA, 2009) and Indonesia has comparative and competitive advantages in coffee production which means had the potential to improve estate, production, and coffee export (Susila, 1999).

North Sumatra Province is the fourth position in the total production of Arabica and Robusta coffee in Indonesia. Total production of North Sumatra in 2010 reached 55,000 ton. Indonesia's largest coffee producers is the Lampung Province (145,000 ton), followed by South Sumatra (138,000 ton), and Bengkulu (55,000 ton). North Sumatra with the average productivity 1,022 kg/ha/yr, is the second position after Aceh with productivity 1,158 kg/ha/yr. North Sumatra is being the largest Arabica coffee producer. Production in 2010 is 46,814 ton with growth 4.59%/yr in the period 2006-2010. The amount of this production contributes 33.20% in national Arabica coffee production. Second place is Aceh Province with the production 39,457 ton and with growth rate 9.79%/yr in the same period. The third until five positions are South Sulawesi, West Sumatra, and NTT respectively (Directorate General of Crop Estate/DGCE, 2012). Other provinces: Bali, East Java, West Sulawesi, Central Java, and Papua, although giving a relatively small production however is also important Arabica coffee-producing region because of the uniqueness of each region.

Main district of arabica coffee producers in North Sumatra are Dairi, North Tapanuli Simalungun, Karo, Humbang Hasundutan, Toba Samosir, Samosir, and Pak-pak Bharat District. Arabica coffee from North Sumatera has global reputation namely Mandheling Coffee and Lintong Coffee. Arabica coffee from Simalungun district contributed significantly for coffee production in North Sumatra as the main specialty Arabica coffee producing region in Indonesia. Arabica coffee from Simalungun district belongs to Mandheling Coffee group (Mawardi, 2008b), and Mandheling Coffee is specialty coffee (Mawardi, 2007; Mawardi, 2009; Wahyudi and Misnawi, 2007).

Arabica coffee variety of Sigarar Utang was grown widely in Simalungun district since 15 years ago, and its development was an interesting phenomena to be examined. Since developed, some problems and potential for the development of specialty Arabica coffee requires serious analysis. The problems and the potential of this development require the importance of research on the production of Arabica coffee with some rationale.

First, the Arabica coffee is a leading commodity in Simalungun district but it's productivity remains relatively low, amounting only 50-65% of the potential production. There is a gap between actual and potential production by 35-50%. Diskin (1997) uses gap between actual production and potential production as one of performance indicator of agricultural productivity. Gap indicator are used then in several empirical studies. In Gayo Highland (Karim, 2012), Arabica coffee productivity is still low than potential productivity of 1.50-2.00 ton/ha/yr. Arabica coffee productivity can reach 60% only of potential production. According to Atekan *et al*. (2005), productivity of coffee in Papua is lower than potential, where one of the factors is still simple cultivation technique without fertilization. Winarsih (1985) stated that, from some of the research results in various coffee producing countries, indicated that coffee productivity per unit of land area is lower than its potential value.

Second, initially extensive acreage and production of coffee from Simalungun was dominated by Robusta coffee, then during the last ten years production area of Arabica coffee is increasing fast relatively. Thirdly, the management of the coffee plantation in North Sumatra is entirely in the people estates i.e. smallholder farmer, so the efforts to increase the production of Arabica coffee would have direct impact for the region and community. Fourth, agropedoclimate of Simalungun District region is suitable for Arabica coffee. Agropedoclimate is the technical suitability of certain commodities to the physical, chemical nature of the land and the local climate, including temperature, precipitation, number of rainy days, light intensity, and other environmental factors (MoA, 2010). Fifth, the coffee commodities designated by the MoA as a priority in the Plantation Revitalization Program in Indonesia starting in 2011. According to Wahyudi *et al*. (2006), the extensification programme of Arabica coffee has been prioritized to North Sumatra Province, then Aceh, West Sumatra, Bengkulu, West Java, West Nusa Tenggara, East Nusa Tenggara and Papua. Sixth, based on the potential of Simalungun District in dry land, smallholder coffee plantation expansion opportunities are still very large.

The recognition of the international market over the products of formal high-quality coffee is done through the certification program. Coffee with a specialty category is specified by certain standards. Consumers will be assured that certification of coffee consumed has been produced in accordance with the principles of sustainable development, so that consumers are willing to pay more in order to care about the aspects of social, economic and ecology. Certification program among coffee product is Organic, Fairtrade, Utz Certified, Rainforest Alliance, C.A.F.E. Practices, Common Code for the Coffee Community (4C), Bird Friendly, and Geographical Indication (Mawardi, 2008b).

A small part of Simalungun arabica coffee which earned certification. The farmers group of Karya Bakti in Sidamanik and Pamatang Sidamanik Subdistrict obtained the certificate C.A.F.E. Practices (Zaenudin, 9 June 2011, personal communication). From the aspect of coffee certification, the study was compared performance of certified and conventional Arabica coffee. The goal knows whether farmer receiving benefits from coffee certification. The result of this study is expected to be beneficial to expanding the recommendation of farming specialty arabica coffee that needs to be included in the certification program through stakeholder partnership. Comparative research between the socioeconomic performance of a specialty coffee organic and conventional coffee was conducted in Nepal (Poudel *et al*., 2010), the socioeconomic performance comparison between areas of coffee farming was done in Vietnam (Doutriaux *et al*., 2008), and a comparison between the growth and production of shade-coffee and sun-coffee was studied in Ethiopia (Bote and Struik, 2011).

