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Land-use change and income inequality in rural Indonesia

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ABSTRACT

Many regions in Southeast Asia are experiencing massive land-use change. While areas covered with tropical forests and traditional agricultural crops, such as rubber, are shrinking, oil palm plantations are rapidly gaining ground. Recent studies have analyzed environmental effects of this land-use change. Relatively little is known about the socioeconomic implications. A few studies have examined economic effects of oil palm cultivation for particular groups of households, such as farmers, but broader effects for different types of rural households are not yet well understood. We address this research gap with data from farm and non-farm households in rural Jambi, one of the hotspots of Indonesia's recent oil palm boom. On average, farm households have significantly higher incomes than non-farm households that often work as agricultural laborers on rubber and oil palm plantations. Both farm and non-farm households are better off in villages with a large share of the land under oil palm than in villages where relatively more rubber and other crops are grown. Oil palm does not seem to have significant effects on overall rural inequality. While oil palm cultivation contributes to increasing inequality among farmers, it tends to decrease income inequality among non-farm households through labor-market and employment effects.

1. Introduction

Many regions in Southeast Asia have recently experienced considerable land-use change. Land areas covered with tropical forest and traditional agricultural crops, such as rubber, have been shrinking. At the same time, oil palm plantations were expanded rapidly. The expansion of the oil palm area was instigated by rising global demand for vegetable oils and biofuels. Palm oil is now the most traded vegetable oil in the world; there is no other crop that yields higher quantities of edible oil per unit of land (Sayer et al., 2012; Cramb and McCarthy, 2016; World Bank, 2017; USDA, 2017). Indonesia is the world's leader in palm oil production with an estimated global market share of 55% (FAO, 2017; USDA, 2017).

These land-use changes have far-reaching environmental and socioeconomic consequences. The expansion of oil palm plantations was found to be associated with deforestation, biodiversity loss, increased greenhouse gas emissions, land conflicts, displacement of forest-dependent tribes, and other social problems (Naylor et al., 2007; Fitzherbert et al., 2008; McCarthy, 2010; Wicke et al., 2011; Cramb and Curry, 2012; Obidzinski et al., 2013; Margono et al., 2014; Abood et al., 2015; Susanti and Maryudi, 2016; Tsujino et al., 2016; Kunz et al., 2017; Prabowo et al., 2017; Purnomo et al., 2017; Purnomo et al., 2018). On the other hand, oil palm cultivation has contributed to rural income growth and economic development (Feintrenie et al., 2010; Rist et al., 2010; Lee et al., 2014; Castiblanco et al., 2015; Gatto et al., 2017; Purnomo et al., 2018). While many of the oil palm plantations were established by large public and private sector companies, approximately 40% of the oil palm area in Indonesia is managed by smallholder farmers (Euler et al., 2016).

Several recent studies with household-level data from Indonesia have shown that smallholder farmers can benefit significantly from cultivating oil palm, in terms of income gains and improved living standards (Euler et al., 2017; Krishna et al., 2017). However, not all farmers are able to cultivate oil palm, because the crop is capital-intensive and local farm households are often credit-constrained (Kubitza et al., 2018a). Even among those farmers who managed to establish oil palm plantations, the benefits are heterogeneous, because of unequal access to inputs, technical know-how, and other factors of production (Krishna et al., 2017). Hence, oil palm expansion may contribute to rising inequality among farmers (McCarthy, 2010), even though effects on income distribution have not been analyzed explicitly. In addition to farmers, landless rural households may also be affected through land-use change. A recent study with data from Sumatra, Indonesia, showed that own farming activities are the main source of income for less than half of all rural households; for most of the rest working on other farms and company plantations as laborers is the major source of household

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income (Bou Dib et al., 2018). In how far the expansion of cash crops in general, and of oil palm in particular, affects the incomes of non-farm households and rural income distribution more broadly is not yet sufficiently understood. This is a relevant research gap, because landless households often belong to the poorest of the poor in rural areas. The present study makes an attempt to contribute to a better understanding.

In particular, we use representative data from rural areas of Sumatra, covering both farm and non-farm households, to analyze and compare income levels, income structures, and sources of inequality with a particular focus on oil palm and rubber. The data were collected in 2015 in 26 randomly selected villages in Jambi Province. Observed regional differences in agricultural land-use types are used to compare mean levels of income, poverty, and inequality between villages with smaller and larger proportions of oil palm land. The rest of this article proceeds as follows. The next section provides some background on oil palm expansion and the situation of poverty and income inequality in Indonesia. The data and statistical approaches are explained in Section 3, while the empirical results are presented in Section 4. Section 5 discusses the results in a broader context, while Section 6 concludes.

2. Background

2.1. Oil palm expansion in Indonesia

Palm oil is a very important ingredient for a number of foods and cosmetic products, and is considered the cheapest source of vegetable oil in international markets (Miyake et al., 2012). This has resulted in the rapid expansion of oil palm plantations in tropical areas of Southeast Asia. Since 2009, Indonesia has been the largest producer of palm oil worldwide (Fig. 1).

In addition to the rising demand from international markets, the growth of the palm oil industry in Indonesia and the involvement of smallholder farmers were also spurred by the Indonesian government's transmigration program in the 1980s and early-1990s (Gatto et al., 2017). The transmigration program involved the voluntary resettling of households from densely-populated Java to less-densely populated islands, such as Sumatra. Families participating in this program settled in newly-established transmigrant villages, where they were allocated 2–3 ha of land and supported in the cultivation of agricultural crops through the provision of subsidized credits, inputs, and technical advice (McCarthy, 2010). In the early 1980s, transmigrant families were primarily supported in the cultivation of rubber. Since the mid-1980s, the government's focus had switched to oil palm (Krishna et al., 2017).

In the late-1980s, almost all smallholder farmers cultivating oil palm were transmigrant families that produced the crop under government-sponsored contracts with public or private companies. Since the mid-1990s, more and more autochthonous farmers had also started to cultivate oil palm, delivering their produce to nearby company mills, mostly without any contracts (Euler et al., 2016). Today, transmigrant and autochthonous families produce oil palm mostly without contracts. Most of the initial contracts expired, and – without the government-subsidized credits – most farmers find it more attractive to cultivate oil palm independently (Gatto et al., 2017). Fig. 2 shows the development of the oil palm area in Indonesia since 1990. In 2016, around 40% of the total oil palm area was managed by smallholder farmers.

