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IMPACTS OF COFFEE AGROFORESTRY AND SUSTAINABILITY CERTIFICATION ON FARMERS' LIVELIHOOD IN SUMATRA-INDONESIA

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ABSTRACT

This study examines the impacts of coffee agroforestry system and sustainability certification on farmers' livelihood in Sumatra-Indonesia. The study applies farm-income analysis and quasi-experimental impact evaluations by interviewing 408 coffee farm-households in Lampung Province. Propensity score matching (PSM) adopted here compares some matching characteristics of adopters of coffee agroforestry system and sustainability certification and the control groups. The results show that both coffee agroforestry systems and sustainability certification have positive significant impacts in improving economic benefits and environmental benefits, although the magnitudes slightly differ. Future policy shall provide better alternatives for farmers' land-use systems that could ensure a better livelihood.

Keywords: Agroforestry system, coffee farming, smallholder farmers

INTRODUCTION

Indonesia is the second largest Robusta coffee producer in the world, just below Vietnam. Arabica coffee is also grown in Indonesia, but less than 15 percent of total annual production, which is mostly in highlands of Northern Sumatra, South Sulawesi, some in Java, Bali, Flores and Wamena in Papua. The vast majority of more than one million hectare of Robusta coffee spread along the Southern Sumatra (Provinces of Lampung, Bengkulu and South Sumatra) and Java (West, Central and East Java) and some in Sulawesi and Bajawa of Flores Island. Coffee is grown by mostly (more than 90 percent) smallholder farmers, cultivating a plot ranging from 0.5 to 2 hectares, except for some small amount of lands which are controlled by large scale state-owned enterprise (PTPNs) in East Java (BPS, 2018).

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Coffee production centers in Lampung are mostly concentrated in the district of Tanggamus and West Lampung, which are adjacent to the Bukit Barisan Selatan (BBS) National Park. Coffee agroforestry system is a typical land use system at the forest margins, instead of coffee monoculture which is has been considered non-sustainable agricultural system. Lampung has long experienced in the changing of land use system from forest cover, to land clearing, intensive agricultural land, to community-based forestry management (see for example Van Noordwijk *et al.*, 2002; Arifin *et al.,* 2009) through a quite complex negotiation support system (NSS). The Government of Indonesia has developed a policy on community-based forest management (HKm=*Hutan Kemasyarakatan*) in 2001, where local people are allowed to grow coffee inside the forest as long as they could maintain the minimum requirements of tree crops in the parcel and to fulfill a composition of shade trees of multi-purpose tree species (MPTS) in the cultivated area. These people are not allowed to own permanently any parcel of lands in the protection forests

Sustainability certification schemes and standards in the coffee sector have emerged in conjunction with growing concerns of environmental governance since in the coffee value chains since the 1990s and have developed more rapidly recently. Coffee agroforestry system is a favorable pre-condition for the development and expansion of sustainability certification on coffee value chains. Sustainability perspectives and the long-term consequences of coffee practices on natural ecosystems and the social-economic dimensions of livelihoods have been discussed more widely by academic, government, private sectors and civil society or non-governmental organizations (Glasbergen and Schouten, 2015; Mithofer *et al.*, 2017; Glasbergen, 2018; Leimona *et al.*, 2018). As the new development paradigms tend to seek alternatives for distortion effects as a result of direct state intervention in commodity supply chains, on the one hand, these government efforts are argued to democratize markets by increasing the role of civil society in regulating production and trade-related activities (Glasbergen, 2018). On the other hand, standards and certification institutions could serve simply as new vehicles of corporate control over global food production, trade and consumption (Neilson, 2008; Arifin, 2010).

The sustainability standards and certifications operated in the study sites in Lampung Province are Rainforest Alliance (RFA) and 4C Association (4C). RFA is an example of third-party certification system, where private sectors or non-government organizations (NGOs) are involved in setting the guidelines and monitoring the standards in the coffee industry. This third-party certification has similar objectives to improve socio-economic and environmental conditions of coffee production and trade. RFA is enforcing standards of minimum compliance threshold, involving local auditors, focusing on quality premium. RFA is generally known as promoting sustainable resource management and providing linkages with input suppliers and agricultural laborers. RFA has been active in Indonesia in the late 1990s, after the Asian Crisis in 1998; it operates mostly in Aceh, Lampung and South Sumatra.

The 4C is the newest among global standards and certifications operated in Indonesia, and just introduced more intensively in Lampung about 2010. This standard is developed in a multi-stakeholder cooperation process, involving global buyers, auditors or certifying agencies, governments of developing countries and farmers' associations. The 4C is enforcing baseline, product-specific standards, towards compliance, and involving accredited third-party auditors, also focusing on quality premium. The 4C is generally known as promoting sustainable coffee practices and providing technical assistance and capacity building through local farmers' organizations. Currently the 4C certificate is managed by the Global Coffee Platform (GCP), and put more attention on the sustainability and improvements from a local baseline towards product-specific standards. The 4C standard offers a market price plus performance premium for coffee bean quality and for meeting the standards such as chain traceability. Farmers producing Robusta coffee in Lampung (and South Sumatra) are joining 4C through farmers' organizations.

This study examines the impacts of coffee agroforestry system and sustainability certification on farmers' welfare, in terms of economic and environmental benefits in Upper Sekampung Watershed in Sumatra-Indonesia. The study applies standard farm-income analysis and quasi-experimental impact evaluation method using a propensity score matching (PSM) technique by analyzing 408 farm households practicing coffee agroforestry systems and the control group (non-adopters), and the household joining sustainability certification and the non-adopters, primarily in two Sub-districts of Pulau Panggung and Air Naningan, in the District of Tanggamus, in the Province of Lampung. The PSM basically compares adopters of coffee agroforestry system, i.e. 216 farmers (53%) who grow 100 shade trees per hectare and multi-purpose tree species (MPTS) and the control group of 192 farmers (47%) that grow less than 100 MPTS (non-adopters). In addition, the PSM also compares the total number of 203 farmers (about half) who have joined coffee certification schemes, primarily Rainforest Alliance (RFA) and 4C certificates, and the remaining half is in the process of adoption (non-adopters).