From the description of that introduction above, this research aimed: (1) analyzing influence of socioeconomic and ecological factors on arabica coffee production, and (2) analyzing certified arabica coffee performance compared to conventional arabica coffee.

## Research Methodology

Survey of arabica coffee farm has been conducted in upland regions of Simalungun District (North Sumatera, Indonesia) in 2011. Partly of the coffee farm data are sourced from arabica coffee survey that conducted by International Finance Corporation (IFC) in 2010/2011. Data from IFC was especially for all certified coffee (C.A.F.E. Practices) in Sidamanik and Pamatang Sidamanik Subdistrict) with sample of 79 household from 320 household population. Some data of conventional arabica coffee also obtained from IFC in Sidamanik, Pamatang Sidamanik, Dolok Pardamean, and Purba Subdistrict. Apart of farm data of conventional arabica coffee from Sidamanik, Silimakuta, Pamatang Silimahuta, and partly in Purba Subdistrict is done by using a questionnaire. Sample size of conventional coffee is 210 household from 16,416 conventional farmers.

Samples size is determined by using a minimum number of samples based on the formula of Cochran (1977):

$$n_o = \left(\frac{t}{r}\right)^2 \left(\frac{s}{\hat{Y}}\right)^2 \text{ and } n = \frac{n_o}{1+\left(\frac{n_o}{N}\right)}$$

where $n_o$ is minimum sample size, $n$ is definitive sample size, $N$ is population size, $t$ is the $t$ value in the student t-table (1.96) for 95% confidence interval, $r$ is the relative error of the average prediction among of 10%, $s$ is standard deviation (predictor to population variance), and $\hat{Y}$ is predictor to average productivity of arabica coffee for population. The value of $s$ and $\hat{Y}$ are 854,64 and 1,635 (certified coffee farm); 1,256.88 and 1,700 (conventional coffee farm). This statistics was obtained from a previous survey by the IFC in 2010/2011 in partnership with Simalungun University.

According to Cochran's formula and the statistics above, then the sample size was calculated as follows for certified coffee farm:

$$n_o = \left(\frac{t}{r}\right)^2 \left(\frac{s}{\hat{Y}}\right)^2 = \left(\frac{1,96}{0,1}\right)^2 \left(\frac{s}{\hat{Y}}\right)^2$$
$$= \left(\frac{1,96}{0,1}\right)^2 \left(\frac{854,64}{1.635}\right)^2 = 384 * 0,2732 = 105$$

Because there were only 320 household of population, then needed a finite populations correction (fpc) and $n$ is calculated as follows:

$$n = \frac{n_o}{1+\left(\frac{n_o}{N}\right)} = \frac{105}{1+\left(\frac{105}{320}\right)} = \frac{105}{1+(0,3281)} = 79$$

For conventional coffee farm calculated as follows:

$$n_o = \left(\frac{t}{r}\right)^2 \left(\frac{s}{\bar{Y}}\right)^2 = \left(\frac{1{,}96}{0{,}1}\right)^2 \left(\frac{s}{\bar{Y}}\right)^2$$
$$= \left(\frac{1{,}96}{0{,}1}\right)^2 \left(\frac{1.256{,}88}{1.700}\right)^2 = 384 * 0{,}5466 = 209{,}89 \approx 210$$

The selection of the sample was conducted by Multi-Stage Cluster Sampling (MSCS). Determination of the sample of households was used Probability Proportional to Size (PPS) and Simple Random Sampling/SRS (Nazir, 2009; Magnani, 1997).

Farm data was analyzed by Multiple Linear Regression Model by relevant test such as: goodness of fit, F-test, and t-test. There were three models developed in this research, i.e. model of certified coffee production (Model 1), model of conventional coffee production (Model 2), and combined model (Model 3). The model is formulated as follows:

$$\hat{Y} = \beta_0 + \beta_1 EXP + \beta_2 WOM + \beta_3 SIZ + \beta_4 TREE + \beta_5 PROD + \beta_6 LBR + \beta_7 CAP + \beta_8 LUSE + \beta_9 LIQU + \beta_{10} SHADE + \beta_{11} ORG + \beta_{12} PRUNE + \beta_{13} CONS + \beta_{14} CBB + \mu$$

where $\hat{Y}$ = production of certified/conventional/all arabica coffee farm (kg/farm); $\beta_0$ = constant term; EXP = farmer's experience (year); WOM = role of women (comparison of women labor with total labor [%]); SIZE = farm size (ha); TREE = number of coffee tree/farm; PROD = productive period (year); LBR = total labor use (mandays/farm); CAP = capital (IDR/farm); LUSE = land use (1 if farmers apply one or combination of intercropping, shaded coffee, and multistrata coffee; 0 if monoculture coffee); LIQU = farmer's financial liquidity (1 if the farmer has liquid financial [has other fixed income outside coffee farming, such as civil servants, employees of state plantation, and others; 0 if otherwise); SHADE = number of shade tree/farm; ORG = proportion of organic fertilizer cost for total cost of fertilizer (%); PRUNE = coffee pruning (1 if farmer is do one or more of coffee pruning types; 0 if otherwise); CONS = land conservation (1 if farmer is do one or more of land conservation practices [mulching, *rorak*, individual or bench terrace]; 0 if otherwise); CBB = coffee berry borer control (1 if farmers do one or combination of farm sanitation, biological control, and traps; 0 if otherwise); $\beta_1$ ... $\beta_{14}$ = regression coefficient, $\mu$ = error term.

