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Land-use change and livelihoods of non-farm households: The role of income from employment in oil palm and rubber in rural Indonesia

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ABSTRACT

Many tropical regions are experiencing massive land-use change that is often characterized by an expansion of oil palm at the expense of forests and more traditional forms of agricultural cropping. While implications of such land-use change for the environment and for local farm households were examined in previous research, possible effects on the livelihoods of non-farm households are not yet well understood. This study analyzes the role of different types of agricultural and non-agricultural employment income for non-farm households in rural Jambi, one of the hotspot regions of Indonesia's recent oil palm boom. Data from a survey show that employment in rubber and oil palm are important livelihood components for non-farm households. Employment in oil palm is more lucrative than employment in rubber, so involvement in the oil palm sector as a laborer is positively associated with total household income. Regression models show that whether or not a household works in oil palm is largely determined by factors related to migration background, ethnicity, and the size of the village area grown with this crop. These results suggest that further expansion of the oil palm area will likely benefit non-farm households through gains in employment income. As non-farm households belong to the poorest segments of the rural population, these benefits should not be ignored when designing policies towards sustainable land use. Possible negative environmental and social externalities of further oil palm expansion are also discussed.

1. Introduction

During the past few decades, oil palm has become one of the most rapidly expanding agricultural crops, especially in Southeast Asia (Euler et al., 2016; FAO, 2017). Indonesia and Malaysia are the biggest producers of palm oil, with a combined world market share of 85% (FAO, 2017). In Indonesia, the land area grown with oil palm grew by almost 50% over the last 10 years. While some of the new oil palm plantations were established on recently deforested land, oil palm has also replaced other agricultural crops such as rubber (Krishna et al., 2017a). About 60% of the oil palm land in Indonesia is managed by large-scale public or private companies, the rest is cultivated by smallholder farmers (Gatto et al., 2015; Euler et al., 2016).

The rapid expansion of oil palm in Southeast Asia has given rise to various environmental and social concerns. Oil palm is often held re-nsponsible for tropical deforestation, loss of biodiversity, increases in greenhouse gas emissions, land property conflicts, and social inequality (Fargione et al., 2008; Fitzherbert et al., 2008; McCarthy and Cramb, 2009; McCarthy, 2010; Wicke et al., 2011; Cramb and Curry 2012; Obidzinski et al., 2013; Dewi et al., 2013; Margono et al., 2014; Tsujino et al., 2016; Austin et al., 2017; McCarthy and Obidzinski, 2017). On the other hand, research also shows that oil palm can contribute to rural economic growth and development (Feintrenie et al., 2010; Rist et al., 2010; Lee et al., 2014; Castiblanco et al., 2015; Gatto et al., 2017). Recent studies found that small-farm households in Indonesia profit significantly from oil palm cultivation in terms of income gains and improvements in living standards (Krishna et al., 2017b; Euler et al., 2017).

However, in order to assesss the role of oil palm, or of land-use change more generally, for rural livelihoods it is insufficient to look at profits and incomes of farmers alone. There are also non-farm households in rural areas that may be affected through various channels, including changing conditions in local labor markets. Non-farm households often belong to the poorest segments of rural populations and typically derive a sizeable part of their income from working as agricultural laborers (von Braun and Gatzweiler, 2014). Land-use change may alter employment opportunities and incomes for these labor-supplying households (McCarthy, 2010; Li, 2011; McCarthy and

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Obidzinksi, 2017). To the best of our knowledge, no previous study has analyzed the role of oil palm and other agricultural crops for the income of non-farm households in Indonesia or elsewhere. Here, we address this research gap with data from a survey of non-farm households that we conducted in Jambi Province on the Island of Sumatra. Jambi has been one of the hotspots of the recent oil palm boom in Indonesia (Clough et al., 2016). Based on our data, including several hundred observations from 26 randomly selected villages, non-farm households account for approximately 60% of all households in rural Jambi.[1] This means that a meaningful assessment of rural livelihoods is not possible without considering non-farm households.

We analyze the magnitude and structure of non-farm household income with a particular focus on the role of employment in oil palm and rubber farms and plantations. Oil palm and rubber are by far the two most important crops in Jambi in terms of the land area cultivated (Gatto et al., 2015; Euler et al., 2016). Using regression models, we also analyze factors that influence a household's decision whether or not to work in oil palm, rubber, and other employed or self-employed activities. Finally, we examine whether employment in oil palm or rubber affects the magnitude of household income after controling for other factors. As household employment decisions are endogenous, income differences cannot be interpreted as net effects of oil palm expansion. Nevertheless, insights into the relationships between land use, employment, and income of non-farm households can broaden the understanding of the socioeconomic trends associated with land-use change and possible sustainability trade-offs.

2. Background

2.1. Land-use change in Jambi

Jambi Province is located along the eastern coast of central Sumatra and was originally covered with tropical rainforest. Significant deforestation already started in Jambi more than 100 years ago to extract timber and grow rubber. For many decades, rubber was the most common cash crop in the region grown by companies and local smallholder farmers. While some oil palm was also grown in Jambi during the first half of the twentieth century, more formal development and growth of the palm oil sector only started during the 1970s (Gatto et al., 2017). Initially, oil palm was only cultivated on large plantations. Since the 1980s, smallholder farmers also started to get involved (Euler et al., 2016).

The area planted with oil palm continued to grow during the last few decades, largely due to the rapid increase in the global demand for vegetable oil. Between 1990 and 2014, the oil palm area in Jambi almost quadrupled (Fig. 1). Much of this increase happened on previously forested land. Remote sensing data suggest that – between 1990 and 2010 alone – the forest area in Jambi decreased by more than one million hectares (Margono et al. 2012; Clough et al., 2016). Many of the new oil palm plantations were established in degraded (heavily logged) forests and shrub lands (Obidzinski et al., 2012; Gatto et al., 2015). It was estimated that around 8% of the new oil palm plantations in Jambi were established through direct clearing of intact forests (Gibbs et al., 2010; Margono et al., 2014).

To some extent, new oil palm plantations were also established on land previously cultivated with rubber, especially extensive rubber plots that are sometimes also referred to as 'jungle rubber' (Gatto et al., 2015, Drescher et al., 2016). The conversion of intensively-managed rubber into oil palm plantations was rare, as long as jungle rubber, forest, or shrub lands were still available. Fig. 1 shows that the rubber area in Jambi also increased between 1990 and 2010. Only more recently, the rubber area started to decline. With increasing land scarcity, more-intensively cultivated rubber is now also sometimes converted to oil palm. Since 2012, oil palm has been the most widely grown crop in Jambi (Fig. 1). Further land-use change can be expected in the future. If recent trends persist, oil palm will continue to grow at the expense of rubber. Against this background, it is important to understand what role these two crops play for the employment and income of local non-farm households.

