

Oil Palm and Gendered Time Use: A Mixed-Methods Case Study from West Kalimantan, Indonesia

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Abstract

Measuring the social impact of oil palm requires the use of multiple metrics which capture different dimensions of wellbeing. To date, most studies have examined welfare outcomes at the household level, relying on a relatively narrow range of welfare outcomes only at the household level. There is a need for a more diverse range of metrics to measure the social impacts of oil palm as well as more explicit accounting for study context and gendered effects. Here we demonstrate the utility of specialised time use methods used in combination with qualitative research to understand intra-household labour dynamics associated with oil-palm adoption. We use a mixed-methods approach to investigate the role of smallholder oil-palm plasma schemes on men and women's time use in Kapuas Hulu District, West Kalimantan. Time allocation is an important determinant of well-being as well as maternal and child nutrition and an indicator of women's empowerment and gender equality. We integrate the results from a fractional multinomial logistic regression of data from 603 individuals with extensive qualitative findings on the subjective experience of time allocation, causes, consequences and coping strategies to manage trade-offs in time allocation. We find that relative to non-oil palm adopting swidden farmers, participation in oil palm plasma schemes is associated with more time spent in productive labour for both men and women, driven by off-farm labour on oil palm plantations. For women, increased time comes at the cost of reduced time spent in rest, leisure and sleep. Increased time spent in off-farm labour drives households to adapt agricultural production methods, changing cash-crop production as well as accelerating swidden transitions. These changes alter gender dynamics and responsibilities within the household. Our results suggest that changes in time allocation may have significant consequences for women's well-being and gender equity. Women in the OP site experienced greater stress over time scarcity and employed coping strategies more frequently. Our findings indicate that time-allocation could be used as an indicator of the effects of oil-palm expansion and adoption on wellbeing and that potential effects of oil-palm on wellbeing, gender equity, and maternal and child nutrition should be considered by policy makers when making land use decisions.

Keywords: Palm Oil; Swidden; Indonesia; Time use; Gender; Forests

1. Introduction

Despite decades of research, there remains no consensus over the social and wellbeing effects of oil palm expansion on local communities in Indonesia (Meijaard and Sheil., 2019). Oil palm expansion and adoption has been associated with increased incomes, economic growth and poverty reduction (Edwards, 2019; Qaim et al., 2020). However, recent suggests oil palm affects different dimensions of wellbeing in different ways, with a pattern of divergent outcomes dependent on pre-oil palm environmental, economic and livelihood conditions (Santika et al., 2019a; 2019b). As such, there have been calls for a more diverse range of metrics to measure the social impacts of oil palm as well as more explicit accounting for study context (Meijaard and Sheil., 2019; Santika, et al., 2019a,b; Ayompe et al., 2021; Nurhasan et al., 2020; Reiss-Woolever et al., 2021). For example, economic benefits of oil palm adoption appear to be most concentrated amongst farmers who were previously market orientated, while formerly subsistence orientated farmers may experience long-term negative (Santika, et al., 2019a,b). In addition, little is known about the effect of different oil-palm smallholder models (Nurhasan *et al.*, 2020).

Another largely unknown effect of oil palm expansion and adoption are intra-household gendered effects. Only a small proportion of studies on oil palm in Indonesia have examined the effects of oil palm adoption on wellbeing from an explicitly gendered perspective (Li, 2015). Local case studies, however, suggest that oil palm adoption may have significant effects on a wide range of determinants of intra-household inequality and women's wellbeing (Julia and White, 2012; Li, 2015; Elmhirst et al., 2015; 2017). Gendered effects of oil palm adoption include the restructuring of intra-household labour dynamics (Maharani et al., 2019; Bissonnette, 2013; Toumbourou and Dressler., 2020; Krishna et al., 2017; Kubitza et al., 2019; Chrisendo et al., 2020). While previous studies have shown how oil palm adoption changes labour participation and gender roles in on-and off-farm activities, no previous study has attempted to quantify gendered dimensions of labour allocation across all aspects of daily life. To do so requires the deployment of specialised time-use methods able to capture the complexities of concurrent activities as well as accurately record time spent in neglected categories of labour including domestic labour and caregiving, alongside rest and leisure activities.

The measurement of time use is vital in understanding hidden dimensions of intra-household labour-allocation – especially in providing evidence of the ‘invisible’ role of women's labour in agricultural livelihoods as well as the routinely underestimated burden of reproductive labour (domestic work and caregiving) (Doss et al. 2011). It also provides insights into a range of other social and wellbeing outcomes. Time use is increasingly used as a measure of women's wellbeing and empowerment (Alkire *et al.*, 2013; Williams, et al., 2016). Time allocation can also negatively affect a multitude of health and nutrition outcomes of women and their dependants (Strazdins *et al.*, 2011; Johnston *et al.*, 2015; William, et al., 2016). This study is the first to explore time allocation in the context of Indonesian oil palm using validated time use research methods. Our quantitative analysis is coupled with results from qualitative research, collected over a period of seven months, which contextualises findings and offers an understanding of the potential pathways through which households reorientate labour towards oil-palm based livelihoods. We aim to answer the following research questions:

1. How does the allocation of men and women's time differ between oil palm adopting and non-oil palm adopting households?
2. What drives patterns of time allocation in different contexts?
3. What is the subjective experience of different patterns of time allocation?

2. Background and context

2.1. Oil palm and gendered labour allocation

Investigations into the gendered effects of oil palm have been limited by the lack of publicly available gender disaggregated data –with the majority of large-scale socio-economic analyses using household, village, or even district level data (Li, 2015). Focus on the household as the unit of analysis also stems from long-history of development narratives centred around households as the productive unit (Elmhirst, 2011; Li, 2015). While majority of quantitative analysis has analysed oil palm at the household level, a number of case studies suggest that oil palm adoption may have adverse effects on intra-household inequality, land-ownership and women's wellbeing (Julia and White, 2012; Li, 2015; Elmhirst et al., 2015; 2017).

Multiple studies from Indonesia have examined the impact of oil palm on gendered time and labour allocation in a range of oil-palm contexts and models. One set of studies has focused on oil palm adoption amongst cash crop farmers in Sumatra, using econometric approaches applied to panel survey data (Kubitza et al., 2019; 2018; Chrisendo et al., 2020). Among former cash crop farmers in Sumatra adopting oil palm as independent smallholders, oil palm reduced on-farm labour-time for both men and women, but resulted in increased participation in off-farm labour only for men (Chrisendo et al., 2020). Men's increased participation in off-farm work is presumed to be derived from the relative labour-efficiency (labour-time per ha of land) of oil palm compared to rubber, which frees-up time for off-farm work (or oil palm expansion). Indeed, these two mechanisms are main pathways by which independent smallholder oil-palm increases income among independent smallholders (Euler et al., 2015). No comparable effect was found for women, perhaps attributable to social and cultural norms restricting access to off-farm labour for women.

In contrast to studies among former market-orientated rubber farmers in Sumatra, studies of oil palm adoption among subsistence farmers in Kalimantan suggest that oil-palm livelihoods may increase the overall burden of productive labour as households continue to manage diverse portfolio livelihoods (Julia and White, 2012; Bissonnette, 2013; Li, 2015; Elmhirst et al., 2016; Maharani et al., 2019; Toumbourou and Dressler, 2020). As subsistence farmers adopt oil palm, many subsistence farmers continue to self-produce the majority of their household's food – at least in the short term (Orth, 2007; Fortin, 2011; Dove, 2011; Li, 2015; Elmhirst et al., 2016; 2017; Jelsma et al., 2017; Toumbourou and Dressler, 2020). Qualitative accounts in this context have shown a transition towards men becoming the primary source of household income, with women taking increasing responsibility for food production (Maharani et al., 2019; Fortin, 2011; Julia and White, 2012; Li, 2015; Toumbourou and Dressler, 2020).

2.2. Socio-economic, Ecological, and Political Context

Situating research within the context of local agrarian and landscape transitions is vital to parse the contexts in which oil palm adoption and expansion may yield positive impacts from those where the impact may be negative (Tyson et al., 2018; Santika, et al., 2019a,b; Nurhasan et al., 2020). The term smallholder covers a vast array of different oil-palm models. However, both official statistics, and a sizable fraction of research studies, report smallholder oil palm as a single entity (Jelsma et al., 2017; Schoneveld et al., 2019; Purwanto et al., 2020). Different oil palm models likely result in different social and economic outcomes, though lack of standardised methods, indicators and definitions has meant that few comparative research attempts have been made (Hidayat et al., 2015; Schoneveld et al., 2019). Likewise, local livelihoods prior to oil palm adoption (such as market integration, degree of commercialisation) influence the impacts of oil palm adoption Santika, et al., 2019a,b), as do regional economic, ecological and policy contexts (including local history of plantation agriculture and market infrastructure) as well as spill-over effects from nearby oil-palm activity (Bissonnette et al., 2017).

2.2.1. Smallholder Models in Indonesia

Smallholder production accounts for 42% of area planted with oil palm and 35% of crude palm oil production in Indonesia (BPS 2013). It is also the fastest growing sector of the Indonesian oil palm Industry, estimated to reach 60% of plantation area by 2020 (Saragih, 2017). Smallholders lie on a continuum between farmers fully tied to corporate plantations as participants in smallholder plasma schemes to fully independent smallholders (IFC, 2013; Daemeter, 2015; Zen et al., 2018; Naylor et al., 2019). Independent smallholders are farmers who sell palm fresh fruit bunches (FFBs) grown on their own land to mills in the absence of formal partnerships or ties. However, for a great many independent smallholders informal ties and networks of middlemen mediate relationships between farmers and mills (Jelsma et al., 2017; Naylor et al., 2019). Independent smallholders may be former participants in smallholder schemes or local farmers who independently adopted oil palm who sell oil directly to mills. However, legal ambiguity and lack of clear definitions can result in an array of medium and large-scale farmers, city investors, proxy owners also being classified as smallholder farmers. Only two studies have used primary survey data methods to estimate oil-palm smallholder heterogeneity among independent smallholder farmers (Jelsma et al., 2017; Schoneveld et al., 2019). While in different contexts, both studies highlight the degree to independent smallholders are dominated by local elites, wealthy outside investors and entrepreneurs. Indeed, many so-called independent smallholders “*neither fit the legal nor popular definition of ‘smallholders’*” (Jelsma et al., 2017).

While independent smallholders (theoretically at least) sell FFBs directly to mills, participants in smallholder plasma schemes are tied to corporate plantations. Since their inception in the late 1970s, smallholder schemes have undergone several stages of evolution, with varying levels of state vs private sector control, financing mechanisms, and revenue sharing arrangements (IFC, 2013; Daemeter, 2015; Zen et al., 2018). All schemes, however, share certain common characteristics; they consist of a core company plantation “*inti*” surrounded by a collection of small parcels of smallholder oil palm “*plasma*” land. Plasma schemes can be categorised into two main groups. The oldest type of model, known as PIR (*Perkebunan Inti Rakyat*), are out-grower schemes where smallholders farm their own oil-

palm land (typically 2ha) and is intimately connected to transmigration schemes (although also present in local communities). Financing and technical assistance is provided by the company, who buy FFPs from smallholders at set prices after deducting for loan repayments, input and other assistance.

Over time out-grower models have become increasingly less generous, and since the 1990s they have been largely replaced by partnership models (Zen et al., 2018). In partnership models, land is pooled with other farmers into a larger plantation managed by the company. Farmers then receive a share of profits which are derived from the area of land that they have leased to the company. While there have been numerous iterations of this type of scheme the KKPA (*Kredit Koperasi Primer Anggota*) has become the dominant model since the 1990s, whereby the partnership arrangement is mediated through village cooperatives. Plasma plots – which in effect operate like shares in a company plantation – are frequently sold and resold, either to wealthier local smallholders, outside investors or back to the company (Cramb et al., 2016; Naylor et al., 2019) and many so-called independent smallholders may simultaneously own plasma plots, even if they themselves have never participated in plasma schemes (Schoneveld et al., 2019).

2.2.2. Smallholder Oil Palm in West Kalimantan

Different oil palm models are not evenly distributed with different types of models clustering in different islands, provinces and districts¹, reflecting the periods in which oil palm was first developed as well as local economic and geographical conditions. Precise data on the extent of different smallholder models in West Kalimantan is not available. Official data, which combines independent and plasma models, suggest that smallholder oil palm is increasing throughout Kalimantan. For example, 57% of planted oil palm area between 2005 and 2015 was classified as smallholder lands² (Schoneveld et al., 2019). However, smallholder oil palm is still relatively underdeveloped in Kalimantan relative to Sumatra, with around half of planted oil palm area being occupied by smallholders in Sumatra but around one quarter in Kalimantan (Purwanto et al., 2020). Different oil palm models are also unevenly geographically distributed throughout West Kalimantan, reflecting local histories of oil palm development, infrastructure development, transmigration and political and social opposition. In areas with more recent oil palm expansion, such as Kapuas Hulu Regency, oil palm expansion continues to be driven by the expansion of company oil palm, with less than 10% of oil palm area occupied by smallholders (Purwanto et al., 2020).

The expansion of corporate plantations is accompanied by the growth of plasma schemes. (Hasudungan, 2018; Hasudungan et al., 2020). Legally, since 2007, all corporate oil palm development have had to include local landowners in smallholder plasma schemes³ and many provinces and districts have similar laws (Potter, 2016; Jong, 2020a,b). Within plasma schemes, there is a general trend away from out-grower models towards company managed models (Gillespie, 2016; Hasudungan, 2018). This is true not only for new plantations but

¹ For example, independent smallholders are prevalent many provinces of Sumatra where smallholders oil palm schemes have existed since the 1970s. Independent smallholders in this context may consist of ex-smallholder scheme participants, or commercialised rubber farmers adopting oil palm independently but benefiting from spill-over effects of local oil-palm processing (Euler et al., 2016; Jelsma et al., 2017)..