## Result

**Performance of Indonesian Coffee**

In 2011, Indonesia ranks third in volume of world coffee production, after Brazil and Vietnam. Indonesia's production volume in 2011 reached 525,000 ton. Brazil's coffee production, is the biggest of which reached 2,609,040 ton and Vietnam 1,110,000 ton. While at the fourth position is Colombia (510,000 ton), slightly below the Indonesia production (ICO, 2012). The performance of coffee production in major producer countries are shown in Figure 1.

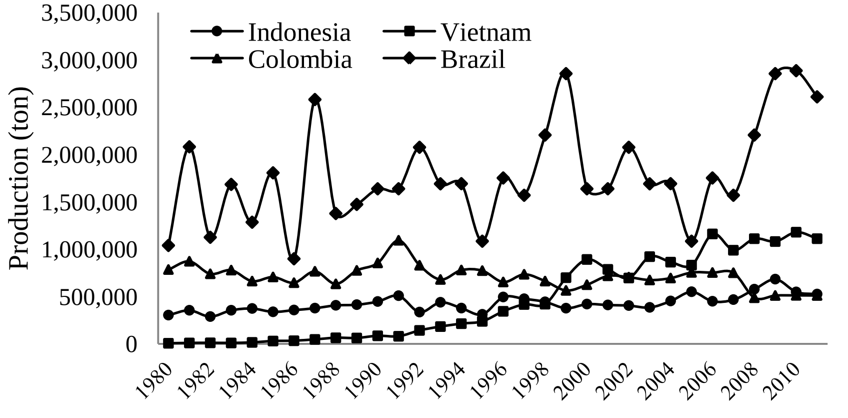
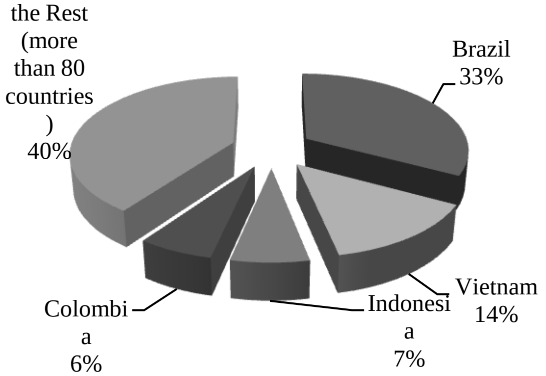



**Figure 1: The development of coffee production in the major producer of the world**
**Source:** ICO (www.ico.org)

Brazil with the largest production (33% of world production) showed very fluctuative production. A more relatively stable production occurred in Indonesia and Colombia. Production trend has been very impressive experienced in Vietnam. In 1998, Vietnam were the fourth in position is now capable of occupying second position since 2000, only within two years.

In 2011, four major producer countries were able to supply about 56% of world coffee production. The largest share was given by Brazil (33%), followed by Vietnam (14%), Indonesia (7%), and Colombia (6%). The rest (40%) were supplied by more than 80 other countries especially India, Ethiopia, Mexico, Honduras, Ivory Coast, Nicaragua, and Costa Rica (Figure 2). World coffee total production in 2011 reached 7,944,420 ton. This production was shared by Brazil (2,609,040 ton), Vietnam (1,110,000 ton), Indonesia (525,000 ton), and Colombia (510,000 ton).

Indonesia is the country with the lowest average productivity (Arabica plus Robusta) among the four major coffee producer countries. In 2009, Indonesia in the aggregate was only able to achieve the productivity of 510 kg/ha/yr. A very impressive productivity has achieved by Vietnam, where in the same year has been able to achieve the productivity of 2,034 kg, followed by Brazil (1,132 kg), and Colombia (545 kg).



