Rubber vs. oil palm: an analysis of factors influencing smallholders' crop choice in Jambi, Indonesia

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Georg-August-Universität Göttingen
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Abstract: The rapid expansion of the oil palm area in many tropical countries has raised concerns about its negative impact on local communities, food security, and on the environment. While the expansion of oil palm in early stages was mainly driven by large private and public companies, it is expected that smallholders will outnumber large estates in the near future. For policy formulation it is hence important to better understand who these smallholders are and why they have started to cultivate oil palm. In this paper, we used a rich dataset collected in the province of Jambi, which is one of the most important production areas for oil palm, to analyse smallholders' decision making by combining qualitative, quantitative, and experimental methods. We identified agricultural expertise, lacking flexibility in labour requirements, availability of seedlings, and investment costs as the major constraints for farmers to cultivate oil palm. Important reasons for oil palm cultivation are the higher returns to labour and the shorter immature phase of oil palm. We also showed that oil palm farmers are neither risk-averse nor risk-loving, rather, they appear to be risk-neutral.

Keywords: Smallholders, crop choice, oil palm, rubber, Indonesia

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Abstract

The rapid expansion of the oil palm area in many tropical countries has raised concerns about its negative impact on local communities, food security, and on the environment. While the expansion of oil palm in early stages was mainly driven by large private and public companies, it is expected that smallholders will outnumber large estates in the near future. For policy formulation it is hence important to better understand who these smallholders are and why they have started to cultivate oil palm. In this paper, we used a rich dataset collected in the province of Jambi, which is one of the most important production areas for oil palm, to analyse smallholders' decision making by combining qualitative, quantitative, and experimental methods. We identified agricultural expertise, lacking flexibility in labour requirements, availability of seedlings, and investment costs as the major constraints for farmers to cultivate oil palm. Important reasons for oil palm cultivation are the higher returns to labour and the shorter immature phase of oil palm. We also showed that oil palm farmers are neither risk-averse nor risk-loving, rather, they appear to be risk-neutral.

Keywords: Smallholders, crop choice, oil palm, rubber, Indonesia

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1 Introduction

Growing global demand for vegetable oils and biofuels has led to a strong increase in the oil palm area in many tropical countries during the last decades. The global area harvested increased from about 10 million ha in 2000 to 17 million ha in 2013 (FAOSTAT, 2014). It is expected that this trend will continue over the next decade (USDA, 2009). Most of the oil palm plantations were established on formerly forested land (Koh and Wilcove, 2008) and to some extent on land, which had been used for rubber and food crop cultivation. This rapid expansion of the oil palm area has raised concerns about its negative impact on biodiversity (Koh and Wilcove, 2008; Fitzherbert et al., 2008), climate change (Fargione et al., 2008), and food security (ADB, 2008). Moreover, NGOs have reported that the expansion of oil palm plantations entails human rights violations, land conflicts and other negative impacts on local communities (FOE, 2008; WRM, 2001).

While the expansion of oil palm in early stages was mainly driven by large private and public companies, smallholder farmers have increasingly started to cultivate oil palm as well (Gatto et al., 2015). In Indonesia it is estimated that smallholders account for 37% of the annual production and for 35% of the area under oil palm (BPS, 2015a). It is expected that smallholders will outnumber large private and state companies in production as well as oil palm acreage in the near future. It is hence important to better understand who these smallholders are and why they have started to cultivate oil palms. There is relatively little information available in the literature about these farmers. The majority of studies on oil palm smallholders rely on case studies in a few selected villages, making generalizations difficult (Belcher et al., 2005; Susila, 2004; Cramb and Sujang, 2013; Rist et al., 2010; Cahyadi and Waibel, 2013). Exceptions are Lee et al. (2013) and Hasnah et al. (2004), who analyzed productivity of oil palm smallholders in Indonesia. Both studies, however, contain hardly any information about the motivation of smallholders to cultivate oil palm as well as their reasons against cultivation.

This study adds to the literature by providing empirical evidence of smallholders' reasons for and against the cultivation of oil palm. We build on a rich dataset collected in Jambi province, Sumatra, which is one of the most important production areas for oil palm in Indonesia. In the research area, however, rubber is still the most important crop for smallholders with a much longer history of cultivation. The crop choice involves hence a decision between rubber and oil palm cultivation and our analysis at the micro-level will focus on these two crops. We combine the results of quantitative, qualitative, as well as experimental research approaches to provide new insights into the decision-making process of oil palm smallholders. Specifically, the following research questions will be addressed:

1) What are major constraints for farmers to engage in oil palm cultivation?

2) What are reasons for smallholders to engage in oil palm cultivation?

3) What are behavioural differences between oil palm and non-oil palm farmers?

The paper is structured as follows: Section 2 describes the conceptual framework used to analyse smallholders' land use decisions. We differentiate between internal and external factors and the latter are described in Section 3. In Section 4 we introduce our database, the analytical procedures as well as the study region. Section 5 presents and discusses our results, while Section 6 concludes.

2 Conceptual framework

The analysis of smallholder behaviour with respect to land use change is guided by a conceptual framework developed by Hettig et al. (2014). They base their concept on the seminal deforestation model by Angelsen and Kaimowitz (1999), which Hettig et al. (2014) update and extend as part of a reviewing process covering the recent empirical and theoretical literature on land-use change. In line with Angelsen and Kaimowitz (1999), they model land use change as the outcome of an agents' decision making process at the micro level. Unlike previous models (e.g. Angelsen and Kaimowitz, 1999; Lambin and Geist, 2006; Rudel, 2007), their concept furthermore emphasizes the relevance of key policies as well as household characteristics and endowments, which take on a leading role in our analysis.