2.2. Land-use change in Jambi

This study focuses on Jambi Province on Sumatra Island, one of the hotspot regions of the recent oil palm boom in Indonesia (Drescher et al., 2016; Clough et al., 2016). Historically, Jambi was covered by tropical rainforest, but significant deforestation already occurred during the first half of the twentieth century, instigated by the rising international demand for timber and natural rubber. Rubber has been cultivated in Jambi for > 100 years and has been the dominant cash crop in the region until recently (Gatto et al., 2015). Rubber in Jambi is primarily grown by autochthonous farm families and to a lesser extent by public and private companies. When the oil palm boom started in the 1980s, new oil palm plantations were mostly established on degraded (logged) forestland. Between 1990 and 2016, the area planted with oil palm in Jambi almost quadrupled (Fig. 3). During the same period, the forest area decreased by more than one million hectares (Margono et al., 2012; Clough et al., 2016).

Interesting to see in Fig. 3 is that the rubber area in Jambi also increased until recently. For autochthonous farm households, rubber remains the dominant crop. Rubber is less capital-intensive than oil palm, and rubber trees can remain productive for many decades (Feintrenie et al., 2010; Lee et al., 2014). Hence, switching from rubber to oil palm was not often observed as long as additional land was still available. Only more recently, with declining rubber prices and increasing land scarcity, oil palm is gradually replacing rubber plantations (Euler et al., 2017).

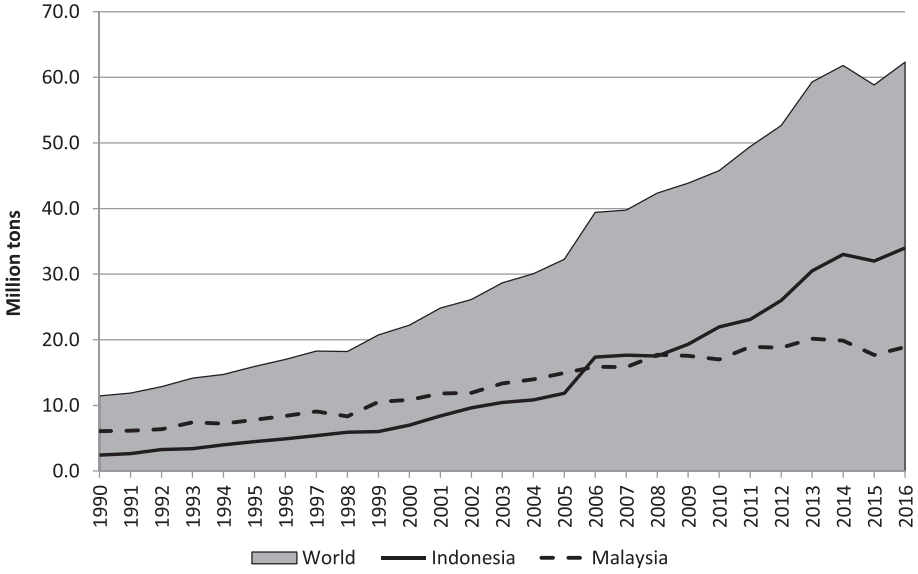

Fig. 1. Palm oil production between 1990 and 2016.
Sources: Own presentation based on data from FAO (2017), USDA (2017), and DJP (2017).

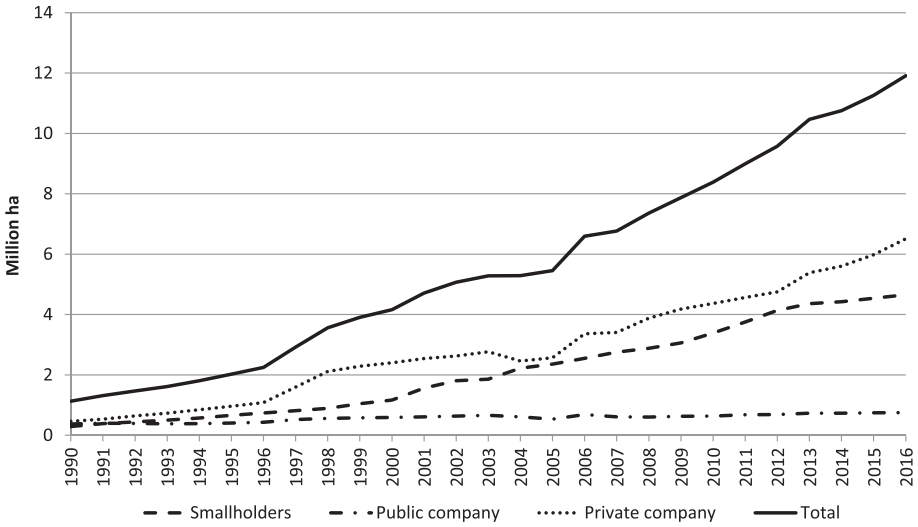

Fig. 2. Oil palm area in Indonesia by farming category (1990–2016).
Sources: Own presentation based on data from DJP (2017) and BPS (2017).

2.3. Poverty and income inequality in Indonesia

Poverty in Indonesia has fallen rapidly during the last 15 years, from around 20% in the early 2000s to 11% in 2016 (World Bank, 2017). Most of this decline in poverty is attributable to economic growth, including growth in the agricultural sector. Even though people living below the poverty line benefited from this growth, inequality increased, with the Gini coefficient rising from 0.34 in 2002 to 0.40 in 2016 (World Bank, 2017). In Jambi Province, the poverty rate is somewhat below the national average; it was reported at 8% in 2016 (BPS, 2017). Similarly, inequality in Jambi is lower than in the rest of Indonesia, even though it also increased over time. Between 2002 and 2016, the Gini coefficient for Jambi Province rose from 0.27 to 0.35 (BPS, 2017). Since agriculture is one of the most important economic sectors in Jambi, the question as to how the observed land-use changes may have contributed to the trends in poverty and inequality is of particular interest. This is analyzed in the following sections.

3. Material and methods

3.1. Household survey

Data for this study were collected through a structured household survey carried out in 2015 in rural areas of Jambi Province, Sumatra, Indonesia. Villages and households for inclusion in the survey were randomly selected using a multi-stage sampling framework. First, four regencies in Jambi (Sarolangun, Batanghari, Muaro Jambi, and Tebo) were purposively selected. These four regencies represent land-use patterns and land-use changes in the province's lowland areas very well (BPS, 2017). Second, 26 villages were randomly selected in these four regencies using village lists from the government's official Village Potential Survey (PODES). Third, in each of the 26 villages, 20–40 households were randomly selected with the exact numbers adjusted to village size. In total, our data set includes data from 841 households and can be considered representative for the lowland areas of Jambi, where most of the rubber and oil palm plantations are located.