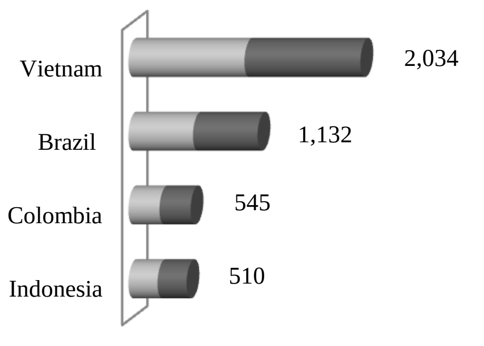




**Figure 2. Share of the world coffee production (2011) and productivity (2009)**
**Source:** ICO (www.ico.org)

**Performance of North Sumatra Coffee**

North Sumatra is the largest producer of Arabica coffee in Indonesia. Production in 2010 reached 46,814 ton with growth of 4.59%/yr in period 2006-2010. The amount of this production contributes by 33.20% to the national production of Arabica coffee. Second place is occupied by the Aceh Province with the production of 39,457 and growth 9.79%/yr in the period 2006-2010. The third until fifth position are South Sulawesi, West Sumatra, and NTT. Spesiaty Arabica coffee producer district in the various provinces, among others, are Dairi, Simalungun, North Tapanuli, Humbahas, Karo District (North Sumatra); Central Aceh, Bener Meriah, Gayo Lues District (Aceh); Tana Toraja, Enrekang (South Sulawesi), Manggarai, Ngada (NTT), and Kintamani (Bali). National level, Arabica coffee production reached 140,512 ton in the 2010 with an average growth rate of 10.3 % during 2006-2010. The amount of production of Arabica coffee is only 21% of national coffee production of 657,909 ton, where the rest 517,397 ton (79%) is robusta coffee. Trend of national production of Arabica coffee in 2006-2012 is presented in Figure 3.

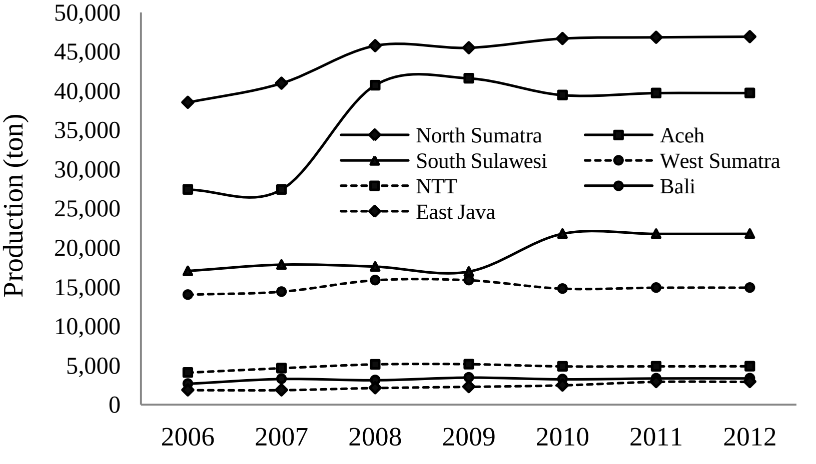
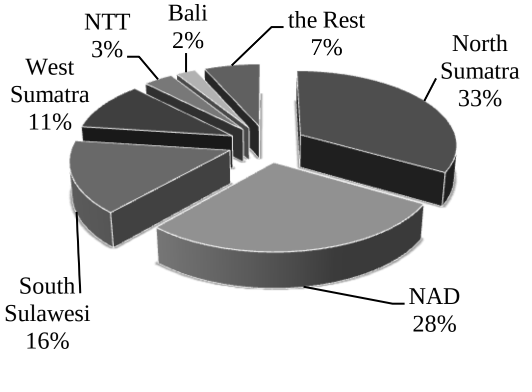



**Figure 3. Development of arabica coffee production per province in Indonesia (2011: preliminary, 2012: estimation)**
**Source:** DGCE (2012)

Based on DGCE data (2011), for the status of people plantation, North Sumatra is the largest producer Arabica coffee in Indonesia with the total production 46,657 ton in 2010. The second position is NAD (Aceh) with total production 39,457 ton followed by South Sulawesi (21,798 ton), West Sumatra (14,788 ton), NTT (4,878 ton), Bali (3,254 ton), East Java (2,485 ton), Papua (1,360 ton) and other provinces (455 ton).

Arabica coffee production from North Sumatra dominates the total production of Indonesia (33.2%), followed by NAD (28.08%), South Sulawesi (15.51%), and West Sumatra (10,52%). Despite top positions in North Sumatra Province in total production, but from the productivity side, the province is still less productive than NAD. Arabica coffee productivity in Sumatra was 1,139 kg/ha/yr, at second position after NAD with the highest productivity of 1,568 kg/ha/yr. Productivity performance in nine other provinces still under 1,000 kg/ha/yr. Even in Papua and West Sulawesi, Arabica coffee productivity were under 500 kg/ha/yr. At national level, productivity of arabica coffee in Indonesia year 2010 was 969 kg/ha/yr. Production share and productivity of arabica coffee according to province was shown in Figure 4.



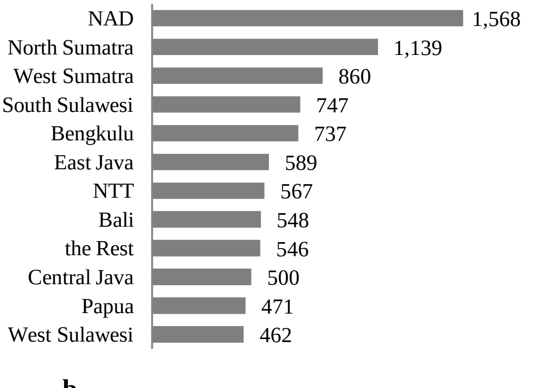




**Figure 4. Production Share (a) and Productivity of Arabica Coffee (b) per Province i**
**Source:** DGCE, 2012

**Model Goodness of Fit**

Test of model suitability is measuring a model that was compiled can be used and continued estimation. Statistics was used to see if some kind of model fit based on a coefficient of determination ($R^2$) tested with statistics F. Regression model is said to be good if $R^2$ approaching the value of 1. Statistics F was used as an instrument to test $R^2$ significancy (Gujarati, 1988). According to Pratisto (2009), the value of statistics F also can be used to determine whether a model may be accepted or not. If statistics F > F critical value or p-value < 0.05, then a model that was compiled can be used to estimate of regression coefficient.