After the introduction, the paper discusses coffee agroforestry system and new schemes of sustainability certification in the study sites and in Indonesia in general. Methodology and analytical frameworks are presented right after, describing the details of data collection, farm-income analysis and PSM procedures to employ impact analysis. The section on results and discussion present the findings and economic arguments and explanations regarding the results of data analysis. The paper concludes with the significance of the research findings, policy relevance and important implications for the future.

1. Coffee Agroforestry and Sustainability Certification in Sekampung Watershed

Sekampung Watershed covers over 484 thousand hectares and 8 districts and municipalities, stretching from Upper Sekampung in the District of Tanggamus to Lower Sekampung in the District of East Lampung. Sekampung is the main watershed in the Province, serving as major food baskets, such as rice, maize, cassava, other secondary crops, fishery products and centers of major agricultural export commodities such as coffee, cocoa, palm oil, coconut, etc. However, the current land use system, especially in the catchment area has led to land degradation in the watershed, where 49 percent of land area is degraded, 34 percent potential to degrade and 17 percent non-degraded. The average rate of soil erosion is 67.5 ton per hectare per year, higher than the 25 ton per hectare tolerable soil loss (Arifin, 2019). The principles of coffee agroforestry system encourage farmers to grow shade trees and other tree crops, multipurpose tree species (MPTS) and sometimes timber trees. These trees provide restraints of the areas from erosions and land degradation, and at the same generate additional income for farmers, for example from the fruits, such as durian, jackfruit, rambutan, etc.

The operational principles of HKm contracts work as follows. Farmers groups interested in securing HKm contracts are required to form recognized farmers' organizations and to follow management guidelines that local forestry officials approve as being protective of the watershed functions of the landscape. Five-year initial contracts can be extended to a maximum of 25 years. As defined by the forestry law, coffee agroforestry system under the HKm permits are community forestry contracts in which the Indonesia government grants a use rights for limited duration to forest lands provided that the communities abide by management requirements. Coffee-agroforestry system is believed as effective as the original forest cover in protecting water yield and water quality (Verbist *et al.*, 2005; Hairiah *et al.*, 2006). Coffee agroforestry system, or sometimes known as coffee multi-strata system, could be considered as an environmentally beneficial land use both in terms of agro-ecosystems and socio-economics (van Noordwijk *et al*., 2002).

Previous studies suggest that coffee farmers receive both direct and indirect benefits from sustainability standards and certifications, primarily RFA, Utz and 4C (Ibnu *et al*., 2015). Other studies suggest a positive effect of certifications on producer organizations and welfare for smallholder farmers, although the direct impacts on income and production are quite small (Beuchelt and Zeller, 2011; Ruben and Fort, 2012; Jena and Grote 2017; and Jena *et al*. 2017). The most significant benefit of these sustainability certification schemes is probably their potential to strengthen social capital and to improve community governance structures in the producing regions as these standards generally require establishment of farmers' organizations and locally adopted codes of conduct.

Comparable studies have been conducted by Ruben and Zuninga (2011) about the comparative impacts of three major coffee certification schemes in Nicaragua and by Ruben *at al.* (2009) about the impacts of fair trade on development in Peru and Costa Rica. In Nicaragua, Fairtrade or FLO certificates provide better prices compared with independent non-certified coffee producers, but private labels CAFE out-compete FLO in terms of yield and quality performance. While FLO could be helpful to support initial market incorporation, private labels like CAFÉ offer more suitable incentives for quality upgrading. In Peru and Cost Rica, coffee farmers joining FLO have modest additional income, and either non-certified FLO farmers reap even larger net benefits, both are statistically non-significant. Similarly, farmers' perceptions regarding past and future welfare improvements generally show little change.

The following explanation by Ruben *et al.* (2009) is worth mentioning here: First, coffee farmers joining FLO tend to focus more on coffee production activities and less attention to other income-generating activities such as for food crops, off-farm work and non-farm activities; Second, FLO coffee production uses more hired labor and inputs that reduce the margin between gross and net revenues; Third, many co-operatives can sell only part of their certified production to the FLO market, thus incurring costs that are not fully recovered by higher prices; Fourth, benefits from the FLO premium that are invested in social services at the community level accrue by definition to all farm-households. Nevertheless, Ruben and Zuninga (2011) suggest that civic certification standards such FLO and RFA might exhibit major effects on local institutions and farmers' behavior; while private standards such as CAFÉ are more effective for improving production and management practices. Dynamic improvement standards may bridge the gap between both.

METHODS

Data Collection

We conducted field surveys, employing a face-to-face interview conducted in December 2013 through January 2014 with 408 households of coffee farmers who adopted agroforestry system in their lands and had joined the coffee sustainability certification. During the data collection, farmers had joined the RFA standards for over 7 years, whereas farmers had joined 4C standards for about 3—4 years. The study implements a cluster random sampling method for data collection, focusing on two sub-districts of Pulau Panggung and Air Naningan in Upper Sekampung Watershed, in the District of Tanggamus, in Lampung Province (Figure 1).

