Oil palm cultivation improves the long-term wellbeing of smallholder farm households

by Daniel Chrisendo, Hermanto Siregar, and Matin Qaim

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Abstract

Oil palm cultivation is a controversial topic because of its manifold sustainability implications. Recent research in Southeast Asia suggests that oil palm cultivation is associated with income gains for many smallholder farmers, but whether these income gains also translate into longer-term improvements in wellbeing remains unclear. Here, we use three rounds of panel data from smallholder farmers in Sumatra, Indonesia, and regression models to analyze effects of oil palm cultivation on various indicators of human capital formation and living standards. Results suggest that oil palm cultivation improves nutrition and increases expenditures on education, two important indicators of human capital formation with expected positive long-term implications. Effects on health expenditures are mostly not statistically significant. Further, we find positive associations between oil palm cultivation and several other wellbeing indicators, including electricity consumption and social connectedness, also after controlling for possible confounding factors. We conclude that oil palm cultivation improves current and longer-term wellbeing of smallholder farm households in this setting.

Keywords: oil palm, smallholder farmers, wellbeing, living standard, rural development

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1. Introduction

In the recent past, oil palm cultivation has raised substantial controversies because of negative environmental effects associated with deforestation and, in some cases, also negative social effects for local communities (Grass et al., 2020; Meijaard et al., 2020; Santika et al., 2019a). However, several studies with data from Indonesia and Malaysia have also shown positive effects of oil palm cultivation on smallholder farmers' profits and incomes (Bou Dib et al., 2018; Chrisendo et al., 2020; Cramb and Curry, 2012; Euler et al., 2017; Gatto et al., 2017; Kubitza et al., 2018; Rist et al., 2010; Zen et al., 2016). Effects in the small farm sector are of particular relevance, because much of the global oil palm land is cultivated by smallholder farmers (Qaim et al., 2020). In Indonesia, for instance, smallholders account for more than 40% of the country's total oil palm plantations (Ministry of Agriculture Indonesia, 2019). However, oil palm income gains may possibly be temporary without necessarily improving longer-term wellbeing and living standards. In this article, we analyze effects of oil palm cultivation on longer-term wellbeing of smallholder farmers in Indonesia.

Obviously, income gains are expected to improve household living standards, but the concrete effects also depend on how reliable the additional income is and how exactly it is spent (Mehraban et al., 2021). Hence, comprehensive studies of human wellbeing should not focus on income alone (Dodge et al., 2012; Seaford, 2011; Steptoe et al., 2015). This is also reflected in the Sustainable Development Goals (SDGs), where nutrition, education, health, and several other dimensions of human wellbeing are explicitly considered (UN General Assembly, 2015). While wellbeing has important subjective components, different quality of life indicators have recently been used for more objective evaluations (Ross et al., 2020; Western and Tomaszewski, 2016). Objective indicators of wellbeing typically relate to human capital, living conditions, and material resources that contribute to current and future welfare of households and individuals. In the literature about the effects of oil palm cultivation, such nuanced indicators of longer-term wellbeing were hardly used up till now. This research gap is addressed in the present analysis.

In particular, we use primary data from a panel survey of farmers in Jambi Province, Sumatra, one of the hotspots of Indonesia's recent oil palm boom. The data were collected in three rounds between 2012 and 2018. We use panel data regression models to analyze effects of oil palm cultivation on various indicators of smallholder wellbeing, including nutrition, education, health, living conditions, and social connectedness. The rest of this article proceeds as follows. Section 2 presents materials and methods, explaining the survey data, the regression approaches, and the concrete wellbeing indicators used. The empirical results are presented in section 3, while section 4 discusses these results in a broader context and concludes.

2. Materials and methods

2.1 Farm household survey

This study uses data from a survey of farm households in Jambi Province, Sumatra, which we conducted in three rounds in 2012, 2015, and 2018. Jambi is one of Indonesia's leading provinces in terms of oil palm production with a particularly large share of smallholder farmers involved. According to official statistics, smallholders cultivate 63% of the oil palm land in Jambi Province (Ministry of Agriculture Indonesia, 2019).

We selected the sample of farmers in Jambi through a multi-stage sampling procedure. Five of the lowland regencies, where most of the oil palm is grown, were chosen purposively, namely Muaro Jambi, Batanghari, Sarolangun, Tebo, and Bungo. In each regency, we randomly selected four districts, and in each district, we randomly selected two villages, leading to a total of 40 villages covered. Five additional villages were chosen purposively to coincide with other project activities (Drescher et al., 2016; Grass et al., 2020). We control for the non-randomly selected villages in all regression models. Depending on the individual village size, we finally selected 6-24 farm households in each village randomly.

In 2012, we interviewed 684 farm households for the first survey round. In 2015 and 2018, we revisited the same households for the second and third survey rounds. Some sample attrition occurred due to outmigration and other factors, but with around 5% in each subsequent round the attrition rates were relatively low. Replacement households were sampled randomly in the same villages, leading to an unbalanced panel.

The face-to-face interviews were conducted in Bahasa Indonesia by a team of local enumerators, who were recruited, trained, and supervised by the researchers. Carefully designed and tested structured questionnaires were used, covering general household characteristics, details on farm and non-farm economic activities, household consumption, and a range of other socioeconomic variables. The interviews were conducted with the household head; for some of the questions, especially those related to household consumption, the spouse assisted whenever possible.

All households in our sample are involved in plantation agriculture, cultivating either rubber, or oil palm, or both. Relatively few farmers additionally grow food crops; food crop production is not very common in the lowlands of Jambi due to the much higher profitability of plantation crops (Euler et al., 2017; Chrisendo et al., 2021). In 2012, 35% of the sample households were involved in oil palm cultivation (Table 1). We refer to these households as oil palm adopters. By 2018, the share of oil palm adopters had increased to 46%.

Table 1. Sample size by oil palm adoption status in the three survey rounds

	2012	2015	2018	Total
Total number of farm households	684	687	689	2,060
Of which…				
Oil palm adopters	240	249	318	807
Non-adopters	444	438	371	1,253

2.2 Regression approaches

We aim to analyze whether oil palm cultivation affects farm households' current and longer-term wellbeing. We are particularly interested in household nutrition, health, and education as indicators of human capital formation. Furthermore, we look at household assets and other material resources that characterize living conditions. Details of the concrete indicators used are explained below. Here, we first want to clarify the main research hypothesis and the general approaches used to test this hypothesis.

The main hypothesis is that oil palm cultivation improves smallholder farmers' current and longer-term wellbeing. This is based on previous findings showing that oil palm cultivation is associated with significant income gains (e.g., Euler et al. 2017; Kubitza et al., 2018; Mehraban et al., 2021). We start the analysis by comparing the different wellbeing indicators between farmers cultivating and not cultivating oil palm (we also refer to these groups as oil palm adopters and non-adopters). Then, to test the hypothesis more formally, we use panel data regression models of the following type:

$$Y_{it} = \alpha + \beta OP_{it} + \gamma Z_{it} + \delta T_t + \varepsilon_{it}$$

where Y_{it} is the wellbeing indicator of interest for farm household i in year t, and OP_{it} is a dummy variable indicating whether or not household i cultivated oil palm in year t. Hence, β measures the effect of oil palm cultivation on the specific wellbeing indicator. We also control for other relevant farm, household, and village characteristics that may influence household wellbeing. These are denoted by the vector Z_{it} and include variables such as farm size, household size, characteristics of the household head (sex, age, education), access to markets and rural services, among others. Finally, T_t is a vector of time fixed effects to control for general trends. ε_{it} is a random error term.