Table 1 shows that coefficient of determination for three model is significant at level $\alpha$ = 1%. Thus, three models are good models and usable to estimate of indenpendent variable that influences on production of arabica coffee.

**Table 1: $R^2$ and Statistic F for Model Goodness of Fit**

| Model | R | $R^2$ | Statistic F | p-value | Decision |
|---|---|---|---|---|---|
| 1 | 0.947 | 0.896 | 39.332 | 0.000 | Model 1 fit |
| 2 | 0.850 | 0.722 | 36.233 | 0.000 | Model 2 fit |
| 3 | 0.798 | 0.637 | 34.363 | 0.000 | Model 3 fit |

**Coffee Production: Socioeconomic and Ecological Dimension**

Comparison of three multiple regression model, especially between Model 1 (certified coffee farm) and Model 2 (conventional coffee farm) was done through regression coefficients estimation by SPSS 20. Based on socioeconomic and ecological dimension, estimation summary of three regression models were presented in Table 2.

**Table 2: Estimation Result of Three Multiple Linear Regression Model**

| Variable | | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|---|
| Constant | $\beta_0$ | 360.045 | (0.555) | -252.377 | (0.515) | -334.271 | (0.337) |
| Farmer's experience | $\beta_1$ | -52.194 | (0.642) | 64.042*** | (0.004) | 53.401*** | (0.004) |
| Role of women | $\beta_2$ | 3.123 | (0.864) | -1.519 | (0.733) | 1.823 | (0.625) |
| Farm size | $\beta_3$ | 205.462*** | (0.000) | 927.022*** | (0.000) | 445.009*** | (0.000) |
| Coffee tree | $\beta_4$ | 0.076*** | (0.008) | -0.162 | (0.143) | 0.068 | (0.293) |
| Productive period | $\beta_5$ | 63.831 | (0.572) | 3.621 | (0.853) | 9.326 | (0.605) |
| Labor | $\beta_6$ | 4.690*** | (0.000) | 0.261*** | (0.000) | 3.611*** | (0.000) |
| Capital | $\beta_7$ | 0.006 | (0.144) | 0.261*** | (0.000) | 0.037*** | (0.000) |
| Land use | $\beta_8$ | 24.975 | (0.744) | 124.396 | (0.214) | 214.318*** | (0.010) |
| Farmer's liquidity | $\beta_9$ | 119.116* | (0.053) | 316.147** | (0.025) | 384.864*** | (0.001) |
| Shade tree | $\beta_{10}$ | -0.162 | (0.729) | -2.846* | (0.076) | -2.070* | (0.071) |
| Organic fertilizer | $\beta_{11}$ | -0.358 | (0.697) | -2.538 | (0.188) | -2.813* | (0.082) |
| Coffee pruning | $\beta_{12}$ | 67.855 | (0.217) | 188.129 | (0.158) | 352.613*** | (0.001) |
| Land conservation | $\beta_{13}$ | -63.155 | (0.196) | -53.791 | (0.541) | 30.024 | (0.697) |
| Control of CBB | $\beta_{14}$ | 45.520 | (0.196) | 35.758 | (0.789) | 221.733** | (0.017) |

Note: p-value in parentheses. ***, **, and * indicates that independent variables significant influenced on coffee production at $\alpha$ = 1%, 5%, and 10%

Based on the result of the estimation with SPSS 20, regression equation for Model 1 (certified coffee farm) can be written as follows:

$$\hat{Y}_1 = 360.045 - 52.194\,EXP + 3.123\,W - 205.462\,SIZE + 0.076\,TREE + 63.831\,PROD + 4.690\,LBR + 0.006\,CAP + 24.975\,LUSE + 119.116\,LIQU - 0.162\,SHADE - 0.358\,ORG + 67.855\,PRUNE - 63.155\,CONS + 45.520\,CBB$$

In Model 1 (certified coffee farm), there are only four independent variables (farm size, number of coffee plant, labor, and farmer's liquidity) that influence significantly on production of Arabica coffee. While 10 independent variables (farmer's experience, role of women, productive period, capital, land use, organic fertilizer, coffee pruning, shade tree, land conservation, and CBB control) indicates no significant influence on the production of Arabica coffee.

Multiple regression equation for Model 2 (conventional coffee farm) can be written as follows:

$$\hat{Y}_2 = -252.377 + 64.042\,EXP - 1.519\,WOM + 927.022\,SIZE - 0.162\,TREE + 3.621\,PROD + 2.769\,LBR + 0.261\,CAP + 124.396\,LUSE + 316.147\,LIQU - 2.846\,SHADE - 2.538\,ORG + 188.129\,PRUNE - 53.791\,CONS + 35.758\,CBB$$

In Model 2 (conventional coffee farm), there are six independent variables (farmer's experience, farm size, labor, capital, farmer's liquidity, and shade tree) that influence significantly on coffee production. While eight independent variables (role of women, number of coffee plant, productive period, land use, organic fertilizer, coffee pruning, land conservation, and CBB control) indicates no significant influence on coffee production.