Face-to-face interviews were conducted by a team of local

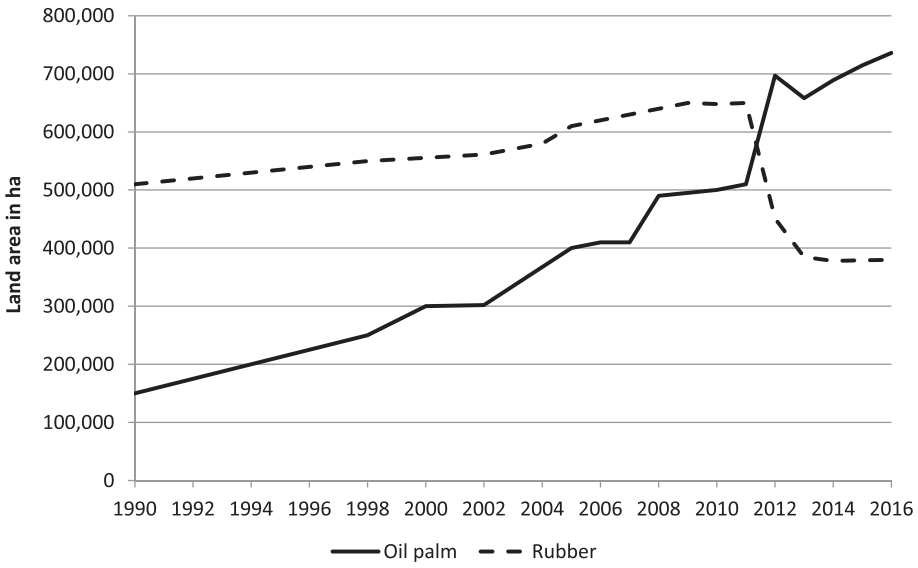

Fig. 3. Oil palm and rubber area in Jambi Province, Indonesia (1990–2016).
Sources: Own presentation based on data from BPS (2017) and DJP (2017).

enumerators, who were selected, trained, and supervised by the researchers. The interviews were carried out in Bahasa Indonesia using structured questionnaires. Detailed data were collected on household demographic structures and all economic activities pursued by the household or individual household members, including farm and off-farm activities. We also captured details of employment contracts and other institutional and socioeconomic characteristics. All income-related data were collected for a recall period of 12 months. In addition to the household-level data, information about land-use patterns at the village level and a few other village characteristics were obtained from village officials.

3.2. Statistical methods

The main objective is to analyze income levels and income sources for different types of households, which can help to assess how land use and land-use change affect income inequality. Total annual household income is calculated as the sum of farm income and off-farm income earned by all household members over a period of 12 months. Farm income includes income derived from the cultivation of rubber, oil palm, and any other agricultural crops, as well as livetsock enterprises. Off-farm income includes employment on rubber and oil palm plantations owned by other farms and companies, other agricultural and non-agricultural employment, self-employed activities (own non-farm businesses), and other income sources, such as transfers or renting out land.

All incomes are calculated as net incomes, meaning that for farming and other self-employed activities production costs are substracted from the gross output value. Production costs include all material inputs, hired labor, rented land, and other purchased production factors and services. Opportunity costs of family labor and own land are not substracted; hence, the income calculated can be interpreted as the net return to the household's own resources. Note that net returns for individual income sources can be negative, which happens when production costs exceeed the gross output value in a particular year. To make incomes comparable between households of different size, we calculate the net income per adult equivalent (AE). All income measures are expressed in Indonesian Rupiahs (IDR). Households are classified as poor if the annual net income per AE remains below the official 2015 poverty line for rural Jambi of 3.96 million IDR (BPS, 2017).

To account for different livelihood strategies of households, we subdivide the total sample into two subsamples depending on the relative contribution of different income sources to total household income. Farm households are defined as households that obtain > 50% of their total income from own farming activities. Non-farm households are defined as households where off-farm income accounts for > 50%. For both subsamples, we analyze the importance of oil palm and rubber as sources of farming and employment income. Furthermore, we compare mean income and poverty levels between farm and non-farm household and test whether observed differences are statistically significant.

We also subdivide the total sample by different types of villages. One classification differentiates between households living in transmigrant and autochthonous villages, depending on whether or not the village was newly established as part of the government's transmigration program. Note that not all households living in transmigrant villages participated in the transmigration program themselves. Spontaenous migration is also common in Jambi, often instigated by the economic opportunities arising from the oil palm boom. Spontaneous migrants are found both in transmigrant and autochthonous villages.

A second village classification differentiates by major land-use types: (i) oil palm-based villages are those where > 50% of the land within the village boundaries is cultivated with oil plam; (ii) rubber-based villages are those where > 50% of the land is cultivated with rubber; (iii) mixed villages are those where neither of these two crops accounts for > 50% of the land within the village boundaries. In mixed villages, food crops such as rice, cassava, and vegetables still play a more important role. Comparing mean income and poverty levels between these types of villages provides some indication of how agricultural land use and land-use change affect the livelihoods of farm and non-farm households.

Income inequality is analyzed with the Gini coefficient. Sources of inequality are examined with a Gini decomposition analysis (Shorrocks, 1983). Total income (Y) consists of income from k different sources, such as farm income from own oil palm cultivation, farm income from own rubber cultivation, off-farm income from working on oil palm plantations etc. Hence, total income Y for each household and also for the sample as a whole can be written as:

$$Y = \sum_{k=1}^{k} y_k \tag{1}$$

The Gini coefficient of total income (G) can then be expressed as:

$$G = \sum_{k=1}^{k} S_k G_k R_k \tag{2}$$

where S_k is the share of income source k in total income, G_k is the Gini coefficient of income from source k, and R_k is the correlation coefficient between income from source k and total income Y. G_kR_k is known as the pseudo-Gini coefficient of income source k (Shorrocks, 1983). The contribution of income source k to total income inequality is given as $S_kG_kR_k/G$, while the relative concentration coefficient of income source k in total income inequality is expressed as:

$$g_k = G_k R_k / G \tag{3}$$

Income sources that have a relative concentration coefficient greater than one contribute to increasing total inequality, while those with a relative concentration coefficient less than one contribute to decreasing total inequality. The source elasticity of inequality is expressed as $(S_kG_kR_k/G) - S_k$ and indicates the percentage effect of a 1% change in income from source k on the overall Gini coefficient. For instance, a positive sign for the elasticity of farm income from own oil palm cultivation would suggest that income inequality among farm households would rise through further expansion of the oil palm land.