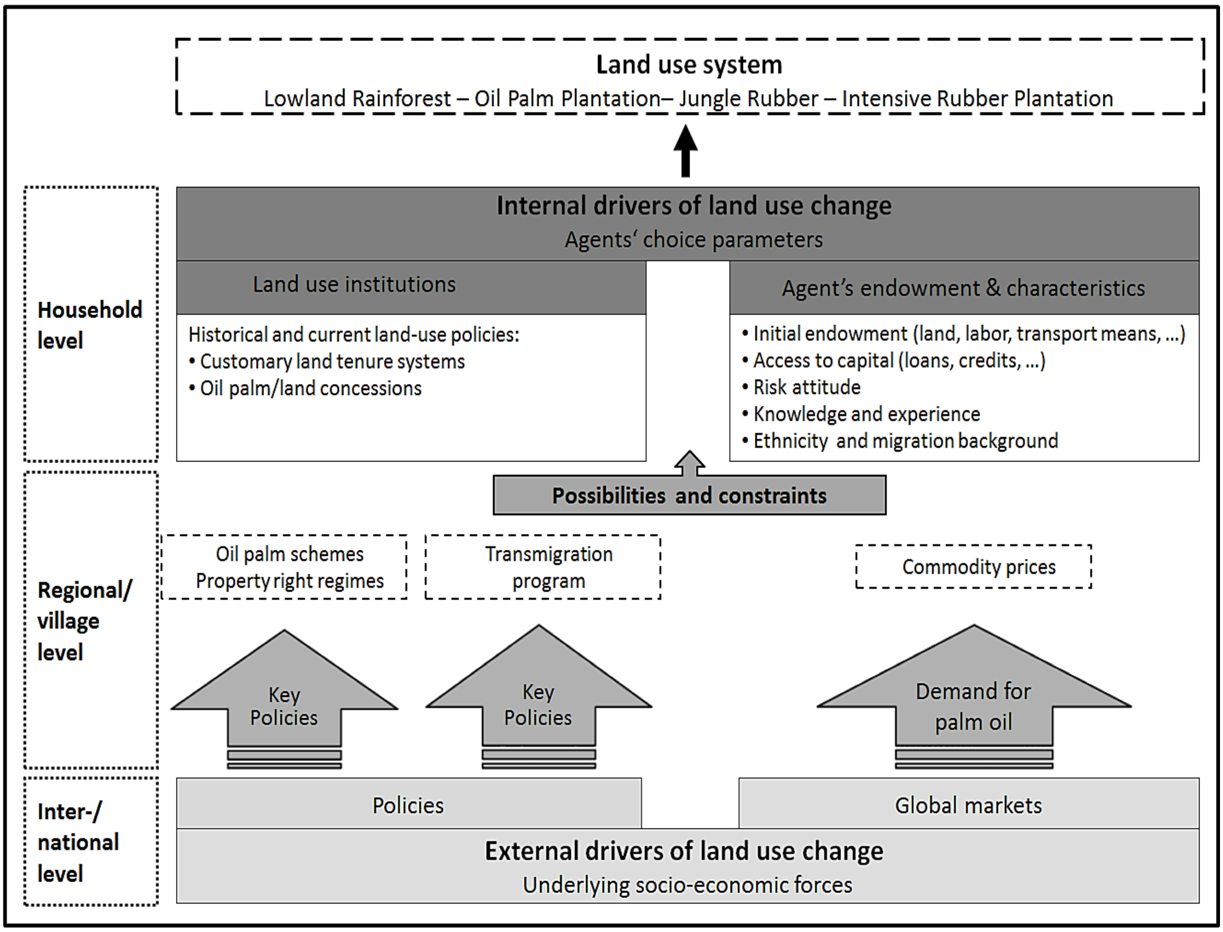
Crop choice and land use decisions of farming households are directly and indirectly influenced by macro-level variables which are assumed to be the underlying causes of land use change. We refer to them as external drivers in order to stress their overarching character and the fact that they exert their influence from outside the decision system. External drivers arise from the international or national level and comprise broader socio-economic forces such as policies and global market signals.

The decision making process is further determined by drivers which have an immediate impact on the agents' choice and hence on land use change. They operate at the micro level and include households' characteristics and endowments, institutions, infrastructure, markets and technology. Since these drivers can be endogenous to decision makers and occur within the agent's scope, they are classified as internal drivers.

We adapt the concept of Hettig et al. (2014) and apply it to our research questions. Our framework, which is depicted in Figure 1, highlights the different spatial scales at which the influencing factors work. It shows how the external drivers of land use change at the (inter-) national level are channelled through the regional level and hereby relate to the internal drivers at the local and household level and, eventually, to the land use decision.

For the purpose of our study, there are mainly three transmission channels from the external to the internal drivers. First, there are policies, like property right regimes and schemes for oil palm development, which directly influence land use decisions at the regional and local level. Second, there are policies, which are translated into migration and resettlement programmes for the region. And third, global market forces create demand for palm oil influencing regional commodity prices. It is via these transmission channels that external drivers significantly influence the internal drivers of land use change, such as tenure and land institutions, capital endowments and other household characteristics. These are crucial parameters for land use decision making at the household level and hence determine the land use system. For example, participants in oil palm schemes were not only often the first smallholders engaged in oil palm production, but they also received official land titles for their plots as well as subsidized loans for the procurement of inputs. This access to land and capital, together with initial endowments, strongly influences a household's decision to cultivate oil palm, which is associated with high investment and input costs. The expansion of oil palm cultivation among smallholders is hence the outcome of a decision making process, which is determined by the interaction between internal and external drivers.

Figure 1: Conceptual framework



Source: Adapted from Hettig et al. (2014)

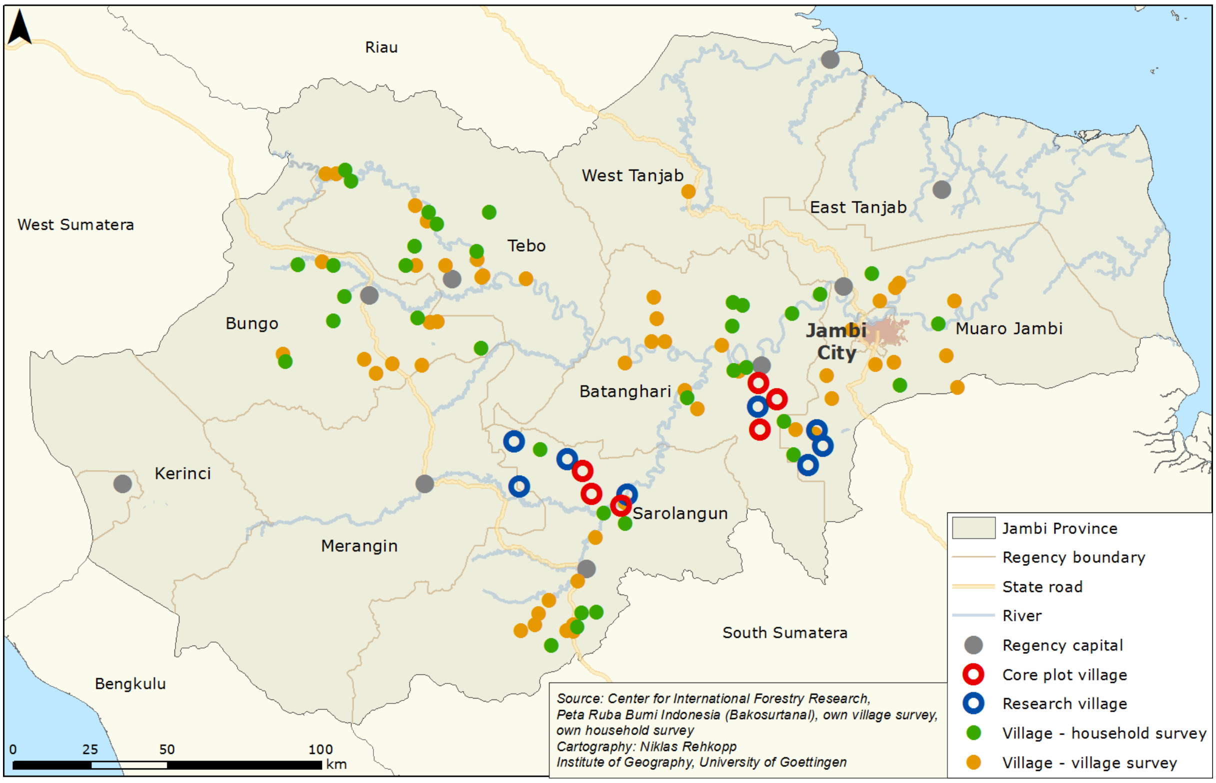
3 Research area and methods

Jambi province is one of Indonesia's most important locations for the production of rubber and palm oil. Today, the province is the fourth largest crude palm oil (CPO) producer in Indonesia, the third largest producer of rubber, and the biggest producer of red areca nuts (Coordinating Ministry for Economic Affairs, 2011). The total size of the province is 5.1 million ha of which 2.1 million ha are classified as forest area. In 2013, 721,400 ha were planted with oil palm (BPS, 2015a) and a further increase is expected in the next decades (Coordinating Ministry of Economic Affairs, 2011). Jambi has been one of Indonesia's REDD+ pilot provinces since 2013. The provincial REDD+ strategy aims to review the current land allocation policy and to enhance law enforcement (Hein, 2013). The consequences of Jambi's provincial REDD+ program are not yet foreseeable but they might decelerate Jambi's oil palm boom. About 456,900 ha of the province are planted with rubber (BPS, 2015a). Jambi has a population of 3.4 million people (63 people/km^2), of which about 80% are working in the agricultural sector (BPS, 2015b).