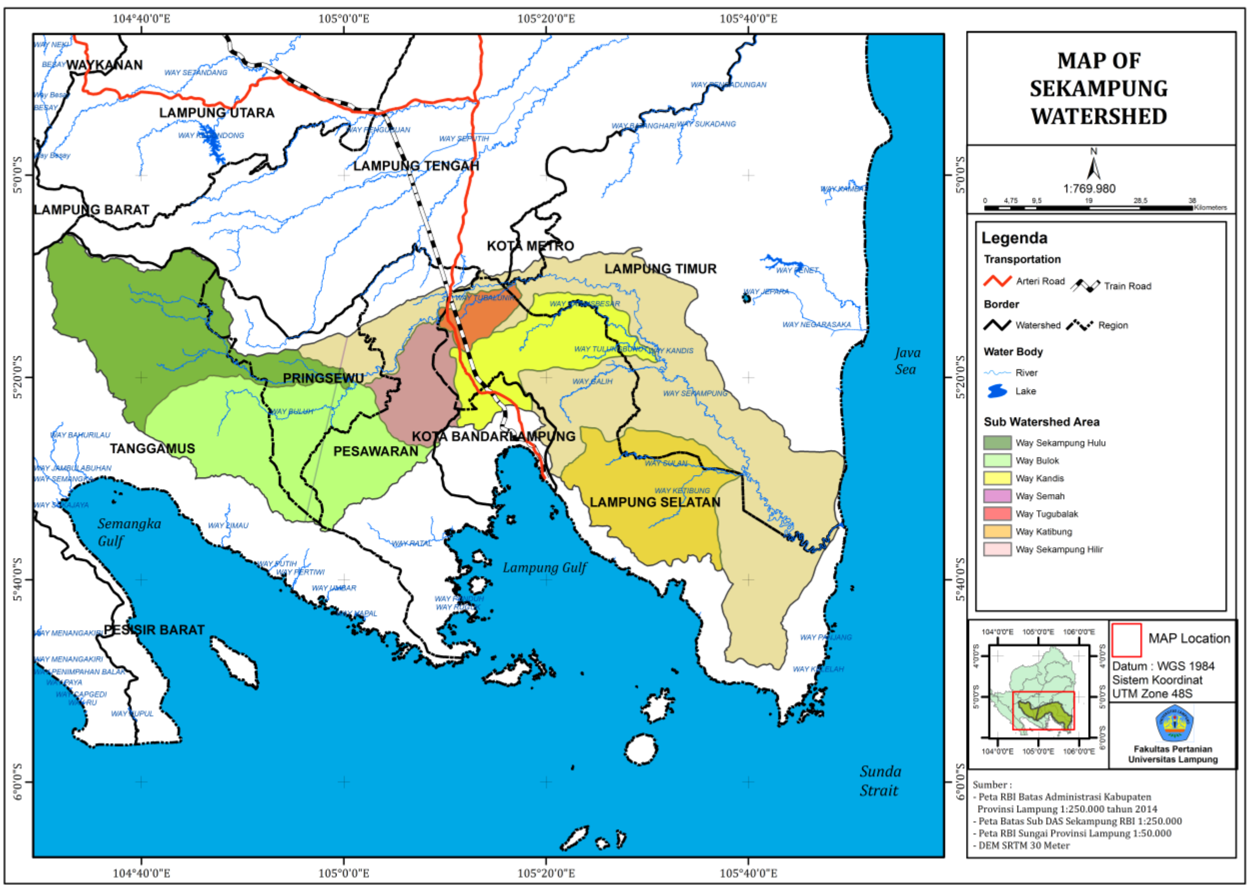

Figure 1. Map of Sekampung Watershed in Lampung Province, Indonesia

Coffee farmers who grow 100 multi-purpose tree species (MPS) or more per hectare in their coffee farms are classified as adopters or participants of coffee agroforestry system. Whereas those who grow less than 100 MPTS or shade tree per hectare in their coffee farms are classified as non-adopters or non-participants of coffee agroforestry system. The cut-off points of 100 MPTS for shade tree per hectare adopted in this study is by taking consideration that one tree could provide some functional shade (light, nutrient, etc.) for about four coffee trees. Meanwhile, the criteria of coffee farm households who join sustainability certification schemes are quite clear. Farmers who have joined either RFA or 4C sustainability certification are classified as adopters or participants; while those who are not joining or in the process of joining the sustainability certification are classified as non-adopters or non-participants.

The study applies a quasi-experimental impact evaluation method using a propensity score matching (PSM) technique by analyzing some relevant variables that shape the characteristics of coffee agroforestry system. PSM constructs a statistical comparison group by modeling the probability of participating (propensity score) in the program on the basis of observed characteristics unaffected by the program, hence the control group or non-participants. The participants are then matched to non-participants based on the propensity score. The average treatment effect of the program is calculated as the mean difference in outcomes across these two groups (matching).

Impact by PSM

Propensity score matching (PSM) constructs a statistical comparison group that is based on a model of the probability of participating in the program on the basis characteristics unaffected by the program (Khandker *et al.,* 2010). Participants are then matched on the basis of this probability, or *propensity score*, to nonparticipants. The average treatment effect of the program is then calculated as the mean difference in outcomes across these two groups. The validity of PSM depends on two conditions: (a) conditional independence (namely, that unobserved factors do not affect participation) and (b) sizable common support or overlap in propensity scores across the participant and nonparticipant samples. Different approaches are used to match participants and nonparticipants on the basis of the propensity score.

On its own, PSM is a useful approach when only observed characteristics are believed to affect program participation. Whether this belief is actually the case depends on the unique features of the program itself, in terms of targeting as well as individual to take up of the program. Assuming selection on observed characteristics is sufficiently strong to determine program participation, baseline data on a wide range of preprogram characteristics will allow the probability of participation based on observed characteristics to be specified more precisely. Participants of a program are then matched to control group or matched non-participants based on the propensity score. The average treatment effect of the program is calculated as the mean difference in outcomes across these two groups (matching).