² As discussed in section 2.2.1, definitions of independent smallholders are ambiguous and include a wide range of medium and large farmers, absentee farmers and out-side investors. Survey data from Central and West Kalimantan suggests that independent oil palm is dominated by local elites and entrepreneurs (both migrant and local) who often lack prior experience of cultivating oil palm, but nevertheless own large plots, farmed often in absentia (Schoneveld et al., 2019). Additionally, although many independent smallholders own multiple plasma plots, few are themselves former plasma scheme participants but instead acquired plasma plots through purchasing them from plasma scheme participants who abandoned oil palm (Schoneveld et al., 2019).

³ At time of writing, changes to this law are being attempted but are still held up in disputes in court. However, even if national law changes, many province and district governments have similar requirements.

also of existing NES out-grower schemes as many companies have applied incentives and coercion to convert towards shareholder models (Dove, 2011; Potter, 2011; Gillespie, 2016; Hasudungan, 2018).

2.2.3. Swidden – Oil Palm Transitions in Kapuas Hulu

Oil palm expansion in Kapuas Hulu cannot be separated from broader transitions in swidden agricultural production. Like similar swidden transitions across South-East Asia, swidden transitions in Kapuas Hulu are influenced by a combination of demographic, market and governance forces (Padoch et al., 2007; Fox et al., 2009). Swidden transitions often share certain characteristics such as the intensification of agriculture, a move from collective to individual land tenure, relocation of cultivation to less upland areas, changes in crops cultivated, market integration, official banning and/or controlling of traditional practices, and restricted land access (Dressler et al., 2016). These transitions often result in shorter fallow times, replacement of swidden with permanent perennial crops and/or annual monocrops, loss of customary land tenure and the enclosure of former swidden land either by expanding plantations or conservation programmes (Mertz et al., 2009; Dressler et al., 2018).

Swidden transitions in Kalimantan pre-date the arrival of oil palm. Traditional Dayak economies are diverse and dynamic, shifting the allocation of resources (land and labour) year-by-year in response to household demands, market fluctuations and land availability (Dove, 1981, 1983; Colfer et al., 2015, 2016). The dynamism of traditional swidden systems has allowed communities to respond to economic opportunities and price (Purwanto, 2018), economic shocks (Wadley and Mertz, 2005), population pressure (Padoch et al., 1998), as well as to political coercion and incentives (Wadley, 2007; Thaler and Anandi, 2017). Changes may also be temporary as communities adapt to the emergence (and subsequent declines) of economic opportunities such logging (Wadley and Eilenberg, 2005; Heri et al., 2010; Purwanto, 2018), agarwood collection (Paoli et al., 2001) and artisanal mining (Shantiko et al., 2013).

Pre-oil palm swidden transitions differ from oil-palm drive swidden transitions in the degree to which changes are irreversible. In Indonesia, oil palm planting cannot legally take place within a village boundary without the consent of local communities. The nature of village consent is highly complex, gendered and consists of asymmetrical power relationships⁴. In consenting to oil palm development communities, whether knowingly or not, give up claim to customary ownership of land on which swidden cultivation depends (Clerc et al., 2012; Rietberg et al., 2018). In addition, abandoning swidden fields and traditional regeneration cycles, reduces the ecological adaptations of swidden agriculture for the landscape leading to reduced soil fertility and ecosystem regulation of pests and increased dependence on chemical inputs (Labrière et al., 2015a,b ; Imang et al., 2018). Swidden transitions may also be more gradual driven by households reorientating labour towards oil palm and finding traditional swidden production incompatible with the labour demands of oil palm livelihoods (Maharani et al., 2019).

2.3. Study approach

This study formed part of a wider investigation into the effects of oil palm on diets and nutrition funded by the Drivers of Food Choice Competitive Grants Programme (DFC) and led by the Center for International Forestry Research (CIFOR) (Purwestri et al., 2019; DFC,

⁴ Power relationships are asymmetrical both between companies and communities but also between community elites and other member of the community (Prabowo et al., 2017; Hasudungan and Neilson, 2020). Several studies have shown that local male elites dominate negotiations on behalf of all village residents (Semedi et al., 2014; Elmhirst et al., 2015; de Vos, 2016) with said elites often receiving substantial rewards to persuade others to drop their opposition to oil palm (Yuliani et al., 2020).

2020). The study aimed to compare diets and nutrition of smallholder oil palm farmers (participants in smallholder plasma schemes) in villages with wide-spread adoption of oil palm with the livelihoods of predominantly subsistent swidden farmers who had not adopted oil palm in villages non-oil palm adopting villages. We refer to these sites as Oil Palm (OP) sites and swidden sites. We do not pretend that swidden villages exactly represent the pre-oil palm state in the oil palm villages. However, included villages were selected carefully from an extensive list of possible villages based on preliminary qualitative research. Selected oil palm and swidden village share similar common historical similarities and have subsequently diverged in different ways. Thus, the swidden villages in this study represent a possible alternative trajectory to oil palm adoption.

Any cross-sectional study design based upon a comparison of oil palm and non-oil-palm adopting households raises the issue of potential endogeneity. It is possible that there may be inherent differences in villages which make them more or less likely to adopt oil palm which may also influence the allocation of time. The need for longitudinal studies to obviate this inherent weakness of cross-sectional designs and is discussed in section 4.6. However, in the absence of longitudinal data, we opted for this comparative approach (comparing households in oil-palm specialist villages with households non-oil palm adopting villages) as it reflects the way in which oil palm is adopted by plasma communities. For plasma agreements, consent being granted by village authorities on behalf of village residents and dividends, compensation and other forms of payments are collectively bargained (Andrianto et al., 2019; Yuliani et al., 2020). Additionally, this approach avoids the issue of survivorship bias inherent in other cross-sectional approaches – as households who abandoned oil palm subsequently adoption included while successful oil-palm farmers are not over-represented in the sample. Further justification for this is approach, combined with potential sources of endogeneity are discussed in more detail in Appendix E.

2.4. Selection of study villages

The selection of study villages was carried out based on extensive preliminary research using a combination of existing publicly available data, consultation with knowledgeable experts and boundary partners and qualitative research. The objective was to find oil palm and non-oil palm adopting villages which shared similar historical livelihoods at a baseline time prior to oil palm development in the region (i.e., before the 2000s). Several criteria were used for identifying candidate villages for inclusion in the study. All candidate villages were required at the baseline period to have (1) indigenous Dayak communities, (2) forest-based agricultural and forest-based livelihoods; (3) comparable access to market and infrastructure. A list of potential villages were selected from all villages within Kapuas Hulu Regency using expert consultation and public data. Focus groups were then carried out in each of the potential villages focusing on historical (pre year 2000) livelihoods, demographics, economic conditions. The final sample consisted of 13 oil palm and 13 non-oil palm villages. In all selected villages, food production was produced via subsistence agriculture primarily slash-and-burn rotational swidden rice cultivation. Livelihoods at the baseline period consisted of swidden agriculture combined with forest-based activities (hunting, fishing, collection of other NTFPs) as well as small-scale rubber agroforestry. No villages with extensive participation in logging or mining activities were included. Land tenure in all villages was historically based upon customary land ownership. In addition to these inclusion requirements, oil palm villages were required to have extensive community wide participation in oil palm plasma schemes. Only one publicly available dataset is available for the study villages at a time period prior to our historical baseline (BPS, 1996). While

indicators are broad, this data supports our premise that oil palm and swidden villages were broadly similar prior to the arrival of oil palm (Table A 6).

2.5. Respondent selection and data

As the primary study was focused on maternal and child nutrition, participants were households with mothers between the ages of 12-months and 5 years. In the swidden site, respondents were randomly selected from eligible candidates using a list of village residents meeting inclusion criteria provided by the local health service posts. In the OP site, the same selection process was applied with the additional criteria that respondent households had to be a participant in an oil-palm plasma scheme. Our survey was a resurvey of a subset of the respondents, with an added survey of the husbands. Selection of women was done randomly from the original survey list. Women's availability was high and there was unlikely to be any systematic bias in women's availability. In contrast however, recruitment of men was more difficult. Men who worked extremely long hours were less likely to be available for surveys as were men who worked as temporary migrant labourers.

2.5.1. Study Timing and Seasonality

Both qualitative and quantitative data was collected simultaneously over the course of seven months between January and August 2018. In Kapuas Hulu, swidden cycles generally consist of harvesting between February and March, land clearing and planting around July and August and planting around August and September (Table A 1). Due to resource constraints, it was not possible to constrain the survey to a single season and obtain a sufficiently large sample. To reduce the risk of seasonal bias, surveys were conducted alternately in oil palm and forest villages. No surveys were carried out with households during labour peaks in the swidden cycle (harvests, planting, burning seasons) or during religious or cultural festivities. However, a control was included in the analysis if other villagers were engaged in these activities. The lack of seasonal data is a limitation of this research (discussed in section 4.6). However, the data captured represents a reasonable approximation of household activities outside of periods of peak labour demand.

2.5.2. Quantitative data collection

A time use questionnaire was developed consisting of both a quantitative time use recall survey and related time use questions. The time use survey module was added to an existing socio-economic and livelihoods survey administered to the male household head and an existing questionnaire focused on diets and food environments given to their spouse. In total, the time use module was carried out with a sample of 295 men and 336 women. Formative research in the sites indicated that only Sundays were taken off from formal work, and that routines were similar on the other six days. As the survey asked about activities in the preceding 24-hours, surveys were not administered on Mondays.

We adapted a 24-hour recall time use survey validated for a wide range of rural agricultural contexts as part of the Women's Empowerment in Agriculture Index (WEAI) (Alkire et al., 2013) with locally relevant activities included such as hunting, fishing, and collecting NTFPs as well as a free text option for 'other' activity. The survey records up to two concurrent activities for each 15-minute block of time in the preceding day, with enumerators classifying activities as primary or secondary. Primary activities are the activities which were the objective of the time-block while secondary activities are those which were done concurrently with the primary activity. The inclusion of secondary activities is important as significant burdens of labour – especially reproductive labour such as childcare – can be missed when this is not considered. The time use survey was administered separately for men

and women as part of a wider questionnaire by trained local enumerators. To reduce recall bias, enumerators used the Day Reconstruction Method (Kahneman et al., 2004), to first outline the major events in the respondents' previous day.

Following enumerator training, a pre-pilot test was conducted using cognitive interviews to improve question phrasing and technique. In addition, we validated the time-use recall survey with a small sample of participant "follows" with women in the swidden site to check recall accuracy and recall bias. Enumerators accompanied women from early morning until before women went to bed, with a different enumerator conducting the recall survey the following day. Despite a small sample size, the validation indicated good overall recall accuracy using relatively broad activity categories, and no systematic under or over reporting of any category.

2.5.3. Qualitative data collection

Focus group discussion covered a wide range of topics including agricultural practices, forest use, land use and land use change, time allocation, household decision making. The time allocation and household decision making component focused on the subjective experience of time allocation and household approaches to managing time and making time related decisions. Women-only focus groups were carried out in each of the 26 study villages. Focus groups consisted of between 10-12 women and covered a broad spectrum of different ages and primary livelihood activities. Focus groups with women had an emphasis on time allocation and labour including many aspects of reproductive labour such as food acquisition, cooking, childcare and other domestic activities. Mixed-gender and male-only focus groups were carried out in 10 villages, split evenly between the forest and OP sites, focusing on recent histories of economic, agrarian and land use change.

In addition to focus groups, we conducted key-informant interviews with 42 men and 29 women using semi-structured interview guides. Key informant interviews with women were split between general interviews focusing on women's livelihoods and time allocation and more detailed interviews focusing on reproductive labour.

2.6. Methods

2.6.1. Quantitative analysis

Rather than modelling absolute times spent in different activities, we elected to model the share of times allocated to activities. This approach is preferable to modelling absolute times as it reflects the inherent trade-offs between activities. We tailored a Fractional Multinomial Logit (FML) model developed by (Mullahy, 2015) and used by Picchioni et al. (2020) in the context of time-use studies with co-variables relevant to the local context. The methodology allows for the calculation of marginal effects that can be interpreted as trade-offs between time allocated in activities, keeping the daily allocation of time constrained to 24-hour in a day. The econometric specification is:

$$\begin{cases} y_t^o = \beta_0 + \beta_1 \mathbf{OIL_PALM} \times \mathbf{SEX} + \beta_2 \mathbf{IND} + \beta_3 \mathbf{HH} + \beta_4 \mathbf{CONTROLS} + \varepsilon \\ y_t^a = \beta_0 + \beta_1 \mathbf{OIL_PALM} \times \mathbf{SEX} + \beta_2 \mathbf{IND} + \beta_3 \mathbf{HH} + \beta_4 \mathbf{CONTROLS} + \varepsilon \\ y_t^r = \beta_0 + \beta_1 \mathbf{OIL_PALM} \times \mathbf{SEX} + \beta_2 \mathbf{IND} + \beta_3 \mathbf{HH} + \beta_4 \mathbf{CONTROLS} + \varepsilon \\ y_t^p = \beta_0 + \beta_1 \mathbf{OIL_PALM} \times \mathbf{SEX} + \beta_2 \mathbf{IND} + \beta_3 \mathbf{HH} + \beta_4 \mathbf{CONTROLS} + \varepsilon \end{cases} \quad (1)$$

Where y_t represents the ratios of time allocated in a day in off-farm activities, agriculture and forest work, reproductive work and leisure activities ($y_t^o = \frac{t_o}{1440}$, $y_t^a = \frac{t_a}{1440}$, $y_t^r = \frac{t_r}{1440}$, and $y_t^p = \frac{t_p}{1440}$ respectively, being the sum of time spent in the different activities (t_o, t_a, t_r, t_p))

equals to 1440 minutes (24 hours)). As our primary outcome of interest is the share of time spent in different activities, we weighted secondary activities and primary activities. In time blocks with both a primary and secondary activity, the primary activity was allocated 80% of the time (12 minutes) and the secondary activity was allocated 20% of the time (3 minutes). A sensitivity analysis was conducted to compare different proportions (Appendix B).