We conduct the decomposition analysis for the whole sample, as well as separately for farm and non-farm households. Interesting to see is whether further oil palm expansion would have the same effect on income inequality among farm and non-farm households. Furthermore, we differentiate by village types, in order to better understand how land use at the village level is associated with inequality.

4. Results

4.1. General characteristics of rural households

Table 1 shows descriptive statistics for general household characteristics, for the sample as a whole, as well as separately for the subsamples of farm and non-farm households (see Table A1 in the Appendix for variable definitions). Of the total sample, 64% are classified as non-farm households, meaning that > 50% of their income is derived from off-farm activities. These are not necessarily landless households, many of them have small pieces of land that they cultivate to generate some farm income. But the fact that less than half of all households has own farming as the main income source clearly underlines the importance of labor markets for people's livelihoods in rural Jambi.

Around 48% of the sample households live in transmigrant villages, the other 52% live in autochthonous villages, with some variation observed between farm and non-farm households. Two-thirds of all households have a migration background, meaning that they themselves or their parents moved to the village as transmigrants or spontaneous migrants. The migration background does not differ significantly between farm and non-farm households. The lower part of Table 1 also shows the breakdown of the sample by dominant village

Table 1
General sample characteristics.

Variable name	Total sample (N = 841)	Farm households (N = 301)	Non-farm households (N = 540)
Socio-economic variables			
Household size (adult equivalents)	2.89 (1.08)	2.98 (1.11)	2.84 (1.06)
Age (years)	44.98 (11.59)	48.00** (12.05)	43.3 (11.00)
Education (years of schooling)	6.62 (3.60)	6.53 (3.57)	6.70 (3.62)
Migrant (dummy)	0.67 (0.47)	0.69 (0.46)	0.66 (0.48)
Village characteristics			
Transmigrant village (dummy)	0.48 (0.50)	0.56* (0.50)	0.44 (0.50)
Autochthonous village (dummy)	0.52 (0.50)	0.44* (0.49)	0.57 (0.50)
Oil palm-based village (dummy)	0.18 (0.38)	0.20 (0.40)	0.17 (0.37)
Rubber-based village (dummy)	0.69 (0.46)	0.71 (0.46)	0.70 (0.46)
Mixed village (dummy)	0.13 (0.33)	0.09* (0.30)	0.15 (0.37)

Notes: Mean values are shown with standard deviations in parentheses.
* Difference between farm and non-farm households significant at 5% level.
** Difference between farm and non-farm households significant at 1% level.

land-use types. Close to 70% of all households live in rubber-based villages, meaning that rubber plantations account for > 50% of the land within the village boundaries. In most of these villages, some oil palm is also cultivated, but rubber remains the dominant crop. Around 18% of the households live in villages where oil palm is the dominant crop, and 13% live in mixed villages, where food crops still play a more important role.

4.2. Role of different income sources

Table 2 shows mean income levels for all sample households, as well as separately for farm and non-farm households (see Table A1 in the Appendix for variable definitions). The total mean income is in a magnitude of 15.5 million IDR (1167 US dollars) per AE and year. This is much higher than the official poverty line of 3.96 million IDR for rural Jambi. However, mean income levels mask the underlying distribution, which has a considerable spread. Fourteen percent of all households fall below the poverty line, which is more than the poverty rate of 8% indicated in official statistics (BPS, 2017). But the official poverty rate refers to Jambi Province as a whole, whereas our sample is restricted to rural areas. In rural areas, poverty is often more prevalent than in urban areas (World Bank, 2017). Striking to see is the difference in mean income levels between farm and non-farm households. Non-farm households have significantly lower incomes than farm households and are much more likely to be poor.

Concerning the income sources, by definition farm income plays a much more important role for farm households than for non-farm households. Most of the farm income is derived from rubber and oil palm cultivation, other crop and livestock activities only play a minor role. Interesting to see is that rubber is a more important source of farm income than oil palm on average, even though this composition may change with further expansion of the oil palm land. For non-farm households, agricultural wages are the most important source of income, accounting for > 40% of total income. Hence, land-use change can have important economic effects also for non-farm households. Most of the agricultural wages stem from employment in rubber and oil palm, with both crops contributing in similar magnitudes.

Much of the rubber employment is through sharecropping

Table 2
Level and composition of rural household incomes.

Income source	Total sample (N = 841)	Farm households (N = 301)	Non-farm households (N = 540)
Farm income ('000 IDR/AE)	6706.96 (18,551.29)	15,625.01** (28,493.21)	1735.98 (3911.07)
Oil palm	2303.51 (9826.83)	5259.77** (15,518.73)	655.67 (2974.79)
Rubber	3998.84 (15,126.77)	8478.47** (24,116.74)	944.46 (2601.31)
Other farming.	394.32 (2582.52)	857.78** (3963.86)	135.99 (1209.06)
Off-farm income ('000 IDR/AE)	8801.16 (16,642.54)	3659.65** (7145.94)	11,667.07 (19,499.62)
Agricultural wages	4213.44 (5349.91)	1373.10** (3553.49)	5796.66 (5528.14)
Oil palm	1798.89 (4427.48)	473.75** (2342.55)	2537.54 (5095.88)
Rubber	2180.45 (3719.67)	757.72** (2733.81)	2973.48 (3955.03)
Other agriculture	234.09 (1483.30)	141.63 (816.65)	285.64 (1746.48)
Non-agricultural wages	1495.78 (8868.20)	542.75* (1865.75)	2027.01 (10,946.98)
Self-employment	2742.67 (13,692.97)	1476.79* (6197.72)	3448.29 (16,414.34)
Other off-farm income	221.22 (1462.43)	77.99* (288.25)	301.06 (1808.04)
Total income ('000 IDR/AE)	15,508.12 (24,926.40)	19,284.66** (30,464.38)	13,403.05 (20,960.43)
Below poverty line (dummy)	0.14 (0.35)	0.08** (0.27)	0.17 (0.38)

Notes: Mean values are shown with standard deviations in parentheses. AE, adult equivalent. IDR, Indonesian Rupiah (official exchange rate in 2015: 1 US dollar = 13,280 IDR).
* Difference between farm and non-farm households significant at 5% level.
** Difference between farm and non-farm households significant at 1% level.

arrangements, where tenant households receive an agreed-upon share of the rubber output rather than a fixed wage. We used locally observed output shares and rubber prices to value the labor income derived from sharecropping arrangements. For oil palm, sharecropping is less often observed. Employment in oil palm is mostly through casual labor arrangements. Only larger oil palm farms and companies sometimes employ laborers on a longer-term basis.