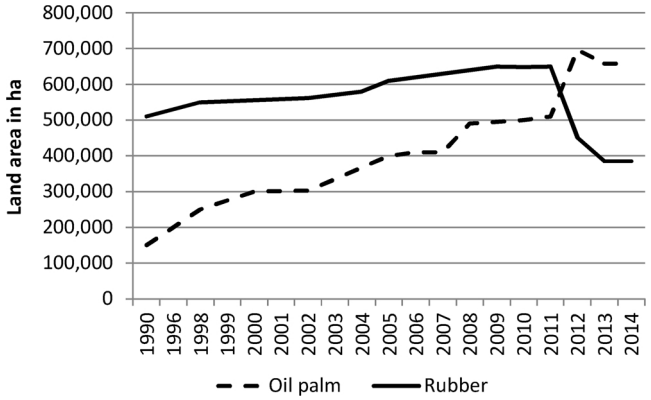

Fig. 1. Oil palm and rubber cultivation in Jambi Province between 1990 and 2014. *Source*: Own presentation based on official government statistics (BPS, 2017).

2.2. Institutional context

The autochthonous population in Jambi belongs to the Melayu ethnicity, but the proportion of people with other ethnicities has been growing due to significant in-migration. Since the early-1980s, the Government of Indonesia encouraged and supported such migration as part of its transmigration program (Fearnside, 1997). The transmigration program involved the voluntary relocation of families from densely populated Java to the so-called 'outer islands' Sumatra, Kalimantan, and Papua. Arriving families from Java were settled in newly established communities, the so-called transmigration villages. In these villages, transmigrant families were allocated a piece of land with full ownership rights and were supported in the cultivation of specific agricultural crops (Elmhirst, 1999; Murdiyarso et al., 2002; Gatto et al., 2017). In the early days of the program, transmigrant families were supported in the cultivation of rice, but soon the government's focus switched to rubber. From the late-1980s onward, new transmigrants were supported in the cultivation of oil palm, usually on land adjacent to large oil palm plantations. These large plantations were managed by public or private companies to which the transmigrant families delivered their harvest under contract (Gatto et al., 2015).

The government-sponsored contracts between palm oil companies and smallholder farmers in Indonesia are typically referred to as 'nucleus estate and smallholder' (NES) schemes (Larson, 1996; Feintrenie et al., 2010; McCarthy and Cramb, 2009; Cramb and McCarthy, 2016).[2] Under these contracts, farmers received subsidized loans and technical support. In addition, the government supported the construction of infrastructure (roads, schools etc.) in transmigrant villages. A recent study showed that communities with NES contracts experienced faster economic development than communities without such contracts (Gatto et al., 2017).

The NES schemes marked the beginning of smallholder farmers' involvement in the palm oil sector in Sumatra. Since the late-1990s, smallholders have also started to adopt oil palm independently without

[1] We define non-farm households as households that earn less than 50% of their income from own farming enterprises. Our survey includes 432 non-farm households. To estimate the proportion of non-farm households in rural Jambi, we also used data from 300 farm households living in the same 26 villages (Drescher et al., 2016; Euler et al., 2017).

[2] In later phases, government support for these NES schemes was phased out and the contracts between palm oil companies and smallholders became known as *Koperasi Kredit Primer untuk Anggota* (KKPA) schemes (McCarthy, 2010).

company contracts (Euler et al., 2016). Nowadays, not only transmigrants but also autochthonous Melayu farmers cultivate oil palm, but for many of the Melayu families rubber remains the major crop (Krishna et al., 2017b). As rubber trees can be productive for several decades, autochthonous Melayu families often have a cultural attachment to rubber, which is not the case for migrants from other parts of Indonesia.

In this study, we do not focus on farm households, but on non-farm households that generate most of their income from being employed or from own non-farm businesses. Non-farm households can be autochthonous people or migrants. In addition to the transmigrant families, there are many other households that migrated to Jambi from Java, from other parts of Sumatra, or also from other islands without government support. To differentiate from the transmigrants, these other migrants are sometimes referred to as 'spontaneous migrants' (Gatto et al., 2015). However, many of the spontaneous migrants settled in transmigrant villages, thus benefiting indirectly from the local economic development spurred by the NES contracts.

2.3. Types of agricultural labor contracts

Rubber and oil palm cultivation in Jambi is hardly mechanized, so a lot of manual labor is required for planting, fertilizing, weeding, spraying, harvesting, and other operations. Overall, rubber is more labor-intensive, while oil palm is more capital-intensive (Feintrenie et al., 2010; Lee et al., 2014). Hired labor is employed on large-scale plantations as well as on smallholder farms (Li, 2011; Obidzinski et al., 2012). Companies with rubber or oil palm plantations usually hire casual laborers without formal contracts for land clearing, but use permanent (or longer-term) contracts for most other operations (McCarthy and Cramb, 2009; McCarthy, 2010; Li, 2011; Sinaga, 2013; Li, 2015).

On smallholder farms, the employment arrangements differ more markedly between the two crops. For oil palm, farms typically hire casual laborers, especially for harvesting (Pye et al., 2012; Li, 2015). Casual laborers in oil palm are mostly male, due to the physical strength required. Many of the casual laborers work for the same oil palm farmer for longer periods of time, yet mostly without a formal contract (Li, 2011). Rubber farmers, on the other hand, primarily employ laborers through sharecropping arrangements, involving both male and female laborers (Li, 2015; Krishna et al., 2017b). Sharecropping in rubber means that the laborers do all the work on a rubber plot, but instead of a fixed wage they receive an agreed-upon share of the farmer's sales revenues. Sharecropping is typically a longer-term arrangement between the farmer and a labor household, but the contracts are informal and can be adjusted from time to time. According to our own survey data, depending on labor supply and demand in a particular location, the age of the rubber trees on a farm, and other factors, sharecropping laborers typically receive a share of 50–70% of the rubber sales revenues. In principle, sharecropping arrangements also exist in oil palm, but these are rarely observed in Jambi.

2.4. Role of agriculture in local labor markets

Employment in the agricultural sector is an important source of income for rural non-farm households in Jambi, as we will show below using our household survey data. However, also from a broader economic perspective, agriculture remains a very important source of employment. Much of the employment in the agricultural sector is casual, so that macro-level statistics may underestimate this sector's role in local labor markets. To get a realistic assessment, the Indonesian Statistical Office carries out National Labor Force Surveys (SAKERNAS) every year using representative household samples. Building on SAKERNAS data for Jambi Province, Fig. 2 (panel A) shows that agriculture is by far the most important sector for the employment of casual laborers. While the sectors' relative role declined somewhat in recent years, in 2015 agriculture still employed around 60% of the casual laborers in Jambi. However, mean wages in the agricultural sector are much lower than in other sectors (Fig. 2, panel B). The main reason is that the agricultural sector primarily employs unskilled laborers (Krishna et al., 2017b). This underlines that agriculture is a particularly important source of employment for low-income households with relatively low levels of formal education (von Braun and Gatzweiler, 2014).