In Jambi province our international collaborative research centre (CRC) focuses on ecological and socioeconomic functions of tropical lowland rainforest transformation systems. The socioeconomic projects of the research centre follow an extensive complementary approach, as they all concentrate on different levels of analysis, starting from the plot and household level up to the national and international level. Moreover, they follow complementarities in terms of their methodological approaches; both quantitative and qualitative tools are developed, applied and adapted to the specific Indonesian context. A joint sampling framework has been developed for the different data collection activities (Figure 2). Starting at the household level in villages, where research plots for the biotic and abiotic research projects of the CRC are located (so-called core villages), we investigate additional villages surrounding them (research village). Further we extend the data collection to the regional level with household and village surveys. National and international levels are analyzed through stakeholder interviews with governmental and non-governmental experts (Faust et al., 2013).

The qualitative data collected focus on political, institutional, and cultural drivers of land use change. The methods applied for this paper include participant observation, semi-structured interviews with stakeholders at village level, problem-centred interviews with households, focus group discussions with key informants, participatory tools like mapping, timelines and comparative cultural study (Faust et al., 2013). When quoting from the interviews, pseudonyms have been given to each respondent to meet the balance between protecting the privacy of the research participants and retaining the context and usefulness of the data.

Figure 2: Research villages in Jambi province



A quantitative village survey conducted in 98 villages focuses on the role of socio-economic and agro-ecological conditions as well as contractual arrangements for land allocation (Gatto et al., 2015). Information was collected on land allocation, demographic characteristics, income activities including contractual arrangements, access to resources and technology use, institutional aspects, conflicts concerning land and resource use, input and output prices, risk perceptions, and village organizations. A quantitative household survey among 701 farming households focuses on current land use patterns and changes over years, the institutional framework (migration, contracts etc.), input-output data from all major plots, off-farm income activities, and food and non-food consumption (Faust et al., 2013). During cleaning of the data, 4 non-farm households were excluded from the analysis leading to a sample size of 697. These households cultivate 363 oil palm and 947 rubber plots, of which 301 and 857 plots were in productive stage. Moreover, the risk attitude was assessed experimentally by conducting Holt and Laury Lottery experiments (Holt and Laury, 2002) with 223 local farmers. The payoffs of the Holt-Laury lottery are shown in Table 1. The experiment was adapted to the case that at least some of the participants have limited education. The probabilities were visualised by coloured balls instead of numbers, which makes the experiment more easily understandable (Ihli and Musshoff, 2013).

Table 1: Payoffs of the Holt-Laury lottery

Choice	Option A	Option B	Differences in the expected payoffs
1	With 10% price of IDR 4,000 With 90% price of IDR 3,200	With 10% price of IDR 7,600 With 90% price of IDR 200	IDR 2,340
2	With 20% price of IDR 4,000 With 80% price of IDR 3,200	With 20% price of IDR 7,600 With 80% price of IDR 200	IDR 1,680
...	...	...	...
9	With 90% price of IDR 4,000 With 10% price of IDR 3,200	With 90% price of IDR 7,600 With 10% price of IDR 200	IDR -2,940
10	With 100% price of IDR 4,000 With 0% price of IDR 3,200	With 100% price of IDR 7,600 With 0% price of IDR 200	IDR -3,600

Notes: The Holt-Laury lottery is a ten paired lottery-choice decisions between option A and option B. Each option has two possible payouts which systematically change their probabilities. Option A has a moderate payout-spread and is therefore the “safe choice”, whereas option B has a high payout-spread making it the “risky choice”. Ex post, one pair is randomly chosen and paid out. The total number of “safe choices” is the Holt-Laury value applied for the analysis.
Source: Authors’ own illustration according to Holt and Laury (2002).

Various econometric methods are applied to analyse the data. The importance of inputs in oil palm and rubber production is investigated by estimating a translog production function. We further use a logit model to estimate the effect of risk attitudes on production decisions and a left-censored Tobit model to assess the effect on oil palm acreage.

4 External drivers of crop choice

According to our conceptual framework, which has been presented in Section 2, we differentiate between internal and external factors. The latter refer to macro-level variables, which affect through different transmission channels the internal drivers. In this section, we will describe key policies and global market signals, which are important for the purpose of our study.

4.1 Key policies

Property-rights regimes in Indonesia and smallholders’ access to land

The most important legislations governing land rights in Indonesia are the Basic Agrarian Law (BAL) of 1960 and the Basic Forestry Act (BFA) of 1967. The BFA classified about 70% of Indonesia’s land area as state forest land, which is thus not subject to the BAL. Based on the BFA, the state has the authority to divide state forest areas into several land use categories with different policy objectives, such as timber production and conversion of the forest area into agricultural land. Moreover, the Minister of Forestry has the authority to issue logging and plantation concessions to private, foreign, and domestic companies. The remaining 30%

of the country's land are subject to the BAL and fall under the authority of the National Land Agency (NLA). The BAL recognizes private ownership and vests control of all unregistered land, which is the vast majority of agricultural land in Indonesia (Galudra et al., 2007).

After the fall of the Suharto regime in 1998, the legal situation concerning the control over and the use of natural resources changed considerably. Particularly the districts (*kabupaten*) gained key decision making powers through the new regional autonomy legislation (Law 22 and Law 25), which was implemented in 2001 (McCarthy, 2004). According to these laws, the districts gain decision making power in all aspects, which are not explicitly assigned to the central government and the provinces. The central government remains responsible for setting policy guidelines and standards, while the provinces mainly play a role for coordination. The decentralization laws, however, were designed without a well-developed implementation plan. Thus power was transferred only gradually with varying degrees and speed depending on the region and its leading actors and their claims to the restitution of resources and rights (Hauser-Schäublin and Steinebach, 2014). Moreover, in 2002 the Ministry of Forestry regained control over the state forests (Barr et al., 2006), which implies that only the decision making power about the control over and the use of natural resources outside of state forests was shifted from the central government to the districts. The districts have, for example, the authority to allocate land to companies for oil palm and rubber cultivation as long as the land is located outside of state forests. As the majority of land is classified as state forest, the decision making power of the districts with respect to land use is, however, limited.

Since the fall of the Suharto regime, customary laws have gained in importance across Indonesia (McCarthy et al., 2012). In this context, customary land refers to land tenure of local communities, who - according to codified law - usually do not hold legal titles for their claimed territories. This implies that customary land cannot be sold and bought legally. Land that can be traded freely among smallholders is restricted to the category of private land accompanied by a land owner's certificate (*Sertifikat Hak Milik SHM*). While local communities had been largely deprived of their land by the constitutional land laws, the transmigrants were granted official land titles by the state.

As a consequence the availability of private land for land seeking smallholders is limited. This leads to the emergence of "illegal" land markets where access is granted through customary land tenure systems of local autochthonous communities. Access through customary tenure systems is hence often the only option for potential buyers but provides less tenure security due to overlapping claims of the state and communities. It is, for example, often not clear if land has already been designated for other uses. In Jambi province the majority of smallholders with the exception of transmigrants acquired access to land through customary tenure based arrangements (Hauser-Schäublin and Steinebach, 2014).