We estimate all models with random effects (RE) and fixed effects (FE) panel estimators and use the Hausman test to choose the appropriate specification (Wooldridge, 2002). The FE model is preferred when there is unobserved heterogeneity that leads to correlation between the oil palm cultivation dummy and the error term. In that case, the RE estimates would be biased. However, the RE estimator is more efficient, especially when the within-household variation of key variables over time is limited, as is true for the oil palm dummy. Hence, whenever the Hausman test fails to reject the null hypothesis of no time-invariant unobserved heterogeneity the RE estimates are preferred.

2.3 Measurement of wellbeing indicators

Nutrition

Healthy nutrition is a key factor for physical and cognitive development in children and for health and economic productivity more generally (Black et al., 2013; Debela et al., 2021; Martorell, 2017; Zhang et al., 2013). We use different household-level indicators to evaluate diets and nutrition, including food expenditures, a dietary diversity score (DDS), and calorie consumption levels per adult equivalent (AE), using data from a 7-day food consumption recall that was included as part of the survey interviews.

DDS counts the number of different food groups consumed by the household and is a common indicator of dietary quality (FAO, 2011). Different food group classifications can be used. We focus on nine healthy food groups (not considering less-healthy foods such as sweets and condiments), namely starchy staples; dark green leafy vegetables; other vitamin-A rich fruits and vegetables; other fruits and vegetables; organ meat; meat and fish; eggs; legumes, nuts and seeds; milk and milk products Thus, the possible range for the DDS is between 0 and 9; higher values stand for higher dietary diversity and quality. For the calorie calculations, quantities of all food items consumed are considered and converted to calorie values using food composition tables for Indonesia (Berger et al., 2013; USDA, 2016).

Health

Health is another key factor for human wellbeing (Bleakley, 2010; Zivin and Neidell, 2013). Given the close association between nutrition and health, the nutrition variables discussed above capture health to some extent, but there are certainly other aspects of health that also matter. While in our survey we did not collect detailed data on the health status of individual household members, we collected data on different types of health expenditures, which can be used as proxies of health status is many situations (Athukorala et al., 2012; Ke et al., 2011; Murthy and Okunade, 2009). The typical assumption is that poor households would only seek medical advice and treatment when absolutely required, whereas richer households would spend more on health treatment and prophylaxis. We follow this assumption and interpret higher health expenditures as a proxy for better health. Annual health expenditures are expressed in monetary values per AE to be comparable across households of different size.

However, there are also arguments why health expenditures may not be a good proxy of health status in some situations. First, health expenditures can only increase when health care facilities are accessible, which is not always the case in rural Indonesia (Parmanto et al., 2008; WHO, 2017). Second, when public health insurance is widespread, household health expenditures may not carry much information about the actual health status of household members. While public health insurance has recently become mandatory in Indonesia (Habibie et al., 2017), not all households are covered yet, and those that are still incur significant out-of-pocket expenses.

Third, high health expenditures might in some cases also proxy for bad health, for instance when frequent injuries occur or certain chronic diseases need regular treatment. This might be especially biasing for our analysis if oil palm cultivation were associated with occupational health hazards that are systematically different from those of other crops. This is not the case in our context.

In any case, given the different limitations, we acknowledge that health expenditures are an imperfect proxy of health status and should therefore not be overinterpreted. To address some of the limitations, we consider different types of health expenditures separately, namely expenses incurred for visiting hospitals, community health centers, doctors, traditional healers, and for buying medicines in local drugstores and shops. Community health centers and traditional healers are usually found in every village, whereas hospitals and doctors are only available in larger towns and cities.

Education

Education is particularly important for human capital formation and long-term wellbeing. However, in many poor households children have to work and are thus partly prevented from attending school. In agricultural households, children often contribute to the labor on the family farm, which is also true in rural Indonesia (Hsin, 2007). Oil palm cultivation is expected to improve child education through two pathways. First, gains in household income reduce the economic need for child work and increase the demand for education as an investment into the future. Second, oil palm requires much less labor per unit of land than rubber or alternative crops (Chrisendo et al., 2021; Euler et al., 2017), so the adoption of oil palm frees family labor to pursue other activities.

But an important question is how to measure education in the context of this study. In Indonesia, children receive a school completion diploma when they complete twelve years of education, including six years of primary school, three years of secondary school, and three years of high school. Studies on educational outcomes often consider school enrollment and dropout rates (Ha and Mendoza, 2010; Parinduri, 2014). But as school enrollment is compulsory in Indonesia and reliable data on actual school attendance are difficult to obtain, these may not be the best indicators for the impact analysis here. Another limitation of school enrollment and dropout rates in our context is the small observed variation for these variables within households over time. Without such variation, it is hardly convincing to attribute any effects to oil palm adoption. Therefore, while we look at data on school enrollment and dropout rates for descriptive comparisons between oil palm adopters and non-adopters, for the regression analysis we use more time-sensitive indicators, namely annual household expenditures on education per school-aged child (only considering households with school-aged children).

We use two education expenditure variables, one related to general school education and the other related to higher education. General education expenditures include registration and tuition fees, books, uniforms, any extra-curricular activities, private lessons, and contributions to the parents-teachers association. Higher education expenditures are proxied through annual out-remittances of the farm household. Out-remittances may serve different purposes, but the main purpose in our regional context is to support family members who live outside the village to pursue higher education, as colleges and universities are typically located in larger cities. Remittances to these family members cover education-related expenditures as well as the general cost of living in the study city.

Living conditions

Housing conditions and ownership of durable consumer assets can affect current and future wellbeing (Bratt, 2002; Coley et al., 2013; Mazur, 2011). We look at house construction materials, considering brick walls (as opposed to wood or clay) and cemented or tiled floors as indicators of better housing conditions. Furthermore, we look at the ownership of different types of assets, such as television, satellite-dish, fridge, washing machine, phone, and motor vehicles. These indicators are all captured through dummy variables.

One of the drawbacks of the dummy variables for housing and living conditions is again that these show relatively low levels of variation within households over time (e.g., investments into a new house or other durable assets are not made every year). Hence, for the regression analysis we use another, more time-sensitive indicator, namely electricity consumption expenditures, which is also known to affect people's wellbeing (Ahmad et al., 2014; Mazur, 2011). Most rural households in Jambi have access to electricity, but the quantity consumed depends on the individual living standard, with richer households typically using electric appliances more frequently than poorer ones. We look at annual electricity expenditures per AE.

Social connectedness

Connectedness includes access to information and social networks with family, relatives, and friends, all of which can affects current and future wellbeing considerably (Jose et al., 2012; Western and Tomaszewski, 2016). In rural areas, people's connectedness is often proxied through participation in social organizations, such as farmers' associations or religious groups (Ibnu et al., 2018; Pratiwi and Suzuki, 2017). But in our sample almost all households are involved in at least one such organization, so that this proxy is not suitable for the impact analysis. Instead, we use the household's annual communication expenditures per AE as an indicator of connectedness. Communication expenditures include telephone, mobile phone, and internet bills for all household members. Mobile phones, internet, and social media have become important mechanisms for accessing information and interacting with social networks in many developing countries, including rural Indonesia (Allen et al., 2014; Pearson et al., 2017; Sekabira and Qaim, 2017).