3. Household survey

We carried out a survey of non-farm households in rural areas of Jambi Province in 2015. Non-farm households are defined as households for which own agricultural production accounts for less than 50% of total income. This does not necessarily mean that non-farm households are not involved in own agricultural production at all. Some of these households cultivate small fields of own land, but most of their income is derived from employed activities and/or self-employed non-farm businesses, such transport, trade, or handicrafts.

Non-farm households are not a homogenous group. Many of them are spontaneous migrants who moved to Jambi during the last 20–30 years in order to benefit from the booming rubber and palm oil sectors (Pye et al., 2012; Gatto et al., 2015). There are also a few transmigrants that obtained land as part of the transmigration program but sold some or all of their land later on due to various reasons, or descendants of transmigrants moving out of their parents' house and starting their own household with little or no land (Li, 2011). Finally, there is also a significant share of autochthonous households with little or no own land, often because they sold their land or lost it due to insecure property rights (McCarthy, 2010; Li, 2015; Krishna et al., 2017a). Further details about the socioeconomic characteristics of non-farm households are provided below. According to our survey data, non-farm households account for around 60% of all households in rural Jambi. Better understanding the livelihoods of non-farm households is important, because they often belong to the poorest population segments in local village settings (von Braun and Gatzweiler, 2014; Gatto et al., 2017).

We used a multi-stage sampling procedure to select households for inclusion in the survey. First, we purposively selected four regencies in Jambi, namely Muaro Jambi, Batanghari, Sarolangun, and Tebo, representing the province's lowland areas where much of Jambi's oil palm land is located and where significant land-use change occurred in recent decades (Fig. 3). Second, we used lists of rural villages in these four regencies from the Village Potential Survey (PODES) to randomly select 26 villages. Third, in each village we randomly selected four sub-villages (so-called 'Rukun Tetangga' or RTs), because at the sub-village level it was much easier to obtain complete household lists and differentiate between farm and non-farm households with the help of the sub-village head. Fourth, in each sub-village, depending on the village size between 3 and 6 non-farm households were randomly selected, leading to 12–24 household observations per village. The total sample includes 432 households.

The survey was implemented between August and November 2015. Data were collected through face-to-face interviews using a structured questionnaire.[3] The interviews were conducted with the household head in Bahasa Indonesia by a team of six enumerators from Jambi University, who were intensively trained and supervised by the researchers. The questionnaire captured details of the different income sources and economic activities of all household members for a period of 12 months. For employment in rubber and oil palm we also asked for details of the labor arrangements, such as type of employer (company or individual farm), type of contract (casual, permanent, sharecropping), wage rates, and possible seasonality. Other demographic,

[3] A copy of the questionnaire is provided in the Online Appendix. Participation in the survey was voluntary, informed consent was obtained from all respondents. International ethical guidelines were followed. Institutional review board approval was not required, as the study was not associated with any health or financial risks for study participants.

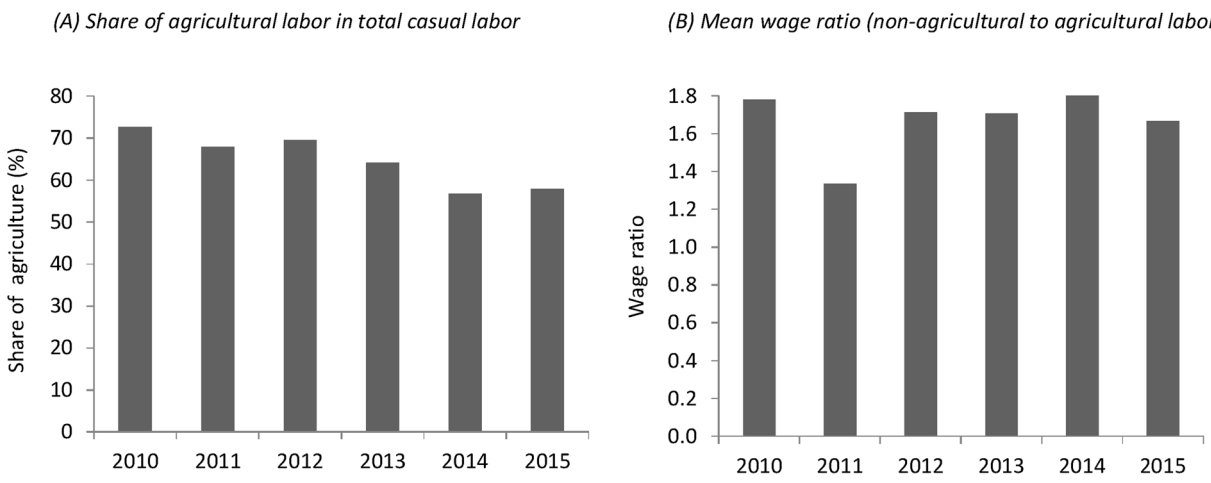

Fig. 2. Role of the agricultural sector in labor markets in Jambi Province (2010–2015). *Source:* Own presentation based on data from SAKERNAS (2010–2015).

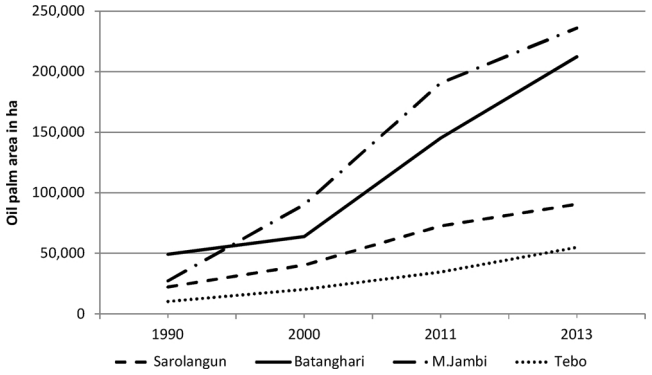

Fig. 3. Development of oil palm area in four regencies of Jambi Province (1990–2013). *Source*: Own presentation based on official government statistics (BPS, 2017).

social, and institutional details – such as household migration history, ethnicity, educational background, and market access – were also captured in the survey. Selected variables related to land use at the village level and village history (e.g., whether the village was established as part of the transmigration program) were collected through additionally consulting village and sub-village heads. Sample descriptive statistics are provided in the next section.

4. Descriptive statistics

4.1. Socioeconomic characteristics of non-farm households

Table 1 shows descriptive statistics for the non-farm households surveyed in rural Jambi. The average sample household has close to four members. Almost all households are headed by men. About two-thirds have a migration background, and 80% of those with migration background came as spontaneous migrants outside of the government-sponsored transmigration program. Close to 60% of all households in the sample belong to the Javanese ethnicity, the rest belongs to the Melayu (26%), Sundanese, Batak, and other ethnicities. In terms of economic indicators, the average annual household income in the sample is 28.3 million Indonesian Rupiah (IDR) (about 2100 US dollars), including all income sources. This is only about half of the average income of farm households in rural Jambi (Krishna et al., 2017b). In other words, non-farm households are significantly poorer than farm households on average.