For Model 3 that is the combined coffee farming, the equation can be written as follows:

$$\hat{Y}_3 = -334.271 + 53.401\,EXP + 1.823\,WOM + 445.009\,SIZE + 0.068\,TREE + 9.326\,PROD + 3.611\,LBR + 0.037\,CAP + 214.318\,LUSE + 384.864\,LIQU - 2.070\,SHADE - 2.813\,ORG + 352.613\,PRUNE + 30.024\,CONS + 221.733\,CBB$$

In Model 3 (combined coffee farm), there are 10 independent variables (farmer's experience, farm size, labor, capital, land use, farmer's liquidity, shade tree, organic fertilizer, coffee pruning, and CBB control) which influence significantly on coffee production. While four independent variables (role of women, number of coffee plant, productive period, and land conservation) indicates no significant influence on coffee production.

**Farmers Income of Certified Versus Conventional Coffee**

To find out if the performance of certified coffee is better than conventional coffee, different test of average with two independent t-test was done. The procedures was adopted Wiley (2011) by using SPSS 20. The testing was conducted with the two stages: test in common variance by using Levene's test for equality of variance, and t-test for equality of mean. The results of difference test of two independent group shown in Table 3.

**Table 3: Performance of Certified and Conventional Arabica Coffee Farm**

| Variables | All farms | | Certified coffee farm | | Conventional coffee farm | |
|---|---|---|---|---|---|---|
| Productivity (kg/ha/yr)[1] | 2,299 | (1,205.89 7) | 2,163 | (1,631.171) | 2,350 | (1.000,424) |
| Farmer's experience (yr) | 8.05 | (2.463) | 9.94*** | (1.667) | 7.34*** | (2.339) |
| Role of women (%) | 78.37 | (10.218) | 83.80*** | (7.650) | 76.33*** | (10.330) |
| Liquid farmer's financial (%) | 35 | (0.478) | 46** | (0.501) | 31** | (0.463) |
| Labor | 164 | (119.046) | 235*** | (146.519) | 137*** | (94.196) |

| | | | | | | |
|---|---|---|---|---|---|---|
| (mandays/ha/yr) | | | | | | |
| Coffee tree/ha | 2,194 | (1,339.999) | 2,867*** | (2,376.146) | 1,942*** | (598.894) |
| Productive period (yr) | 4.94 | (2.146) | 4.90 | (1.667) | 5.00 | (2.304) |
| Farm size (ha) | 0.74 | (1.412) | 0.88** | (0.639) | 0.69** | (0.439) |
| Coffee price (IDR/kg) | 19,508 | (1,364.826) | 20,027*** | (420.869) | 19,313*** | (1,526.790) |
| Revenue (IDR million/ha/yr) | 49.18 | ($5.225 \times 10^7$) | 42.79 | ($3.242 \times 10^7$) | 51.58 | ($5.787 \times 10^7$) |
| Total cost (IDR million/ha/yr) | 9.72 | ($9.643 \times 10^5$) | 10.35 | ($6.737 \times 10^6$) | 9.48 | ($1.053 \times 10^7$ |
| Capital (IDR million/ha/yr) | 0.83 | ($1.412 \times 10^6$) | 2.51*** | ($1.837 \times 10^6$) | 0.20*** | ($1.545 \times 10^5$) |
| Net income (IDR million/ha/yr) | 39.46 | ($4.334 \times 10^7$) | 32.44 | ($2.621 \times 10^7$) | 42.10 | ($4.802 \times 10^7$) |
| Control of CBB (%) | 46 | (0.499) | 76*** | (0.430) | 34*** | (0.476) |
| Doing land conservation (%) | 60 | (0.492) | 70** | (0.463) | 56** | (0.498) |
| Doing coffee pruning (%) | 40 | (0.492) | 47 | (0.502) | 38 | (0.487) |
| Organic fertlizer (%) | 27 | (23,576) | 27 | (24,684) | 26 | (23,201) |
| Land use (%) | 65 | (0,477) | 58 | (0,496) | 68 | (0,467) |
| Shade tree (tree/ha) | 13 | (46,394) | 30*** | (75,302) | 7*** | (26,665) |

Note: standard deviations in parentheses; [1]productivity in parchment *** and ** indicates means are significantly different in independent t-test at 1% and 5% test level

Table 3 indicates that by using terms of common variance (Levene's test), there are eight significantly different of socioeconomic variables between certified and conventional coffee. These variables are the farmer's experience, role of women, Liquid farmer's financial, labor, number of coffee tree, farm size, coffee price, and capital; while the other variables (productivity, farmer's education, revenue, total cost, and net income) do not significantly different. Performance of ecological variables are also better for certified coffee. Control of CBB, land conservation practices, and shade tree on certified coffee are better than conventional coffee. While variable of coffee pruning, organic fertilizer, and land use, there are not significantly different between the two types of farm.