Deflation of monetary values

Several of the wellbeing indicators discussed above are measured in terms of annual household expenditures. These are expressed in the local currency, Indonesian Rupiah (IDR), either per AE or, in the case of education expenditures, per school-aged child. As we use data from three survey rounds and several years, these monetary values need to be deflated to be comparable. We deflate all monetary data to 2012 values. One option would be to use the general consumer price index for these calculations. However, different categories of consumer goods may be subject to different price developments over time (Gilbert and Morgan, 2010), which is why we decided to use specific price indices for the different expenditure categories (food, health, education, electricity, communication), all referring to Jambi Province. In the regression models, all deflated monetary values are used in logarithmic form for better empirical fit.

3. Results

3.1 Descriptive results

Table 2 shows descriptive comparisons of selected variables between oil palm adopters and non-adopters from pooled data, combining all three survey rounds (separate comparisons by survey round can be found in Table A1 in the Appendix). As expected, oil palm adopters are wealthier than non-adopters, as indicated by larger farm sizes and higher total household expenditures. Looking at nutrition, oil palm adopters perform better in terms of all indicators. Oil palm adopters have significantly higher food expenditures, more diverse diets, and higher levels of calorie consumption than non-adopters.

Table 2. Household nutrition and health expenditure by oil palm adoption status

Variables	**Oil palm adopters**	**Non-adopters**
Average farm size (ha)	6.634***	3.771
	(9.386)	(5.707)
Total household expenditure (million IDR/AE/year)	15.385***	11.517
	(12.324)	(8.200)
Household food expenditure ('000 IDR/AE/year)	7866.864***	6620.022
	(4376.625)	(3438.123)
Share of food expenditure in total expenditure	0.576***	0.620
	(0.167)	(0.146)
Dietary diversity score (0-9)	6.937***	6.585
	(1.134)	(1.249)
Calories (kcal/AE/day)	3375.535***	2916.345
	(1606.568)	(1359.568)
Total health expenditure ('000 IDR/AE/year)	341.672	248.440
	(1743.266)	(1385.251)
Hospital expenditure ('000 IDR/AE/year)	244.994	183.289
	(1676.197)	(1355.727)
Community health center expenditure ('000 IDR/AE/year)	13.989	9.955
	(123.426)	(38.987)
Doctor expenditure ('000 IDR/AE/year)	20.233	20.839
	(120.636)	(172.954)
Traditional healer expenditure ('000 IDR/AE/year)	7.510	9.038
	(30.107)	(73.419)
Medicine expenditure ('000 IDR/AE/year)	54.947***	25.318
	(366.800)	(101.333)
Number of observations	807	1,253

Notes: Mean values for the pooled sample, including 2012, 2015, and 2018 survey rounds, are shown with standard deviations in parentheses. All monetary values deflated to 2012, using price indices specific for each expenditure category. In 2012, 1 US$ was equivalent to IDR 9,670. AE, adult equivalent. Mean differences between adopters and non-adopters tested for statistical significance. *** significant at the 1% level.

Health expenditures are shown in the lower part of Table 2. While the total health expenditures of oil palm adopters are almost 40% higher than those of non-adopters, this difference is not statistically significant. Also for most of the health expenditure subcategories, differences between adopters and non-adopters are not statistically significant. The only exception is expenditure for medicine, where oil palm adopters spend significantly more.

Table 3. Education indicators by oil palm adoption status

Education variables	**Oil palm adopters**	**Non-adopters**
Children's school enrollment (%)	0.996	0.991
	(0.054)	(0.089)
Children's school dropout rates (%)	0.118	0.140
	(0.294)	(0.320)
Education expenditure ('000 IDR/school-aged child/year)	938.831***	433.960
	(3253.433)	(1402.113)
Number of observations	529	817
Girls' school enrollment (%)	0.990	0.995
	(0.097)	(0.068)
Girls' school dropout rates (%)	0.114	0.126
	(0.305)	(0.318)
Number of observations	330	482
Boys' school enrollment (%)	1.000**	0.986
	(0.000)	(0.118)
Boys' school dropout rates (%)	0.123*	0.166
	(0.313)	(0.357)
Number of observations	319	508
Total out-remittances ('000 IDR/AE/year)	1571.992**	767.574
	(8358.749)	(3381.483)
Number of observations	807	1,253

Notes: Mean values for the pooled sample, including 2012, 2015, and 2018 survey rounds, are shown with standard deviations in parentheses. For school education variables, only households with school-aged girls and/or boys are considered. All monetary values deflated to 2012. In 2012, 1 US$ was equivalent to IDR 9,670. AE, adult equivalent. Mean differences between adopters and non-adopters tested for statistical significance. *, **, *** significant at the 10%, 5% and 1% level, respectively.

Table 3 compares the education indicators between oil palm adopters and non-adopters (a breakdown by survey round is shown in Table A2 in the Appendix). School enrollment rates are close to 100% for children in both types of farm households, which is expected given that school enrollment is compulsory. However, school dropouts, defined as not completing the usual twelve years of schooling, occur. Typical reasons for dropouts are that older children have to work and/or that the household can no longer afford the education-related expenditures. Dropout rates in oil palm adopting households are somewhat lower than in non-adopting households, even though the difference is not statistically significant.

Table 3 also shows a further breakdown of school enrollment and dropout rates differentiating by the child's sex. Strikingly, while no significant differences between oil palm adopters and non-adopters are observed for girls, this is different for boys. Boys in oil palm adopting households are significantly more likely to be enrolled in school and less likely to drop out than their counterparts in non-adopting households. This can possibly be explained by the labor requirements that are lower in oil palm than in alternative crops. In Indonesia, it is more common for boys to help on the family farm, whereas girls are more involved in household chores (Hsin, 2007). Much larger differences are observed for household education expenditures, which is true for general school education and for higher education proxied by out-remittances. For both types of expenditures, oil palm adopting households spend more than double the amounts of non-adopting households.

We now turn to the comparison of living conditions, which are shown in Figure 1. The wall and floor materials of the houses do not differ significantly between oil palm adopters and non-adopters. However, oil palm adopters are significantly more likely to own certain assets, such as television, satellite-dish, fridge, washing machine, and four-wheel motor vehicle. Unsurprisingly, oil palm adopters also have significantly higher electricity expenditures than non-adopters (Table 4). Finally, in terms of social connectedness, Table 4 shows that oil palm adopters also spend significantly more on communication. These differences in electricity and communication expenditures between adopters and non-adopters also remain when looking at the different survey rounds separately (Table A3 in the Appendix).