Today different semi-formal land titles issued by village and sub-district authorities are used to legitimate land ownership and to facilitate "illegal" transactions of land, which is in legal terms under the authority of the Ministry of Forestry (Hein, 2013). Village heads legitimize land transactions through issuing village level land titles. By issuing village land titles within state forests, village governments expand their competences formally and spatially. The title *Surat Ketarangan Tanaman Tumbuh* issued by village governments is not legally binding but certifies rights to rubber or oil palm plots (ibid). The title *Sporadik* is also issued by village authorities and certifies rights to land and is even accepted as collateral for accessing loans.

Oil palm smallholder schemes

Between 1977 and 2000, oil palm cultivation has been heavily promoted by the Indonesian government through nucleus-estate-smallholder (NES) schemes and through a special rural microfinance programme called KKPA ('Koperasi Kredit Primer untuk Anggota', which translates to `Primary Cooperative Credit for Members'). Participants in the NES scheme received 2 to 3 ha of land under oil palm at the periphery of a governmental estate. Agricultural inputs and extension services were provided by the government through a loan system. After loan repayment, the participants received formal titles for their land. At the core of the plantation area an oil palm mill was established, allowing the processing of the fresh fruit bunches within a short period after harvest. From 1984 onwards the scheme has been opened-up for private companies. In exchange for oil palm concessions and access to subsidized capital provided by the state, private companies had to assure the involvement of smallholders, who in turn guaranteed to produce the required commodities at an agreed quantity, quality, and price. The schemes were often coupled to the transmigration program, which was dominated by migrants from Java and Bali, but also included a share of local farmers. Since 1995, the NES scheme has been replaced by the KKPA programme, which provided subsidised loans to cooperatives to cover the costs for plantation establishment (Zen et al., 2005). The KKPA programme phased-out in 2000, because the state no longer subsidised the loans (McCarthy et al., 2012).

After 2000 the state reduced its role to the supervision of private sector - community partnerships. In the so-called partnership schemes, which were implemented from 2005 onwards, villages provide land in return for the inclusion in private oil palm plantations. The specific arrangements vary largely and depend upon negotiations between the villages and estates (McCarthy et al., 2012).

The transmigration program

In 2015 the total population of Indonesia is projected to reach 255.5 million while in Jambi province the population will reach 3.4 million. However, the provincial population has been growing above average for the last decades and is projected to do so in the future. The total population of Jambi has tripled since 1971 and doubled since 1980. It is expected that it will further increase with an average annual growth rate of 1.2% until 2035, which will be above the national average of 0.9%. At the same time the total fertility rate in Jambi province declined from more than 6% in 1971 to 2.3% in 2012, which is below the national average of 2.6%. Hence, in-migration likely accounts for the above-average population growth (BPS, 2015b).

Already in 1905 the first transmigration project was implemented under Dutch colonial rule aiming to reduce population pressure in Java. Transmigrants were sent to Sumatra, “the most accessible of the outer islands” (Fearnside, 1997: 553). During 1905-1941, some 190,000 people were moved. After World War II, Sukarno launched a new transmigration program in 1950. However, he was not able to reduce population pressure on Java largely due to his rejection of family planning programs (Fearnside, 1997).

The World Bank-sponsored transmigration program under Suharto’s New Order regime was implemented in 1967. This program likewise aimed to counterbalance population densities between mainly Java and Bali and, for instance, Kalimantan and Sumatra (Bock, 2012). Sumatra has accepted roughly one third of all transmigrants (540,000 out of 1.6 million households until 1993), and Jambi province accepted 70,000 households until 1995 (Miyamoto, 2006). Transmigrants accounted for more than 90,000 families towards the end of the New Order Regime in 1997 (Potter, 2012).

Apart from the above described general and state-sponsored transmigration other forms of spontaneous transmigration exist, which increasingly replaced it. Partly sponsored migrants, for instance, had to bear travel expenses themselves but were given land titles on site, others moved completely independently from any migration scheme (Fearnside, 1997).

Even after the end of the government program, transnational migration has not come to an end. “Transmigration from Java to rural areas of the ‘outer islands’ appeared finished in Indonesia after the fall of the Suharto regime in 1998 and decentralisation in 2001. However, the rapid growth of oil palm plantations in the past decade has led to a renewed call for transmigrants by district heads seeking an expanded labour force. A new system has evolved on a district-to-district basis with applicants in ‘sending districts’ (…) being matched to requests from ‘receiving districts’ (…), which largely depend on levels of plantation investment near proposed new transmigration sites” (Potter, 2012: 272).

4.2 The demand for palm oil

Oil Palm fruits produce two distinct types of oils: crude palm oil from the mesocarp and palm kernel oil from the kernel. In 2011, 68% of palm oil and palm kernel oil were used for food purposes, followed by industrial uses (27%) and biodiesel (5%) (USDA, 2012, as cited in FNR, 2012). Palm oil represents the largest constituent of edible oil with a production of 59.4 million tons in the marketing year 2013/14. Together with palm kernel oil (7 Mt) it accounted for 38.8% of the world's oil and fats production. In the same year, Indonesia accounted for 50% of the global palm oil production as well as of global palm oil exports. The largest importers of palm oil are the EU, China, and India representing 50% of world imports (USDA, 2015).

Palm oil is extremely competitive due to its high productivity and low production costs (Sheil et al., 2009; Scholz, 2004). Oil palm trees produce up to 10 times more oil than other leading oilseed crops such as soybean or rapeseed (Mba et al., 2015; Thoenes, 2006).

For the coming decade the OECD-FAO Agricultural Outlook 2014 expects a further increase in vegetable oil demand due to global population growth, increases in income and rising demand for biodiesel. It is expected that targeted biofuel blending mandates will increase global and Indonesian biodiesel production by 54%. Global trade of biodiesel, however, is predicted to increase only slightly due to domestic biodiesel targets or import restrictions in the European Union (OECD-FAO, 2014).

5 Internal drivers of crop choice

The above described external factors affect through different transmission channels the internal drivers of land use change, which will be described in the following section. We will begin by describing land use change at the village level, the evolution of oil palm production among smallholders, and the socioeconomic characteristics of the producers. We then proceed with major constraints as well as reasons for farmers to cultivate oil palm.

5.1 Land use change at the village level

We begin our analysis by investigating land use changes at the village level, which does not include concession areas. This implies that the changes presented in Table 2 are driven by decisions of individual households and not by large-scale governmental and private enterprises.

Jambi’s lowlands are subject to tremendous land-use changes. Most prominent are the rise in oil palm area and the loss in forest area. Oil palm acreage increased more than tenfold between 1992 and 2012 (Table 2). In 2012, oil palm plantations account for about 13% of the total area. In this respect rubber is much more important as it occupies about 52% of the total area, while the increase was much more moderate with 6% and 41% for plantation and jungle rubber, respectively. In the same time period, the forest area decreased drastically by 63%. The forest area share decreased from about 28% in 1992 to less than 10% in 2012.