With matching methods, one tries to develop a counterfactual or control group that is as similar to the treatment group as possible in terms of *observed* characteristics. The idea is to find, from a large group of nonparticipants, individuals who are *observationally similar* to participants in terms of characteristics not affected by the program (these can include preprogram characteristics, for example, because those clearly are not affected by subsequent program participation). Each participant is matched with an observationally similar nonparticipant, and then the average difference in outcomes across the two groups is compared to get the program treatment effect. If one assumes that differences in participation are based solely on differences in observed characteristics, and if enough nonparticipants are available to match with participants, the corresponding treatment effect can be measured even if treatment is not random (Khandker *at al.*, 2010).

The empirical issue to credibly identify groups that looks alike. Identification is a problem because even if households are matched along a vector, *X*, of different characteristics, one would rarely find two households that are exactly similar to each other in terms of many characteristics. Because many possible characteristics exist, a common way of matching households is propensity score matching. In PSM, each participant is matched to a nonparticipant on the basis of a single propensity score, reflecting the probability of participating conditional on their different observed characteristics *X* (see Khandker *et al.*, 2010). Participants and non-participants must be representative and highly comparable groups. They are typically constructed from large survey. In general, the more observations, the better the results. Data quality is a key for good comparison among two groups.

The following is the stages to estimate the impact using PSM.

1) First stage: regress treatment on observables

$$T_{it} = X_{it}\beta + \varepsilon_{it} \quad (1)$$

2) Second stage: from individual probabilities of treatment and save observations where there is overlap (region of common support)

$$\Pr(T_{it} = 1) = \Phi\left(-X_{it}\hat{\beta}\right) = \hat{p}_{it} \quad (2)$$

3) Third stage: compare outcomes of treated observations to similar non-treated observations (average treatment effect = the effect of agroforestry and/or sustainability certification).

$$\hat{\delta} = \frac{1}{N\,(N-1)} \sum_{i\in T} \sum_{j\notin T} \omega_{ij}\left[Y_{it} - Y_{jt}\right]$$

$$\frac{\partial \omega_{ij}}{\partial\left|\hat{p}_{it} - \hat{p}_{jt}\right|} \leq 0 \quad (3)$$

i.e., the weight of a comparison (between treated vs. controlled units) in the analysis decreases as the units get less similar

In our study, the analysis of the treatment effect of the coffee agroforestry system and sustainability certification using the PSM method is focused on the treatment effect on the treated (TOT), instead of the average treatment effect (ATE) (see Khandker *et al.,* 2010). In other words, only internal validity is estimated, rather than external validity of the sample, as the comparability between coffee farmers adopting agroforestry and non-adopters and those adopting sustainability certifications of Rainforest Alliance (RFA) and/or Common Code of Coffee Community (4C) and non-adopters. This overlap condition is the point of departure to examine the impact of the programs, i.e. coffee agroforestry and sustainability certification.

RESULTS AND DISCUSSIONS

Farmers' Characteristics

Farmers in the study sites in Upper Sekampung have adopted coffee agroforestry system for a while using shaded trees and multi-strata coffee system to secure household income and to contribute to conservation practices in the catchment area of the watershed. The average multi-purpose tree species (MPTS) grown by farmers in the study sites are 213, consisting of 23 fruit trees such as: petai (*Parkia sp.*), durian (*Durio sp.*), avocado (*Avocado sp.*), jengkol (*Archidendron sp*), clove (*Caryophyllorum sp.*) and others, and 221 timber trees such as: *dadap (Eryhtrina sp.), medang (Actinodaphne sp.), cempaka (Magnolia sp.), albisia (Albizia sp.), sengon (Paraserianthes sp.)*, teak (*Tectona sp*), *lamtoro* (*Leucaena* sp.), and other trees. Coffee farmers who are joining community-based forestry management (HKm) are adopting the agroforestry system, as the share trees and MPTS are among important requirements to be qualified as a legal recipient of HKm user-rights. The coffee farms within or adjacent to the protection forest, are generally have more MPTS than the coffee farms in the individual lands or communal lands.

Farmers in Upper Sekampung who have adopted agroforestry system are 216 households or 53 percent of the total 408 household samples and who have not adopted the system are 192 or 47 percent. Most of the household samples are men (88.5 percent), while the women are only 11.52 percent. The average age of coffee farmers is 44.2 years, where the adopters are a bit higher, 44.6 years old, while the average age of non-adopters are 43.4 years old. Coffee farmers in the study sites have been farming for 18.6 years as they are the third or second generation of migrants and settlers from Java (see Table 1). Table 1 also presents the standard deviation of each variable regarding the characteristics of farm households in the study sites of Upper Sekampung Watershed in Lampung. Farmers adopting coffee agroforestry have more farming experience (18.6 years) than non-adopters of agroforestry system (17.8 years). Coffee farmers have about 3 household dependences, about 2 adults and 1 child (not shown in Table 1).

Table 1. Characteristics of Coffee Agroforestry Farm-Households in Upper Sekampung

Coffee Farmers	**Sample**	**Age (Year)**	**Farming Years**	**Land Size (ha)**	**Coffee (tree/ha)**	**MPTS (tree/ha)**
Non-adopter of Agroforestry	192	43.4	17.8	1.13	1,776	49
(Standard Deviation)		*(12.7)*	*(12.6)*	*(0.65)*	*(946)*	*(46)*
Adopter of Agroforestry	216	44.6	19.1	1.47	1,834	346
(Standard Deviation)		*(12.42)*	*(11.4)*	*(1.00)*	*(819)*	*(451)*
All-Samples	**408**	**44.2**	**18.6**	**1.33**	**1,810**	**223**
(Standard Deviation)		*(12.6)*	*(11.9)*	*(0.89)*	*(873)*	*(376)*

The number of coffee trees grown by the sample households in Upper Sekampung is 1,810 trees per hectare, in which agroforestry adopters grow 1,834 trees per hectare, which is higher than the coffee trees grown by non-adopters, which are 1,776 coffee trees per hectare. The number of multi-purpose tree species (MPTS) grown in the study sites are 223 units per hectare, in which agroforestry adopters grow 346 trees per hectares, while non-agroforestry adopters only grow 49 trees per hectare. It reflects the rules of HKm policy where farmers obtaining permit to utilize state forest shall increase the number of shade trees and timber trees gradually up to 400 MPTS trees. One should note, however, as the composition of MPTS is much higher than the coffee trees, the coffee productivity is threatened to decline. Land holding size of coffee farmers in the study sites is 1.33 hectare per household, far below the ideal condition to improve the farmers' livelihood and rural development in general. Coffee farmers who adopt agroforestry system control the land of 1.47 hectare in average, a bit higher than the average farm area controlled by non-adopters, which is 1.13 hectare. Adopter farmers might need a larger land area to grow more MPTS up to 400 trees and to improve the livelihood, as protection forests need to maintain water yield and water quality and other ecological services.