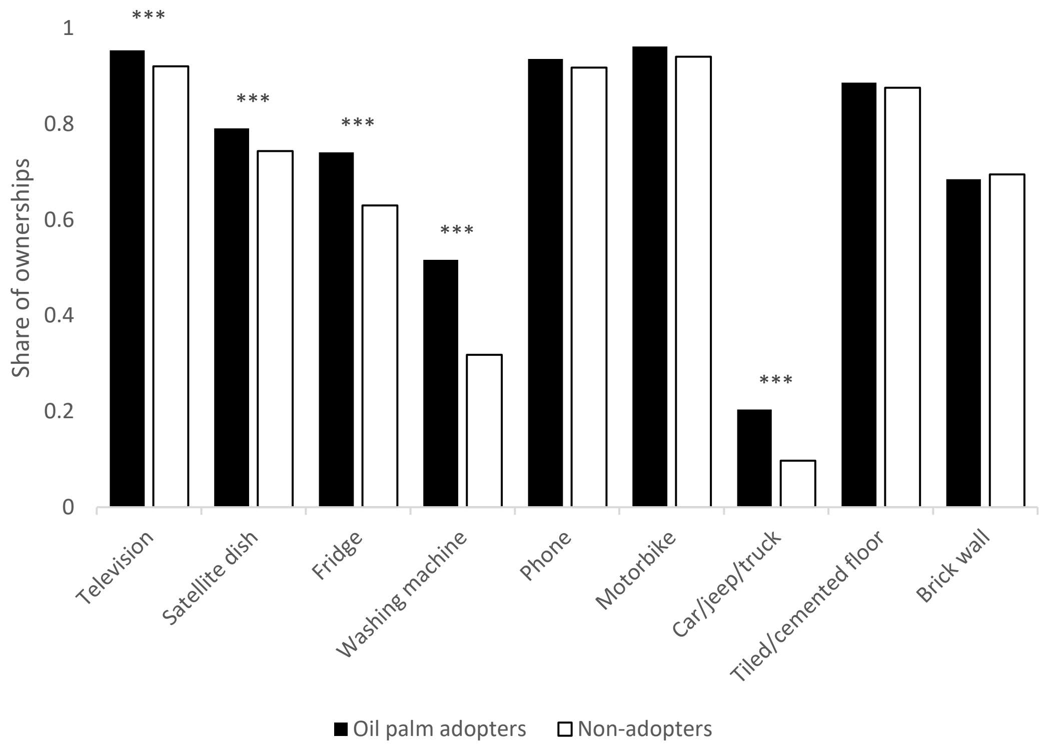

Figure 1. Living conditions and asset ownership by oil palm adoption status

Notes: *** difference is statistically significant at 1% level.

Table 4. Household electricity and communication expenditure by oil palm adoption status

Variables	Oil palm adopters	Non-adopters
Electricity expenditure ('000 IDR/AE/year)	46.960***	37.661
	(36.948)	(39.244)
Communication expenditure ('000 IDR/AE/year)	20.153***	15.191
	(25.026)	(22.469)
Number of observations	807	1,253

Notes: Mean values for the pooled sample, including 2012, 2015, and 2018 survey rounds, are shown with standard deviations in parentheses. All monetary values deflated to 2012. In 2012, 1 US$ was equivalent to IDR 9,670. AE, adult equivalent. Mean differences between adopters and non-adopters tested for statistical significance. **, *** significant at 5% and 1% level, respectively.

3.2 Regression results

We now present the estimation results from the panel data regression models to evaluate the effects of oil palm adoption/cultivation on the different wellbeing indicators while controlling for possible confounding factors. The RE and FE estimation results for all models are shown in

Tables 5-7, together with the Hausman test statistics. In most cases, the Hausman test is not statistically significant, so the RE specifications are preferred. Reassuring, however, is that the FE estimates of the oil palm adoption effects all point in the same direction; often the FE estimates are also in a similar magnitude as the RE estimates, only that the standard errors are larger due to the limited variation of the oil palm adoption status within households over time.

Table 5 Effects of oil palm cultivation on dietary diversity and calories consumption

Variables	**DDS**		**Calorie (log, kcal)**	
	RE	**FE**	**RE**	**FE**
Oil palm cultivation (dummy)	0.243***	0.181	0.081***	0.032
	(0.061)	(0.122)	(0.019)	(0.040)
Total land size (ha)	0.009**	0.001	0.005***	0.001
	(0.004)	(0.010)	(0.001)	(0.003)
Female-headed household (dummy)	-0.080	-0.296*	-0.045	-0.117**
	(0.114)	(0.180)	(0.036)	(0.059)
Household size	0.097***	0.121***	-0.062***	-0.059***
	(0.018)	(0.028)	(0.006)	(0.009)
Age of household head (years)	-0.007**	-0.008	0.001	0.001
	(0.003)	(0.006)	(0.001)	(0.002)
Education of household head (years)	0.040***	-0.009	0.009***	0.010
	(0.009)	(0.019)	(0.003)	(0.006)
Migrant household (dummy)	0.233***		0.049**	
	(0.063)		(0.020)	
Access to credit (dummy)	0.027	0.005	0.063***	0.080***
	(0.059)	(0.077)	(0.019)	(0.025)
Non-random village (dummy)	0.284***		0.100***	
	(0.091)		(0.028)	
Distance to market (km)	0.005	-0.002	-0.000	0.001
	(0.004)	(0.007)	(0.001)	(0.002)
Survey round 2015 (dummy)	0.051	0.050	-0.102***	-0.099***
	(0.058)	(0.062)	(0.019)	(0.020)
Survey round 2018 (dummy)	0.140**	0.146**	0.079***	0.089***
	(0.060)	(0.071)	(0.020)	(0.023)
Constant	5.974***	6.581***	7.977***	8.024***
	(0.190)	(0.381)	(0.060)	(0.125)
Hausman test, χ^2	15.88		8.54	
Number of observations	2,060	2,060	2,060	2,060

Notes: Coefficient estimates of random effects (RE) and fixed effects (FE) panel data models are shown with standard errors in parentheses. *, **, *** significant at the 10%, 5%, and 1% level, respectively

The effects of oil palm cultivation on household nutrition are shown in Table 5. The RE estimates on the dietary diversity score (DDS) suggest that oil palm cultivation is associated with a 0.24 increase in the number of food groups consumed by the household. Furthermore, oil palm cultivation is associated with an 8% increase in calorie consumption.[1] These results suggest that oil palm cultivation contributes to improved nutrition and dietary quality, also after controlling for confounding factors.

The effects of oil palm cultivation on different categories of health expenditures are shown in Table 6. Most of these estimates are not statistically significant, with the only exception of medicine expenditures. Oil palm cultivation increases medicine expenditure by 19% when using the RE estimates. Interestingly, the effects estimated with the FE specification are even larger (54%). We discussed above that health expenditures may not be perfect proxies of people's health status, so some caution with the interpretation is warranted.

Table 7 shows the estimation results for other expenditure categories, including education, electricity, and communication. Oil palm cultivation increases general education expenditures per school-aged child by more than 40%, and expenditures for higher education (proxied by out-remittances) by more than 50%. This is fully consistent with anecdotal evidence during the field work: several farmers told us how the income gains from oil palm have helped to invest into their children and even send some of them to college. The other results in Table 7 suggest that oil palm cultivation increases electricity expenditures and communication expenditures by around 20% each. These are clear indications that oil palm cultivation improves current and longer-term wellbeing, as hypothesized.

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[1] Calorie consumption per AE and day is expressed in logarithmic form. The percentage effect of dummy variables in log-linear models is calculated as $(e^{\hat{\beta}-\frac{1}{2}\widehat{VAR}(\hat{\beta})}-1)\cdot 100$.