Table 1 shows that 38% of the non-farm households in our sample work in oil palm, meaning that one or more of the household members worked in somebody else's oil palm farm or company plantations during the last 12 months. Most of this work in oil palm is through casual labor arrangements. Sixty-eight percent of the households work in rubber, mostly as sharecroppers. Agricultural employment in other crops is relatively rare in the study region (only 5% of the sample households). Thirteen percent of the households have one or more members with employment in non-agricultural sectors, and 17% pursue self-employed non-farm activities. Non-agricultural employment includes jobs in construction, manufacturing, education, and other services, while self-employed activities include trading of agricultural commodities, shop-keeping, handicrafts etc.[4] As can also be seen from Table 1, the average household in the sample has 0.6 ha of own land. Around 21% are involved in small-scale oil palm cultivation themselves.

Fig. 4 shows the average wage rates received by households employed in oil palm and rubber (panel A). Wage rates are higher in oil palm employment, although some differences are observed according to major village land-use types.[5] Households employed in oil palm also work more hours per month than households employed in rubber (Fig. 4, panel B).[6] Higher wage rates per hour and longer hours worked, lead to higher average incomes for households employed in oil palm, as compared to households employed in rubber.

4.2. Structure of income of non-farm households

Fig. 5 shows how different income sources contribute to total household income. Employment in rubber and oil palm together accounts for 70% of total income, underlining the importance of these two crops for non-farm households' livelihoods. On average, rubber has a higher income share (44%) than oil palm (26%).[7] However, this pattern changes across income terciles, as Fig. 5 also shows. With rising overall

[4] The numbers of who works in what type of employment in Table 1 do not add up to 100%, because most households have more than one source of income.

[5] While sharecroppers do not work on a fixed-wage basis, we calculated the shadow wage rate for each sharecropping household based on the number of hours worked and the share of the revenues received.

[6] Rubber is more labor-intensive than oil palm when considering the number of hours required for the cultivation of one ha (Euler et al., 2017). The numbers in Fig. 4 do not reflect the labor requirements per ha, but count the number of hours that members of non-farm households worked as employed laborers in a particular crop.

[7] Note that these are average income shares calculated over all households in the sample (N = 432). When only considering households that are employed in rubber and not in oil palm (N = 232), the rubber income share is 74%. When only considering households that are employed in oil palm and not in rubber (N = 120), the oil palm income share is 82%. The remaining households (N = 80) work in both crops or in none of these crops. Households only employed in rubber are significantly poorer (annual mean income of 21.5 million IDR) than households only employed in oil palm (annual mean income of 31.1 million IDR).

Table 1
Sample descriptive statistics.

Variable name	Variable description	Mean	Std Dev
Socioeconomic characteristics			
Household size	Number of household members	3.896	1.269
Age	Age of household head (years)	41.81	10.62
Male	=1 if household head is male, 0 otherwise	0.984	0.126
Education	Years of education of household head	6.421	3.480
Migrant	=1 if household has migration background, 0 otherwise	0.674	0.469
Land owned	Total land owned in ha	0.64	1.068
Oil palm cultivation	=1 if household cultivates oil palm on own farm, 0 otherwise	0.206	0.405
Credit	=1 if household has access to credit, 0 otherwise	0.461	0.499
Melayu	=1 if household belongs to Melayu ethnicity	0.259	0.439
Javanese	=1 if household belongs to Javanese ethnicity	0.592	0.491
Other ethnicity	=1 if household belongs to Sundanese, Batak, or other ethnicity	0.171	0.377
Assets ownership	Asset index (based on principal components analysis)[a]	2.38	1.032
Total income	Total annual household income ('000 Indonesian Rupiah)	28,250	50,243
Employment			
Oil palm employment	=1 if household works in oil palm, 0 otherwise	0.377	0.485
Rubber employment	=1 if household works in rubber, 0 otherwise	0.682	0.465
Other agric. employment	=1 if household works in other crops., 0 otherwise	0.051	0.220
Non-farm employment	=1 if household works in non-farm sectors, 0 otherwise	0.129	0.336
Self-employment	=1 if household is self-employed, 0 otherwise	0.167	0.373
Employment arrangements			
Company	=1 if household works in palm oil or rubber company, 0 otherwise	0.268	0.443
Oil palm casual	=1 if household is casual laborer in oil palm, 0 otherwise	0.363	0.481
Oil palm permanent	=1 if household is permanent laborer in oil palm, 0 otherwise	0.007	0.083
Oil palm sharecropping	=1 if household is sharecropper in oil palm, 0 otherwise	0.005	0.068
Rubber casual	=1 if household is casual laborer in rubber, 0 otherwise	0.074	0.262
Rubber sharecropping	=1 if household is sharecropper in rubber, 0 otherwise	0.643	0.479
Oil palm history	=1 if previous generation was working in oil palm, 0 otherwise	0.065	0.246
Rubber history	=1 if previous generation was working in rubber, 0 otherwise	0.049	0.215
Village characteristics			
Autochthonous	=1 if autochthonous village, 0 otherwise	0.527	0.499
Transmigrant oil palm village	=1 if transmigrant oil palm village, 0 otherwise	0.25	0.433
Transmigrant rubber village	=1 if transmigrant rubber village, 0 otherwise	0.222	0.416
Share of oil palm in village	Share of oil palm land area in total village land	0.235	0.267
Share of rubber in village	Share of rubber land area in total village land	0.468	0.335

Notes: The number of observations for all variables is N = 432.
[a] The asset index was calculated following Viyas and Kumaranayake (2006), using data on household ownership of the following assets: tractors, trucks, cars, motorbikes, fridges, air conditioners, television, satellite dishes, and washing machines. Larger index values indicate relatively more assets owned.