Off-farm activities (t_o) are defined as all income generating activities which do not take place on the respondents' household farm, for which they receive financial remuneration. While this category consists primarily of waged agricultural labour (both oil palm and non-oil palm), it also includes non-agricultural salaried positions (e.g., teachers, civil servants, corporate office jobs) as well as independent and household business activities (e.g. shops or handicrafts). Agricultural and forest-based activities (t_a) is defined as time spent in labour relating to a household's farm production – whether for self-consumption or for sale – and includes both swidden agriculture and cash crops such as rubber or pepper. This category also includes all collection of forest products including non-timber forest productions (NTFPs) such as wild edible foods both for own-consumption and sale. Reproductive labour (t_r) includes domestic labour in the home (cooking, cleaning, household chores) and outside the home (food shopping) as well as caregiving activities. Finally, leisure and personal time (t_p) is time engaged in recreational and leisure activities as well as time taken for personal care (e.g., washing, personal hygiene). Based upon standard methodology from the International Classification of Activities for Time-Use Statistics (ICATUS)(UNSD, 2016) we include time travelling to an activity within time allocated to that activity.

Our focus in the estimation of (1), is on the vector ***OIL_PALM*** \times ***SEX*** that includes the full factorial interactions between sex (male and female) and a dummy variable capturing whether the village is in a forest or oil-palm plasma site. The vector ***IND*** includes individual characteristics (age and education), while the household characteristics are captured in the vector ***HH***. These include household composition, wealth, and whether the spouse had wage work. Finally, control variables (vector ***CONTROL***) include farm characteristics (land size, farm diversity, use of inputs). While no surveys were conducted while households were engaged in peak-labour demand swidden activities (planting, harvesting, slash and burning) a dummy variable was included if the survey was conducted during a month when such activities are common in the swidden cycle.

The model was estimated in Stata with command FMLOGIT (Buis, 2008). The estimations control for autocorrelation among the outcome variables, heteroskedasticity, and non-linearities. Standard errors throughout are clustered at household level.

2.6.2. Qualitative Analysis

Transcripts of interviews and focus group discussions were translated from Bahasa Indonesia to English and a subset were back translated to Bahasa Indonesia to validate the translation process. Thematic analysis of qualitative data was carried out in NVivo 12 using a combination of deductive and inductive approaches (Braun et al., 2006). Development of themes followed a multi-phase process as described by Nowell et al. (2017) beginning with codes generated from broad a priori themes relating to time allocation, intra-household allocation of time, time-saving strategies and technologies alongside with new codes added inductively from the data. The final codebook and descriptions of themes is provided in Table A 5.

3. Results

3.1. Quantitative Results

3.1.1. Household and individual characteristics

The final data set consisted of 603 individuals comprised of 200 household pairs (where data were available for both men and women from the same household) as well as 65 individual men and 138 individual women. Individuals in the swidden site made up 45.4% of the sample with the remaining 54.4% coming from the OP site. In the swidden site, participants were predominantly female (58%) while in the OP site, males and females were equally represented. The descriptive statistics of the households are reported in Table 1. While we do not observe differences in the land endowments, households in the OP sites are wealthier and tend to be smaller, with fewer younger and older members. Table 2 shows the individual characteristics of the respondents. On average, women in the OP site were younger than women in the swidden site and significantly better educated.

[TABLE 1 ABOUT HERE]

3.1.2. Time use

Mean shares of time for each group are reported in Table 3. Shares of time are the proportion of a respondent's time engaged in a particular activity over a day (24 hours, 1440 minutes) and can range from 0 (no time spent in activity) to 1 (all the respondent's time spent in activity). On average, men spent most of their awake time in productive activities. While in forest areas the work was predominantly on their own farm or collecting of forest products; in oil-palm areas, wage work took on average 30 per cent of their time (equal to more than seven hours a day). Men's time in reproductive work, leisure and sleeping was similar in the two sites. This contrasts with the pattern of time use of women. On average, women in the oil palm sector worked two hours more than those in the swidden sites and spent 72 minutes less on leisure and personal activities and had 45 minutes less of sleep.

[TABLE 2 AND TABLE 3 ABOUT HERE]

3.2. Regression Results

Regression marginal effects are reported in Figure 1. Marginal effects of covariates on time shares in activities are reported in

Table A 2. The significance level of the trade-offs by sex (within) and areas (between) of predicted shares of time spent in different activities are reported in Table 4. Both men and women in the OP site spent less time in agricultural and forest activities and significantly more time in off-farm labour compared with the swidden site. However, the reduction in the share of time spent in agricultural and forest-based activities was greater for men than for women. Women spent 12% more time than men in reproductive work, without any significant difference between sites.

The different pattern of activities between each site reflects the substitution of activities in the oil-palm and swidden site. In non-oil palm areas, the additional time women engage in reproductive work is compensated by a lower amount of off-farm work compared to men. However, in oil-palm areas, the amount of work done by women does not compensate for the entire difference and less time is available for leisure and personal activities and sleep

compared to men. Compared with the swidden site, both men and women allocate more of their time to wage work and less of their time to agricultural production. However, for women the additional time that women spend in wage work in oil-palm areas is associated with a reduction of personal and leisure time.

[FIGURE 1 AROUND HERE]

[TABLE 4 AROUND HERE]

3.3. Qualitative Results

Focus groups and key informant interviews revealed clear differences in the experience of time allocation, time pressure, trade-offs and coping strategies. Table 5 summarizes the key differences between sites, while themes are illustrated by additional quotes in Table A 4. Major themes were classified into broad groups including the subjective experience of time allocation, causes of trade-offs in time allocation, managing trade-offs in time allocation, labour-saving efficiencies, coping strategies for time pressure and efficiency and consequences of time patterns of time allocation.

3.3.1. Subjective experience of time

"The [breaks] are not enough, because I come home from work at 2. There is a bit of rest, sometimes, but 3 o'clock, it must be food preparation, looking for clean water to drink." (OP_KI_F_V10)

"In the evening working too, working the evening. If you rest when you are tired, it is impossible. We are pushed for time. If you are resting the work is not continuing. (OP_KI_F_V9)"

Both men and women reported more severe time pressure in the OP site, compared with the swidden site, though the experience of time pressure differed with men reporting physical exhaustion from oil-palm labour but women reporting stress and tiredness due to managing competing demands on their time. The periodicity of time pressure differed between sites. Unlike the OP site, where time pressure was seen as persistent, time pressure in the swidden site was cyclical, with periods of intense labour almost always followed by periods of low labour combined with rest and recuperation.

"Even on Sundays we sometimes go to the fields. There is no rest..." (OP_KI_F_V9)

A key emergent theme was the importance of breaks and socialising. Women in the OP site took only one short rest period between returning from the plantation and going out to household fields. During official breaks in plantation labour, women returned home (often against the instructions of supervisors) to begin cooking and carrying out other domestic duties. Women also forwent leisure time the evenings to begin preparation of breakfast so that men could wake up and immediately eat before going to work. The contrast with the swidden site is clear. In the latter, women and men spend much of the day together and both take breaks between activities and periodic rests during work.

"By the evening we are already tired. We are already sleepy. We do not have energy [to socialise] and need to wake up in the morning" (OP_KI_F_V12)

3.3.2. Trade-Offs in Time Allocation and Coping strategies

Respondents in focus groups and key informant interviews were asked to free list trade-offs in time and labour allocation. Trade-offs were defined as conflicts between activities such that more time spent on one activity meant less time spent on another. Trade-offs identified

were collated and categorised into broad themes. The most common type of trade-off identified by both men and women in both sites concerned trade-offs between time spent in income production and food production. Women in both sites also identified several trade-offs between time spent in productive labour and reproductive duties.

Income producing and food producing activities:

"Finding land is not yet a difficulty. For us, the only difficulty is finding time" (OP_KI_F_5)

Respondents in both the swidden site and the OP site identified trade-offs in time allocation between food-producing and income generating activities. An emergent theme from discussions was the degree of flexibility or inflexibility of income generating activities. In the swidden site, time spent in income generating activities could be increased or decreased in response to short-term household needs and seasonal swidden cycles. While access to off-farm waged labour was limited, income could always be obtained by allocating more time to rubber collection or the collection and sale of NTFPs⁵. Likewise, both these activities could be reduced or paused without consequences such as reduced yields or losing a job⁶. In contrast, the primary source of income in the OP site, waged plantation labour, required fixed shifts of 4-7 hours per day, six days a week, at set time of the day. Rubber cultivation was seen as incompatible with oil palm labour both for the time it required to collect and due to conflicting schedules⁷. As a result, households switched from rubber to pepper cultivation. Other income generating activities such as hunting or collecting NTFPs were also considered too time consuming to be compatible with oil palm labour.

"It [fields] used to be far because we walked. Now it feels close for us because we use a motorbike. Now people think they don't want to have a field far away because it takes time. Now people think, because they are busy working, they will farm closer to their homes so they are easy to maintain, easy to monitor" (OP_KI_FGD_V5)"

Respondents in the OP site also cited conflicts between traditional swidden agriculture and plantation labour. Most respondents felt unable to abandon food crop production and rely solely on income from oil palm labour. However, swidden was considered too time consuming – primarily because of the time necessary to travel to and from fields located far from the village – but also due to seasonal labour requirements around harvest season and land-clearing and burning seasons. Management of this conflict was achieved through reducing time spent in food crop production by making changes to rice production. By relocating fields away from steep slopes to more accessible locations close to village or roads, households were able to reducing time spent walking to and from rice fields. This also meant that motorbikes could be used to access fields quickly as well as transport heavy goods. In some villages, swidden cycles had been lost entirely, with households switching to permanent rice fields in naturally occurring hollows which flooded during the rainy season. This transition reduced the labour required annually to prepare fallows for planting by cutting, clearing and burning. Not all households had abandoned swidden cycles altogether; many households simply reduced the frequency of field rotation and reduced the length of fallow periods.

"For example, if we do it manually, traditionally, it takes one month. But now we use herbicides, with that it is much faster, for example, 2 weeks becomes two days" (OP_KI_M_V9)

⁵ Yields of rubber are not limited to the area of rubber land gardens owned by households due to a well-established and standardised system of profit sharing whereby households may collect rubber on land owned by others.

⁶ Rubber yields are not reduced from less frequent harvesting.

⁷ Both activities requiring labour in the early mornings. Rubber yields were said to be greatest when temperatures were cooler.

The move away from traditional swidden systems was made possible using income from oil palm labour to purchase chemical inputs, as well as increased access, knowledge and experience using chemicals acquired from oil palm labour. Respondents frequently cited declining soil fertility and increased pests after abandoning fallow systems. Use of chemicals allowed households to overcome these barriers. Chemical inputs also, in combination with reduced fallow length, reduced the need for certain types of labour including cutting, burning and clearing land (due to younger forest regrowth), thus reducing labour required during peak swidden seasons. Income from plantation labour also enabled labour to be hired during peak periods. This practice was also common in the swidden site – but often took the form of reciprocal labour exchanges between households and kin (*kotong royong*). This practice, though common before, had died out in the OP site as it required taking off workdays in plantation labour. For daily labourers, contractual terms allowed both men and women to take unpaid time off as required. However, women were more likely than men to take this time off during peak rice labour seasons. For men, the option of hiring outside labour was seen as preferable to taking time off if daily plantation wages in were greater than the cost of hiring labour.

Productive, Reproductive and Leisure Time

Yes sometimes, if we are busy. We will skip the rest" (OP_KI_F_V8)

Women in both sites reported challenges in managing the competing demands of reproductive labour such as cooking and childcare alongside productive labour in on-farm and off-farm labour. Women in both sites reported sacrificing leisure time and sleep to meet the demands of domestic labour and caregiving. Women had similar strategies in both sites for coping with time pressure and time scarcity – but women in the OP site reported using these strategies more frequently. For example, one strategy was using evenings to cook and prepare meals for the next day. While this was seen as an occasional necessity in the swidden site, it was a daily practice for many women in the OP site.

"We wake up earlier [than husbands], around 4 we wake up, we prepare breakfast and so on for our husbands... so they will be able to directly eat breakfast and immediately go to work" (OP_KI_F_V4)

You don't have time because ... when we come home from work, we work again to take care of our husbands" (OP_KI_F_V7)

Other common strategies to cope with time scarcity were reducing the time spent acquiring and cooking food by purchasing food (mainly OP site), collecting wild foods close to a respondent's activity space (both sites), selecting quicker foods to cook (both sites) or through using faster cooking fuels (OP site only). Finally, out-sourcing of childcare to other family members such as grandparents was common – but considerably more frequent in the OP site. Some childcare was also outsourced to oil palm company employees when other family members were unavailable in formal or informal company supplied (but fee-paying) childcare.