In terms of sustainability certification, coffee farmers in Upper Sekampung, about half of these farmers (202 households) are also adopting sustainability certification, mostly 4C certification (149 households, 36.5 percent) and Rainforest Alliance RFA (53 households, 13 percent, while the other half (206 households) are in the process of adoption (Table 2). Table 2 also presents the composition of coffee trees and MPTS, where RFA certified coffee farmers grow the highest number of coffee trees (2,029 trees per hectare) and MPTS (236 trees per hectare). Interestingly, the division between adopters and non-adopters of sustainability certifications does not influence the number of MPTS grown by coffee farmers. This also shows that agroforestry system has been adopted first by coffee famers in the study area, while sustainability certification comes later. RFA generally have more stringent certification criteria compared to the newly developed 4C certification. In this case, RFA certified coffee farmers are the real adopters of coffee agroforestry system in Upper Sekampung in Lampung.

Table 2. Characteristics of Coffee Certification Farm-Households in Upper Sekampung

Coffee Farmers	**Sample**	**Age (Year)**	**Farming Years**	**Land Size (ha)**	**Coffee (tree/ha)**	**MPTS (tree/ha)**
Non-Certification	206	44.1	18.3	1.35	1,661	225
(Standard Deviation)		*(12.7)*	*(12.2)*	*(0,85)*	*(741)*	*(299)*
4C Certification	149	43.2	17.7	1.34	1,938	215
(Standard Deviation)		*(11.5)*	*(10.9)*	*(0.97)*	*(1,053)*	*(479)*
RFA Certification	53	45.9	22.0	1.18	2,029	236
(Standard Deviation)		*(16.0)*	*(13.4)*	*(0.80)*	*(6.79)*	*(315)*
Total	**408**	**44.2**	**18.6**	**1.33**	**1,810**	**223**
(Standard Deviation)		*(12.6)*	*(11.9)*	*(0.89)*	*(873)*	*(376)*

Moreover, the farm area of land controlled by these farmers does not differ significantly, averaging 1.34 hectare of 4C farmers, 1.18 hectare for RFA and 1.35 for the farmers not yet adopting sustainability certification. The majority of farm-households in the study sites own the land (94 percent), while 26 households rent the land to the other farmers living in Sekampung and some in the City of Bandar Lampung. The majority of area (nearly 90 percent) controlled by households is under 2.25 hectare which provide constrains for improving the livelihood in the study sites. In this case, the majority of households (89.4%) only control the lowest area of coffee farm of 0.25—2.25 hectares and the remaining 8.8 percent controls medium size of land (2.26—4.25 hectare) and 1.6 percent controls largest area of farm land (not shown in the Table).

Farm-Income Analysis

The results of farm-income analysis of coffee farm-households are presented in the following Table 3 for coffee agroforestry system and Table 4 for sustainability certification. Some important findings of the farm-income analysis could be summarized as follows: Average coffee production in Upper Sekampung is 386.6 kilogram per hectare, which is far below the national average of 645 kilograms per hectare, mostly due to traditional farming practices and simple processing techniques. Coffee crops remain profitable in the study sites, but ample opportunities could be explored to improve the coffee yield and quality to fulfill increasing demand for coffee. The standard farm-economic analysis generally differentiates between revenue to cost ratio (R/C ratio) and benefit to cost ratio (B/C ratio). R/C ratio compares the total revenue—which is the total production multiplied by farm-gate price of the product—to the total cost—which is the total input use multiplied by the input price. B/C ratio compares the total benefit or the net difference between total revenue and total cost – to the total cost. R/C ratio of coffee production is 2.72, indicating that every one thousand Rupiah spent for the production costs could generate revenue of Rp2,720 per hectare coffee farm. Considering the farmers' income from MPTS and other crops, the B/C ratio of total farm in the study sites is 6.44, indicating that every one thousand Rupiah spent for farming activities could generate income of Rp6,440 per hectare.

Table 3. Farm-Income Analysis of Coffee Agroforestry System in Upper Sekampung

Elements of Farm Income	Unit	Non-Adopters Agroforestry	Agroforestry Adopters	Total
Coffee Production	Kg/ha	383.0	389.1	386.6
Coffee Price	Rp/kg	16,236	16,401	16,333
Revenue from coffee	Rp/ha	6,277,141	6,458,433	6,383,339
Tradable Input Cost	Rp/ha	452,828	518,984	491,581
Fixed Instrument Cost	Rp/ha	104,670	107,354	106,242
Family labor Cost	Rp/ha	837,683	897,394	872,661
Hired Labor Cost	Rp/ha	809,588	725,839	760,529
Other Costs	Rp/ha	120,038	108,479	113,267
Total Production Costs	Rp/ha	2,324,807	2,358,051	2,344,281