Table 6. Effects of oil palm cultivation on annual health expenditures (expressed in log terms)

Variables	Hospital expenditure		Community health center expenditure		Doctor expenditure		Traditional healer expenditure		Medicine expenditure	
	RE	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**	**RE**	**FE**
Oil palm cultivation (dummy)	0.172	0.144	-0.045	-0.194	0.047	0.265	-0.025	-0.065	0.178**	0.438**
	(0.105)	(0.234)	(0.068)	(0.152)	(0.071)	(0.169)	(0.056)	(0.137)	(0.082)	(0.200)
Total land size (ha)	0.006	-0.006	-0.004	0.007	0.011**	0.008	0.004	-0.015	0.012**	0.015
	(0.007)	(0.020)	(0.004)	(0.013)	(0.005)	(0.014)	(0.004)	(0.012)	(0.005)	(0.017)
Female-headed household	-0.066	-0.097	-0.100	-0.072	0.201	0.138	0.006	-0.075	-0.268*	-0.330
	(0.199)	(0.344)	(0.129)	(0.224)	(0.137)	(0.250)	(0.108)	(0.202)	(0.158)	(0.294)
Household size	0.034	0.105**	0.016	-0.000	0.014	0.057	-0.011	0.039	-0.004	0.033
	(0.032)	(0.053)	(0.020)	(0.034)	(0.022)	(0.038)	(0.017)	(0.031)	(0.025)	(0.045)
Age of household head (years)	0.003	-0.017	0.004	0.004	0.001	-0.012	-0.006**	0.001	0.005	0.003
	(0.005)	(0.012)	(0.003)	(0.008)	(0.003)	(0.009)	(0.002)	(0.007)	(0.004)	(0.010)
Education of household head	0.004	0.018	-0.012	0.017	0.022**	0.007	0.004	0.004	0.010	0.023
	(0.015)	(0.036)	(0.009)	(0.023)	(0.010)	(0.026)	(0.008)	(0.021)	(0.011)	(0.031)
Migrant household (dummy)	0.184*		-0.012		-0.013		0.175***		0.064	
	(0.104)		(0.067)		(0.070)		(0.055)		(0.080)	
Access to credit (dummy)	0.019	-0.140	0.098	0.248***	0.098	0.150	0.052	0.017	-0.061	-0.214*
	(0.107)	(0.147)	(0.069)	(0.096)	(0.074)	(0.107)	(0.059)	(0.086)	(0.086)	(0.126)
Non-random village (dummy)	-0.068		-0.170*		-0.129		-0.004		0.040	
	(0.150)		(0.097)		(0.101)		(0.079)		(0.116)	
Distance to market (km)	-0.010	-0.007	-0.009*	-0.024***	0.003	-0.002	0.002	-0.011	0.006	-0.015
	(0.008)	(0.013)	(0.005)	(0.009)	(0.005)	(0.010)	(0.004)	(0.008)	(0.006)	(0.011)
Survey round 2015 (dummy)	-0.022	0.082	-0.456***	-0.479***	0.137*	0.159*	0.397***	0.387***	0.338***	0.383***
	(0.112)	(0.118)	(0.072)	(0.077)	(0.080)	(0.086)	(0.065)	(0.069)	(0.094)	(0.101)
Survey round 2018 (dummy)	-0.058	0.135	-0.541***	-0.563***	0.048	0.092	0.403***	0.374***	1.043***	1.036***
	(0.114)	(0.136)	(0.074)	(0.088)	(0.082)	(0.098)	(0.066)	(0.079)	(0.096)	(0.116)
Constant	0.357	1.017	0.836***	0.765	0.108	0.579	0.294*	0.041	0.647**	0.566
	(0.326)	(0.730)	(0.210)	(0.475)	(0.223)	(0.529)	(0.176)	(0.427)	(0.256)	(0.624)
Hausman test, χ^2	12.76		12.91		7.90		14.20		14.13	
Number of observations	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060	2,060

Notes: Coefficient estimates are shown with standard errors in parentheses. *, **, *** significant at the 10%, 5%, and 1% level, respectively.

Table 7. Effects of oil palm cultivation on different kind of expenditures (in logarithm IDR)

Variables	Education expenditure (school)		Out-remittances (higher education)		Electricity expenditure		Communication expenditure	
	RE	FE	RE	FE	RE	FE	RE	FE
Oil palm cultivation (dummy)	0.353*	0.574	0.415***	0.545*	0.181***	0.200*	0.180***	0.146
	(0.195)	(0.436)	(0.150)	(0.315)	(0.057)	(0.110)	(0.066)	(0.131)
Total land size (ha)	0.021	-2.6e-5	0.045***	0.039	0.001	-0.011	0.020***	0.017
	(0.013)	(0.037)	(0.010)	(0.027)	(0.004)	(0.009)	(0.004)	(0.011)
Female-headed household (dummy)	-0.463	-0.598	-0.308	-0.378	0.041	-0.120	0.186	-0.141
	(0.411)	(0.766)	(0.282)	(0.463)	(0.105)	(0.162)	(0.123)	(0.193)
Household size	0.005	0.004	-0.375***	-0.461***	-0.113***	-0.143***	0.025	0.002
	(0.063)	(0.109)	(0.044)	(0.071)	(0.017)	(0.025)	(0.019)	(0.030)
Age of household head (years)	0.011	-0.020	0.007	-0.004	0.000	-0.001	-0.003	-0.004
	(0.010)	(0.028)	(0.007)	(0.016)	(0.003)	(0.006)	(0.003)	(0.007)
Education of household head (years)	0.065	-0.081	0.109***	0.030	0.027***	0.000	0.062***	0.009
	(0.028)	(0.073)	(0.021)	(0.049)	(0.008)	(0.017)	(0.009)	(0.020)
Migrant household (dummy)	-0.062		0.494***		0.078		0.077	
	(0.196)		(0.150)		(0.059)		(0.068)	
Access to credit (dummy)	0.262	0.241	0.401***	0.346*	0.044	-0.079	0.335***	0.240***
	(0.193)	(0.273)	(0.148)	(0.198)	(0.054)	(0.069)	(0.064)	(0.082)
Non-random village (dummy)	-0.369		-0.173		0.005		-0.174*	
	(0.284)		(0.218)		(0.085)		(0.098)	
Distance to market (km)	-0.011	-0.010	-0.012	0.021	-0.010**	0.004	-0.010**	-0.019**
	(0.015)	(0.027)	(0.011)	(0.018)	(0.004)	(0.006)	(0.005)	(0.007)
Survey round 2015 (dummy)	0.686***	0.853***	-0.185	-0.191	0.160***	0.181***	-0.593***	-0.582***
	(0.194)	(0.228)	(0.151)	(0.159)	(0.053)	(0.055)	(0.063)	(0.066)
Survey round 2018 (dummy)	0.157	0.508*	-0.245	-0.157	0.285***	0.322***	0.056	0.080
	(0.203)	(0.280)	(0.155)	(0.183)	(0.054)	(0.064)	(0.065)	(0.076)
Constant	1.580**	3.883**	1.358***	2.893***	3.380***	3.818***	1.676***	2.359***
	(0.622)	(1.544)	(0.464)	(0.982)	(0.175)	(0.343)	(0.205)	(0.409)
Hausman test, χ^2	11.36		27.73***		25.42***		24.17***	
Number of observations	1,346	1,346	2,060	2,060	2,060	2,060	2,060	2,060

Notes: Coefficient estimates are shown with standard errors in parentheses. The education expenditure models only include households with school-aged children.*, **, *** significant at the 10%, 5%, and 1% level, respectively.

4. Discussion and conclusion

Oil palm has been one of the fastest expanding agricultural crops in the humid tropics over the last 20 years, especially in Southeast Asia. Several recent studies showed that growing oil palm instead of or in addition to other crops is associated with significant income gains in the small farm sector (Kubitza et al., 2018; Mehraban et al., 2021; Rist et al., 2010). However, what was hardly known so far is how the additional income from oil palm cultivation is spent and whether it also contributes to longer-term wellbeing in smallholder households. This knowledge gap was addressed in this article with panel survey data from farm household in Jambi Province on the Island of Sumatra, Indonesia. The data were collected in three rounds between 2012 and 2018 and include a large variety of wellbeing indicators.