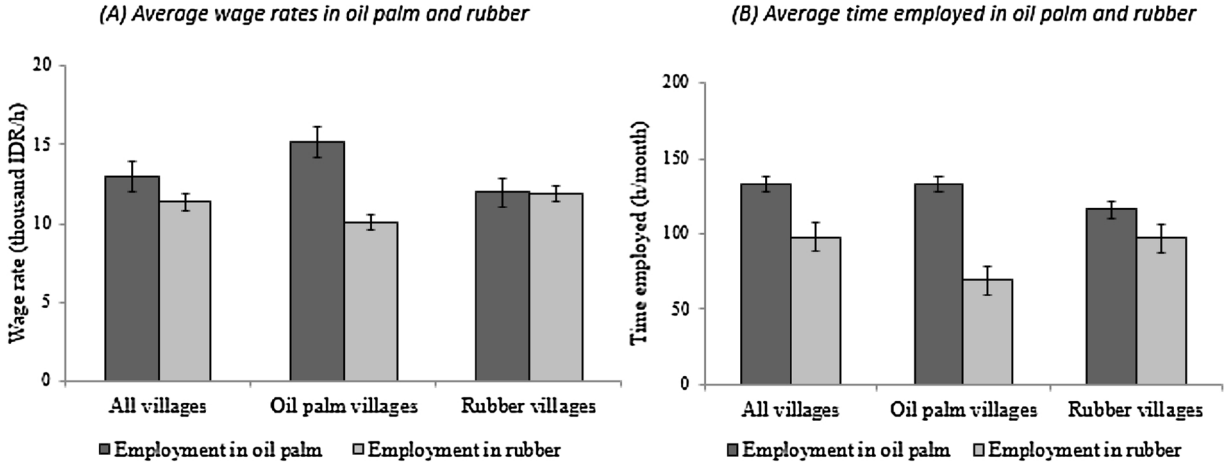

Fig. 4. Average wage rates and hours employed in oil palm and rubber.
Notes: Calculations based on own survey data. Mean values are shown with error bars. For each column in the graphs, only households that were actually employed in oil palm/rubber were considered. The total number of villages included is 26, of which 11 were classified as oil palm villages (oil palm area in the village > 50%), and 15 as rubber villages (rubber area in the village > 50%).

income, the share of income from employment in rubber decreases. For the poorest households (first tercile), employment in rubber accounts for over 60% of total income, for the richest households (third tercile) it only accounts for 24%. On the other hand, the importance of oil palm increases with overall income. The contribution of self-employment and other income sources to total income is also higher in relatively richer households.

These simple comparisons do not allow causal inferences.

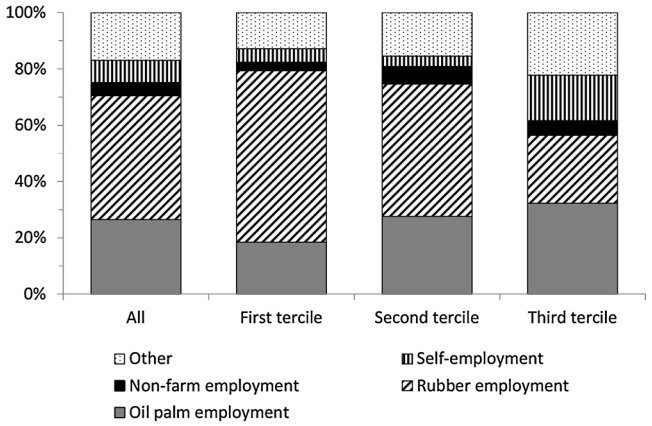

Fig. 5. Structure of total household income by income tercile.

Nevertheless, the results in Fig. 5 underline that the share of income from rubber employment is negatively associated with total household income, whereas the association between the share of income from oil palm and total household income is positive. This is consistent with field observations during the survey: households with employment in oil palm tend to live in better houses and are more likely to have access to electricity and tapped water than households with employment in rubber.

5. Determinants of participation in different types of employment

5.1. Modeling approach

The previous section has shown that households with employment in rubber tend to be poorer than households with employment in oil palm. Against this background it is interesting and important to understand what factors influence household employment decisions. Households can be involved in more than one type of employment. This can be accounted for in a multivariate probit (MVP) model with dummies for participation in different types of activities as dependent variables. In an MVP model, the different equations are estimated simultaneously, thus allowing for non-zero correlation between the various employment activities (Greene, 2014).

We consider five different types of employment, namely oil palm employment, rubber employment, other agricultural employment, non-farm employment, and self-employment. Accordingly, the MVP model is specified as follows:

$$Y_{Mij} = \beta'_M X_{Mij} + \varepsilon_{Mij} \quad \text{M=1,...5}$$

where Y_{Mij} is a dummy variable indicating whether or not household i in village j participates in activity M, X_{Mij} is a vector of household- and village-level explanatory variables, β_M is a vector of parameters to be estimated, and ε_{Mij} is a normally distributed random error term. We expect that household characteristics – such as age, education levels, asset ownership, and ethnicity – will play a role for employment decisions. In addition, village characteristics – such as the share of rubber and oil palm land in the village and whether or not the village was established as part of the transmigration program – may have an effect on local employment opportunities.

5.2. Estimation results

Estimation results from the MVP model are shown in Table 2(the correlation matrix for the residuals from the different equations is shown in Table A1 in the Appendix). For interpretation, we primarily focus on the determinants of employment in oil palm (column 1) and rubber (column 2). Javanese households with a migration background are significantly more likely to be employed in oil palm than local households from the Melayu ethnicity.[8] Melayu households are more likely to be employed in rubber. These patterns are related to the history of land use in Jambi Province. As explained, rubber was the dominant cash crop in Jambi during the twentieth century. This means that autochthonous rural families have a long tradition of working in rubber. And this tradition seems to be perpetuated, not least through the observed sharecropping arrangements. As mentioned, sharecropping arrangements tend to be longer-term relationships between rubber farmers and labor households. Sometimes, these arrangements are even transferred from parents to children. Indeed, having previous-generation family members who worked in rubber significantly increases the probability of own employment in rubber, while decreasing the probability of being employed in oil palm (Table 2).

Most migrants who came from outside of Jambi do not have such a family tradition of working in rubber. A few of the early migrants, who arrived in Jambi before the oil palm boom started, found employment in rubber. But most of the migrants who came to Jambi since the early-1990s started working in oil palm. In fact, the growing palm oil sector and its demand for labor was an important reason for many households from outside the region to migrate to Jambi.

The size of the land owned by households reduces the probability of being employed in oil palm on other farms or plantations. This is plausible, because households with a larger land size typically spend more time working on their own farm. However, after controlling for land size, own cultivation of oil palm tends to increase the probability of oil palm employment, which may be explained by the experience gained with this crop.

Looking at the village-level variables in the lower part of Table 2 shows that living in a transmigrant oil palm village (i.e., where transmigrant families were supported in oil palm cultivation) increases the probability of being employed in oil palm, while decreasing the probability of being employed in rubber. Similarly, the share of oil palm in total village land increases the probability of employment in oil palm, while decreasing the probability of employment in rubber. These results are unsurprising, as they reflect local patterns of labor demand and employment opportunities.

Interestingly, the share of oil palm in total village land also increases the probability of being involved in self-employed activities (column 5 of Table 2). Previous research in Jambi showed that oil palm cultivation leads to significant income gains in farming households (Euler et al., 2017; Krishna et al., 2017b). Such income gains can boost local demand for goods and services offered by small non-farm businesses, thus improving opportunities for self-employed activities. Other factors that are positively associated with self-employment include ownership of land and other assets, as well as own oil palm cultivation. Finally, households of Javanese ethnicity are more likely to be involved in self-employed activities than Melayu households.

6. Correlates of household income

6.1. Factors influencing total household income

The descriptive analysis above suggested that employment in oil palm is positively associated with total household income. We now examine this relationship further with regression models, controlling for possible confounding factors. In particular, we regress total household income on oil palm employment and other covariates that may also influence income. One way to measure oil palm employment could be to simply take the employment dummy variable that was also used in

[8] The variables migrant and Javanese are positively correlated, but not all migrants are of Javanese ethnicity. Some of the migrants also came to Jambi from other parts of Sumatra, or from different islands.