4.3. Income differences by village type

Table 3 shows mean income and poverty levels differentiated by village type. Total household incomes are somewhat higher in transmigrant than in autochthonous villages. In both types of villages, farm households have significantly higher mean incomes and are less affected by poverty than non-farm households.

Bigger differences between village types are observed when using the classification by dominant land-use type. The lowest income levels and the highest poverty rates are observed in mixed villages, where food crop cultivation dominates and plantation cash crops play a less important role. In mixed villages, farm and non-farm households are equally poor. Mean income levels are higher in oil palm and rubber-based villages, suggesting that the cultivation of these plantation crops contributes to economic development. However, significant differences are also observed between the plantation-based villages. Mean household incomes in oil palm-based villages are 38% higher than in rubber-based villages, and poverty rates are significantly lower.

These results suggest that oil palm cultivation benefits farm and non-farm households alike. To be sure, this comparison of mean income levels in different types of villages is not a rigorous impact assessment of the economic effects of oil palm cultivation. The oil palm area in a

Table 3
Household income and poverty rates by village type.

Village type	Total income ('000 IDR/AE)			Below poverty line (dummy)		
	All households	Farm households	Non-farm households	All households	Farm households	Non- farm households
Transmigrant	16,094.55	19,588.16**	13,567.27	0.14	0.07***	0.14
	(27,923.97)	(34,158.22)	(22,096.90)	(0.35)	(0.28)	(0.39)
Autochthonous	14,963.38	18,890.80**	13,276.52	0.13	0.08**	0.16
	(21,794.58)	(24,992.48)	(20,076.90)	(0.34)	(0.28)	(0.37)
Oil palm-based	20,842.75	24,333.97	18,489.12	0.08	0.03*	0.11
	(29,817.13)	(25,719.13)	(32,215.49)	(0.27)	(0.18)	(0.32)
Rubber-based	15,056.37	19,050.54***	12,763.22	0.14	0.08***	0.18
	(25,116.27)	(33,010.94)	(18,845.19)	(0.35)	(0.27)	(0.39)
Mixed	10,591.09	10,245.64	10,712.00	0.19	0.18	0.20
	(12,070.52)	(12,976.41)	(11,820.74)	(0.40)	(0.39)	(0.40)

Notes: Mean values are shown with standard deviations in parentheses. The total number of villages in the sample is 26. First classification: 12 transmigrant and 14 autochthonous villages. Second classification: 9 oil palm-based, 13 rubber-based, and 4 mixed villages. AE, adult equivalent. IDR, Indonesian Rupiah (official exchange rate in 2015: 1 US dollar = 13,280 IDR).

* Difference between farm and non-farm households significant at 10% level.

** Difference between farm and non-farm households significant at 5% level.

*** Difference between farm and non-farm households significant at 1% level.

village is endogenous and correlated with a number of other characteristics that may influence household incomes through various channels. The comparisons in Table 3 do not control for such confounding factors. However, studies with historical data from Jambi suggest that the villages with a high proportion of oil palm land today are particularly those where oil palm cultivation started early on, already back in the late-1980s and the early-1990s (Euler et al., 2016). And these early-adopting oil palm villages were often poorer in those days than the villages where oil palm adoption started later (Gatto et al., 2017). The reason is that the richer villages in the early-1990s were villages with highly-productive rubber plantations, where the economic need to adopt a new plantation crop was not particularly pronounced. Against this background, the hypothesis that oil palm contributed to accelerated income growth for farm and non-farm households seems justified. For farm households, the main mechanism is through higher farm incomes from own oil palm cultivation. For non-farm households, the larger oil palm area at the village level means better and more lucrative employment opportunities (Bou Dib et al., 2018).

4.4. Income inequality

Table 4 presents the Gini decomposition analysis for our rural household sample. The total Gini coefficient is 0.48, which is higher than what is reported for Jambi in official statistics (BPS, 2017). But again, the official statistics include rural and urban areas, whereas our sample includes rural households only. Farm income accounts for 44% of total household income, but is responsible for 53% of total inequality. This means that – holding other income sources constant – an increase in farm income would lead to rising inequality. The source elasticity of 0.11 shown in the last column of Table 4 suggests that a 1% increase in farm income would increase the Gini coefficient by 0.11%, or a 10% increase in farm income would increase the Gini coefficient by 1.1%. This effect is mainly driven by farm income from oil palm cultivation, whereas the source elasticity for farm income from rubber is small and statistically insignificant. In other words, farm income from oil palm cultivation contributes significantly to income inequality in rural Jambi.

However, as already discussed, oil palm cultivation does not only

Table 4
Gini decomposition by income source.

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G) - S_k$
Farm income	0.44	0.79	0.81	53.26	0.11**
Oil palm	0.15	0.99	0.80	23.05	0.08** (0.02)
Rubber	0.27	0.84	0.70	26.03	0.02 (0.03)
Other farming	0.03	1.29[a]	0.52	4.18	0.02** (0.01)
Off-farm income	0.57	0.58	0.74	46.74	−0.11** (0.03)
Agricultural wages	0.28	0.62	0.24	8.00	−0.20** (0.01)
Oil palm	0.12	0.90	0.32	6.30	−0.05** (0.01)
Rubber	0.14	0.75	0.03	0.60	−0.14** (0.01)
Other agriculture	0.02	0.10	0.35	1.10	−0.01* (0.01)
Non-agric. wages	0.10	0.92	0.64	11.13	0.02 (0.02)
Self-employment	0.19	0.93	0.84	26.81	0.09** (0.01)
Other off-farm	0.02	0.92	0.24	0.80	−0.01** (0.01)
Total		0.48			

Notes: All households are included (N = 841). For the source elasticities, bootstrapped standard errors are shown in parentheses (López-Feldman, 2006; Davidson, 2009).

[a] The Gini coefficient for this particular income source is larger than one, because a certain fraction of households had a negative net income from this source in the survey year.

* Significant at 10% level.

** Significant at 1% level.

Table 5
Gini decomposition with alternative income classification.