While this six-year period of study may not suffice to evaluate long-term effects conclusively, we included indicators of human capital formation that can proxy for current and future wellbeing, such as child education, nutrition, health, living conditions, and social connectedness. Our estimates of panel data regression models suggest that oil palm cultivation leads to significantly positive effects on education, dietary quality, and nutrition. The educational effects are particularly large in magnitude. Oil palm adopters spend around 40% more on child schooling than non-adopters. Adopters also spend around 50% more on out-remittances to support higher education of family members, thus enhancing the income-earning potential of the next generation considerably. These effects also hold after controlling for confounding factors, such as farm size, education of the household head, and market access, among others.

In terms of health, we found positive effects of oil palm cultivation on medicine expenses and insignificant effects on other types of health expenditures. Further, we found that oil palm adoption improves the household living conditions and social connectedness, increasing the expenditures on electricity and communication by around 20% each. These results clearly support the hypothesis that oil palm cultivation increases current and long-term wellbeing of smallholder farm households in Jambi.

Of course, these positive economic and social effects should not be seen in isolation from the environmental effects of further oil palm expansion. The environmental performance of oil palm is not necessarily worse than that of rubber or other alternative crops if cultivated on existing farmland (Qaim et al., 2020). However, some of the oil palm expansion in Jambi is at the expense of forestland, which leads to serious negative externalities in terms of biodiversity loss and greenhouse gas emissions (Grass et al., 2020; Meijaard et al., 2020). Hence, an important policy implication is to support smallholder oil palm cultivation on the existing farmland, while effectively protecting the remaining forestland. Complementary investments into rural infrastructure, services, and off-farm employment opportunities will be useful to promote broader regional development for the benefit of oil palm farmers and other rural households. The income gains and the educational improvements resulting from the oil palm boom also bode well for gradually raising more environmental awareness.

Our finding from Jambi that oil palm cultivation improves the current and long-term wellbeing of smallholder farm households cannot be generalized. In Jambi, most smallholder farmers had been involved in cash crop production (especially rubber) even before starting to cultivate oil palm, which is also one of the reasons why today much of the total oil palm land in Jambi is managed by smallholders. Similar conditions are also observed in other provinces of Sumatra, a few other islands of Indonesia, and large parts of Malaysia (Cramb and Curry, 2012; Qaim et al., 2020; Zen et al., 2016). However, in other places where oil palm is expanding, such as Kalimantan and Papua, smallholder farming is still more subsistence-oriented and markets are less developed. In these situations, much of the oil palm is cultivated by large companies and smallholder farmers benefit less (Santika et al., 2019b).

Future research with longer-term panel data from various geographical settings will be useful to gain further insights into the effects of oil palm cultivation on human wellbeing and other sustainability dimensions under different conditions. Using subjective welfare measures, in addition to the objective indicators employed here, could also be an interesting approach in follow-up studies.

References

Ahmad, S., Mathai, M. V., Parayil, G., 2014. Household electricity access, availability and human well-being: Evidence from India. Energy Policy 69, 308–315. https://doi.org/10.1016/j.enpol.2014.02.004

Allen, K.A., Ryan, T., Gray, D.L., McInerney, D.M., Waters, L., 2014. Social media use and social connectedness in adolescents: The positives and the potential pitfalls. Aust. Educ. Dev. Psychol. 31, 18–31. https://doi.org/10.1017/edp.2014.2

Athukorala, W., Wilson, C., Robinson, T., 2012. Determinants of health costs due to farmers' exposure to pesticides: An empirical analysis. J. Agric. Econ. 63, 158–174. https://doi.org/10.1111/j.1477-9552.2011.00326.x

Berger, J., Blanchard, G., Ponce, M.C., Chamnan, C., Chea, M., Dijkhuizen, M., Doak, C., Doets, E., Fahmida, U., Ferguson, E., Hulshof, P., Kameli, Y., Kuong, K., Akkhavong, K., Sengchanh, K., Le, B.M., Tran, T.L., Muslimatun, S., Roos, N., Sophonneary, P., Wieringa, F., Wasantwisut, E., Winichagoon, P., SMILING Consortium Group, 2013. The SMILING project: a North-South-South collaborative action to prevent micronutrient deficiencies in women and young children in Southeast Asia. Food Nutr. Bull. 34, 133–139. https://doi.org/10.1177/15648265130342S115

Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., De Onis, M., Ezzati, M., Grantham-Mcgregor, S., Katz, J., Martorell, R., Uauy, R., 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 382, 427–451. https://doi.org/10.1016/S0140-6736(13)60937-X

Bleakley, H., 2010. Health, human capital, and development. Annu. Rev. Econ. 2, 283–310. https://doi.org/10.1146/annurev.economics.102308.124436

Bou Dib, J., Krishna, V. V., Alamsyah, Z., Qaim, M., 2018. Land-use change and livelihoods of non-farm households: The role of income from employment in oil palm and rubber in rural Indonesia. Land Use Policy 76, 828–838. https://doi.org/10.1016/j.landusepol.2018.03.020

Bratt, R.G., 2002. Housing and family well-being. Hous. Stud. 17, 13–26. https://doi.org/10.1080/02673030120105857

Chrisendo, D., Krishna, V.V., Siregar, H., Qaim, M., 2020. Land-use change, nutrition, and gender roles in Indonesian farm households. For. Policy Econ. 118, 102245. https://doi.org/10.1016/j.forpol.2020.102245

Chrisendo, D., Siregar, H., Qaim, M., 2021. Oil palm and structural transformation of agriculture in Indonesia. Agric. Econ. in press.

Coley, R.L., Leventhal, T., Lynch, A.D., Kull, M., 2013. Relations between housing characteristics and the well-being of low-income children and adolescents. Dev. Psychol. 49, 1775–1789. https://doi.org/10.1037/a0031033

Cramb, R., Curry, G.N., 2012. Oil palm and rural livelihoods in the Asia-Pacific region: An overview. Asia Pac. Viewp. 53, 223–239. https://doi.org/10.1111/j.1467-8373.2012.01495.x

Debela, B.L., Gehrke, E., Qaim, M., 2021. Links between maternal employment and child nutrition in rural Tanzania. Am. J. Agric. Econ. 103, 812-830 https://doi.org/10.1111/ajae.12113

Dodge, R., Daly, A., Huyton, J., Sanders, L., 2012. The challenge of defining wellbeing. Int. J. Wellbeing 2, 222–235. https://doi.org/10.5502/ijw.v2i3.4

Drescher, J., Rembold, K., Allen, K., Beckschäfer, P., Buchori, D., Clough, Y., Faust, H., Fauzi, A.M., Gunawan, D., Hertel, D., Irawan, B., Jaya, I.N.S., Klarner, B., Kleinn, C., Knohl, A., Kotowska, M.M., Krashevska, V., Krishna, V., Leuschner, C., Lorenz, W., Meijide, A., Melati, D., Nomura, M., Pérez-Cruzado, C., Qaim, M., Siregar, I.Z., Steinebach, S., Tjoa, A., Tscharntke, T., Wick, B., Wiegand, K., Kreft, H., Scheu, S., 2016. Ecological and socio-economic functions across tropical land use systems after rainforest conversion. Philos. Trans. R. Soc. B Biol. Sci. 371, 20150275. https://doi.org/10.1098/rstb.2015.0275

Euler, M., Krishna, V., Schwarze, S., Siregar, H., Qaim, M., 2017. Oil palm adoption, household welfare, and nutrition among smallholder farmers in Indonesia. World Dev. 93, 219–235. https://doi.org/10.1016/j.worlddev.2016.12.019

FAO, 2011. Guidelines for measuring household and individual dietary diversity. Food and Agriculture Organization, Rome.