Table 2
Determinants of participation in different employment activities.

	(1) Oil palm employment	(2) Rubber employment	(3) Other agric. employment	(4) Non-farm employment	(5) Self-employment
Household level					
Household size	0.038	0.028	0.193[d]	0.036	−0.032
	(0.063)	(0.069)	(0.082)	(0.064)	(0.063)
Age	−0.041[e]	0.026[d]	0.019	0.014[c]	0.0122
	(0.009)	(0.010)	(0.012)	(0.008)	(0.008)
Education	0.017	−0.051[c]	0.019	0.034	0.034
	(0.024)	(0.026)	(0.036)	(0.027)	(0.025)
Migrant	0.405[d]	−0.435[d]	0.037	0.011	0.113
	(0.191)	(0.222)	(0.284)	(0.199)	(0.187)
Asset ownership	0.032	−0.126	−0.071	0.0288	0.301[e]
	(0.083)	(0.097)	(0.125)	(0.085)	(0.202)
Land owned	−0.142[c]	−0.072	0.013	−0.177[c]	0.348[e]
	(0.079)	(0.075)	(0.127)	(0.101)	(0.085)
Oil palm cultivation	0.769[e]	−0.042	−0.393	−0.321	0.204[e]
	(0.205)	(0.212)	(0.382)	(0.244)	(0.074)
Credit access	−0.188	−0.010	0.213	−0.0172	0.212
	(0.161)	(0.188)	(0.250)	(0.165)	(0.161)
Javanese[a]	0.809[e]	−0.867[e]	0.616[c]	−0.134	0.457[c]
	(0.231)	(0.253)	(0.322)	(0.240)	(0.241)
Other ethnicity[a]	−0.016	−0.507[d]	−0.320	0.123	0.017
	(0.219)	(0.241)	(0.426)	(0.211)	(0.209)
Oil palm history	6.136	−1.478[e]	−4.255	−0.125	−0.389
	(215.8)	(0.412)	(538.6)	(0.337)	(0.315)
Rubber history	−0.748[e]	2.238[e]	0.058	0.429[d]	−0.224
	(0.220)	(0.431)	(0.293)	(0.202)	(0.216)
Village level					
Transmigrant oil palm village[b]	0.849[e]	−0.771[e]	0.930	0.615	−0.144
	(0.206)	(0.216)	(0.620)	(0.393)	(0.379)
Transmigrant rubber village[b]	−0.153	4.797	−0.122	−0.058	0.418[c]
	(0.223)	(99.11)	(0.359)	(0.232)	(0.222)
Share of oil palm in village	1.903[e]	−3.639[e]	−2.352[d]	−0.197	0.964[c]
	(0.489)	(0.581)	(1.025)	(0.565)	(0.503)
Share of rubber in village	−0.367	1.021[e]	0.326	0.451	−0.0007
	(0.287)	(0.304)	(0.408)	(0.338)	(0.308)
Constant	0.002	0.092	−2.645[d]	−2.475[e]	−3.123[e]
	(0.884)	(0.884)	(1.047)	(0.910)	(0.862)

Notes: Coefficient estimates from a multivariate probit model are shown with robust standard errors in parentheses; N = 432; log likelihood = −484.35; Chi-squared = 70.35.
[a] Reference group is Melayu.
[b] Reference group is autochthonous village.
[c] Significant at 10% level.
[d] Significant at 5% level.
[e] Significant at 1% level.

the previous section. However, while many households work either in oil palm or in rubber, a few households also derive income from employment in both crops. Typically, households with employment income from both oil palm and rubber primarily concentrate on one of these crops and only receive a small share from the other. To avoid ambiguity, we therefore use two dummy variables, one for households that work only in oil palm and the second for households that work in both oil palm and rubber. The reference group comprises households that only work in rubber.[9] To allow for non-linear effects and facilitate interpretation in percentage terms, the dependent variable – total household income – is expressed in logarithmic form (Table 3).

Three versions of this income model are shown in Table 3 with different covariates included. Column (1) only includes the two oil palm employment dummy variables without any other covariates. The coefficient for 'employment in oil palm only' is positive and highly significant. On average, households that are employed only in oil palm have 32% higher total incomes than households that are only employed in rubber. The dummy variable for employment in both crops has a coefficient that is positive but not statistically significant.

Since employment in oil palm is influenced by a number of socio-economic factors, it is important to control for these factors, which is done in columns (2) and (3) of Table 3. In column (2), we only include household-level variables. Unsurprisingly, larger households and those with more own land and better educated household heads have higher total incomes. However, even after controlling for these factors, the effect of oil palm employment remains significant and in the same magnitude as in column (1).

In column (3) of Table 3, we additionally include village-level variables. A higher share of oil palm and also a higher share of rubber in total village land both have positive and significant effects on total household income. This is plausible, because these two cash crops provide more employment for non-farm households than local food crops such as rice or cassava. However, the effect of oil palm is larger than that of rubber: in a hypothetical village where all the land was cultivated with oil palm (share of oil palm in village land equal to 1), non-farm households would have 47% higher incomes than in a village without any oil palm cultivation. For rubber, the corresponding effect would be 28%.[10] To some extent, these differences can be explained

[9] These dummy variables only refer to oil palm and rubber employment. Employed only in oil palm or only in rubber simply means that these households are not employed in the other crop; it does not mean that these households could not also be employed or self-employed in other sectors.

[10] The negative and significant income effect in transmigrant rubber villages is probably related to the relatively old age of the rubber trees and thus lower crop productivity in these villages. The rubber plantations in these villages were mostly planted in the early-1980s.

Table 3
Factors influencing total household income.

	(1) Total income (log)	(2) Total income (log)	(3) Total income (log)
Household level			
Employment in oil palm only[a]	0.318[f]	0.331[f]	0.231[e]
	(0.075)	(0.085)	(0.095)
Employment in oil palm and rubber[a]	0.0132	0.072	0.045
	(0.118)	(0.120)	(0.119)
Household size		0.063[d]	0.064[d]
		(0.029)	(0.028)
Age		0.006[d]	0.006
		(0.004)	(0.004)
Education		0.029[e]	0.032[e]
		(0.011)	(0.011)
Land owned		0.261[f]	0.243[f]
		(0.033)	(0.033)
Javanese[b]		0.067	0.026
		(0.089)	(0.099)
Other ethnicity[b]		0.142	0.131
		(0.111)	(0.094)
Village level			
Transmigrant oil palm village[c]			0.059
			(0.159)
Transmigrant rubber village[c]			−0.189[d]
			(0.101)
Share of oil palm in village			0.471[e]
			(0.229)
Share of rubber in village			0.278[f]
			(0.134)
Constant	9.707[f]	8.865[f]	8.639[f]
	(0.046)	(0.230)	(0.243)
R-squared	0.037	0.195	0.237

Notes: Coefficient estimates from ordinary least squares regressions are shown with robust standard errors in parentheses; N = 432. The three models in columns (1), (2), and (3) differ only in terms of the covariates included, as shown in each column.
[a] Reference group is households only employed in rubber.
[b] Reference group is Melayu.
[c] Reference group is autochthonous village.
[d] Significant at 10% level.
[e] Significant at 5% level.
[f] Significant at 1% level.

through the wages that are higher in oil palm than in rubber (see above). However, as mentioned, the expansion of oil palm is also associated with infrastructure improvements and overall economic growth at the village level, which can contribute to income gains for non-farm households also through various other channels.