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G$) − S_k
Oil palm (combined)	0.27	0.86	0.67	29.35	0.03 (0.02)
Rubber (combined)	0.41	0.63	0.58	26.63	−0.13* (0.04)
Other agriculture (combined)	0.05	1.14[a]	0.50	5.28	0.01 (0.01)
Non-agricultural wages	0.10	0.92	0.65	11.13	0.02 (0.02)
Self-employment	0.19	0.94	0.84	26.81	0.09* (0.02)
Other	0.02	0.91	0.24	0.80	−0.01* (0.01)
Total		0.48			

Notes: All households are included (N = 841). For the source elasticities, bootstrapped standard errors are shown in parentheses (López-Feldman, 2006; Davidson, 2009).
[a] The Gini coefficient for this particular income source is larger than one, because a certain fraction of households had a negative net income from this source in the survey year.
* Significant at 1% level.

affect farm income, but also off-farm income through labor-market effects. Table 4 shows that off-farm income as a whole, and agricultural wage income in particular, is inequality-decreasing. Agricultural wage income consists primarily of income from employment in rubber and oil palm, and both types of employment contribute significantly to reduced total inequality.

So far, we have differentiated between farm and off-farm income, whereby oil palm and rubber played a role in both income categories. We now use an alternative income classification, where we calculate total oil palm income as the sum of the earnings derived from oil palm farming and oil palm employment. In the same way, total rubber income is calculated as the sum of the earnings from rubber farming and rubber employment. This alternative income classification helps to assess how rubber and oil palm contribute to income inequality more broadly through farming and employment channels combined. Results of the Gini decomposition analysis with this alternative income classification are shown in Table 5.

Oil palm income accounts for 27% of total household income and is responsible for 29% of total inequality. The source elasticity of total inequality is positive but small and statistically insignificant. Hence, there is no strong evidence that further growth of oil palm income would lead to a rise in overall inequality. It seems that the inequality-increasing effect of oil palm through the farm-income channel is offset by the inequality-decreasing effect through the employment channel. The employment channel benefits non-farm households in particular, and these are generally poorer than farm households. For rubber income, the source elasticity in Table 5 is negative and statistically significant, meaning that further growth of rubber income would lead to decreasing inequality.

We continue with this alternative income classification that combines farm and employment effects of oil palm and rubber but now look at the two subsamples of farm and non-farm households separately. The Gini decomposition analysis for both subsamples is shown in Table 6. For farm households (upper part of Table 6), growth in oil palm income increases inequality to a significant extent, whereas for non-farm households (lower part of Table 6), growth in oil palm income reduces inequality. Growth in rubber income reduces inequality among both types of households. These findings confirm the earlier results discussed above.

Interesting to observe is that income from self-employment increases inequality, and especially so among non-farm households (Table 6). Self-employment includes various business activities, such as transport, trade, processing, and small-scale manufacturing. Relatively richer households find it easier to exploit such business opportunities,

Table 6
Gini decomposition by type of households.

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G$) − S_k
Farm households (N = 301)					
Oil palm (combined)	0.30	0.90	0.80	40.13	0.10** (0.04)
Rubber (combined)	0.54	0.60	0.70	42.20	−0.12** (0.05)
Other agriculture (combined)	0.05	1.03[a]	0.46	4.63	−0.01 (0.01)
Non-agricultural wages	0.03	0.93	0.52	2.53	−0.01 (0.00)
Self-employment	0.08	0.94	0.80	10.74	0.03** (0.01)
Other	0.01	0.89	−0.19	−0.13	−0.01*** (0.00)
Non-farm households (N = 540)					
Oil palm (combined)	0.24	0.80	0.53	20.53	−0.03* (0.02)
Rubber (combined)	0.29	0.61	0.32	11.60	−0.18*** (0.02)
Other agriculture (combined)	0.03	1.26[a]	0.43	3.51	0.01 (0.01)
Non-agricultural wages	0.15	0.90	0.71	19.81	0.05 (0.04)
Self-employment	0.26	0.93	0.87	42.64	0.17*** (0.04)
Other	0.02	0.90	0.34	1.41	−0.01 (0.01)

Notes: For the source elasticities, bootstrapped standard errors are shown in parentheses (López-Feldman, 2006; Davidson, 2009).
[a] The Gini coefficient for this particular income source is larger than one, because a certain fraction of households had a negative net income from this source in the survey year.
* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level.

Table 7
Gini coefficients by household and village types.

Type of village	All households	Farm households	Non-farm households
Transmigrant	0.50	0.51	0.49
Autochthonous	0.49	0.50	0.48
Oil palm	0.49	0.50	0.47
Rubber	0.50	0.52	0.49
Mixed	0.45	0.52	0.47

often due to their better physical, human, and social capital endowments.

We also carried out the Gini decomposition analysis by village type, differentiating between transmigrant and autochthonous villages and between villages with different dominant land-use types. These additional analyses are shown in Tables A2 and A3 in the Appendix. In all types of villages, oil palm contributes to increasing inequality through the farm-income channel and to decreasing inequality through the off-farm employment channel. Significant associations between the Gini coefficients and the village types are not observed (Table 7).

5. Discussion

This is the first study that has analyzed the relationship between land use and income inequality in Southeast Asia using data from both farm and non-farm households. Including non-farm households is important, as these often belong to the poorest of the poor in rural areas and may be affected by land-use change through labor markets (Bou Dib et al., 2018). We have used survey data from Jambi Province on Sumatra Island, one of the hotspots of Indonesia's recent oil palm boom.

The data show that around 60% of the households in rural Jambi obtain more than half of their income from economic activities other than independent farming. The most important income sources for these non-farm households are employment in oil palm and rubber plantations. These plantations either belong to local farm households or to large public and private companies. On average, non-farm households are significantly poorer than farm households. We also found significant differences in mean income levels between villages with different dominant land-use types. The lowest incomes and the highest poverty rates are observed in villages where much of the area is cultivated with food crops. Villages where more rubber is cultivated are significantly richer. The highest mean income levels and the lowest poverty rates are observed in villages where oil palm is the dominant land-use type. These comparisons suggest that oil palm contributes to economic development and poverty reduction. Farm households benefit from oil palm cultivation in terms of higher farm profits, whereas non-farm households benefit from oil palm through new lucrative employment opportunities.