Elements of Farm Income	Unit	Non-Adopters Agroforestry	Agroforestry Adopters	Total
Household Income from Coffee	Rp/ha	3,952,333	4,100,383	4,039,058
Farm Income from Coffee	Rp/ha	3,114,650	3,202,989	3,166,398
Revenue from MPTS	Rp/ha	2,951,082	2,618,235	2,756,106
Revenue from other crops	Rp/ha	6,490,393	9,593,620	8,308,215
Total Farm Income	Rp/ha	13,393,809	16,312,238	15,103,379
Revenue to Cost (R/C) Ratio-Coffee		2.70	2.74	2.72
Benefit to Cost (B/C) Ratio-Total Farm		5.76	6.92	6.44

However, the production system of coffee farm in Indonesia is not very efficient, shown by the share of labor cost is very high, about 70 percent, consisting of family labor 37.22 percent and hired labor 32.44 percent of the total costs of Rp2.3 million per hectare. Whereas, the share of tradable inputs costs such as manures, fertilizer and pesticide to the total production costs is about 21 percent. A high labor cost reflects an increasing wage rate in rural areas in Indonesia, which could indicate that rural labor has started to move away from agricultural sector, especially the youth group. The low yield of coffee production in Upper Sekampung and in Indonesia in general is mostly driven by low application of modern inputs, which might result in low quality of coffee produced by the farmers. Interpreting the results of farm income analysis in terms of sustainable coffee production system should be conducted with care. Coffee farming activities in Upper Sekampung might not be harmful to the environment, especially to soil and water contamination as the use of chemical fertilizer is so low. However, the threat of coffee farming activities to the environment is when farmers are expanding the coffee farm to the forest frontiers, especially to protection forest and possibly to Bukit Barisan Selatan (BBS) National Park, adjacent to the coffee farms in the study sites.

In this case, coffee agroforestry system and sustainability certification play important roles for the sustainability perspectives in such fragile environment of Upper Sekampung Watershed. Our farm-income analysis shows that B/C ratio of the total farm for agroforestry adopters is 6.92, which is significantly higher than that of non-agroforestry adopters of 5.76. Every one thousand Rupiah spent in the whole farm could generate Rp6,920 for agroforestry adopters and Rp5,760 for non-agroforestry adopters. Revenues from MPTS and other crops have contributed significantly to the performance of coffee farming system in the study sites. Coffee farmers adopting agroforestry system have received additional income sources, mostly from selling other agricultural products, such as local fruits, timber trees, etc.

Table 4. Farm Income Analysis of Coffee Sustainability Certification in Upper Sekampung

Elements of Farm Income	Unit	Non-Certified	4C	RFA	Total
Coffee Production	Kg/ha	334.0	343.4	712.5	386.6
Coffee Price	Rp/kg	16,199	16,252	17,077	16,333
Revenue from coffee	Rp/ha	5,416,215	5,627,803	12,266,406	6,383,339

Elements of Farm Income	Unit	Non-Certified	4C	RFA	Total
Tradable Input Cost	Rp/kg	502,769	492,812	444,639	491,581
Fixed Instrument Cost	Rp/ha	99,729	95,507	161,736	106,242
Family labor Cost	Rp/ha	656,225	1,004,532	1,343,170	872,661
Hired Labor Cost	Rp/ha	702,331	764,905	974,434	760,529
Other Costs	Rp/ha	131,088	103,863	70,437	113,267
Total Production Costs	Rp/ha	2,092,142	2,461,619	2,994,415	2,344,281
Household Income from Coffee	Rp/ha	3,324,073	3,166,184	9,271,990	4,039,058
Farm Income from Coffee	Rp/ha	2,667,848	2,161,652	7,928,820	3,166,398
Revenue from MPTS	Rp/ha	2,907,919	1,954,258	4,420,289	2,756,106
Revenue from other crops	Rp/ha	8,131,653	8,838,241	7,504,399	8,308,215
Total Farm Income	Rp/ha	14,363,645	13,958,683	21,196,679	15,103,379
Revenue to Cost (R/C) Ratio-Coffee		2.59	2.29	4.10	2.72
Benefit to Cost (B/C) Ratio-Total Farm		6.87	5.67	7.08	6.44

Farm income analysis of coffee sustainability certification shows significant performance differences among certification schemes. Average coffee production of farmers joining Rainforest Alliance (RFA) certificate is the highest, 712.5 kilogram per hectare, followed by that of farmers joining 4C certificates of 343.4 kilogram per hectare. Coffee production of that non-joining sustainability certification is the lowest, 334 kilogram per hectare, as the farmers in this group do not receive any technical assistance, training programs and other empowerment activities. Technical assistance, training and empowerment are generally conducted through farmers' organization. Farmers not joining certification programs might have farmers' organization, but the organization is generally not very active, including receiving training and empowerment programs. As consequences, both R/C ratio of coffee farm and B/C ratio of the total farm among farmers joining RFA are the highest, 4.10 and 7.08 respectively. Every one thousand Rupiah spent in the production process by RFA coffee farmers has generated revenue of Rp4,100 per hectare and generated benefits of Rp7,080 per hectare. Revenues from MPTS and from other crops have made a difference in the economic performance of RFA farmers, compared to 4C farmers and those in the process of adoption of coffee sustainability certification.

Some other important characteristics of coffee sustainability certification that contribute to the economic performance of farming system include, the production factors, from tradable inputs, labor allocation, of both family labors and hired labors, other relevant costs. Coffee farmers adopting RFA certificates use the highest labor inputs, over 77 percent, consisting of 44.86 percent family labors and 32.54 percent hired labor. Whereas coffee farmers adopting 4C certificates use 71.88 percent of labor inputs, consisting of 40.81 percent family labor and 31.07 percent of hired labor. More intensive use of labor inputs in coffee sustainability certification are mostly allocated to crop care, from production process to coffee harvest. Farmers in the study sites have to hire labor force from neighbor within the village, from neighboring villages, and from neighboring sub-districts. The intensive labor use could determine the coffee quality in the study sites as the sustainability certification schemes encourage farmers to adopt selective picking of red cherry of coffee fruits. This method sometimes is combined with delaying strip picking when more fruits have ripened requires more labor inputs, although with the costs of reducing labor productivity, (in terms of labor quantity per day). Yet, improved harvest practice is a key to achieving the product quality required for any of the certification schemes.