Table 2: Land use and land use changes between 1992 and 2012

	Change in area (%)			Area shares (%)		
	1992-2002	2002-2012	1992-2012	1992	2002	2012
Oilpalm	362	149	1050	1,2	5,6	12,6
Plantation rubber	9	-3	6	35,3	39,5	35,0
Jungle rubber	-17	71	41	13,0	11,0	17,1
Fallow	5	4	9	12,9	13,9	13,1
Forest	-38	-40	-63	28,2	17,9	9,8
Paddy rice	-26	-28	-47	4,2	3,2	2,1
Other agriculture	504	30	686	0,4	2,3	2,7
No agricultural uses	33	26	67	4,9	6,6	7,6

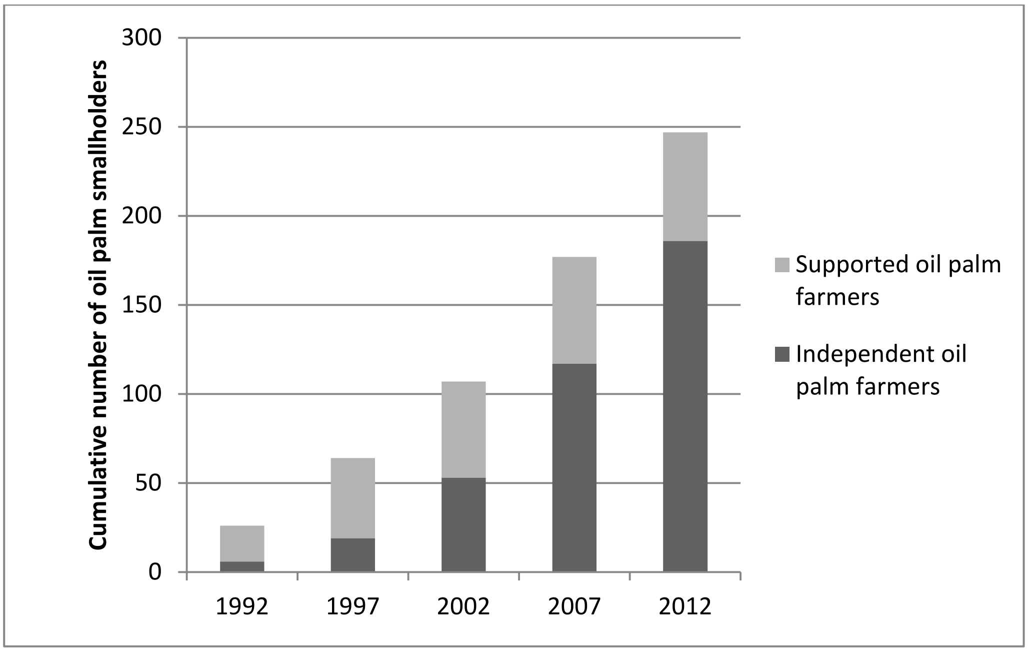
N=72 in 1992, N=76 in 2002 and N=90 in 2012

Source: village survey

5.2 Evolution of smallholder's oil palm production

Smallholders started to cultivate oil palm in the late 1980s. All of these smallholders participated in NES schemes. The number of supported oil palm farmers – these are farmers, who participated in NES or KKPA schemes - increased until 2002 (Figure 3), when the support of the government stopped. Given the usual repayment period of 9 to 10 years (Zen et al., 2005), it can be assumed that almost all of the supported farmers are not bound to estates anymore. They can hence decide by themselves how to use their land. From the mid 1990s onwards, more and more independent smallholders – these are farmers, who did not participate in NES or KKPA schemes - engaged in oil palm cultivation and today they outnumber supported smallholders.

Figure 3: Evolution of smallholder's oil palm production



N=247
Source: household survey

5.3 Socioeconomic characteristics of oil palm smallholders

We further refine our analysis of smallholders' oil palm expansion by looking at farm, household, and village characteristics of producers of oil palm vs. farmers, who do not cultivate oil palm. All values reported in Table 3 refer to the year 2012. Out of the 697 interviewed farmers, 247 reported to cultivate oil palm, which is equivalent to a share of 35%.

Oil palm producers cultivate significantly more land than non-oil palm farmers (Table 3). On average, oil palm farmers cultivate 6.51 ha of land compared to 3.31 ha of non-oil palm farmers, which is equivalent to almost twice the area. Oil palm farmers started to grow oil palms, on average, in 2003 cultivating 3.57 ha, which represents 65% of the total acreage. 25% of them received support from an oil palm company. Rubber is cultivated by 62% of the oil palm farmers representing 33% of the total acreage. On average, oil palm farmers started to grow rubber in 1998, which is five years earlier compared to oil palm. As rubber cultivation started earlier and the area under rubber does not differ between oil palm and non-oil palm farmers, it seems, that oil palm is rather added to the farmers' land use portfolio than substituting other land uses like rubber. Non-oil palm farmers are rather specialised in rubber production. 95% of the non-oil palm farmers cultivate rubber on 3.18 ha, which is equivalent to 91% of their cultivated area.

With respect to household characteristics, oil palm farmers own significantly more land and the share of certified land is higher, which is mainly due to supported oil palm farmers, who received official land titles after debt repayment. The share of female headed households is significantly lower in case of oil palm farmers. The two groups do not differ significantly in terms of household size, age and education of the household head.

Table 3: Socioeconomic characteristics of oil palm and non-oil palm farmers

Variable	Oil palm farmers (N=247)	Non-oil palm farmers (N=450)	All farmers (N=697)
Farm characteristics			
Cultivated area (ha)	6.51** (10.26)	3.31 (4.65)	4.45 (7.31)
Year when oil palm cultivation started	2003 (6.14)	na	2003 (6.14)
Area under oil palm (ha)	3.57** (5.78)	0	1.26 (3.83)
Share of oil palm in total farm size (%)	65**	0	23
Share of supported oil palm farmers (%)	25	na	9
Share of households cultivating rubber (%)	62**	95	83
Year when rubber cultivation started	1998 (9.68)	1997 (9.78)	1997 (9.75)
Area under rubber (ha)	2.87 (6.07)	3.18 (4.65)	3.07 (5.19)
Share of rubber in total farm size (%)	33**	91	71
Household characteristics			
Land owned (ha)	8.16** (16.57)	3.96 (7.13)	5.45 (11.57)
Share of land with title (%)	54**	38	44
Share of female headed households (%)	5**	12	9
Number of adult household members	2.96 (1.21)	3.00 (1.25)	2.98 (1.23)
Age of household head (years)	44.84 (12.25)	44.66 (12.16)	44.72 (12.18)
Education of household head (years of schooling)	7.87 (3.67)	7.31 (3.60)	7.51 (3.63)
Village level characteristics			
Share of households residing in a village, where oil palm is cultivated by smallholders (%)	100**	95	97

Notes: Mean values are shown with standard deviation in parenthesis. *, ** indicate differences are significant at the 5% and 1% level, respectively.
Source: household survey

Concerning village characteristics, we find that 95% of the non-oil palm farmers live in villages, where other smallholders grow oil palms. This finding indicates that beyond access to mills further constraints to oil palm cultivation must exist. These constraints will be investigated further in the following section.

5.4 Constraints to oil palm adoption

Qualitative research identified agricultural expertise, lacking flexibility in labour requirements, availability of seedlings, and investment costs as the major constraints for farmers to cultivate oil palm. These factors will be described in the following paragraphs.