Gatto, M., Wollni, M., Asnawi, R., Qaim, M., 2017. Oil palm boom, contract farming, and rural economic development: Village-level evidence from Indonesia. World Dev. 95, 127–140. https://doi.org/10.1016/j.worlddev.2017.02.013

Gilbert, C.L., Morgan, C.W., 2010. Food price volatility. Philos. Trans. R. Soc. B Biol. Sci. 365, 3023–3034. https://doi.org/10.1098/rstb.2010.0139

Grass, I., Kubitza, C., Krishna, V. V., Corre, M.D., Mußhoff, O., Pütz, P., Drescher, J., Rembold, K., Ariyanti, E.S., Barnes, A.D., Brinkmann, N., Brose, U., Brümmer, B., Buchori, D., Daniel, R., Darras, K.F.A., Faust, H., Fehrmann, L., Hein, J., Hennings, N., Hidayat, P., Hölscher, D., Jochum, M., Knohl, A., Kotowska, M.M., Krashevska, V., Kreft, H., Leuschner, C., Lobite, N.J.S., Panjaitan, R., Polle, A., Potapov, A.M., Purnama, E., Qaim, M., Röll, A., Scheu, S., Schneider, D., Tjoa, A., Tscharntke, T., Veldkamp, E., Wollni, M., 2020. Trade-offs between multifunctionality and profit in tropical smallholder landscapes. Nat. Commun. 11, 1186.

https://doi.org/10.1038/s41467-020-15013-5

Ha, W., Mendoza, R., 2010. The intended and unintended consequences of social protection on school dropout in post-crisis Indonesia. J. Int. Dev. 22, 1115–1133. https://doi.org/10.1002/jid.1750

Habibie, W.L., Hardjosoekarto, S., Kasim, A., 2017. Health reform in Indonesia towards sustainable development growth (Case study on BPJS Kesehatan, health insurance in Indonesia). Rev. Integr. Bus. Econ. Res. 6, 375–383.

Hsin, A., 2007. Children's time use: Labor divisions and schooling in Indonesia. J. Marriage Fam. 69, 1297–1306. https://doi.org/10.1111/j.1741-3737.2007.00448.x

Ibnu, M., Offermans, A., Glasbergen, P., 2018. Certification and farmer organisation: Indonesian smallholder perceptions of benefits. Bull. Indones. Econ. Stud. 54, 387–415. https://doi.org/10.1080/00074918.2018.1506093

Jose, P.E., Ryan, N., Pryor, J., 2012. Does social connectedness promote a greater sense of well-being in adolescence over time? J. Res. Adolesc. 22, 235–251. https://doi.org/10.1111/j.1532-7795.2012.00783.x

Ke, X., Saksena, P., Holly, A., 2011. The determinants of health expenditure: A country-level panel data analysis, Working Paper of the Results for Development Institute. Washington, DC.

Kubitza, C., Krishna, V. V., Alamsyah, Z., Qaim, M., 2018. The economics behind an ecological crisis: Livelihood effects of oil palm expansion in Sumatra, Indonesia. Hum. Ecol. 46, 107–116. https://doi.org/10.1007/s10745-017-9965-7

Martorell, R., 2017. Improved nutrition in the first 1000 days and adult human capital and health. Am. J. Hum. Biol. 29, 1–12. https://doi.org/https://doi. org/10.1002/ajhb.22952

Mazur, A., 2011. Does increasing energy or electricity consumption improve quality of life in industrial nations? Energy Policy 39, 2568–2572. https://doi.org/10.1016/j.enpol.2011.02.024

Mehraban, N., Kubitza, C., Alamsyah, Z., Qaim, M., 2021. Oil palm cultivation, household welfare, and exposure to economic risk in the Indonesian small farm sector. J. Agric. Econ. https://doi.org/10.1111/1477-9552.12433.

Meijaard, E., Brooks, T.M., Carlson, K.M., Slade, E.M., Garcia-Ulloa, J., Gaveau, D.L.A., Lee, J.S.H., Santika, T., Juffe-Bignoli, D., Struebig, M.J., Wich, S.A., Ancrenaz, M., Koh, L.P., Zamira, N., Abrams, J.F., Prins, H.H.T., Sendashonga, C.N., Murdiyarso, D., Furumo, P.R., Macfarlane, N., Hoffmann, R., Persio, M., Descals, A., Szantoi, Z., Sheil, D., 2020. The environmental impacts of palm oil in context. Nat. Plants 6, 1418–1426. https://doi.org/10.1038/s41477-020-00813-w

Ministry of Agriculture Indonesia, 2019. Tree crop estate statistics of Indonesia 2018-2020: Palm oil. Jakarta.

Murthy, V.N.R., Okunade, A.A., 2009. The core determinants of health expenditure in the African context: Some econometric evidence for policy. Health Policy 91, 57–62. https://doi.org/https://doi.org/10.1016/j.healthpol.2008.10.001

Parinduri, R.A., 2014. Do children spend too much time in schools? Evidence from a longer school year in Indonesia. Econ. Educ. Rev. 41, 89–104. https://doi.org/10.1016/j.econedurev.2014.05.001

Parmanto, B., Paramita, M. V., Sugiantara, W., Pramana, G., Scotch, M., Burke, D.S., 2008. Spatial and multidimensional visualization of Indonesia’s village health statistics. Int. J. Health Geogr. 7, 1–14. https://doi.org/10.1186/1476-072X-7-30

Pearson, A.L., Mack, E., Namanya, J., 2017. Mobile phones and mental well-being: Initial evidence suggesting the importance of staying connected to family in rural, remote communities in Uganda. PLoS One 12, e0169819. https://doi.org/10.1371/journal.pone.0169819

Pratiwi, A., Suzuki, A., 2017. Effects of farmers' social networks on knowledge acquisition: Lessons from agricultural training in rural Indonesia. J. Econ. Struct. 6, 8. https://doi.org/10.1186/s40008-017-0069-8

Qaim, M., Sibhatu, K.T., Siregar, H., Grass, I., 2020. Environmental, economic, and social consequences of the oil palm boom. Annu. Rev. Resour. Econ. 12, 321–344. https://doi.org/10.1146/annurev-resource-110119-024922

Rist, L., Feintrenie, L., Levang, P., 2010. The livelihood impacts of oil palm: Smallholders in Indonesia. Biodivers. Conserv. 19, 1009–1024. https://doi.org/10.1007/s10531-010-9815-z

Ross, D.A., Hinton, R., Melles-Brewer, M., Engel, D., Zeck, W., Fagan, L., Herat, J., Phaladi, G., Imbago-Jácome, D., Anyona, P., Sanchez, A., Damji, N., Terki, F., Baltag, V., Patton, G., Silverman, A., Fogstad, H., Banerjee, A., Mohan, A., 2020. Adolescent well-being: A definition and conceptual framework. J. Adolesc. Heal. 67, 472–476. https://doi.org/10.1016/j.jadohealth.2020.06.042

Santika, T., Wilson, K.A., Meijaard, E., Budiharta, S., Law, E.A., Sabri, M. Struebig, M.J., Ancrenaz, M., Poh, T.M., 2019a. Changing landscapes, livelihoods and village welfare in the context of oil palm development. Land Use Policy 87, 104073.