In the model in column (3) of Table 3, the coefficient of employment in oil palm remains positive and significant, but it is somewhat smaller than the coefficients in columns (1) and (2). This comparison further supports the finding that oil palm contributes to income gains among non-farm households through various channels.

6.2. Factors influencing income from oil palm and rubber employment

In addition to understanding the effects of oil palm and rubber employment on total household income, it is also interesting to identify and compare factors that influence the level of employment income from these two crops. Such analysis is undertaken in this subsection. In particular, in separate models we regress income from oil palm employment and income from rubber employment on a set of explanatory variables. Households not employed in one of these crops have zero income for the respective model. We use a Tobit estimator to account for this left-censoring of the dependent variables. Estimation results are shown in Table 4.

Columns (1) and (3) of Table 4 show the models for income from oil palm and rubber employment with household-level and village-level explanatory variables included. The estimates in column (1) suggest that education has a significantly positive effect on income from oil palm employment. Every additional year of schooling increases income from oil palm employment by 443 thousand IDR. Interesting to see is that the same effect is not observed in rubber. In other words, for employment in rubber better education does not necessarily seem to pay off.[11] We also see differences in the effects of age. While for rubber employment age does not seem to play a significant role, the income from oil palm decreases with rising age. This is probably related to the physical strength required for the manual operations in the oil palm crop, especially harvesting.

In terms of the village-level variables, the share of oil palm in the village significantly increases the income from oil palm employment while decreasing the income from rubber employment (Table 4). For the share of rubber in the village, the signs of the coefficients are reversed. This as such is unsurprising. Noteworthy, however, is that the positive effect of the share of oil palm in column (1) is much larger than

Table 4
Factors influencing income from oil palm and rubber employment.

	(1) Income from oil palm employm.	(2) Income from oil palm employm.	(3) Income from rubber employm.	(4) Income from rubber employm.
Household level				
Household size	−355.76	−244.35	601	421.4
	(1058)	(391.62)	(461.59)	(428.9)
Age	−98.41[e]	−98.54[d]	126	87.1
	(56.42)	(52.87)	(71.97)	(69.78)
Education	443.49[e]	194.3	−5.05	79.17
	(168.8)	(155.5)	(145.1)	(202.6)
Migrant	3,481[e]	2,485[e]	−901	484.2
	(1138)	(1047)	(1115)	(1096)
Land owned	−164.44	−302.2	−306.4	−92.87
	(829.6)	(741.6)	(472.4)	(380)
Javanese[a]	3,809[e]	2,445[e]	−4,825[f]	−3,635[f]
	(1798)	(1652)	(1238)	(1196)
Other ethnicity[a]	1,754.6	2,128	−587.8	−267.3
	(1591)	(1529)	(1674)	(1541)
Village level				
Transmigrant oil palm village[b]	5,381[e]	6,647[f]	−2,359	−6,131[f]
	(5464)	(1698)	(1971)	(1077)
Transmigrant rubber village[b]	−5,858[f]	−3,142[f]	−1,619	−4,371[e]
	(1115)	(929.7)	(1473)	(1497)
Share of oil palm in village	22,916[f]		−8,977[f]	
	(4098)		(2522)	
Share of rubber in village	−3,549[d]		3,463[d]	
	(2114)		(2152)	
Employment contract				
Company employment		10,941[f]		1,338
		(1629)		(1033)
Permanent contract[c]		7,430[d]		
		(4748)		
Sharecropping contract[c]		26,629		10,117[f]
		(19,476)		(1015)
Constant	4,520	2,892	4,446	−999.3[f]
	(3496)	(3260)	(4823)	(3868)
Pseudo R-squared	0.289	0.338	0.168	0.271

Notes: Coefficient estimates from Tobit regressions are shown with robust standard errors in parentheses; N = 432. In all models, income is measured in thousand Indonesian Rupiah. The two models in columns (1) and (2) have income from oil palm employment as dependent variable, whereas the two models in columns (3) and (4) have income from rubber employment as dependent variable. Otherwise, the four models differ only in terms of the covariates included, as shown in each column.
[a] Reference group is Melayu.
[b] Reference group is autochthonous village.
[c] Reference group is casual labor arrangement.
[d] Significant at 10% level.
[e] Significant at 5% level.
[f] Significant at 1% level.

[11] We saw in Table 2 that households with better education are less likely to be employed in rubber.

the negative effect in column (3). In other words, the expansion of oil palm at the village level leads to gains in employment income from that crop that are larger than the losses in employment income from rubber.[12]

In the models in columns (2) and (4) of Table 4 we additionally include variables characterizing the types of employment contracts that households have in oil palm and rubber. As these contract-related variables are closely correlated with village-level factors, we had to exclude some of the village variables to avoid problems of multicollinearity. The results in column (2) suggest for oil palm that being employed on a company plantation leads to higher income than being employed on an individual farm. Wage rates paid by companies are not necessarily higher than those paid by individual farmers, but company contracts are usually associated with lower fluctuations in terms of working hours. A significant company effect is not observed for rubber in column (4), even though it should be stressed that employment on rubber company plantations is relatively rare in our sample.

Having a permanent employment contract in oil palm is associated with higher income than working under casual labor arrangements (column 2 of Table 4). To some extent, this is also related to differences in terms of working hours. However, people with a permanent contract are often also employed for tasks where more skills are required, so that average wage rates are also higher than for casual laborers. Permanent employment contracts hardly exist in rubber, which is why this variable was not included in column (4). But for rubber we see that sharecropping contracts lead to much higher employment incomes than casual labor arrangements. This is also why sharecropping arrangements are popular among non-farm households in Jambi, especially for Melayu households in autochthonous villages where employment opportunities outside of the rubber sector were relatively rare in the past.

7. Discussion

The data from rural Jambi have shown that employment in rubber and oil palm is an important livelihood component for non-farm households, accounting for 70% of total household income on average. Poorer households depend much more on employment in rubber, whereas for richer households employment in oil palm is of larger importance. The role of self-employed non-farm businesses – such as transport, trade, or handicrafts – also increases with total household income.