3.3.3. Gender roles and allocation of time and labour

"Men can work in all kinds of jobs for the oil palm company because men are more able and men only work for companies. They do not need to do other work, such as taking care of household activities, farming, etc." (OP_KI_F_V7)

Men had access to a wider range of jobs in the oil palm sector, including the best paying jobs. As daily labourers, men were paid more per hour and worked longer hours than women. Both

men and women respondents cited greater knowledge and capacity with machinery as well as more physical tasks as the reason for the pay differential. The pay differential commonly cited as a reason why men preferred to worked long hours. Men had access to overtime work that women did not (such as truck drivers and security guards). It was common for men to combine plantation labour with over-time work leaving little time for other tasks during the day. As a result, women carried out most of the farming during the six-day working week.

"My husband leaves early in the morning and comes back home at night, or late afternoon. Sometimes when he works as a driver he has to work late at night. So he doesn't have time to work with me unless there is a day off. It is like this, when men are busy with their work activities, automatically the women do the farming." (OP_KI_F_V6)

While most women did not have the option to work longer hours, it was also not seen as desirable. Both men and women, cited caregiving and domestic duties as a reason why longer women could not work longer hours. In both sites, women were the primary care givers and took on the majority of reproductive labour including cooking and domestic work. Compared with the swidden site, women in the OP site took on a wider range of roles in food producing agriculture compared with women in the swidden site (Table 6).

Women were ultimately responsible for day-to-day food acquisition in both sites but men were more heavily engaged helping in the swidden site. Growing vegetables was only carried out by women in the OP site and was the most frequent reason to visit fields. Growing rice remained a joint household responsibility although men did not dedicate much time to this task during workdays, with most of men's labour in rice fields be on Sundays and holidays. Income was jointly produced by swidden household (with the exception of Agarwood and temporary migratory labour). Rubber was sold to local traders jointly by the household, often against credit for food. NTFPs (excluding Agarwood) were also sold by both men and women regardless of who collected them. In contrast, women's income in the OP site, though important for the household economy was considered supplementary to men's.

"Both [men and women] try to earn money. Only it is more for the men, the men have to earn money, but she only helps. If she can get money, it is okay. But if she can't get money then she will think - he must go earn money" (OP_KI_F_V3)

A noticeable contrast between sites was the degree to which households operated as a unit with members working alongside each other. In the swidden site (and prior to adopting oil palm in the OP site), men and women spent most of the working day time working side-by-side – first in rubber fields and then in swidden fields. In contrast, men and women in the OP site did not see each other for most of the day and worked side-by-side only on Sundays and holidays.

[TABLE 5 AROUND HERE]

[TABLE 6 AROUND HERE]

4. Discussion

Our study compares men and women's time allocation in villages where livelihoods are based upon oil palm smallholder plasma schemes (OP site) with those in villages which did not adopt oil palm but instead practice relatively traditional swidden agriculture (swidden

site). Swidden villages are not directly analogous to OP villages prior to oil palm adoption – livelihoods are likely to have diverged over time – but share common characteristics prior to oil palm expansion in the region. The main livelihoods carried out in swidden villages (forest-based swidden agriculture, rubber agroforestry and NTFP extraction) are the same livelihoods practiced in the oil palm villages prior to the adoption of oil palm (see Table A 6). Thus, the comparison in this study between groups represents an exploration of different trajectories from a shared historical baseline.

The core difference between the sites is the greater time spent in off-farm labour in the oil palm site. Both quantitative and qualitative results show substantially more time allocated to off-farm work in the oil palm site compared to the swidden site for both men and women. This increase is predominantly attributable to wage labour on oil palm plantations. In the oil palm site 89.9% of men's and 87.2% of women's time, spent in off-farm labour was spent in oil palm plantation employment. On average, men spent 4.3 hours longer in off-farm employment in the oil palm site compared with the swidden site, while women spend 4.5 hours longer. Time allocated to oil-palm labour necessitates reductions in time elsewhere. Both men and women spent substantially less time in on-farm labour in the oil palm site (with greater reductions for men than women). In addition, women time spent less time in personal and leisure activities as well as sleep. Our qualitative results illustrate how differences in gender roles between sites derive in part from the changing nature of opportunity costs of labour as well as gendered consequences of time and labour-saving adaptations employed to mitigate time-allocation trade-offs.

4.1. Income producing and food producing labour

Livelihoods among smallholder swiddening Dayaks have been described as “*dual or composite economies*” (Dove, 2011) consisting of an income generating set of activities combined with a set of unrelated food producing activities. Often seen as a transitional stage, this characteristic of Dayak smallholder livelihoods has proven remarkably resilient to market forces, cash-crop prices and economic opportunities (Höing and Radjawali, 2017). Livelihoods in the two sites in this study both resemble this characterisation. In the swidden site, the combination is primarily rubber and swidden (with some NTFP collection), while in the oil palm site the combination is plantation labour and a more sedentary form of rice cultivation. In neither the swidden nor the oil palm site specialisation in income producing activities (i.e., rubber or oil palm labour) would be sufficient to support a household. Likewise, in neither site would subsistence alone be a viable strategy.

While the dual economy strategy exists in both sites, there are essential differences in the way households optimise between income generation and food production. The swidden site, time and labour are allocated to each flexibly, according to need. This is possible because time allocated to income generation (rubber and NTFPs) can be easily increased, reduced, paused or restarted. In the OP site however, plantation labour is fixed and inflexible consisting of a minimum number of hours per day at fixed times of the day. The increased time spent in oil palm labour, combined with insufficient income to rely on oil palm alone necessitates time and labour-saving changes to agricultural production. Rubber, which is both time consuming and best collected during early mornings when oil palm labour is carried out, is replaced with pepper. Changes are also made to rice production, as swidden cultivation relocates closer to villages, and fallow lengths are shortened – reducing the need for long walks to and from fields and reducing the labour (primarily men's) required for opening new fields. Interestingly, we found little evidence that agrarian change resulted from land scarcity due to oil palm expansion. Most respondents still claimed they had access to swidden land and sufficient farmland was available. Likewise, although rubber cultivation had declined

significantly – many households still retained rubber gardens. While there may be discrepancies between perceived access and ownership of land due to the erosion of customary land rights (Clerc et al., 2012), it is clear that changes to agricultural production were driven, initially at least, not by a lack of land, but by a lack of time. While swidden land was not considered scarce, prime land close to roads and villages was in high demand and local land markets emerged to buy and sell these plots.

4.2. Time Scarcity, Reproductive Labour and Leisure Time

Relative to the swidden site, both men and women in the OP site experienced time scarcity and time pressure. For women, this time pressure resulted in women sacrificing time spent in leisure and rest. Compared with the swidden site, women in the OP site spent less time in personal and leisure activities as well as sleep. The regression results suggest that domestic labour including cooking, cleaning and childcare is relatively inelastic – i.e., it cannot be reduced to compensate for increases in time spent elsewhere. Our qualitative findings indicate that women may sacrifice rest and leisure time to maintain their ability to care for children and carry out other domestic duties. One striking example is women returning home during breaks in plantation labour (often against the instruction of supervisors) to begin cooking mid-day meals. Women in the OP site were also more likely to go to bed after their husbands, sacrificing sleep and leisure time to prepare breakfast so men could quickly eat before plantation work the next morning.

4.3. Gender Roles and Household Gender Dynamics

The two sites displayed different patterns in the allocation of time and labour. Compared with the swidden site, women in the OP site took on a greater share of responsibility for household food production. This is reflected both in the relative shares of time spent in own-production for men and women, as well as the wider range of roles carried out in own-production. Likewise, compared with the swidden site, men in the OP site took on a greater share of the responsibility of income production. While in absolute terms the time spent in agricultural production was reduced for men and women, in relative terms, time spent in agricultural and forest-based activities was reduced to a greater extent for men than women. Thus, it appears that men benefited more than women in terms of reducing agricultural labour and benefited the most from labour-saving efficiencies.

4.4. Household-Decision Making

4.4.1. Participation in off-farm labour

The underlying driver behind changes in time and labour allocation was differences in participation in off-farm labour. Participation in off-farm labour in the swidden site was limited by lack of opportunities. Obtaining regular salaried off-farm work generally requires migrating, at least temporally away from forest villages. In contrast, in the OP site, both men and women had access to ample opportunities for off-farm work in the form of waged plantation labour, with men also having access to numerous other sources of supplemental off-farm work such as driving trucks and security work.

The degree of participation in plantation labour in the OP site reflects the nature of the plasma scheme model. We explicitly did not investigate contractual arrangements with oil

palm companies⁸. Nevertheless, though classified as plasma smallholder farmers, the livelihoods of respondents more closely resembled that of waged plantation labourers than smallholder farmers. Participants received almost all their income from and spent the almost all their income-generating time in waged plantation labour for oil palm companies⁹. Very few plasma participants in our survey farmed their oil palm plot. Our observation that the livelihoods of smallholder plasma scheme participants bear closer resemblance to waged plantation workers than oil-palm farmers is matched by numerous other studies amongst formerly subsistence orientated farmers in Kalimantan (Julia and White, 2012; Bissonnette, 2013; Li, 2015; Elmhirst et al., 2017; Maharani et al., 2019). Such ‘one-roof management’ systems are increasingly common in Kalimantan as companies aim to move away from inefficiencies of out-grower systems and centralise management of plantations (Zen et al., 2016; Hasudungan, 2018), enabled by legal loopholes and a government preference for direct compensation negotiations between affected communities (Gillespie, 2011; Purwanto et al., 2020).

These results highlight the fact that the mechanisms through which oil palm adoption increases participation in off-farm labour may differ by context and smallholder model. Amongst fully independent smallholders who do not engage in subsistence food production, switching from rubber to oil palm may free up time. In this context therefore, cultivating oil palm as an independent smallholder can be viewed as a “*labour-saving technology*” (Kubitza et al., 2019) which increases men’s participation (but not women’s) in off-farm labour by freeing up time from agricultural work (Chrisendo et al., 2020). However, in this context among subsistence farmers whose adoption in oil palm livelihoods is as part of smallholder plasma schemes, participation in off-farm labour is driven not by the labour-efficiency of oil-palm, but insufficiency of income generated via plasma dividends.

4.4.2. Opportunity costs of on-farm labour

Different levels of access to off-farm labour creates different opportunity costs of on-farm labour. Results from focus group discussions surrounding household priorities show that households aim to maximise income by spending as much time as possible in off-farm labour while also producing sufficient food to meet the bulk of their needs. As oil palm labour was more profitable than competing income generating activities households aimed to maximise time spent in this activity by reducing time spent in on-farm labour.

The opportunity costs of on-farm labour however are different for men than women. In the OP site men are paid at a higher rate, are offered more hours and have access to more types of off-farm labour than women. Similar gendered pay disparities have been found in multiple other accounts of oil palm labour (Julia and White, 2012; Bissonnette, 2013; Li, 2015; Elmhirst et al., 2015; 2017). As a result, households aim to maximise men’s time in plantation labour in a joint-utility maximising fashion (Becker, 1965) in order to maximise household income within the constraint of producing sufficient food to feed the family. Labour-saving adaptations to swidden cultivation disproportionately reduce men’s time, as

⁸ Our study covered too many villages to conduct a detailed investigation of contractual arrangements. Sensitivity around the topic of contractual arrangements with companies was encountered during formative research. To reduce bias in results we therefore explicitly avoided this topic of research. Formative research suggested that contractual arrangements between individuals, communities as a whole and the oil palm company differed between villages. A wide-variety conflicting opinions and perspectives were heard, but ground truthing claims is extremely difficult without triangulation from multiple sources alongside long-term ethnographic investigations. Due to the large number of villages, there are likely to multiple realities for different communities and different sub-populations. Generalisations of this study as a representative of plasma transitions should not be made.

⁹ Many respondents received no income whatsoever from plasma farming despite being enrolled in plasma schemes, pointing instead to community development projects paid for by companies and or housing improvements. Only 3% of plasma farming households reported revenue from plasma dividends in their top 3 sources of household income.

well as allow women to carry out tasks formerly carried out by men. For example, men's role in transporting heavy goods is reduced through motorbike access to fields near roads, and male labour required for cutting and clearing land is lessened through reduced fallow cycle frequency and/or the use of herbicides. The effect is a shift not only in time allocation but also household gender roles.

These findings support previous qualitative studies that have shown that swidden-oil palm transitions result in changes in the gendered distribution of labour (Julia and White, 2012; Villamor et al., 2014, 2015; Li, 2015; Elmhirst et al., 2017; Maharani et al., 2019). For example, we found near identical shifts in gendered labour dynamics to (Maharani et al., 2019) who showed how changing gender dynamics were driven by labour-saving adaptations such as changes to the farming system (shortening/shipping fallow periods, relocating fields closer to roads), access to technology (use of chemical inputs, motorbikes) which reduced the need for many forms of physical labour which were previously carried out by men.

4.4.3. Intra-household dynamics

While decisions to maximise returns on men's labour appear to be made at the household level, we have little data on intra-household decision making. Women's agency in such decisions is a vital component of the process missing in our study (see section 4.6.). Decision making also occurs in context of local social and cultural norms and expectations. Women's social and cultural role in reproductive labour, especially as caregivers and cooks, was seen as immutable and a major factor in why women could not work longer hours in productive labour. Likewise, greater pay for men than women in oil palm labour was considered uncontroversial by both men and women with respondents typically cited the more physical nature of men's labour. However, men were also given nearly all the positions of less physically demanding roles as supervisors and office workers. Women were also seen as lacking the knowledge to mix chemical inputs – despite both men and women applying chemical inputs in plantation labour. It should also be noted, that contractual arrangements are usually the product of village level negotiations between local elites and companies – from which women are often excluded (Julia and White, 2012; Elmhirst et al., 2015; Yuliani et al., 2020). Thus, both levels of pay and access to work are the product of pre-existing cultural and social views on gender roles, filtered through agreements made by village elites on behalf of communities.