## Discussion

### Socioeconomic Dimension

Farmer's experience showed significant effect on coffee production in conventional coffee farm (Model 2) and combined farm (Model 3), while in the certified coffee farm (Model 1) showed a negative effect on coffee production. The results of this research are different than Nchare (2007) research which found that the higher farmer's experience gave an indication of increasing inefficiency of Arabica coffee production. Poudel *et al*. (2011) research in Nepal showed that the effect of farmers experience was not significant on efficiency of coffee production. The role of women was not significantly effects on coffee production on three models. The role of women in this research was the percentage of labor of women from the total amount of labor employed in management of arabica coffee farm. Labor of women were dominantly applied in the maintenance of coffee farm, with a portion 78% of the total labor.

Farm size had positive and significant effect on coffee production. The results of this study in accordance with Wollni and Brümmer (2009) in Costa Rica, Doutriaux *et al*. (2008) in Vietnam, Poudel *et al*. (2010) in Nepal, and Safa (2005) in Yemen. The number of coffee plant had positive and significant effect on coffee production in certified coffee farm (Model 1). These results indicated that more population of coffee plants, the higher production of arabica coffee. Different result was found in combined farm (no significant effect), even a negative sign was found in conventional coffee farm. Population average of arabica coffee in Simalungun District is 2,194 tree/ha. With the number of this population, in general, farmers apply 2 m x 2.5 m planting distance. Thus, farmers in the Simalungun were advised to apply planting distance recommended for variety of Sigarar Utang, i.e. 2 m x 2.5 m or population of 2,000 plants per hectare.

Productive period is positive but not significantly effect on coffee production on all models. Productive period is the length of productive coffee plant since the beginning of fruit setting, which is a modification of the variable of plant age which was used in some earlier researchers, such as Wollni and Brümmer (2009).

Labor has positive and highly significant effect on coffee production on all model. This is in accordance with the study of Wollni and Brümmer (2009), Doutriaux *et al*. (2008), Poudel *et al*. (2010), and Safa (2005). To that end, recommendation of this study is to make optimal use of family labour; hence the use of hired labor as much as possible needs to be reduced. The goal is reducing of production cost, and increasing farmer's income.

Capital has positive and highly significant effect on coffee production, except on the certificate coffee farm (Model 1). Capital of farming is the amount of expenditure to buy chemical and organic fertilizer. Logical recommendation from this research is then to increase proportional allocation of cost for coffee fertilizer purchase. The use of organic fertilizers is still low about 10% of recommendation, while the use of chemical fertilizers is around 15% of recommended fertilization. Thus, the recommendations of the research is necessary to increase organic and chemical fertilizer use for arabica coffee. Gusli (2012) stated that fertilization of coffee plant according to recommendation and combined with other standard practices (pruning, sanitation, management of organic materials and integrated pest and disease control) can increase productivity of coffee more than 2 ton/ha/yr, even over 4 ton/ha/yr.

Land use system has positive and highly significant effect on coffee production (Model 3). It means, intercropping, shaded-coffee, and multistrata system can increased coffee production. Asten *et al*. (2011) found that intercropping of coffee and bananas is more profitable than monoculture coffee.

Farmer's liquidity has positive and significant effect on coffee production on three model. It showed that fund availability to maintain and manage farm adequately is a substantial condition in order to able increasing coffee production. Fund availability was measured by approach of fixed farmers revenue from outside of coffee farm, namely farmer individual formal job of state plantation, state official, teacher, army/police, and any other job that provides fixed income. This research result is in line with research of Mauro (2010) in highlands of Papua New Guinea who concluded that farmer's liquidity is an important factor in investing of small scale coffee farm. In contrast, limited access to formal credit became an obstacle in development of coffee so government should facilitate to encourage farmers in investing in new technology. Other studies on farmer's liquidity by Nchare (2007), Bolarinwa and Fakoya (2011), Poudel *et al*. (2011), and Hermanto (2009) were also in line with this study result.

**Ecological Dimension**

Ecological variables (shade tree, organic fertilizer, land conservation) were shown negative effect on coffee production. Verbist *et al*. (2004) suggested that coffee monoculture cultivation would give more yield, but at the same time soil nutrient depleted quickly. Therefore, if additional intake of nutrient from the outside in the form of chemical fertilizers is not available, then productive period will be shorter and production will be lower. Bote and Struik (2011) concluded that environmental conditions of a shaded coffee were better than monoculture coffee. For the production and coffee quality, there is no significant difference between shaded and sun coffee. Van der Vossen (2005) stated negative impact of shade trees, namely, if the shade tree population increases then bean production will decrease due to process of flowering is reduced; water use competition between shade and coffee plant at the time of dry season; an increase in labor cost to shade pruning, potentially increasing pests and diseases, for example CBB. Nevertheless, shade tree has positive role to improve quality of cup coffee. Research of Moreira *et al*. (2008) in the area of biggest Arabica coffee producers in the world in the southern of Minas Gerais, Brazil, concluded that there was a tendency for better quality coffee at a shaded coffee farming system.

With regard to the role of organic fertilizer on coffee production, Kadir and Kanro (2006) found that organic fertilizer did not show a significant difference to the number of production branches when compared with the coffee plant without organic fertilizer. Similar results were found by Rubiyo *et al*. (2004).

Coffee pruning and control of CBB are positive and significant effect on coffee production, only in Model 3. Kadir *et al*. (2004) indicated that coffee pruning would give a role in improving growth of coffee plant (amount of productive branch, number of coffee flower). CBB is one of pest that reduces production and quality of coffee (Sulistyowati, 1986). CBB control which is considered to be the most effective way is to disconnect life cycle of CBB through farm sanitary. Beding and Limbongan (2005) found that application of *Beauveria bassiana* powder was able to reduce population of CBB about 25%, while *B. bassiana* solid was able to reduce of CBB about 14%.