Regression models were used to analyze the determinants of household participation in different types of employment. Major factors explaining whether non-farm households work in oil palm or rubber are related to migration background and ethnicity. Migrant households from Java and other islands were found to be much more likely to work in oil palm than autochthonous Melayu households who have a stronger tradition of working in rubber. At the same time, employment in oil palm was found to be associated with significantly higher household incomes, also after controlling for other factors. This means that migrant non-farm households are significantly richer than autochthonous non-farm households on average.

The results also showed that opportunities to work in oil palm increase significantly with the share of total village land cultivated with oil palm. While this result is not surprising, it suggests that further expansion of the oil palm area will likely benefit non-farm households through higher employment incomes. Non-farm households that heavily depend on working in rubber may suffer from such land-use change through lower incomes from rubber employment. But our regression results suggest that such income losses will likely be overcompensated by the gains that arise through newly emerging employment opportunities. Apart from working in oil palm, the expansion of the oil palm area at the village level also contributes to significant increases in income from self-employed activities. This can be explained by oil palm developments being associated with general infrastructure improvements and growth in the local village economy, leading to a boost in demand for locally produced goods and services.

To be sure, we did not explicitly analyze the impacts of land-use change, as this would require panel data with several rounds of observations over time. Our analysis only used cross-section data. We also acknowledge that household employment decisions are endogenous and may be influenced by unobserved factors that we could not properly control for in the analysis. Similarly, the share of the oil palm and rubber area in a village is not a random variable and may also be influenced by unobserved factors. Against this background, the estimated coefficients should not be over-interpreted in terms of causal effects. Nevertheless, even when only interpreting in terms of associations, the results clearly show that oil palm cultivation is positively associated with the income of non-farm households in rural Jambi. This allows the cautious conclusion that further land-use change towards oil palm will likely benefit rural non-farm households economically. Given that non-farm households typically belong to the poorest population segments in rural Indonesia, the economic gains from employment in oil palm can contribute to poverty reduction.

However, our finding of economic gains for non-farm households does not imply that all households in rural Jambi would benefit from oil palm expansion to the same extent. Previous research suggested that the oil palm expansion has contributed to rising inequality among farming households due to various reasons (Cramb and McCarthy, 2016; Gatto et al., 2017). Euler et al. (2017) showed that the absolute income gains from oil palm adoption are positively correlated with initial income levels. Similarly, Krishna et al. (2017b) showed that farmers with access to capital and additional land benefit more from oil palm adoption than capital- and land-constrained farmers. Some farmers without sufficient access to capital sold their land, thus losing the basis for own agricultural production (McCarthy, 2010).

Our results suggest that oil palm expansion may exacerbate inequality also among non-farm households, possibly further intensifying ethnic and geographical divides. Due to different cultural traditions, Melayu households are much less involved in oil palm employment than Javanese or other migrant households. Similarly, non-farm households in autochthonous villages with a smaller share of oil palm land have fewer opportunities to benefit from the economic boom in the palm oil sector. Even though not explicitly analyzed here, rising intra-village inequality is in line with other recent empirical studies (McCarthy, 2010; Euler et al., 2016; Gatto et al., 2017).

Beyond rising inequality, the oil palm boom in Indonesia is associated with other social and environmental externalities. The biodiversity loss and climate change effects induced by tropical deforestation are well documented (Fitzherbert et al., 2008; Clough et al., 2016; Drescher et al., 2016). These are global problems that need to be managed. However, deforestation and oil palm expansion cause local environmental problems too, thus directly reducing the quality of life of households living in affected areas. Forest fires, which are often used deliberately to clear forestland for agricultural production, contribute to serious air pollution and haze (Obidzinski et al., 2012). In sloped terrain, deforestation can lead to soil erosion and landslides. Also when no deforestation is involved, switching from rubber to oil palm can reduce environmental quality, as oil palm is typically cultivated with higher input intensities (Kubitza et al., 2018). Higher quantities of chemical fertilizers and pesticides can negatively affect wildlife and fresh water resources (Dudgeon et al., 2006; Obidzinski et al., 2012). Such negative externalities need to be considered in a broader analysis of the effects of oil palm expansion.

[12] Note that this comparison of income gains and losses holds true on average. Individual households may suffer from income losses if they lose employment in rubber without finding new employment in oil palm. This may potentially happen because the worker requirements in both crops are not identical.

8. Conclusion

Indonesia and other regions in the tropics are experiencing massive land-use change that is often characterized by an expansion of the area cultivated with oil palm at the expense of forests and more traditional forms of agricultural land use (Wicke et al., 2011; Margono et al., 2012; Obidzinski et al., 2013). The implications of such land-use change for the environment and for local farm households have been examined in previous research (Fargione et al., 2008; Fitzherbert et al., 2008; McCarthy and Cramb, 2009; Wicke et al., 2011; Margono et al., 2014; Euler et al., 2017; Krishna et al., 2017b; McCarthy and Obidzinski, 2017). However, land-use change may also affect non-farm households through labor markets and other possible spillovers. Economic effects of land-use change on non-farm households were hardly analyzed in previous research. In this study, we have contributed to the literature by analyzing the role of different types of agricultural and non-agricultural employment income for non-farm households in rural Jambi, one of the hotspot regions of Indonesia's recent oil palm boom (Clough et al., 2016). Non-farm households often belong to the poorest population segments in rural areas, so that better understanding the possible ramifications of land-use change for these households is of particular relevance for development policy.

Oil palm and rubber are the most important agricultural crops in Jambi, cultivated by large companies as well as smallholder farmers. Our data revealed that employment in both crops is an important livelihood component for non-farm households, accounting for 70% of total household incomes. Employment in oil palm is more lucrative than employment in rubber, so involvement in the oil palm sector as a laborer is positively associated with total household income. Regression models showed that whether or not a household works in oil palm is largely determined by factors related to migration background, ethnicity, and the size of the village area grown with this crop. These results suggest that further expansion of the oil palm area will likely benefit non-farm households through gains in employment income. These economic gains could contribute to poverty reduction. At the same time, further oil palm expansion may contribute to rising inequality and also causes environmental problems at global and local scales. Policies towards more sustainable land use require the consideration of economic, social, and environmental dimensions.

Author declaration

The authors declare that they have no known conflicts of interest associated with this publication. All authors have read and approved the final version of the manuscript.

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Appendix A

Table A1
Correlation matrix from the multivariate probit model.

	Oil palm employment	Rubber employment	Other agricultural employment	Non-farm employment
Rubber employment	−0.152[c] (0.195)			
Other agricultural employment	−0.308[a] (0.172)	0.241 (0.164)		
Non-farm employment	0.0287 (0.119)	0.110 (0.127)	−0.288 (0.129)	1
Self-employment	−0.129 (0.112)	−0.241[a] (0.144)	−0.312[b] (0.149)	−0.331[c] (0.126)

Notes: Correlation coefficients of the residuals in the different equations are shown with standard errors in parentheses; N = 432. The likelihood ratio test of equal correlation coefficients is rejected ($p < 0.01$).

[a] Significant at 10% level.

[b] Significant at 5% level.

[c] Significant at 1% level.

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2018.03.020.

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