4.5. Time allocation, swidden transitions and agrarian change

Two main mechanisms drove changes in agricultural production; (1) the replacement of rubber cultivation with less time consuming but more capital-intensive cash crops such as pepper and (2) changes to swidden cultivation such as the relocation away from upland slopes, shortening fallow periods and reducing rotation frequency, and intensification through use of chemical inputs. Agrarian changes such as the progressive abandonment of swidden have wide-ranging consequences for the broader landscape. These changes echo swidden transitions across Southeast Asia (Dressler et al., 2016; Padoch et al., 2007; Fox et al., 2009). Several studies have identified similar transitions in Kapuas Hulu and other regions of Borneo driven first by logging (Reed Lee Wadley, 1997; Padoch et al., 1998; Carol J. P. Colfer, 2008) and then by oil palm (Mertz et al., 2013; Maharani et al., 2019). Our results closely match those of Maharani et al. (2019) who found shortening of fallows, relocation of fields closer to villages and increased use of chemical inputs in swidden-oil palm transitions. The changing gender dynamics observed in our study are simply the latest development in a long history of changing gender dynamics within swiddening communities in Kapuas Hulu. Changes in gender-dynamics seen during the logging boom share similarities with latter

changes in gender-dynamics caused by oil palm's expansion (Elmhirst et al., 2016). Colfer, (2008) documented the effects of a nascent logging industry on gender dynamics amongst swiddening Kenyah Dayaks in East Kalimantan. The parallels with this case study are striking. New off-farm labour opportunities emerged which benefited men more than women leading to men becoming seen as responsible for income generation. At the same time, new technology (such as chainsaws and outboard motors) reduced the workload for men within swidden cultivation but not for women. These changes affected not only the allocation of time and labour but also had lasting effects upon intra-household gender dynamics.

4.6. Limitations and future research

A major limitation of this research is the cross-sectional nature of the survey resulting in the potential for endogeneity bias. This can arise if there are unobserved village properties that make it more or less likely to adopt oil palm which also affect the allocation of time and labour in some way. While our best attempts were made to control for this possibility at the site selection stage (section 2.3), there may still be unknown sources of endogeneity and longitudinal studies are necessary to confirm these findings. Longitudinal studies would also be helpful in exploring the effects of seasonality. While we controlled for high-labour periods in the regression model and avoided conducting surveys during burning, planting and harvests, the lack of seasonal data is a major limitation of this study. To explore the effect of seasonality of labour on time allocation, longitudinal studies across seasons, over multiple years are needed. Similarly, future studies should pay close attention to work patterns throughout the week. As formative research indicated that Sundays were a day-of-rest we did not conduct 24-recall surveys on Mondays. Further investigation, however, reveals that in the OP site, these days off plantation work are used for men and women to work together in own production. Thus, estimates of time allocated to own production are likely to be artificially low in the OP site.

This time use study formed part of a wider investigation into maternal and child diet and nutrition. As a result, the sample was limited to mothers of small children from indigenous Dayak ethnicities and we are unable to explore intersections with numerous other characteristics such as wealth, ethnicity, age, migration and social and political capital. In the OP site, this caveat is particularly pertinent. It has been widely noted that oil palm is a “rich farmer's crop” (McCarthy 2010) – requiring substantial capital investments in seedlings and fertilizers as well as the means to wait between planting and the first harvest. Access to oil palm, therefore, often requires prior wealth or access to credit. While in theory smallholder partnership schemes are designed to overcome the technological, knowledge and capital barriers to oil palm adoption among smallholders, participation is still only available for sub-section of land-owning residents. Wealthier and more politically connected local elites often benefit disproportionately from such schemes (Yuliani et al., 2020). This likely includes access to different types of jobs which can affect the allocation of time. Poorer households are also more likely to sell their plasma stake back to the company or other residents (Li, 2015). This too can impact the allocation of time and labour. Our study also overlooks the complex reality of intergeneration dispossession of land (Elmhirst et al., 2017) as well as the reality of migrant labour upon which oil palm production depends (Pye et al., 2012; Elmhirst et al., 2015; Lindquist, 2017; Maharani et al., 2019). Future studies, with larger and more diverse samples of respondents are needed to fully explore these effects alongside the complementary qualitative research needed to interpret these findings.

Inherent in the study design are certain assumptions about how households allocated their time. By modelling shares of time allocated to different activities, the model highlights individual-level trade-offs in time allocation. The qualitative study identifies household-level

time use strategies and decision-making, but does not address the issue of how these decisions are made within the household. Further consideration of intra-household power dynamics and agency over time allocation are needed to contextualise these results. Our study also excludes other members of households such as grandparents, adult and teenage children and other kin relations; the results show that the allocation of some activities (especially childcare) to other household members is an important coping strategy for women faced with time pressure. Consideration of time allocation amongst other household members as well as wider kin relations is necessary to quantify absolute times spent in different activities. Such surveys would be necessary, for example, to explore whether oil palm affects the total time children spend in childcare.

Mixed methods are highly suited for explorations of changes in labour and time (White, 1984; Stevano et al., 2019). Our study reiterates the importance of mixed methods in studies exploring the effects of oil palm expansion in Indonesia. Mixed method research, though suited to socio-ecological investigations, is underrepresented in oil palm research globally (Reiss-Woolever et al., 2021). In our study, many aspects of time and labour transition could not be explained by either quantitative or qualitative methods alone. For example, conclusions based just on qualitative data might have under-emphasized the degree to which women's agricultural labour is lower in the OP site in absolute terms. Similarly, conclusions based only on the quantitative data would not have detected the complex set of interrelated decision-making processes nor the physical and mental stress of time pressure experienced by women. Increased use of mixed-method research could mitigate the use of over-simplistic narratives such as the 'feminisation of agriculture', 'liberation from on-farm work' or 'engagement in opportunities for off-farm labour' and instead focus on the suite of simultaneous drivers and feedback loops which determine wellbeing outcomes in contexts of rapid livelihood and landscape change.

Our study also reveals the importance of using robust time use methodologies with full-accounting 24-hour recall time use methods able to capture simultaneous activities. Without such methods it is impossible to observe the true effect on livelihood changes or the coping strategies employed to cope with time scarcity. Recent research has shown the promise of new and innovative approaches to time use research (e.g., accelerometers and GPS) (Picchioni et al., 2020; Srinivasan et al., 2020). Application of these methods in conjunction with full-accounting time use recall methods could reveal the effects of agrarian and landscape change on energy expenditure and physical exertion. Future research could also benefit from further disaggregation of time use categories – in particular, different types of waged labour and disaggregation of time spent of agricultural production time by crop type and production system.

5. Conclusion

Adopting oil-palm based livelihoods creates gendered shifts in the allocation of household time. The effects of smallholder oil palm adoption on intra-household gender dynamics and allocation of time and labour will depend not only on the model of oil palm production but also the baseline conditions and livelihoods of the adopting households. For example, among commercialised farmers in Sumatra, independently switching from rubber to oil palm reduced on-farm labour for both men and women, but increased participation in off-farm labour only for men (Chrisendo et al., 2020). However, for former subsistence farmers in Kalimantan participating in oil palm plasma schemes both men and women's participation in off-farm labour is increased, though at different rates, leading to shifts in the gendered allocation of

household labour (Julia and White, 2012; Li, 2015; Elmhirst et al., 2015; 2017; Maharani et al., 2019; Toumbourou and Dressler., 2020).

Building upon previous studies of gendered labour dynamics in oil palm adopting communities, this study uses primary data collected using robust standardised time-research methods amongst both women and men in oil palm and non-oil palm communities combined with qualitative research on men and women's experience of time as well as the causes, experience and management of trade-offs in time allocation between different activities. Our results suggest that oil palm adoption (participation in smallholder plasma schemes) amongst former swidden farmers drastically alters the intra-household allocation of time and labour. Oil palm adoption is associated with more time spent in off-farm labour for both men and women – but significantly more so for men than for women. Likewise, oil palm adoption is associated with a less time spent in agricultural and forest activities for both men and women – but significantly more so for men than for women. These findings indicate a trade-off between time spent in off-farm labour and time spent in agricultural and forest-based activities. This trade-off is corroborated by the qualitative findings which indicate that households in the oil palm site maximise time spent in off-farm labour and minimise time spent in agricultural and forest-based activities at the household level shift as much agricultural labour towards women as possible. This is achieved through a series of changes to agricultural production which interact in complex non-linear ways with broader landscape processes of land use and agrarian change.

The increased time women spend in productive labour in the oil palm comes at the cost of personal and leisure time as well as sleep. Our qualitative findings confirm that women perceived an overall scarcity of time, and that this time pressure manifests itself in the form of mental and physical stress. Time pressure may have significant effects upon maternal and child nutrition as well as subjective well-being and women's empowerment (Kadiyala, Harris and Gillespie, 2014; Johnston *et al.*, 2015; Stevano *et al.*, 2019). Further research is required to integrate time use with new and emerging measures of subjective well-being (Diener, Oishi and Tay, 2018). Investigation of these pathways is urgently needed to fully understand the welfare effects of oil palm adoption in Indonesia. At the same time, effects of time pressure on maternal and child nutrition should be explored through the lens of food acquisition and food choice behaviour and through the effect on women's energy expenditure.

Our study indicates that oil palm adoption (participation in smallholder plasma schemes) amongst formerly subsistent swidden farmers in Kalimantan may have significant implications for gender equity, well-being and maternal and child nutrition via changes in household time allocation. Similar studies using specialised time use methods but using longitudinal study designs are needed to determine whether these findings have general applicability. Our results reflect one specific context, at once specific stage of a broader landscape, agrarian and economic transition. In addition, our sample was restricted to a relatively homogeneous group of ethnically similar, indigenous land-owning households with mothers of small children. Further investigation of time use effects in different contexts and different models of oil palm adoption are needed, as well as investigations into how wealth, class, age, ethnicity, land ownership, migrant status, and education interact with labour transitions.

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Table 1: Household characteristics, by location.

	Forest (n=272)		Oil Palm (n=331)		Difference
	Mean	SD	Mean	SD	
Demographic					
Female	0.58	0.49	0.50	0.50	0.08*
Children <14yrs	2.51	1.12	2.27	1.14	0.24**
Children 14-18yrs	1.52	1.15	1.42	1.02	0.10
Adults >60yrs	0.28	0.57	0.16	0.44	0.12***
Socio-Economic					
Female employment	0.44	0.50	0.89	0.32	-0.45***
Land area	1.66	1.93	1.29	4.17	0.38
Wealth (asset index)	-0.73	1.27	0.82	1.68	-1.55***
Farming					
Hired labour (y/n)	0.75	0.43	0.65	0.48	0.10**
No rice (y/n)	0.03	0.17	0.18	0.39	-0.15***
Fertilizer on rice field (y/n)	0.00	0.07	0.20	0.41	-0.19***
Pesticide on rice field (y/n)	0.13	0.34	0.24	0.43	-0.11***
Herbicide on rice field (y/n)	0.12	0.33	0.13	0.34	-0.01
Chemical input on rice field (y/n)	0.36	0.48	0.29	0.45	0.07
Grows rubber (y/n)	0.53	0.50	0.21	0.41	0.31***
Grows pepper (y/n)	0.04	0.19	0.21	0.40	-0.17***

Notes : *** 0.1 percent significant, ** 1 percent significant, * 5 percent significant.

Table 2: Individual characteristics, by sex and location

	Men (n=281)					Women (n=322)				
	Forest (n=115)		Oil Palm (n=166)		Difference	Forest (n=157)		Oil Palm (n=165)		Difference
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age (years)	31.01	4.68	29.93	5.81	1.07	29.32	5.12	27.72	5.57	1.60*
Primary education (%)	0.49	0.50	0.67	0.47	-0.18*	0.48	0.50	0.76	0.43	-0.29***
Middle school education (%)	0.30	0.46	0.19	0.39	0.11	0.19	0.39	0.10	0.30	0.09*
High school education (%)	0.22	0.41	0.14	0.35	0.07	0.33	0.47	0.14	0.35	0.19***
High Season (%)	0.65	0.48	0.67	0.47	-0.02	0.49	0.50	0.61	0.49	-0.12

Notes : *** 0.1 percent significant, ** 1 percent significant, * 5 percent significant.

Table 3: Allocation of time use, by sex and location. Results are reported as mean shares of time.

	Men					Women				
	Forest		Oil Palm		Difference	Forest		Oil Palm		Difference
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Wage Work	0.12	0.15	0.30	0.10	-0.18***	0.06	0.10	0.25	0.11	-0.19***
Agriculture and Forest	0.20	0.14	0.05	0.07	0.15***	0.13	0.12	0.03	0.06	0.10***
Reproductive Labour	0.07	0.08	0.07	0.06	0.01	0.19	0.09	0.18	0.10	0.02
Personal and Leisure	0.26	0.08	0.25	0.07	0.01	0.26	0.08	0.21	0.05	0.05***
Sleep	0.34	0.04	0.34	0.04	0.01	0.35	0.03	0.33	0.03	0.02***

Notes : *** 0.1 percent significant, ** 1 percent significant, * 5 percent significant.

Table 4: Statistical difference of predicted shares of time spent in different activities, by sex (within) and areas (between).