From the ecological dimension, application of coffee pruning, control of CBB, and land conservation, combined with a shade tree and application of organic fertilizers are important for improving coffee quality. Thus, the increase in application of ecological variables at the farm level will play multiple role to enhance productivity, improve coffee quality and support sustainability of coffee production.

**Certified vs Conventional Coffee Farm**

Based on Lyngbæk *et al.* (2001) study about organic multistrata and conventional coffee farm, amount of labor used was higher on organic coffee farm than conventional coffee farm. Meanwhile productivity of certified coffee farm is lower than conventional coffee farm. The lower productivity in certified coffee farm must be compensated with the minimum premium price of 38%.

The interesting question is why much capital and labor at certified coffee farm do not generate better productivity and income? Possibly the most logical answer is based on the field observation. First, certified coffee farm (Sidamanik and Pamatang Sidamanik Subdistrict) in general is located in sloping land with relatively low land quality that compared with location of most conventional coffee farm (Dolok Pardamean, Purba, Silimakuta, and Pamatang Silimahuta Subdistrict).

Second, in conventional coffee farm, some 68% of farmers do intercropping system which allocated labor and fertilizer intensively for seasonal crops such as chili, potato, tomato, cabbage, carrot, or corn. Fertilizer and labor usage for seasonal crop is a shared cost along with the Arabica coffee plants. This farming practice was strongly contribute to higher productivity and income of conventional coffee farm. The four districts of location of conventional coffee farms (Dolok Pardamean, Purba, Silimakuta, and Pamatang Silimahuta Subdistrict) are main region of horticulture producer in North Sumatra Province, even in Indonesia.

Due to lower productivity and higher capital in certified Arabica coffee farm, then its also lower revenues compared with conventional coffee farm. This is in line with the results of Lyngbæk *et al*. (2001) study which stated that the income of organic certified farms in Costa Rica was lower than conventional coffee farm.

Coffee price in farmer level is showing that performance of certified coffee farm is better than conventional coffee. The certified coffee price is higher than conventional coffee price through year 2011. Certified coffee farmers sell parchment at IDR20,027/kg, while the price of conventional coffee is IDR19,313/kg. The difference in the price is IDR714/kg, and it was statistically significant different i.e. premium prices for certified coffee 3.57%. In addition, the risk of price fluctuations of certified coffee is lower than conventional coffee, based on the value of variance. The lower of price variance, then the smaller of price fluctuation risk between the farmers.

Based on Bacon (2008) who conducted empirical study regarding Fair Trade and Organic Certification in Nicaragua, the price premium was the highest retrieved by farmers if their cooperatives are directly selling to the roasting companies. The second highest premium price was obtained when selling to Fair Trade cooperatives, then selling to Organic cooperatives, conventional coffee cooperatives, exporters of agricultural enterprises, and the lowest when selling to local collecting traders.

Valkila (2009) found that farmers income depends on two major factor: market price and premium price in farmer level. If the market price is low but premium price is high (23%), then farmers income of organic coffee is higher than conventional coffee, although productivity of organic coffee lower than conventional coffee. Otherwise, if the market price is high but premium prices is low (only 7%), then organic coffee farmer will receive lower income than conventional coffee farmer. In this condition, the lower productivity of organic coffee must be compensated with a higher premium prices. It means to increase farmers income and sustainability of specialty coffee production.

## Conclusion and Recommendation

Increased production of arabica coffee can be done with intensification strategy, through: increased application of suitable fertilizer recommendation, facilitation of arabica coffee farm credit, land use optimization (intercropping or multistrata system), optimizing of family labor used, application of good agricultural practices (GAPs), i.e. shade tree, organic fertilizer, coffee pruning, land conservation, and biological control of CBB. The strategy of extensification should be conducted if efforts of intensification have been showing an increase in production.

Ecological factors have important role in development of arabica coffee in Simalungun highland. Ecological variables (coffee pruning, control of CBB, and land conservation) give positive and significant impact on coffee production. Application of these three variables combined with shade tree and organic fertilizer are important factor to improve coffee quality. Thus, the increase in application of ecological variables at farm level will play multiple role, i.e. to enhance productivity, to improve coffee quality and support sustainability of coffee production.

Productivity of certified Arabica coffee is lower (8%) than conventional coffee. Certified coffee price is only slightly higher (3.57%) than conventional coffee price. Based on these results, certification of coffee has not provided any real benefits for the farmers. Application of ecological variables need incentives for farmers i.e. an effort to raise the premium price to 26% higher than conventional coffee. With such a premium price, farmer's income of certified coffee is higher by 25% compared to conventional coffee. In addition, to improve coffee quality through certification program as long as it is maintained by exporters, it must be managed by the farmer-based institution.

The study recommends that farmers to increase application of GAPs, while local governments should improve the facilitation for the farmers to take intensification strategy as a priority. Strategy of extensification (increased acreage for planting) should preferably taken when intensification strategy have shown an increase of coffee production and productivity.

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