Differences in management and agricultural expertise

Oil palm is a relatively new crop in the research area and hence knowledge about crop management is not widespread among the local population. Training on oil palm cultivation was almost exclusively given to participants in oil palm schemes. For rubber the situation is different, because it is a long-established crop in Jambi. As previously indicated in Table 2, rubber was cultivated on almost 40% of the area in 1992, while oil palm occupied just 8.6% at that time. Additionally, household survey data reveals that rubber plots are significantly older than oil palm plots (Table 4). The average age of rubber plots is 19 years compared to 12 years in case of oil palm. As one farmer stated: *"In former times people from Bungku did not know oil palm. In 2002/2003 began the building of the asphalt road by the district government and access to Bungku became more easy. Since then many outsiders came and planted oil palm. Since then the people of Bungku became familiar with oil palm. Most of these newcomers come from Java, Jambi, Medan Lampung and Bangko. I myself do plant rubber because I do not have any experience with planting and tending oil palm"* (Pak Toni, September 2012)

The use of external inputs also differs significantly between the two tree crops (Table 4). Expenditures for oil palm production are almost four times higher than for rubber. On average, oil palm farmers spend IDR 2.5 million per ha and year, while rubber farmers just spend IDR 0.7 million per ha and year. These higher total expenditures are mainly driven by higher fertilizer and herbicide use. Fertilizer is applied on 81% and herbicides are used on 83% of all oil palm plots. For rubber plots, fertilizer and herbicides are applied on 27% and 47% of the plots, respectively. Moreover, if fertilizer is applied, the expenditures on oil palm plots are more than two times higher than on rubber plots. A farmer testifies: *"Actually I prefer rubber because I grew up with rubber [...]. Rubber also only has to be fertilized twice a year – in the beginning of the hot season and the beginning of the cold season. Oil palm needs other and more fertilizer"* (Pak Achmad, September 2012).

Table 4: Plot characteristics and input use of rubber and oil palm

Variable	Oil palm plots (N=301)	Rubber plots (N=857)
Plot characteristics		
Plantation age (years)	11**	17
	(6.2)	(9.9)
Distance from home (km)	3.2**	4.7
	(4.1)	(9.7)
Distance from road (km)	0.6**	1.0
	(1.4)	(1.7)
Share of plots under sharecropping (%)	3**	18
Material input costs		
Share of plots fertilizer is used (%)	78**	28
Expenditures on chemical fertilizer[a] (1,000 IDR per ha)	2253**	889
	(1827)	(931)
Share of plots herbicides are applied (%)	81**	49
Expenditures on herbicides[a] (1,000 IDR per ha)	346	336
	(260)	(266)
Share of plots material inputs are used (%)	93**	81
Total expenditures on material inputs (1,000 IDR per ha)	2595**	719
	(2465)	(932)

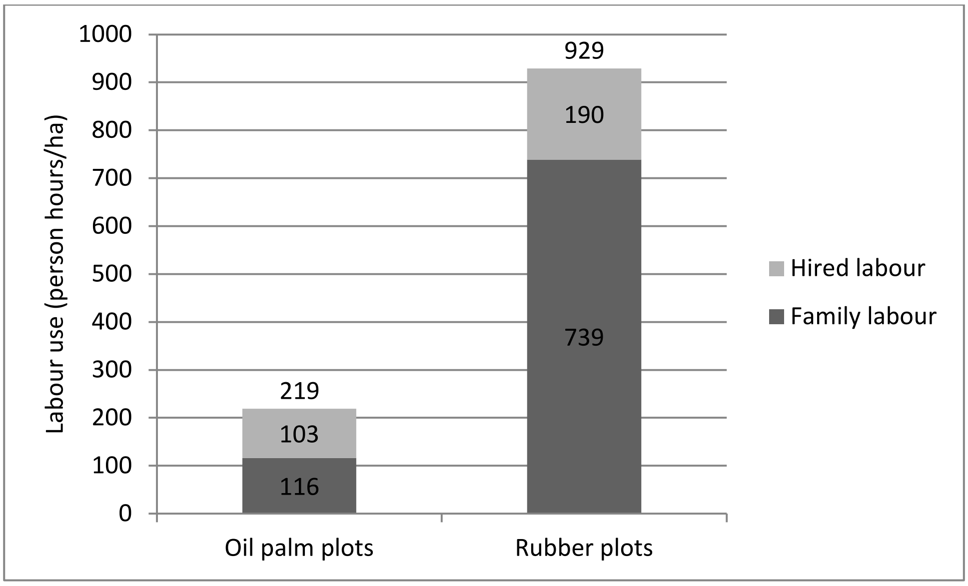
Notes: Mean values are shown with standard deviation in parenthesis. Only productive plots were included in the analysis. *, ** indicate differences are significant at the 5% and 1% level, respectively. [a]Conditional on using fertilizer and herbicides, respectively.
Source: household survey

Labour requirements and flexibility

Labour use on rubber plots is more than four times higher than on oil palm plots (Figure 4). On average, rubber requires 929 hours of labour per ha and year and oil palm just 205 hours per ha and year. Family labour use is even almost seven times higher on rubber plots than on oil palm plots. On rubber plots 739 hours of family labour per ha and year are used while it is just 116 hours on oil palm plots. *"We migrants from Kerinci prefer oil palm instead of rubber. We did not have experience neither with oil palm nor rubber. But oil palm is less work than rubber"* (Pak Eddi, September 2012).

During the interviews, the respondents, however, stressed, that labour use in rubber is much more flexible than in oil palm. Oil palm should be harvested twice a month and the fruits have to be processed within 24 hours. During peak times of harvesting, labour and transportation must be guaranteed. Rubber could be tapped every two days but can also be left idle for various reasons like shortage of labour. *"The only restriction we have in the rubber harvest is the rain. Rubber does not decay. If you harvest oil palm it has to be sold directly. If you wait for one or two days, you will lose. This makes it difficult"* (Pak Dedi, July 2013).

Figure 4: Labour use on oil palm and rubber plots



N=301 for oil palm and N=857 for rubber
Source: household survey

Availability of oil palm seedlings

Until recently oil palm seedlings and saplings were not easily available to smallholder farmers outside the NES schemes. They were not available from traders and the Governmental Agency for Plantations (*DINAS Perkebunan*) did not distribute seedlings to smallholders until 2000. Rubber seeds were easily available from traders and they could even be collected in existing rubber plots. *"The village head was the first to plant rubber in Bungku. We worked in his rubber gardens and secretly collected rubber seeds in the early morning dawn to plant rubber ourselves"* (Pak Mik, August 2012). Additionally, rubber seeds were distributed to local communities by the provincial government promoting further cultivation of rubber. *"In the beginning we did not understand how to handle rubber or oil palm. We received rubber seeds from the government"* (Ibu Mira, September 2012).

However, it seems that availability of oil palm seedlings has changed considerably. According to household survey data, the share of farmers, who obtained or purchased seedlings in 2012, does not differ between oil palm and rubber (Table 5) indicating similar access to seedlings. In terms of sources of purchased seedlings, estate companies and output traders are more important for oil palm than for rubber. Official dealers, farmer groups/cooperatives, and government sources are more important for rubber than for oil palm.

Table 5: Sources of seedling for rubber and oil palm (%)

Variable	Oil palm	Rubber
Share of farmers, who did not obtain seedlings in the last 12 months	85.8	89.0
Share of farmers, who obtained seedlings for free	0.4	0.7
Share of farmers, who purchased seedlings	13.8	10.3
Sources of seedlings if purchased		
Estate company/contractor	8.8	0.0
Official dealer	14.7	30.0
Unofficial dealer	11.8	15.0
Farmer group/cooperative	8.8	15.0
Output trader	32.4	11.7
Government	2.9	8.3
Other farmer	20.6	20.0

N=697
Source: household survey

Investment costs

The investment costs for oil palm are significantly higher compared to rubber. On average, the investment costs for oil palm amount to IDR 1.99 million, while for rubber IDR 0.76 million are spent (Table 6). Main reasons for the higher investment costs are higher expenditures on seedlings and fertilizer. *"I have 4 ha land. I plan to plant 2 ha with oil palm and 2 ha with rubber. Because oil palm needs a bigger investment than rubber"* (Pak Achmad, September 2012).