	Wage Work	Agriculture and Forest	Reproductive Labour	Personal and Leisure	Sleep
Male (baseline) vs Female					
Forest	-0.07***	-0.05***	0.12***	-0.00	0.01*
Oil Palm	-0.04***	-0.02*	0.12***	-0.04***	-0.02***
Forest (baseline) vs Oil- Palm					
Male	0.10***	-0.12***	-0.00	0.01	-0.00
Female	0.13***	-0.08***	0.01	-0.03**	-0.03***

Notes : *** 0.1 percent significant, ** 1 percent significant, * 5 percent significant.

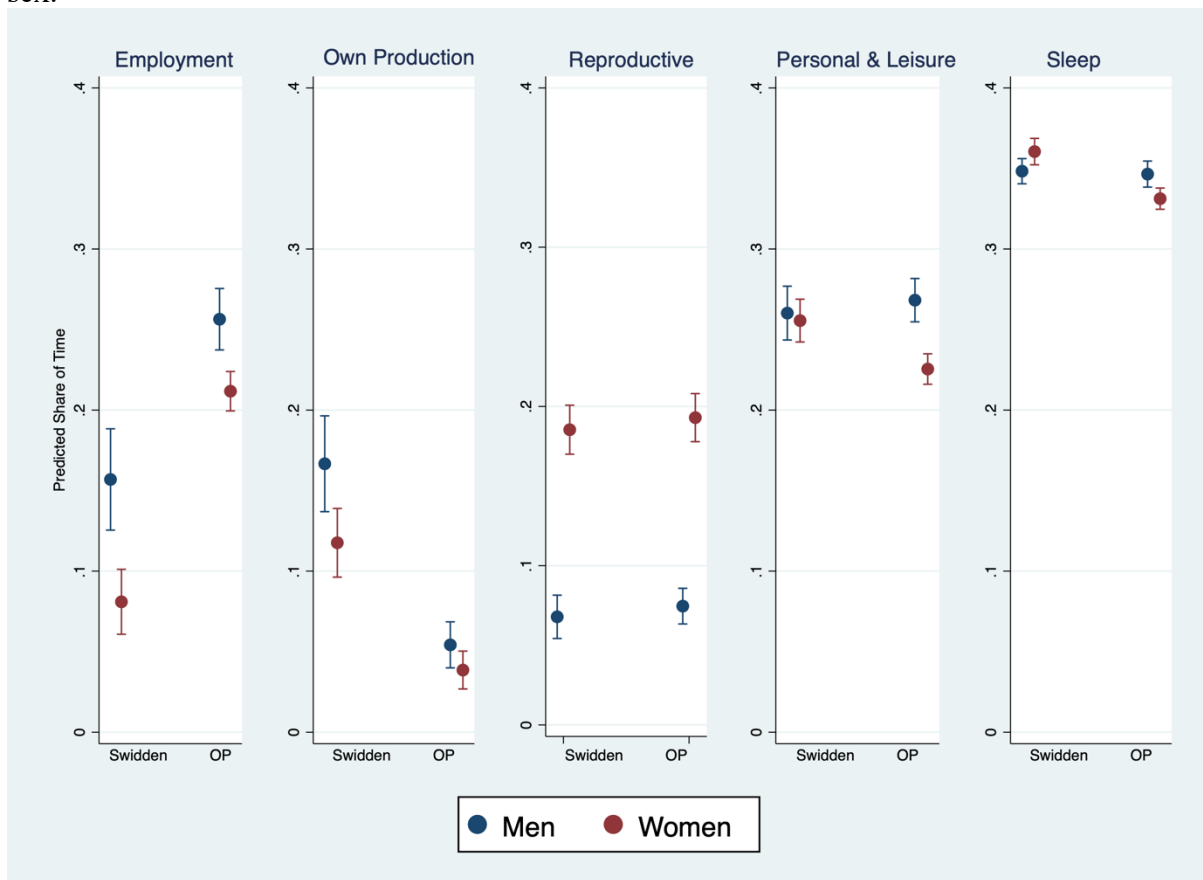
Table 5: Emergent Themes and descriptions

Theme	Oil Palm	Forest
Subjective Experience of Time Allocation		
Periodicity of time pressure	<ul style="list-style-type: none"> • Time pressure is consistent without periods or rest 	<ul style="list-style-type: none"> • Cyclical periods of intensity followed by rest periods.
Physical and mental exhaustion	<ul style="list-style-type: none"> • Men experience mainly physical exhaustion • Women experience both physical and mental exhaustion • Women report stress at managing competing demands of carrying for husband and children alongside own-production and waged labour 	<ul style="list-style-type: none"> • Time pressure is experienced as busyness not exhaustion
Social dimension of time allocation	<ul style="list-style-type: none"> • Women perceived few opportunities to socialise with other women outside of festivities and holidays Men and women do not see each other for much of the day • Women spend farming time alone or while carrying children • Socialising for men occurs at sides of road during breaks and following waged labour as well as evenings • Women's evenings are primarily filled with domestic activities such as preparing next day's breakfast. Women carry out domestic duties instead of socialising during plantation breaks. 	<ul style="list-style-type: none"> • Men and women work together all day as household unit • Socialising occurs in later afternoons and evenings • Social time may be constrained for women in evenings due to cooking and cleaning duties
Causes of trade-offs in Time Allocation		
Flexibility of income generating activities	<ul style="list-style-type: none"> • Fixed contracted hours daily • No flexibility to account for seasonal demands of swidden • Time of day required for oil palm labour conflicts with rubber production 	<ul style="list-style-type: none"> • Work outside village (e.g., Agarwood seeking, temporary oil palm labour) can be arranged around low labour demand periods of swidden agriculture • Time spent in rubber can be increased, decreased, or paused according to seasonal demands of swidden and need for household income • Time spent in rubber is not limited by area of land planted by rubber due to profit sharing arrangements
Managing Trade-Offs in Time Allocation		
Household Decision Making	<ul style="list-style-type: none"> • Aim to maximise men's time spent in income producing activities as men are paid more • Women not able to work as long due to childcare and domestic duties • Men aim to take on well-paid over-time work 	<ul style="list-style-type: none"> • Household decision making based upon short-term need • Income production can be upscaled on demand through more time spent in rubber or downscaled to allow more time for own production activities

Dual Livelihoods	<ul style="list-style-type: none"> • Income from oil palm insufficient to allow households to purchase entire family's food supply 	<ul style="list-style-type: none"> • Dual livelihoods mitigate risks through diversification
Labour-Saving Efficiencies		
Labour saving modifications to rice production	<ul style="list-style-type: none"> • Relocation of fields closer to villages and roads reduces travel time • Reduced fallow length and reusing plots in successive years reduces extent of cutting and burning trees • Use of tree poisons reduced need for cutting and burning trees • Increased use of fertilizers compensates for reduction in soil fertility from relocating and reducing swidden cycles • Use of pesticides and herbicides reduces pests and weeds and compensates for loss of natural swidden adaptations • Observed tendency for dependency on chemical inputs to increase over time 	<ul style="list-style-type: none"> • Selection of swidden site is the most important factor in determining productivity and labour demands of rice production • Use of chemicals varies by villages but when used is used sparingly. • Most likely to use chemicals on rice production are those who already purchase chemicals for cash crops such as chillies and some rubber farmers. • Application of chemicals is seen as poor value for money when same effects can be achieved through swidden rotation. Money is seen as best spent on goods and services which cannot be grown. • Some villages have experimented with but then abandoned more intensive agriculture
Crop choice	<ul style="list-style-type: none"> • Rubber not grown due to time constraints • Pepper grown instead which is more capital intensive but requires less time 	<ul style="list-style-type: none"> • Many crops are perennials which can be harvested as and when needed or available • Wild and semi-cultivated foods harvested from forests and fallows
Coping Strategies		
Activity bundling childcare with other activities	<ul style="list-style-type: none"> • Ability to carry out childcare whilst carrying out other tasks is constrained by children not being allowed on oil palm plantations • Plantations and villages and surroundings are not considered safe for children to play unsupervised or loosely supervised 	<ul style="list-style-type: none"> • Older children can play loosely supervised while carrying out agricultural work or else play freely unsupervised around the village • Younger children can be carried on slings during agricultural work
Outsourcing childcare	<ul style="list-style-type: none"> • Grandparents are preferred source of childcare while women work in plantations • If not available, mothers can leave children with company employees in informal day-care arrangements or with security guards • Payment for day-care is deducted from women's wages and women leave food with which to feed children • New mothers stay at home only if household is wealthy enough 	<ul style="list-style-type: none"> • New mothers stay at home where possible • Children are kept with mother and family members at all times • Childcare takes place alongside other tasks

Reducing time acquiring and cooking food	<ul style="list-style-type: none"> • Purchasing foods from mobile vendors • Consumption of pre-prepared foods from vendors (occasional) • Collection of wild ferns while walking to and from plantations. Wild ferns and sweet potato harvested from edges of plantations. • Selection of quicker foods to cook (vegetables, instant noodles, eggs) and reducing consumption of foods which take longer (meat) 	<ul style="list-style-type: none"> • Opportunistic collection of wild foods while collecting rubber, farming or walking to and from fields • Food acquisition as a leisure activity e.g., hunting / fishing • Selection of quicker foods to cook (vegetables, instant noodles, eggs)
Consequences		
Gendered Effects of Swidden Transition	<ul style="list-style-type: none"> • Reduced need for male labour in cutting and burning season as fewer large trees to clear • Reduced need for male labour in carrying heavy loads and harvests due to shorter distances and access via motorbike • Women able to take on some clearing work with chemical inputs • Men continue to mix chemical inputs due to better 'knowledge;' 	<ul style="list-style-type: none"> • Men and women work side-by-side but in different tasks • Women leave fields earlier than men to return home to begin cooking
Traditional Land Tenure and Labour Arrangements	<ul style="list-style-type: none"> • Transition away from customary ownership of land and emergence of land market • Reduced use of traditional reciprocal labour exchange agreements 	<ul style="list-style-type: none"> • Traditional reciprocal labour-exchange arrangements are still strong. Labour is exchanged in wide family units or more official farmers groups • Customary land tenure governed by customary inheritance rules • Former fallows closer to villages converted to rubber follow less traditional customary tenure arrangements
Gender roles in food production	<ul style="list-style-type: none"> • Women primarily responsible for day-to-day food acquisition and cooking • Day-to-day agricultural activities are vegetable gardening (women) and livestock management (men and women) • Men and women equally responsible for rice production but with different roles • Men's tasks are more physical in nature or require technical knowledge of chemicals and machinery 	<ul style="list-style-type: none"> • Women responsible for cooking but food acquisition joint enterprise • Food acquisition is gendered. Men hunt, fish and collect heavy WEPs which require carrying (e.g., palm hearts). Women engage in opportunistic collection of WEPs and collect vegetables from agriculture. • Men and women equally responsible for rice production but with different roles. • Men's roles are more physically demanding such as cutting and clearing land and carrying heavy loads

Figure 1: Predicted shares of time spent in different activities for forest and oil palm areas, by sex.



Notes: The bar plots show mean and 95% confidence intervals of time shares, predicted from the fractional multinomial logit model.

Table 6: Consensus views on gender roles from focus group discussions. x = job normally done by gender, - = not present in site, (x) = occasional but not common

		Forest		Oil-palm	
		Men	Women	Men	Women
Plantation	Operating machinery	-	-	X	
	Applying chemicals	-	-		X
	Mixing chemicals	-	-	X	
	Harvesting FFB from palms	-	-	X	
	Picking fruits from floors	-	-		X
	Loading trucks and wheelbarrows	-	-	X	
Other off-farm	Company office jobs	-	-	X	
	Oil palm mill work	-	-	x	
	Supervisor positions	-	-	X	
	Village Officials	X	X	X	(x)
	Teachers, nurses, midwives etc.		X		X
	Truck drivers	-	-	X	
Business	Local shop	X	X	X	X
	Trading and transportation	X		X	
	Skilled Trades	X		X	
	Handicrafts		X		X
Own production	Planting	X	X	X	X
	Weeding		X		X
	Harvesting (Rice)	X	X	X	X
	Harvesting (Vegetables)	X	X		X
	Applying Chemicals	-	-	(x)	x
	Building huts and shelters	X		-	-
	Clearing Land	X		X	X
	Carrying and transporting	X		X	X
Cash crop	Rubber tapping	X	X	-	-
	Pepper planting and harvesting	-	-	X	X
	Commercial vegetable gardens	X	X	-	-
	Cash crop weeding and maintenance	X	X		X
	Cash crop harvesting	X	X	X	X
Forest	Hunting	X		X	
	Fishing	X		X	
	Collecting Wild Fruits and Vegetables		X		X
	Sale of NTFPs	X		-	-

APPENDIX A: Supplementary Tables

Table A 1: Seasonal swidden calendar in Kapuas Hulu*

	January	February	March	April	May	June	July	August	September	October	November	December
Land Clearing												
Burning												
Planting												
Weeding												
Harvesting												

* Months shown are ranges during which activities may occur. Activities themselves may take only a period of weeks. Data is based on focus group discussions.

Table A 2: Marginal effects of covariates on time shares in activities.