Santika, T., Wilson, K.A., Budiharta, S., Law, E.A., Poh, T.M., Ancrenaz, M., Struebig, M.J., Meijaard, E., 2019b. Does oil palm agriculture help alleviate poverty? A multidimensional counterfactual assessment of oil palm development in Indonesia. World Dev. 120, 105–117. https://doi.org/10.1016/j.worlddev.2019.04.012

Seaford, C., 2011. Policy: Time to legislate for the good life. Nature 477, 532–533. https://doi.org/10.1038/477532a

Sekabira, H., Qaim, M., 2017. Can mobile phones improve gender equality and nutrition? Panel data evidence from farm households in Uganda. Food Policy 73, 95–103. https://doi.org/10.1016/j.foodpol.2017.10.004

Steptoe, A., Deaton, A., Stone, A.A., 2015. Subjective wellbeing, health, and ageing. Lancet 385, 640–648. https://doi.org/10.1016/S0140-6736(13)61489-0

UN General Assembly, 2015. Transforming our world: the 2030 Agenda for Sustainable Development. New York.

USDA, 2016. National nutrient database for standard reference. United States Department of Agriculture, Washington D.C.

Western, M., Tomaszewski, W., 2016. Subjective wellbeing, objective wellbeing and inequality in Australia. PLoS One 11, e0163345. https://doi.org/10.1371/journal.pone.0163345

WHO, 2017. State of health inequality: Indonesia. World Health Organization, Geneva.

Wooldridge, J.M., 2002. Econometric analysis of cross section and panel data. MIT Press, Cambridge, MA.

Zen, Z., Barlow, C., Gondowarsito, R., McCarthy, J.F., 2016. Interventions to promote smallholder oil palm and socio-economic improvement in Indonesia, in: Cramb, R., McCarthy, J.F. (Eds.), The Oil Palm Complex Smallhoders, Agribusiness and the State in Indonesia and Malaysia. NUS Press, Singapore, pp. 78–108.

Zhang, L., Yi, H., Luo, R., Liu, C., Rozelle, S., 2013. The human capital roots of the middle income trap: The case of China. Agric. Econ. 44, 151–162.

https://doi.org/10.1111/agec.12059

Zivin, J.G., Neidell, M., 2013. Environment, health, and human capital. J. Econ. Lit. 51, 689–730. https://doi.org/10.1257/jel.51.3.689

Appendix

Table A1. Household nutrition and health expenditure by oil palm adoption status and survey year

Variables	**Oil palm adopters**			**Non-adopters**		
	2012	**2015**	**2018**	**2012**	**2015**	**2018**
Average farm size (ha)	6.673 (9.666)	6.623 (9.541)	6.613 (9.073)	3.948 (6.044)	4.022 (6.652)	3.265 (3.720)
Total household expenditure (million IDR/AE/year)	15.717 (10.266)	15.126 (10.771)	15.338 (14.691)	11.963 (8.184)	11.176 (7.300)	11.387 (9.164)
Food expenditure (million IDR/AE/year)	8.545 (4.662)	7.660 (4.279)	7.517 (4.182)	7.172 (3.752)	6.254 (3.164)	6.392 (3.278)
Share of food expenditure in total expenditure	0.587 (0.161)	0.560 (0.155)	0.571 (0.178)	0.631 (0.135)	0.602 (0.150)	0.618 (0.151)
Dietary diversity score (0-9)	6.929 (1.101)	6.964 (1.144)	6.921 (1.152)	6.552 (1.246)	6.555 (1.282)	6.660 (1.214)
Calories (kcal/AE/day)	3416.343 (1757.298)	3101.858 (1572.149)	3559.030 (1485.528)	2917.594 (1419.927)	2611.110 (1122.198)	3275.209 (1453.924)
Total health expenditure ('000 IDR/AE/year)	369.182 (2070.627)	440.685 (2239.743)	243.383 (742.847)	216.491 (1011.218)	336.420 (2006.793)	182.806 (705.499)
Hospital expenditure ('000 IDR/AE/year)	291.147 (2044.043)	322.326 (2127.000)	149.609 (662.474)	166.369 (987.100)	257.136 (1970.025)	116.355 (676.544)
Community health center expenditure ('000 IDR/AE/year)	16.669 (60.802)	7.565 (34.790)	16.997 (186.956)	14.166 (38.096)	7.664 (42.995)	7.621 (34.486)
Doctor expenditure ('000 IDR/AE/year)	16.103 (77.848)	28.920 (182.021)	16.549 (80.171)	18.056 (134.088)	32.552 (254.341)	10.341 (54.833)
Traditional healer expenditure ('000 IDR/AE/year)	2.483 (17.934)	10.836 (37.739)	8.700 (30.311)	1.600 (10.382)	14.450 (111.576)	11.551 (57.446)
Medicine expenditure ('000 IDR/AE/year)	42.780 (331.349)	71.039 (539.338)	51.528 (177.238)	16.300 (58.225)	24.618 (116.134)	36.938 (120.516)
Number of observations	240	249	318	444	438	371

Notes: Mean values are shown with standard deviations in parentheses. All monetary values deflated to 2012.

Table A2. Education indicators by oil palm adoption status and survey year

Education variables	Oil palm adopters			Non-adopters		
	2012	**2015**	**2018**	**2012**	**2015**	**2018**
Children's school enrollment (%)	0.994 (0.078)	0.996 (0.043)	0.997 (0.036)	0.994 (0.063)	0.988 (0.106)	0.990 (0.036)
Children's school dropout rates (%)	0.101 (0.275)	0.140 (0.309)	0.114 (0.296)	0.117 (0.282)	0.164 (0.347)	0.141 (0.331)
Household education expenditure ('000 IDR/AE/year)	366.271 (1126.076)	138.190 (350.592)	310.036 (1227.792)	157.499 (663.635)	129.015 (385.844)	80.415 (191.002)
Number of observations	164	167	198	303	287	227
Girls' school enrollment (%)	0.990 (0.102)	0.988 (0.102)	0.992 (0.089)	0.992 (0.082)	0.994 (0.078)	1.000 (0.000)
Girls' school dropout rates (%)	0.082 (0.267)	0.143 (0.332)	0.114 (0.310)	0.102 (0.289)	0.160 (0.354)	0.115 (0.308)
Number of observations	97	107	126	187	166	129
Boys' school enrollment (%)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	0.995 (0.073)	0.981 (0.131)	0.978 (0.146)
Boys' school dropout rates (%)	0.105 (0.283)	0.146 (0.338)	0.117 (0.316)	0.159 (0.338)	0.182 (0.374)	0.155 (0.360)
Number of observations	102	106	111	190	179	139
Total out-remittances ('000 IDR/AE/year)	3202.083 (14346.660)	309.068 (989.686)	358.992 (2272.968)	1351.599 (5079.234)	207.528 (901.283)	113.455 (634.704)
Number of observations	240	249	318	444	438	371

Notes: Mean values are shown with standard deviations in parentheses. All monetary values deflated to 2012.

Table A3. Electricity and communication expenditure by oil palm adoption status and survey year

Variables	**Oil palm adopters**			**Non-adopters**		
	2012	**2015**	**2018**	**2012**	**2015**	**2018**
Electricity expenditure ('000 IDR/AE/year)	43.537 (43.749)	45.937 (31.441)	50.345 (35.120)	36.248 (30.193)	35.233 (25.937)	42.217 (57.404)
Communication expenditure ('000 IDR/AE/year)	24.238 (30.392)	15.422 (21.151)	22.234 (24.101)	17.676 (24.405)	12.168 (22.002)	17.357 (22.513)
Number of observations	240	249	318	444	438	371

Notes: Mean values are shown with standard deviations in parentheses. All monetary values deflated to 2012.