The role of different income sources for income inequality has been analyzed through Gini decomposition analysis. Oil palm cultivation contributes to higher income inequality among farm households. This was also suggested in other recent studies with farm household data from Indonesia (Euler et al., 2017; Krishna et al., 2017). These earlier studies showed that farmers with better access to land and financial capital find it easier to adopt oil palm and benefit more than farmers who are land- and capital-constrained. However, an explicit analysis of the effects of oil palm cultivation on income inequality was not carried out previously. Our data show that income inequality among farmers has increased through the expansion of oil palm, whereas total rural inequality has not. The reason is the positive effect of oil palm through the employment channel, which benefits non-farm households, reduces inequality, and thus offsets the inequality-increasing effect through the farm-income channel.

It should be noted that the Gini decomposition analysis and the estimated source elasticities of income inequality are static tools that examine the effect of an increase in one source of income while holding other sources constant. This was realistic in the past, because the expansion of oil palm often occurred in degraded forest areas or fallow land. However, in the future, oil palm may be expanded more on existing rubber land, so that an increase in the oil palm area may possibly be accompanied by a decrease in the rubber area and therefore also a decrease in rubber income. Since rubber income was found to be inequality-reducing, it is possible that further oil palm expansion would be associated with rising overall inequality. This should be monitored to avoid undesirable social outcomes. Rising inequality can possibly be prevented through specific policies, such as credit programs targeted at capital-constrained households. If properly designed, credit programs may not only benefit farmers, but also non-farm households through stimulating self-employed non-farm business activities.

A general limitation of our study is that we look at associations between land use and income inequality, and that these associations cannot be interpreted as the net impact of land-use change on household income. A rigorous impact analysis would have to use regression models to control for possible confounding factors. Combining the Gini decomposition analysis with regression models is not straightforward with the cross-section data available. Our result that the expansion of oil palm is positively associated with household income in farm and non-farm households is in line with other recent studies that used regression models to control for confounding factors (Euler et al., 2017; Krishna et al., 2017; Bou Dib et al., 2018; Kubitza et al., 2018b). But, as mentioned, these earlier studies did not explicitly analyze effects on income inequality. Hence, follow-up work with panel data would be very interesting to evaluate the net effects of oil palm expansion on income inequality. Beyond income, comparing the working conditions for laborers in oil palm, rubber, and other sectors would also be useful to gain a more comprehensive understanding of social implications (Cramb and McCarthy, 2016; McCarthy and Obidzinski, 2017; Pye, 2018).

This study has focused on economic and social dimensions. From a comprehensive sustainability perspective, environmental effects of land-use change need to be considered as well. At least to some extent, the expansion of oil palm in Indonesia has been at the expense of tropical rainforests with a concomitant loss in biodiversity and significant additional greenhouse gas emissions (Fitzherbert et al., 2008; Carlson et al., 2013; Koh et al., 2011; Gunarso et al., 2013; Margono et al., 2014; Clough et al., 2016; Pirker et al., 2016). The expansion of oil palm plantations is also held responsible for frequent forest fires and haze pollution with negative health effects for the local population (Page et al., 2002; Pye, 2018). Even a switch from rubber to oil palm may cause negative environmental and health effects, as oil palm is often produced more intensively with higher quantities of chemical fertilizers and pesticides (Dudgeon et al., 2006; Obidzinski et al., 2013; Krishna et al., 2017).

6. Conclusion

Many regions in Southeast Asia are experiencing massive land-use change. While areas covered with tropical forests and traditional agricultural crops, such as rubber, are shrinking, oil palm plantations are rapidly gaining ground. Several studies have analyzed environmental effects of such land-use changes, but relatively little is known about the broader socioeconomic implications. A few recent studies have examined economic effects of oil palm cultivation for farm households in Indonesia. But a focus on farm households is insufficient, given that rural non-farm households may also be affected by land-use change. In this study, we have addressed this research gap with data from farm and non-farm households in rural Jambi, one of the hotspots of Indonesia's recent oil palm boom. We have used the data to analyze and compare income levels, income structures, and sources of inequality with a particular focus on oil palm and rubber.

Our results suggest that oil palm contributes to economic development and poverty reduction. Farm households benefit from oil palm

cultivation in terms of higher farm profits, whereas non-farm households benefit from oil palm through new lucrative employment opportunities. Oil palm contributes to increasing inequality among farm households, but it helps to reduce inequality among non-farm households, which belong to the poorest of the poor in rural Jambi. Oil palm does not seem to significantly affect total rural inequality, because the inequality-decreasing effect through the employment channel offsets the inequality-increasing effect through the farm profit channel. While these results are plausible, it should be stressed that the data and statistical approaches used cannot establish causality. Follow-up research with panel data would be valuable to further analyze the effects of oil palm expansion on income inequality.

In closing, we stress that the persistent oil palm expansion is associated with environmental problems. While these were not the focus of this study, policies towards sustainable land use need to jointly consider economic, social, and environmental dimensions. It is very likely that future land-use change and oil palm expansion will occur in Indonesia and other regions of Southeast Asia. Interdisciplinary research can help to better understand sustainability tradeoffs and design appropriate policies.

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Appendix A

Table A1
Variable definitions.

Variable name	Variable descriptions
Household size	Number of household members expressed in adult equivalents
Age	Average age of adult household members (years)
Education	Years of schooling of household head (years)
Migrant	1 if household has migrant background, 0 otherwise
Transmigrant village	1 if village was newly established as part of the government's transmigration program, 0 otherwise
Autochthonous village	1 if traditional village, 0 otherwise
Oil palm-based village	1 if oil palm accounts for > 50% of land within village boundaries, 0 otherwise
Rubber-based village	1 if rubber accounts for > 50% of land within village boundaries, 0 otherwise
Mixed village	1 if no single crop accounts for > 50% of land within village boundaries, 0 otherwise
Total income	Total net annual household income in IDR per adult equivalent
Farm income	Annual income from own farming in IDR per adult equivalent
Oil palm	Annual income from own oil palm farming in IDR per adult equivalent
Rubber	Annual income from own rubber farming in IDR per adult equivalent
Other farming	Annual income from other own farming activities in IDR per adult equivalent
Off-farm income	Annual off-farm income in IDR per adult equivalent
Agricultural wages	Annual income from agricultural employment in IDR per adult equivalent
Oil palm	Annual income from oil palm employment in IDR per adult equivalent
Rubber	Annual income from rubber employment in IDR per adult equivalent
Other agriculture	Annual income from other agricultural employment in IDR per adult equivalent
Non-agricultural wages	Annual income from non-farm employment in IDR per adult equivalent
Self-employment	Annual income from self-employed activities in IDR per adult equivalent
Other	Other off-farm income (transfers etc.) in IDR per adult equivalent
Below poverty line	1 if total income is below official poverty line for rural Jambi, 0 otherwise

Table A2
Gini decomposition in transmigrant and autochthonous villages.