	Wage Work	Agriculture and Forest	Reproductive Labour	Personal and Leisure	Sleep
Female	-0.067*** (0.011)	-0.026*** (0.008)	0.123*** (0.008)	-0.026*** (0.006)	-0.003 (0.004)
Oil palm	0.119*** (0.014)	-0.094*** (0.015)	0.007 (0.008)	-0.015 (0.009)	-0.016*** (0.006)
Female employment	0.135*** (0.013)	-0.018* (0.010)	-0.048*** (0.008)	-0.056*** (0.008)	-0.013*** (0.005)
Age	0.001 (0.001)	0.000 (0.001)	-0.002** (0.001)	0.000 (0.001)	0.000 (0.000)
Middle school edu.	-0.013 (0.013)	0.008 (0.011)	0.005 (0.010)	0.006 (0.009)	-0.005 (0.005)
High school edu.	-0.004 (0.012)	0.003 (0.009)	0.001 (0.009)	-0.003 (0.007)	0.003 (0.004)
High season	-0.001 (0.009)	0.004 (0.008)	0.010 (0.007)	-0.023*** (0.007)	0.009** (0.004)
Wealth (asset index)	0.002 (0.003)	-0.006** (0.003)	0.000 (0.002)	0.002 (0.002)	0.002* (0.001)
Children <14yrs	-0.003 (0.005)	0.003 (0.004)	0.003 (0.003)	-0.000 (0.003)	-0.002 (0.002)
Children 14-18yrs	-0.000 (0.005)	-0.012*** (0.004)	0.008** (0.004)	0.002 (0.003)	0.002 (0.002)
Adults >60yrs	0.006 (0.010)	0.000 (0.008)	0.004 (0.007)	-0.014** (0.006)	0.004 (0.003)
Land area (log)	0.001 (0.005)	0.005 (0.004)	-0.002 (0.003)	-0.005 (0.004)	0.001 (0.002)
Hired labour	0.005	0.008	-0.002	0.000	-0.011

	(0.013)	(0.014)	(0.011)	(0.012)	(0.007)
Fertilizer	-0.000	-0.011	0.001	0.003	0.007
	(0.015)	(0.018)	(0.013)	(0.012)	(0.008)
Pesticide	0.023	-0.017	-0.021**	0.005	0.009
	(0.014)	(0.014)	(0.010)	(0.010)	(0.006)
Herbicide	-0.010	0.008	-0.009	0.028***	-0.017***
	(0.013)	(0.010)	(0.008)	(0.007)	(0.005)
No rice	0.009	0.017	0.005	-0.018	-0.013*
	(0.013)	(0.017)	(0.011)	(0.012)	(0.008)
Grows rubber	-0.030***	0.023**	0.012	-0.006	0.001
	(0.011)	(0.010)	(0.008)	(0.008)	(0.005)
Grows pepper	-0.014	0.019	0.003	-0.008	0.000
	(0.013)	(0.019)	(0.011)	(0.010)	(0.007)
Chi-squared	1308.44***				
BIC	1748.543				
AIC	1417.883				
N	603				

Note: Fractional Multinomial Logit model. Robust standard errors clustered at household level. *** denotes statistical significance at 1% level, ** at 5% level and * at 10% level.

Appendix B: Sensitivity Analysis

Table A 3: Sensitivity analysis showing differences in ratios between weighting concurrent primary and secondary activities as 50% each and as 80% primary and 20% secondary.

	Weighting 0.5		Weighting 0.8		t	p
	Mean	SD	Mean	SD		
Ratio off-farm	0.19	0.15	0.19	0.15	-0.09	0.92
Ratio forest and agriculture	0.09	0.12	0.09	0.12	0.03	0.97
Ratio of reproductive activities	0.13	0.10	0.13	0.10	0.09	0.92
Ratio personal and leisure	0.25	0.07	0.25	0.07	-0.01	0.99
Ratio sleep	0.34	0.04	0.34	0.04	0.03	0.97

Appendix C: Selected quotes to illustrate themes

Table A 4: Example quotes for qualitative themes (OP sites)

<u>Subjective Experience of Time Allocation</u>	
Physical exhaustion, tiredness, energy	<i>"The rest is not enough, the body aches sometimes." (OP_KI_F_V3)</i>
	<i>"By the evening we are already tired. We are already sleepy. We do not have energy [to socialise] and need to wake up in the morning" (OP_KI_F_V12)</i>
Days off	<i>"Even on Sundays we sometimes go to the fields. There is no rest..." (OP_KI_F_V9)</i>
Breaks and rest	<i>"When you come home from work from palm oil, you go home, you rest first, you eat and then take a break. If you have rested already, then we'll go to the fields .It is not possible to go straight to the fields because we are too tired." (OP_KI_F_V4)</i>
	<i>"The [breaks] are not enough, because I come home from work at 2. There is a bit of rest, sometimes, but by 3 o'clock we must prepare food, look for clean water to drink." (OP_KI_F_V10)</i>
	<i>"We are busy working but in the afternoon, after coming home from working on palm oil, we have to rest for a while. After then we go to work again" (OP_KI_F_V12)</i>
Busyness / multiple demands	<i>"You don't have time because ... when we come home from work, we work again to take care of our husbands" (OP_KI_F_V7)</i>
	<i>"In the evening working too, working the evening. It is impossible to rest when you are tired. We are pushed for time. If you are resting the work is not continuing. (OP_KI_F_V9)"</i>
	<i>"Indeed, there is no time. It is true. We have time, but we use all our all time looking after children. (OP_KI_F_V1)"</i>

Opportunities to socialise

"How can we have time to get-together?" (OP_KI_F_V8)

"We hang out in the stall together with the group, so we rest by hanging out. We will spend the time like that and then will return to work. After returning to work, we only rest again at night." (OP_KI_M_V2)

"...to hang out? It depends, we rarely do that [socialise while working]. Hanging out in groups is rarely done unless there is a wedding or there are [customary events] when we group together to work." (OP_KI_F_V2)

Working as household unit

"My husband works more [than me] in the oil palm. I go alone to farm land. I go with my children or siblings like that. Usually if we are farming in the garden, we are alone without my husband." (OP_KI_F_V4)

Existence of trade-offs in time allocation (sleep/
rest vs reproductive; productive vs reproductive;
paid work vs agricultural work)

"Finding land is not yet a difficulty. For us, the only difficulty is finding time" (OP_KI_F_5)

"We wake up earlier [than husbands], around 4 we wake up, we prepare breakfast and so on for our husbands... so they will be able to directly eat breakfast and immediately go to work" (OP_KI_F_V4)

"Yes sometimes, if we are busy. We will skip the rest" (OP_KI_F_V8)

"Women do lighter work for a shorter time. We go home quicker and usually we divide our time to do other activities such as farming, care for the house, care for children and others." (OP_KI_F_V9)

"The men who work as drivers, they have to work late at night, so men don't have the time to help women unless there is a day off" (OP_KI_F_V6)

"We are too busy. There is no time to grow vegetables or garden vegetables for sale" (OP_KI_F_V7)

Labour and Time Saving Efficiencies

Swidden changes (relocation of fields, shorter fallows, less frequent rotation, chemical inputs)

"The first difference is [the fields] are getting smaller, the second is chemicals are used like fertilizer, herbicides, pesticides. It is changing now, before if it was more natural then, now we use of herbicides, pesticides" (OP_KI_M_V4)

"We rarely open [new] land that has large trees. It is too much work. Also, because land is scarce, so we do our farming on the same land" (OP_KI_M_V2)

"It [fields] used to be far because we walked. Now it feels close for us because we use a motorbike. Now people think they don't want to have a field far away, because it takes time. Now people think because they are busy working, they will farm closer to their homes so they are easy to maintain, easy to monitor" (OP_KI_FGD_V5)"

"Actually, the clearing is easier because the fields have been open for many years." (OP_KI_M_V6)

"It is much better to sawah [permanent unirrigated wet rice]. Like before to give an example, because the fields move around the trees are so big, so we cut down and we burn it down then we clear it, then we will straighten it. For the sawah you do not need to clear. You can do it all with a hoe. Straight after hoeing you plant, it is not like this with moving around." (OP_KI_M_V2)

"Because sawah [permanent unirrigated wet rice] is not too tiring, caring for it is easier and faster. For example, in August we spray, in in September we are planting, the rest is just waiting for the results. If it was a ladang [swidden]. you have to cut down, then clear, then drill, then clean etc., that's the problem." (OP_KI_FGD_V9)

"For fertilizer and chemicals it is really important, yes, because it can speed up work time like that" (OP_KI_M_V6)

"We used to work the fields here manually without using poison [herbicide], without using fertilizer because in the past we did not recognize chemicals and we worked on the fields with a traditional system. But now we are working the in fields after we have used poison [herbicide] or fertilizer so the process time is faster (OP_KI_M_8)

"For example, if we do it manually, traditionally, it takes one month. But now we use herbicides, with that it is much faster, for example, 2 weeks becomes two days" (OP_KI_M_V9)

Outsourcing of childcare

"If we are working in the oil palm, [the children] come home from school and go to their grandmother's place, sometimes they are alone." (OP_KI_FGD_V9)

"When the child is left at the company place, usually women will bring provisions for the children. If women do not have time to bring provisions for their children, usually there are people who sell food so that women can buy the food and leave it with the security guards and the guards can then provide food to their children." (OP_KI_FGD_V2)

"There are people who take care of our children when we go to oil palm, if like us there is no one to look after children at home" (OP_KI_F_V8)

"So it usually depends if they [women] work in the company and there are people at home to look after them. Usually they prefer to leave their children with family at home, but for example they want to work in a palm oil company, they have children and no one takes care of them at home they can bring them to day-care at the palm company" (OP_KI_F_V1)

"..this day-care was made a long time ago by palm oil companies and there are people who can look after children when left by working women. The [day-care staff] there have been paid by palm oil companies like that" (OP_KI_F_V12)

Use of chemical inputs

Gender Roles in Agriculture

Technical knowledge of machinery and chemicals

"For women, they cannot operate the machine, because the women here do not care enough to learn, because when dealing with machines they think it is too heavy" (OP_KI_F_V7)

"Normally the men do the clearing using a machine, because it is a machine it is more normally the men." (OP_KI_FGD_V2)

Physical labour

"The work done by women is a little light work, a little easy. For the work done by the men, the work is more difficult. For example, women, weeding, planting, harvesting, like that. When they are clearing the land, the women weed the grass, the men cut down the trees – the work is more difficult ... When it is harvest, the women can harvest but the men help harvest and transport the harvest from the fields to the house, it's a hard job to transport all the crops to the house. Then the men use the machine to thresh rice and then the men transport the rice that [been milled]. The women take care of the rice which was dried in the sun." (OP_KI_F_V9)

Time Use Coping Strategies

Supervision of children while working

"When we were children, we were more free before. I saw it, children could play in the surrounding natural area and their parents did not forbid it because they can freely play. It is different from the children who are here because the company is polluting and so on, so the children play more at home or children are left with someone who can look over them. The environment is not safe like that." (OP_KI_F_V3)

Select foods quicker to cook	<i>"If there is a busy day, maybe we cook eggs or fried noodles. It's the most practical and the easiest to get. If it's hard to buy noodles, just eggs. We can cook and eat that right away." (OP_KI_F_V5)</i>
Use quicker cooking methods	<i>"Before we used to cook using firewood and kerosene stoves, now we use gas canisters to make it faster to cook. To get the gas stove, there is help from the government and buy it in palm oil." (OP_KI_F_V5)</i>

Household Decision Making

Household decision making	<i>"Both [men and women] try to earn money. Only it is more for the men, the men have to earn money, but she only helps. If she can get money, it is okay. But if she can't get money then she will think - he must go earn money" (OP_KI_F_V3)</i>
Seasonal demands of rice production	<i>"Because of fear of rain, the rice will get wet. So usually wives will coordinate with husbands when it is the harvest season. We will coordinate, either the husband takes time off work and he will help the wife to harvest the land, or the second option, the father continues to work in oil palm but the father provides money and which is given to the mother to pay more people so that the harvest is finished quickly" (OP_KI_F_V12)</i>
Gendered access to labour, contractual terms and pay	<p><i>"There is supervisor work, he is under the foreman, a clerk is in charge of attending people who work like that. It is like that, these are the good jobs, but only for men. Men can do these jobs. Women are not able." (OP_KI_FGD_V9)</i></p> <p><i>"Men get paid more. Men can do heavy and non-heavy work, they work longer hours and work faster." (OP_KI_F_V4)</i></p> <p><i>"Nothing [paid leave], so we report that we will take a one-week leave, we set a date from when to when, so as long as they we are on leave, we do not get a salary from the company" (OP_KI_M_3)</i></p>

Prioritising of men's labour (based upon contractual / pay differences)

"My husband leaves early in the morning and comes back home at night, or late afternoon. Sometimes when he works as a driver he has to work late at night. So he doesn't have time to work with me unless there is a day off. It is like this, when men are busy with their work activities, automatically the women do the farming." (OP_KI_F_V6)

"The men work for a long time, men have higher salaries because men's work is also heavier than women's. Women's income is smaller than men because women share time, for example, when they are in the fields. When they work on the farm usually they will take time off and not work in a palm oil company, so that the salary obtained by women are smaller than the men." (OP_KI_F_V10)

"The men are more senior because they work in one but and if the women works in a job it is for a short time so she can go home and can work in other activities such as farming and other activities like that." (OP_KI_FGD_2)

Prioritising men's off-farm labour based upon gender roles (men as income producers / women as caregivers)

Men look for and many other jobs besides farming because they have to earn money, they have to meet the needs of school children and so on, so men are more willing to divide their time to make money (OP_KI_F_10)

"Men can work in all kinds of jobs for the oil palm company because men are more able and men only work in companies. They do not need to do other work, such as taking care of household activities, farming, etc." (OP_KI_F_V7)

Gendered consequences of swidden changes

"The other reason is because of time. For example, in weeding work, weeding takes longer. In 1 hectare there is more grass than trees. If there are only a few trees, maybe weeding 1 hectare takes a woman 1 week but the man only 2 days.... For burning land in 1 day it is finished, so the men work for a short amount of time and women can work long hours in the fields."