Table 6: Investment costs in year 1 of rubber vs. oil palm plots

Variable	Oil palm (N=12)	Rubber (N=19)
Material input costs (1,000 IDR per ha)		
Expenditures on seedlings	1447 (1588)	526 (852)
Expenditures on chemical fertilizer	436 (896)	82 (354)
Expenditures on herbicides	94 (162)	128 (238)
Expenditures on other inputs	12 (28)	47 (126)
Total expenditures on material inputs	1990* (1927)	762 (1001)

Notes: Mean values are shown with standard deviation in parenthesis. * indicates differences are significant at the 5%. The number of observations is much smaller than in the household survey, because questions about investment costs were only asked to households that had established a new plantation in 2012.
Source: household survey

5.5 Reasons for oil palm cultivation

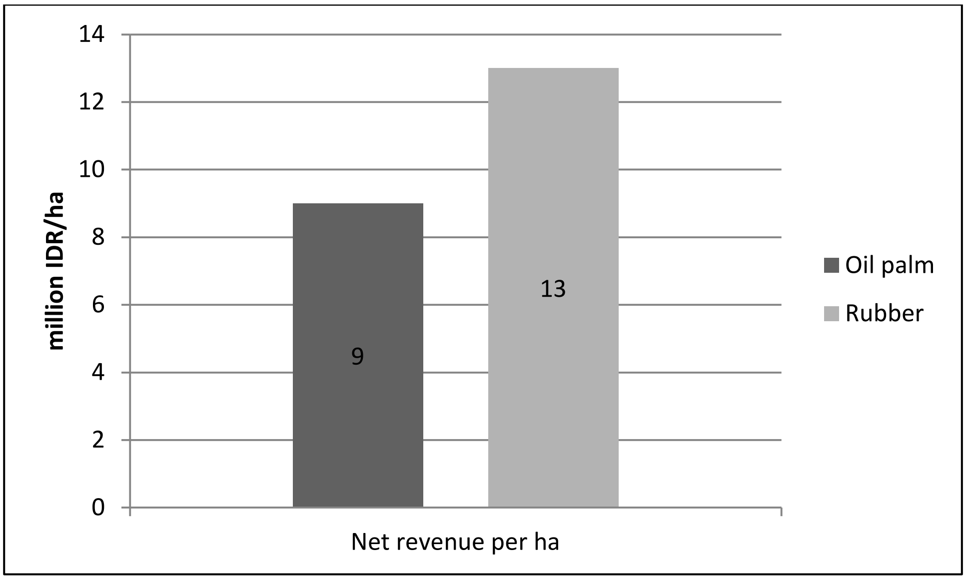
Apart from the above mentioned constraints to oil palm cultivation, the respondents also stressed various advantages of oil palm over rubber cultivation; particularly the higher returns to labour and the shorter immature phase of oil palm. We will elaborate these points in the following paragraphs.

Returns to land and labour

Higher returns have often been mentioned by the respondents during the qualitative interviews as an important reason for oil palm cultivation. *"Of course oil palm needs bigger investment than rubber, but to own oil palm makes the heart happy"* (Pak Eddi, September 2012). There is also the hope, that the investment into oil palm will improve the livelihood of future generations. *"[People] plant oil palm because they want to have a better live for their children and grandchildren"* (Pak Nurdin, September 2012).

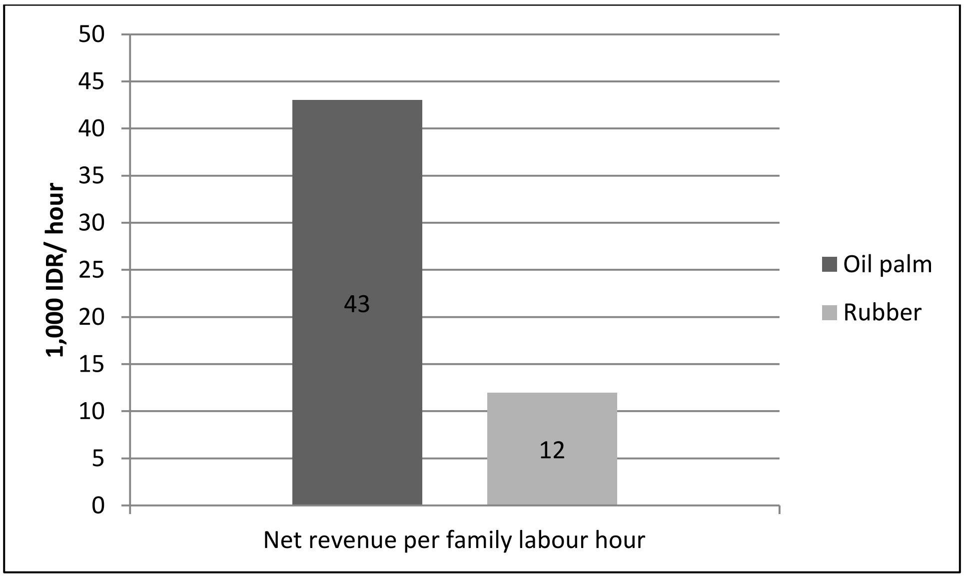
Household survey data, however, suggests that the returns to land are higher for rubber than for oil palm. On average, the net revenues per hectare of rubber are IDR 13 million, while they are just IDR 9 million for oil palm (Figure 5). The returns to land for rubber are hence one-third higher than for oil palm. But to yield such net returns, rubber cultivation requires more than four times more labour than oil palm as shown above. This leads to much lower returns to family labour for rubber (Figure 6). Every family labour hour used in oil palm returns IDR 43,000, while the return is just IDR 12,000 per hour in rubber. This difference in returns has also been highlighted during the qualitative interviews. *"[We] get better income from rubber than from oil palm. But rubber means a lot of work"* (Pak Januar, June 2013). Why the respondents then consider oil palm as the better choice to improve livelihoods? The lower labour requirement of oil palm enables households to cultivate more area and to engage in other income activities, such as running a food stall, which increases total household income. *"One person can take care of 2 ha of rubber. But in comparison to that, one person can manage about 10 ha of oil palm plantation. [...] We only need to work in the oil palm plantation two times a month, so the other 28 days we can find some other work"* (Pak Januar, June 2013).

Figure 5: Returns to land for rubber and oil palm plots



N=301 for oil palm and N=857 for rubber
Source: household survey

Figure 6: Returns to labour for rubber and oil palm plots



N=301 for oil palm and N=857 for rubber
Source: household survey

Immature phase of rubber

Another reason for cultivating oil palm mentioned during the qualitative interviews is the difference in the immature phase. Oil palm trees become productive four years after planting and they are then used for about 20 years. Farmers start to tap rubber trees about seven years after planting and the trees are tapped for about 25 years. While both crops need a long term perspective, farmers deemed the difference in the productive period an important argument for their crop choice. *"Most people here plant rubber, but for a quick return oil palm is faster. If people plant rubber, they often have to wait 7 or 10 years for the first yield. But from oil palm, you can make a living of faster"* (Pak Zain, September 2012). Another respondent explained: *"The reason why I changed my first field into palm oil is so that I can harvest earlier"* (Pak Taufik, August 2013).

5.6 Elasticities of inputs in oil palm and rubber cultivation

We further investigate the importance of inputs in oil palm and rubber cultivation by estimating a production function. We chose the translog functional form due to its flexibility. The dependent variable is the natural logarithm of the yield in kg per plot in 2015. All continuous independent variables are also log transformed. Table 7 presents the estimation results. The estimated coefficients represent the partial production elasticities of the inputs used and can be interpreted as the percentage change in output per one percent change in the input used.