Impact Analysis with PSM

As mentioned previously, impact analysis using propensity score matching (PSM) is to statistically compare both the economic benefits and environmental benefits among coffee farmers adopting agroforestry system and non-adopting agroforestry. In this study, we compare economic benefits using a proxy of farm-income performance of coffee farmers growing 100 MPTS trees per hectare and the "matched participants" of those growing less than 100 MPTS per hectare in the study sites. Moreover, we also compare environmental benefits using a proxy of fertilizer application of coffee farmers growing 100 MPTS per hectare and the similar "matched participants" of those growing less than 100 MPTS per hectare.

During the iteration of the PSM analysis using "R Software", only 400 samples of coffee-farm household from the total number of 408 samples are valid to go through the statistical comparison. In this process, the number of treated observations is 211, which is exactly matching the number of observations. The impact analysis using PSM is conducted both for farm-income as a proxy of economic benefits and chemical fertilizer application as a proxy of environmental benefits. The results of PSM analysis is presented in Table 5, which is somehow consistent with the results of standard farm-income analysis, presented previously. It should be noted that impact analysis by PSM could be applied to other important characteristics attributable to coffee agroforestry system in the study area.

Table 5. Economic and Environmental Impacts of Coffee Agroforestry System

Description of PSM Analysis	Mean Difference of Farm Income (Rp)	Mean Difference of Fertilizer Use (kg)
Estimated value	2,628,528*	-0.72156**
Standard of Error	1,503,765	0.27428
T-Statistics	1.748	-2.6307
p-value	0.08047	0.00852

Notes: * Significant at 90%
** Significant at 95%

Table 5 also reveals that coffee agroforestry system has positive impacts on economic benefits and environmental benefits, although the p-values are quite small, implying that the variance cannot be all explained by observed variables. The difference in estimated farm income is about Rp2.63 million per hectare between farmers adopting agroforestry and those of non-adopting. Income from MPTS and other cash crops have provided more economic opportunities that could generate revenues for the households, such as the sales and revenues from fruits, trees, and timbers. Moreover, coffee agroforestry system also has impacts on environmental benefits, shown by reduction in chemical fertilizer application of 0.72 kilogram per hectare. The agroforestry system has provided the nitrogen for coffee trees from natural fixation by legume-nodulating bacteria (LNB) available in leguminous shade trees among the MPTS. The shade trees by themselves have also served as soil erosion controls of the coffee farm and water regulation management of the upper watershed. In short, coffee agroforestry system adopted in the Upper Sekampung Watershed in Lampung, has contributed to conservation practices in coffee production and other food production activities in the study sites.

Moreover, impact analysis using propensity score matching (PSM) is also conducted to statistically compare both the economic benefits and environmental benefits among coffee farmers joining sustainability certification, especially Rainforest Alliance (RFA) and 4C certification schemes, and farmers who are not-joining certification as control variables or “matched participants”. The criteria in the study sites are quite clear, as these two certification schemes have worked in different compounds in the sub-districts. At the time of the study, none of these farmers are joining two certification schemes at once, as the field officers and internal control system (ICS) field managers of RFA and 4C closely monitor the implementation of certification schemes. The PSM analysis results are presented in Table 6, which could be summarized as follows: The mean difference between farmers joining RFA certificates and the control variable or those not joining certification schemes is Rp6.32 million; whereas farmers joining RFA certificates have higher farm income of Rp7.83 million from farmers joining 4C certificates. Coffee farmers joining Rainforest Alliance (RFA) certification have significantly higher economic benefits (higher income) than their control groups (those not joining certification). Coffee farmers joining 4C certification have no significant difference in economic benefits with their control groups (not joining certification). Finally, coffee farmers RFA certification has significantly higher economic benefits than 4C certification scheme.

Table 6. Economic and Environmental Impacts of Coffee Sustainability Certification

Comparison	**Mean difference of Farm Income (Rp)**	**Mean difference of Fertilizer Use (kg)**
Control group and RFA certificate	-6,318,305*** (-6.747)	0.645*** (4.667)
Control group and 4C certificate	1,514,419 (1.904)	-0.348 (1.661)
RFA and 4C certificates	7,832,723*** (8.715)	-0.992*** (-6.295)

Notes: Number in the brackets (….) is t-value
*** Significant at 99%

Moreover, coffee farmers joining Rainforest Alliance (RFA) certification have significantly higher environmental benefits (less fertilizer) than their control groups (those not joining certification). Coffee farmers joining 4C certification have no significant difference in environmental benefits with their control groups (those not joining certification). Finally, coffee farmers joining RFA certification has significantly higher environmental benefits than 4C. These differences could be associated with the characteristics of sustainability certification that have attempted to ensure the principles of environmental friendliness of coffee farming practices, developing more sustainable global value chains, hence improving the livelihood of coffee produces, which are mostly smallholder farmers. These certification schemes provide many options that might have attracted smallholder farmers to join the programs, such as offering market price and performance premiums relatively close to the global coffee price, encouraging farmers to develop farmers' organizations, cooperatives or economic-partnership organizations (KUBE=*Kelompok Usaha Bersama Ekonomi*), focusing on environmental conservation, biodiversity and organic agriculture (see Ibnu *et al.*, 2015). In the study area, RFA certification scheme has been initiated in the study area since 2009, while 4C scheme has just started in 2012.