Consequences of Time Allocation

Loss of Soil Fertility

"In the past it was not necessary to use fertilizers, because of fertile soils, if now the soil is less fertile, we need fertilizer" (OP_KI_M_12)

"Like my brother-in-law. First, when he opened the land he didn't need spray, no fertilizer, they cut it, after they cut it they hoe it, and it is ready to plant. But after the harvest they need to give compost and fertilizer to plant the soil again" (OP_KI_M_8)

Appendix D: Codebook for Thematic Analysis

Table A 5: Codebook for thematic analysis

No.	Theme/ Sub-Theme	Description
Subjective Experience of Time <i>Experience of time use, effect of time allocation decisions, physical and mental and wellbeing effects of time allocation</i>		
1	Breaks and Rests	Breaks and rest periods during and between work
2	Daily and Weekly Routines	Daily routines for men and women. Patterns of time allocation throughout the week.
3	Excess Time	Activities carried out when there is extra time. Indicators of excess time. Experience of having sufficient time.
4	Intersectionality	Intersections of gender with wealth, class, education, age, ethnicity etc.
5	Seasonal Fluctuations in Time Allocation	Seasonal changes in time and labour allocation. Peak and low periods of labour-demand. Swidden cycles.
6	Socialising	Opportunities to socialise with others during work or leisure time
7	Time pressure OR Time Scarcity	Lack of time, business, stress over lack of time
8	Variety and drudgery of work	Perceived variety of work, satisfaction or dissatisfaction with variety of work
9	Weekends and days off	Availability and use of weekends and days off
Trade-offs in Time Allocation <i>Perceived trade-offs, conflicts, clashes, incompatibility of time spent, between time allocated in different activities</i>		
10	Childcare and Productive Labour	Trade-offs between child care activities and productive labour (paid work or own-production activities)
11	Domestic Work and Productive Labour	Trade-offs between domestic work (reproductive labour excluding childcare) and on and off-farm labour

12	Income Generation and Food Production	Trade-offs between time spent in income generating activities and food producing activities
Managing Trade-offs Strategies, efficiencies, coping strategies and changes to livelihoods to manage/ mitigate trade-offs in time allocation		
12	Coping Strategies	Coping strategies employed to reduce time pressure / manage busy periods / increase efficiency in time allocation
a	Activity Bundling	Combining multiple activities to increase efficiency / reduce time. Concurrent childcare, concurrent food acquisition etc.
b	Substitution of activities	Substitution of activities with quicker versions. E.g. reducing cooking time through selection of quicker coking foods / use of quicker cooking fuels
13	Efficiencies Adaptations or Changes to cash crop production	Substitution of crops / changes in cultivation practices
14	Efficiencies Adaptations or Changes to food production	Changes to rice production specifically cited as resulting from time-allocation trade-offs
a	Extra Household Labour	Labour from outside household. Reciprocal Labour exchange or hired labour.
b	Modifications to swidden systems	Modifications made to traditional swidden systems to increase time/labour efficiency. Includes changes in fallow length, rotation frequency, relocation of fields closer to villages and roads
c	Use of Chemical Inputs and machinery	Use of fertiliser, pesticides and herbicides to reduce time and labour / increase efficiency. Use of machinery and motorised transportation.
Household Decision Making Factors affecting household decision making in making time allocation decisions		
13	Opportunity Costs of Agricultural Labour	Factors affecting opportunity costs of on-farm labour. Differential opportunity costs for men and women.
a	Access to off-farm labour	Access to off-farm labour opportunities. Access to overtime work. Access to higher-paying office jobs and supervisory positions.
b	Contractual Arrangements	Contractual arrangements such as pay, job security, flexibility of work (ability to start-stop-work), contracted hours. conditions, bonus systems etc.
c	Gendered Wage Gap	Pay differential between men and women
d	Other sources of off-farm income (non-employment)	Off-farm income from non-employment activities. Sale of NTFPs, handicrafts, small business activities etc.

14	Household Level Strategies	Household level strategy / livelihood approach
a	Flexible allocation of labour	Flexible allocation of labour between income and food producing activities. Desire / ability / practice of switching between income producing activities and food producing activities in response to perceived current / future household demands.
b	Gendered Division of Labour	Household decision making to allocate time and labour along gendered lines
c	Risk Tolerance and Risk Mitigation	Tolerance of risk, desire for diversified income and food sources, ability to cope with shocks, poor harvests etc.
15	Perceived Capabilities and Competencies	Gendered perspectives on capabilities / competencies in different types of work
a	Physical Demands of Labour	Activities requiring physical strength and/or strategies to overcome strength requirements
b	Specialised technical knowledge	Specialised technical knowledge required for operation of machinery / mixing chemicals
c	Women's Reproductive Roles	Women's assumed dominance and superior competence in reproductive labour
<u>Effects of Managing Trade-offs in Time Allocation</u> Consequences attributed to changes in livelihoods which occurred as a result of managing trade-offs in time allocation		
16	Gender Roles	Changes in gender roles and responsibilities stemming from modifications made to manage time allocation trade-offs
17	Land Markets and Land Scarcity	Emergence of land market in location of relocated agriculture

Appendix E

Study site selection and potential sources of endogeneity

Comparison of oil-palm and non-oil palm adopting villages

We opted for comparisons between randomly selected households within oil-palm and non-oil palm villages, as opposed to the random selection of oil-palm and non-oil palm adopting households within villages with both oil-palm and non-oil palm households for the following reasons: (1) Comparisons of oil-palm and non-oil palm adopting households within mixed villages are likely to suffer from important omitted variable biases due to difficulty for controlling for such important potential issues such as a household's political connectedness and local influence in land use and land rights decisions; (2) comparisons between oil-palm and non-oil palm adopting households are likely to suffer from survivorship bias with households who were successful at oil palm being over-sampled while unsuccessful oil palm farmers risk being categorised as non-oil palm adopters. This effect likely increases with time as unsuccessful farmers sell their land to more successful farmers and adopt alternative livelihoods or migrate out of villages. (3) Oil-palm plasma agreements are made at community levels – with consent being granted by village authorities on behalf of village residents and where dividends, compensation and other forms of payments are collectively bargained; (4) non-oil palm livelihoods are dependent on diverse landscape mosaics of forests, fallows, agroforests and fields which may be reduced or lost after oil palm development; (5) oil palm often precipitates a loss of customary rights and land tenure upon which forest-based swidden livelihoods depend.

Potential Sources of Endogeneity

The decision or opportunity (or lack thereof) to adopt oil palm is not random. There are five potential reasons why oil palm may not have been developed in a particular village; (1) a community may have been approached by an oil-palm company but rejected the company offer and terms; (2) the area is unsuited to oil palm cultivation due to poor soils or steep slopes; (3) it is not commercially viable to grow oil palm in the area due to poor infrastructure and market access; (4) government permits cannot be obtained to grow oil-palm in the area due to land use zoning as conservation forest, national park, or as being allocated to other-non oil-palm land uses (e.g. forestry); (5) a village is situated too far away from existing oil palm plantations and mills. Each of these factors introduces potential sources of endogeneity if differences between oil palm and swidden villages in these characteristics also affect the allocation of labour and time.

We identified five categories of potential endogeneity which were used to create study site selection criteria: cultural, geographical, economic and political endogeneity. These potential sources of endogeneity are discussed briefly below and steps taken to mitigate them are shown in Table A 7: Potential sources of endogeneity and selection criteria Table A 7.

Cultural endogeneity would exist if communities in villages that adopted oil palm differed from communities' villages which did not adopt oil palm in terms of their ethnic make-up or social and cultural laws and traditions which affected both the likelihood of a community rejecting oil-palm companies as well as the range of agricultural and other livelihood activities carried out. One example of cultural endogeneity might be differences at the baseline period in customary rules and practices. Stronger customary laws over land tenure could lead to a rejection of oil palm companies whilst also affecting the likelihood that certain livelihoods were practiced such as NTFP extraction or rotational shifting cultivation. Differences in these livelihood activities would then explain differences in time and labour allocation.

Geographical endogeneity would exist if oil palm and non-oil palm adopting villages differed at the baseline period in such a way that affected the viability of oil palm development or the likelihood of the issuance of government permits to grow oil palm as well as the allocation of time and labour at the baseline period. Examples of geographical endogeneity include current land-use practices and industry (e.g., the presence of logging) which may have affected livelihood occupations or if different slopes or soil types prevented certain types of agricultural production.

Economic endogeneity would exist if, at the baseline period, oil-palm and non-oil palm adopting villages differed in terms of wealth, access to financial services such as credit, infrastructure and market access in such a way that it also affected the allocation of time and labour. For example, communities with better access to markets and better access to financial services might be more likely to engage in cash crop production which affected the allocation of time and labour.

Political endogeneity would exist if, at the baseline period land use zoning by government authorities which affected whether oil palm could be developed in an area in or around a village also affects the livelihood options available to any particular community. For example, if land was classified as a national park or conservation area which prevented both oil palm development but also slash and burn agriculture.

Village Characteristics Prior to Oil Palm

Table A 6 shows a comparison of village level data between the two sites in 1996, the earliest available date of publicly available village data. In every village included in the study, the main occupation of the majority of respondents was reported as food-producing agriculture in 1996. No villages in the study had irrigated rice in the year 1996, and villages in each site had similar areas of non-irrigated rice per household, and similar areas of plantation (including rubber agroforestry) per household. There was a higher (though not statistically significant) area of non-rice agricultural fields in the OP site compared with the swidden site – but this category is broad, encompassing a wide range of land uses. There were no major differences between oil palm and swidden villages in terms of infrastructure and market access. Both sites had a mixture of villages which were primarily accessible by boat and villages which were accessible by road. In the case of villages accessible by road, all were roads from soil or other materials with no villages having stone or asphalt roads. The time to a permanent market via usual transportation was similar in most villages except for two villages in the OP site which were slightly further away.

	<u>Forest (Mean)</u>	<u>(SD)</u>	<u>OP (Mean)</u>	<u>(SD)</u>
<u>Demographics</u>				
Number of Households	363.17	84.24	347.5	175.66
<u>Livelihoods</u>				
Main occupation agriculture (% of villages)	100	-	100	-
Proportion of Households Farmers (main occupation)	0.9	0.09	0.94	0.03
Main agricultural sub-sector = Food Crops	100	-	100	-
<u>Agriculture and Land Use</u>				
Total Village Area (ha)	79911.5	118196	93511.25	94561
<i>Village Locality</i>				
-Hill Area	50	-	50	-
- Non-Hill Area	50	-	50	-
<i>Area of land (ha per hh):</i>				
- Rice (any)	1.03	0.26	0.99	0.44
- Irrigated Rice	0	-	0	-
- Unirrigated Rice	2.06	0.51	2.34	0.99
- Non-rice Agriculture	8.29	1.47	15.67	10.59
- Plantation (including rubber agroforestry)	93.32	132.38	90.22	74.51
<u>Infrastructure & Market Access</u>				
<i>Village Access (% of villages):</i>				
-Main access via road	0.67	-	0.5	-
-Main Access via Boat	0.33	-	0.5	-
<i>Type of road (if present)</i>				
- Soil/earth	100	-	100	-
<i>Market Access:</i>				
Time to nearest market ² (hours)	44.8	16.59	66.29	36.04
<i>Perceived access to market:</i>				
- difficult/very difficult ³	100	-	100	-
Market in villages (% of villages)	0	-	0	-
<u>Financial Services</u>				
<i>Access to credit:</i>				

Bank Services	0	-	0	-
Credit Unions	0	-	0	-

Table A 6: Descriptive data showing differences between oil palm adopting and non-oil palm adopting villages at a historical baseline prior to oil palm adoption. Based upon village level data from PODES 1996 (BPS, 1996). (1) Main occupation of the majority of village residents (2) Time to market with permanent building (3) Subjective rating of easyness / difficulty of accessing market with permanent building (likert scale).

<u>Class of Endogeneity</u>	<u>Reason for adopting / not adopting oil palm</u>	<u>Potential Effect Upon Allocation of Time and Labour</u>	<u>Selection Criteria</u>	
Cultural	Rejection of oil palm stronger in some cultural groups or in communities with stronger influence of customary rights and laws	Different ethnic and cultural groups may specialise in different livelihoods	<ul style="list-style-type: none"> - All villages to be majority ethnic Dayaks at both baseline and survey period - No transmigrant villages or villages with significant immigration included - Similar cultural traditions regarding customary practices surrounding agriculture, forest use and livelihoods 	
Geographical	Oil palm not viable due to steep slopes / poor soils	Different crops / livelihood activities are viable/ not viable	- Similar gradients and soil types in all villages	
	Different forest cover levels at baseline	Different livelihood options available	- All villages heavily forested at baseline period. No history of logging or large-scale plantation agriculture.	
Economic	Current livelihood practices affects probability of community giving or refusing consent to oil palm companies	Differences in livelihoods affect allocation of time and labour	- All villages at baseline period predominantly engaged in swidden agriculture combined with NTFP extraction and smallholder rubber agroforestry	
	Wealthier villages more likely to accept/reject oil palm	Households will allocate time differently in wealthy villages from less wealthy villages due to livelihood opportunities	- Similar levels of village wealth at baseline period	
	Villages with poor market access less likely to be desired as OP sites	Differences in market access may affect opportunities for commercialised agriculture and livelihood opportunities	- All villages similar levels of market access in terms of both time and difficulty	
	Different access to financial and credit services affect alternative non-oil palm livelihood opportunities	Differences in access to credit may affect opportunities for commercialised agriculture and livelihood opportunities	- All villages have similar levels of access to financial and credit services	
Table A 7: Potential sources of endogeneity and selection criteria				

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