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G$) − S_k
Transmigrant villages (N = 405)					
Farm income	0.50	0.77	0.84	59.30	0.11** (0.04)
Oil palm	0.19	0.94	0.80	25.21	0.08** (0.03)
Rubber	0.27	0.85	0.66	28.09	0.02 (0.05)
Other farming	0.05	1.16 [a]	0.67	6.00	0.01 (0.01)
Off-farm income	0.51	0.61	0.71	40.70	−0.11** (0.04)
Agricultural wages	0.24	0.67	0.23	6.22	−0.18** (0.02)
Oil palm	0.12	0.86	0.37	6.52	−0.05** (0.01)

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Table A2 (*continued*)

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G$) − S_k
Rubber	0.12	0.81	−0.14	−2.02	−0.13** (0.02)
Other agriculture	0.02	0.99	0.21	0.16	−0.01*,***(0.01)
Non-agric. wages	0.08	0.90	0.57	7.30	−0.01 (0.01)
Self-employment	0.18	0.94	0.85	27.29	0.09** (0.04)
Other	0.01	0.90	0.20	0.21	−0.01** (0.01)
Autochthonous villages (N = 436)					
Farm income	0.40	0.79	0.78	49.50	0.12** (0.04)
Oil palm	0.10	1.08[a]	0.81	17.66	0.08** (0.03)
Rubber	0.28	0.81	0.66	31.84	0.04 (0.03)
Other farming	0.02	1.59[a]	0.36	2.00	0.01 (0.01)
Off-farm income	0.62	0.55	0.78	50.50	−0.12** (0.04)
Agricultural wages	0.33	0.57	0.29	10.01	−0.23** (0.02)
Oil palm	0.13	0.86	0.29	6.40	−0.06** (0.02)
Rubber	0.17	0.71	0.11	1.20	−0.16** (0.01)
Other agriculture	0.03	0.96	0.42	2.41	−0.01 (0.01)
Non-agric. wages	0.12	0.93	0.69	15.02	0.04 (0.04)
Self-employment	0.17	0.93	0.84	24.71	0.05** (0.03)
Other	0.03	0.92	0.32	0.86	−0.01 (0.01)

Notes: All households are included (N = 841). For the source elasticities, bootstrapped standard errors are shown in parentheses (López-Feldman, 2006; Davidson, 2009).

[a] The Gini coefficient for this particular income source is larger than one, because a certain fraction of households had a negative net income from this source in the survey year.

* Significant at 10% level.

** Significant at 1% level.

Table A3
Gini decomposition in oil palm-based, rubber-based, and mixed villages.

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G$) − S_k
Oil palm-based villages (N = 185)					
Farm income	0.44	0.80	0.82	51.64	0.08 (0.06)
Oil palm	0.36	0.85	0.84	47.10	0.12** (0.05)
Rubber	0.08	0.87	0.28	3.30	−0.05*** (0.02)
Other farming	0.02	1.42[a]	0.40	1.24	−0.01 (0.01)
Off-farm income	0.57	0.64	0.74	49.36	−0.08 (0.06)
Agricultural wages	0.24	0.72	0.15	5.29	−0.19*** (0.02)
Oil palm	0.21	0.73	0.26	7.11	−0.15*** (0.02)
Rubber	0.03	1.64[a]	−0.29	−1.62	−0.06*** (0.01)
Other agriculture	0.01	1.00	−0.43	−0.20	−0.01 (0.01)
Non-agric. wages	0.05	0.90	0.50	3.70	−0.01 (0.01)
Self-employment	0.26	0.93	0.86	40.06	0.14** (0.05)
Other	0.02	0.92	0.15	0.31	−0.01* (0.01)
Rubber-based villages (N = 548)					
Farm income	0.46	0.78	0.82	56.40	0.11*** (0.03)
Oil palm	0.09	1.09[a]	0.80	15.70	0.06** (0.02)
Rubber	0.35	0.80	0.73	37.60	0.05 (0.03)

(*continued on next page*)

Table A3 (*continued*)

Income source	Income share (S_k)	Gini coefficient (G_k)	Correlation with total income distribution (R_k)	Percentage contribution to total inequality ($S_kG_kR_k/G$)	Source elasticity of total inequality ($S_kG_kR_k/G$) − S_k
Other farming	0.02	1.40[a]	0.58	3.10	0.01* (0.01)
Off-farm income	0.56	0.58	0.73	45.60	−0.11*** (0.03)
Agricultural wages	0.28	0.60	0.26	8.51	−0.12*** (0.01)
Oil palm	0.09	0.90	0.34	5.06	−0.04*** (0.01)
Rubber	0.18	0.70	0.10	2.32	−0.16*** (0.02)
Other agriculture	0.02	0.98	0.45	1.13	−0.01* (0.01)
Non-agric. wages	0.11	0.93	0.70	13.57	0.03 (0.02)
Self-employment	0.14	0.94	0.83	22.80	0.08*** (0.03)
Other	0.02	0.91	0.25	0.72	−0.01** (0.01)
Mixed villages (N = 108)					
Farm income	0.30	0.91	0.76	43.80	0.15* (0.07)
Oil palm	0.07	1.03[a]	0.40	5.30	−0.01 (0.02)
Rubber	0.15	1.26[a]	0.66	24.53	0.11 (0.08)
Other farming	0.10	1.02[a]	0.73	13.97	0.08 (0.05)
Off-farm income	0.72	0.48	0.80	56.20	−0.15* (0.07)
Agricultural wages	0.36	0.61	0.24	11.29	−0.26*** (0.05)
Oil palm	0.14	0.84	0.16	3.70	−0.10*** (0.03)
Rubber	0.18	0.74	0.10	2.53	−0.17*** (0.03)
Other agriculture	0.05	0.97	0.47	5.06	−0.01 (0.02)
Non-agric. wages	0.15	0.89	0.60	17.66	0.06 (0.04)
Self-employment	0.17	0.90	0.79	27.10	0.10** (0.03)
Other	0.01	0.84	0.07	0.15	−0.02** (0.01)

Notes: All households are included (N = 841). For the source elasticities, bootstrapped standard errors are shown in parentheses (López-Feldman, 2006; Davidson, 2009).

[a] The Gini coefficient for this particular income source is larger than one, because a certain fraction of households had a negative net income from this source in the survey year.

* Significant at 10% level.

** Significant at 5% level.

*** Significant at 1% level.

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