The certification schemes in the study sites, in the province and in other production centers in Indonesia have somehow restructured the coffee value chains as these standards have created awareness of sustainability aspects of production and processing of agricultural commodities and along the value chains (Neilson, 2008; Arifin, 2010; Glasbergen, 2018). The demands of sustainability certifications for better traceability, documentation, audits and contractual relationships between parties involved have increased significantly, although creating new costs. The costs of these positive developments are, however, mostly being borne by coffee producing countries, causing these smallholder coffee farmers cannot afford to pay the certification costs by themselves. Even though coffee farmers joining sustainability certification receive higher prices compared to non-certified farmers (Ibnu *et al.*, 2015), these smallholder farmers remain the most vulnerable and the weakest actor in the coffee value chains. Farmers remain facing uncertainty about price fluctuation and market access, especially during global uncertainty. Market mechanisms which have become the major driving force of sustainability certification clearly have some restrictions, especially about the value chain approach and regarding quality standards and human safety. Our findings have confirmed similar impact studies of different coffee sustainability certifications on development in Nicaragua (Ruben and Zuniga-Arias, 2011) and in Peru and Costa Rica (Ruben *et al*., 2009). Important implications of sustainability certifications could be laid out more clearly, such as more attention on social capitals, governance partnership between coffee farmers in the South and global coffee buyers in the North, and policy response by government agencies in the South (Glasbergen, 2018)

Finally, both coffee agroforestry system and sustainability certification encourage farmers' organizations or cooperatives, so that their impact on economic and environmental benefits have work through the process of strengthening social capital among such farmers' economic organizations (Neilson, 2008, Glasbergen, 2018). Coffee agroforestry and certification schemes have expanded market access, especially to global markets, increased participations among stakeholders, and improved market structures and price transparency, hence increasing price premium received by adopters or program participants (Rueda and Lambin, 2013). Unfortunately, farmers' knowledge about certification schemes is low, although they have general knowledge on recommended activities, such as harvesting the red cherries, not using the banned pesticides, etc. Farmers' organizational structures are generally weak, not meeting the general requirements of sustainability certification schemes (Ibnu, *et al*., 2015). Smallholder farmers remain having high dependence on traditional social relationship with collector traders and the sources of financial capital at rural areas (Astuti, *et al.,* 2015). Where agroforestry system and sustainability certification schemes have strengthened social capital in the coffee farmers' organizations or in rural areas in general, these "new systems" might have led to long-term improvements in the livelihood of coffee farm households (Glasbergen, 2015).

CONCLUSION AND POLICY RELEVANCE

This study concludes that coffee agroforestry system and sustainability certification have significant impacts on the economic and environmental benefits of the coffee farm-households in Sumatra-Indonesia. The significance of this study could be summarized as follows:

First, the results of farm-income analysis show significant differences between coffee farm-households adopting agroforestry system and non-adopters. Benefit to cost (B/C) ratio of total farm for agroforestry adopters is 6.92, which is significantly higher than that of non-agroforestry adopters of 5.76. Revenues from MPTS and other crops have contributed significantly to the performance of coffee farming system in the study sites. Coffee agroforestry system by growing more MPTS trees in the farm has provided additional revenues for the farm-households, both from fruit tree crops and timer products. Moreover, shade trees and MPTS have served as soil erosion controls and water regulation management, hence contributing to conservation practices in the coffee farm in the upper watershed.

B/C ratio of the total farm of farmers joining RFA certificates is 7.08 or the highest compared to that of farmers joining 4C certificates (5.67), but lower than that in the process of adoption of coffee sustainability certification (6.87). Price premium on high coffee quality or the beans that meet the quality standards being set by the coffee buyers and revenues from MPTS and from other crops have made a difference in the economic performance of farm-household joining sustainability certification. In additions, coffee farmers adopting sustainability certifications have shown more active, well-expressed farmers' organization and perceived better social capital and improved community cooperative governance in the producing regions. Within these active farmers' group, generally there are "champions" or intermediaries who play important roles in increasing public awareness, serving as a clearinghouse for information, capacity building and training the smallholder farmers, negotiating farm gate price and its premium etc.

Second, the results of propensity score matching (PSM) analysis on farmers adopting agroforestry system show significant values of mean difference as high as Rp6.32 million between farmers joining RFA certificates and the control variable or farmers not joining certification schemes. Coffee farmers joining RFA certificates have higher economic benefits, shown by higher farm income of Rp7.83 million than the farmers joining 4C certificates. Coffee farmers joining RFA certificates have also significantly higher environmental benefits, by applying less chemical fertilizer than the farmers not joining certification schemes. Coffee farmers joining RFA certification has significantly higher environmental benefits than 4C, which could be associated with the characteristics between these two certification schemes. RFA certification schemes are developed to ensure the principles of environmental friendliness, developing more sustainable global value chains, hence improving the livelihood of coffee producers. In short, both farm-income analysis and PSM analysis suggest that coffee agroforestry system has some important characteristics that are closely associated with coffee sustainability certifications.

Third, coffee agroforestry system and sustainability certification adopted in Sumatra-Indonesia and other similar areas in coffee producing countries in the last decades have revealed systematic policy reforms in adapting sustainability at local level and at the same time improving coffee quality. The policy relevance is probably beyond agroforestry system and sustainability certification, such as connecting coffee farmers to the world market, improving the competitiveness of the coffee industry, quality assurance systems and other related empowerment programs in the coffee value chain. While the impact analysis on the micro-economic level of farm-households, the policy relevance is to encourage macro-perspectives of agroforestry systems and sustainability certifications for increasing the welfare of smallholder farmers, reducing rural poverty and transforming the global value chains. The strategic issues for the future include how to transform smallholder farmers from sole producers of raw products to entrepreneur farmers who could run the diversified businesses in agriculture as a whole or in agribusiness as a system. Equally important issues are how to provide alternatives for farmers' decision on land-use systems to ensure the profitability level of agroforestry systems and sustainability certifications in the watersheds and in the country in general.

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