In general plot size, labour and capital determine production and productivity in both crops (Table 7). The magnitude and significance, however, differs between oil palm and rubber. Higher labour input increases, ceteris paribus, the output level in both crops, although the scale is higher for rubber. A one percent increase in labour leads to a rise of the output level of 0.31%, while for oil palm the increase is 0.22%. The higher labour elasticity of rubber might be explained by differences in labour deployment. In rubber a rise in labour input means an increase in tapping frequency, which directly leads to a higher output. In oil palm additional labour does not directly lead to higher yields since the output mainly depends on the ripeness of the fruits. In terms of plot size, the results show a higher elasticity in oil palm production. A one percent increase in plot size leads to a 0.75% increase in output, which is the highest partial elasticity of all production factors. For rubber, the increase is 0.50%. These results suggest that it makes economically more sense to allocate additional land to oil palm rather than rubber, even though the average returns to land are lower. For capital, the results reveal a higher elasticity in oil palm cultivation compared to rubber. Moreover, fertilizer application, which is modelled as a dummy, is important in both systems, while the applied amount appears to be less relevant for oil palm production.

Summing up the point elasticities of plot size, labour, capital and fertiliser provides us with a measure of scale elasticities of 0.98 for rubber and 1.09 for oil palm. The scale elasticity indicates decreasing returns to scale for rubber production and slightly increasing returns to scale for oil palm. Increasing returns to scale indicate a rather capital-intensive production. Higher investments into the production, as tractors, seedlings etc., generally correlate with high scale elasticities. Decreasing returns to scales are mostly found in labour-intensive types of production, where smaller volumes of production are also efficiently feasible. Keeping this in mind and considering the calculated returns to land and labour, the estimation displays a labour- intensive rubber production and a capital- intensive oil palm production.

Table 7: Estimation results of the partial production elasticities

Variable	Oil palm (N=280)	Rubber (N=724)
Log plot size	0.747*	0.504***
Log labour	0.220**	0.314***
Log amount of fertiliser	0.047	0.114**
Log number of trees	-0.07	-0.056
Log plantation age	0.164**	-0.027
Log capital	0.080***	0.053**
Fertilizer used (dummy)	-0.141*	-0.091*
Batanghari[a]	0.130*	-0.104**
Muara Jambi[a]	0.195*	-0.11
Tebo[a]	0.245	-0.007
Bungo[a]	0.124	-0.04
Intercept	0.647***	0.587***

Notes: Estimated coefficients are shown. For clarity, this table only displays the partial elasticities; squared terms and interaction terms are omitted. *, **, *** indicate differences are significant at the10%, 5% and 1% level, respectively. [a]Base category is Sarolangun.

These results confirm our previous findings. The large amount of labour and the lower return to labour in rubber production coincides with the finding of the labour-intensive production via the scale elasticities. The high elasticity of labour and the intensive use of labour may indicate limitations in the availability of labour in rubber production. Vice versa the results suggest a shortage of land with respect to oil palm production.

5.7 Risk attitudes and crop choice

Changing land use towards a perennial crop like oil palm can be seen as an investment. Since each investment implies risk, the farmers' risk attitude might influence such an investment decision. This section analyses the effect of the risk attitude on the decision to start oil palm production and on the acreage dedicated to oil palms. We use a logit model to estimate the effect of risk attitude on the production decision and a left-censored Tobit model to assess the effect on oil palm acreage. The risk attitude is measured by the Holt-Laury value (Holt and Laury, 2002), which decreases with risk aversion. The estimates indicate a relation between risk attitude and land use decisions and should not be interpreted as a causal relationship due to the potential endogeneity of risk attitude in the regression models.

The Holt-Laury value shows a significant inverted U-shaped influence on both the production decision and the oil palm acreage (Table 8). This indicates that especially risk-loving as well as very risk-averse farmers have a lower probability to cultivate oil palm compared to farmers with moderate risk attitude. Moreover, the latter farmers also tend to have bigger oil palm plantations than their peers. The difference accounts for up to 1 ha compared to risk-loving farmers.

These results suggest that the extreme risk-averse farmers are less willing to make the high initial investments needed for establishing oil palm plots, since it is too risky for them. Apart from that, it might also be that there are options to generate a more stable income, which are hence preferred by risk-averse farmers. Furthermore, risk-loving farmers are also less likely to have oil palms and they also tend to establish smaller oil palm plantations. This might indicate that alternative investment possibilities exist, which are more profitable than oil palm, but also more risky. All in all it seems that oil palms are preferred by the moderate risk-averse farmers. Investment in oil palms seems to be too risky for the risk-averse, while the generated returns are considered too low by the risk-loving farmers.

Table 8: Estimated coefficients for the decision to cultivate oil palm and oil palm acreage

Variable	Decision to cultivate oil palm	Oil palm acreage
Holt-Laury value	0.37**	0.53**
Holt-Laury value squared	-0.02*	-0.03**
Local migrant (dummy)[a]	0.62	0.85
Transmigrant (dummy)[a]	3.42***	4.94***
Years in school	-0.17	-0.72**
Years in school squared	0.00	0.03*
Age	-0.05**	-0.07***
Land (ha)	0.06	0.23***
Intercept	0.11	1.32

Notes: Estimated coefficients are shown. *, **, *** indicate differences are significant at the10%, 5% and 1% level, respectively. [a]Base category is non-migrant.

Beyond that, transmigrants show a higher probability to cultivate oil palm than non-migrants. They also tend to have bigger oil palm plantations. Moreover, younger farmers have a higher probability to cultivate oil palm and they tend to have bigger oil palm plantations than older farmers. The farm size significantly determines oil palm acreage, but shows no significant influence on the probability to start cultivating palm oil.

6 Conclusions

The rapid expansion of the oil palm area in many tropical countries has raised concerns about its negative impact on local communities, food security, biodiversity, and climate change. While the expansion of oil palm in early stages was mainly driven by large private and public companies, smallholder farmers have increasingly started to cultivate oil palm as well. It is expected that smallholders will outnumber large private and state companies in production as well as oil palm acreage in the near future. For policy formulation it is hence important to better understand who these smallholders are and why they have started to cultivate oil palm. In this paper, we used a rich dataset collected in the province of Jambi, which is one of the most important production areas for oil palm, to analyse smallholders' decision making by combining qualitative, quantitative, and experimental methods. In following such a multi-dimensional, we provided empirical evidence that allows for an in-depth understanding of smallholders' land use choices, which is intended to support politicians in formulating appropriate regional policies. In particular, we wanted to better understand the major constraints and reasons for farmers to engage in oil palm cultivation, and explore behavioural differences between oil palm and non-oil palm farmers.

Building on a conceptual framework of land use choice, we differentiate between internal and external factors. The latter refer to macro-level variables at the international and national level, which affect through different transmission channels the internal drivers of oil palm cultivation. Government policies, such as the transmigration program, promoted the uptake and spread of oil palm. But also prevailing property-rights regimes determine the access to private land and thus who is able to further expand oil palm cultivation. Another fundamental factor that influences land use choices is the prospective demand for palm oil and related international prices for the commodity. Currently, the world is experiencing a sharp decline in crude palm oil prices which negatively affects profitability and likely disincentive smallholders to invest in oil palm. The price-effect, however, seems to be location dependent. In Africa, where palm oil production is dominated by large-scale estates the price drop creates opportunities for smallholder farmers. Estates increasingly contract-out their production and thus spread the associated risks with farmers (Ghazoul et al., 2015).

At the household level we identified internal factors that influence smallholders' choices to cultivate oil palm instead of rubber, which is still the dominant crop in our study region. For instance, compared to rubber farmers, oil palm farmers cultivate more area and own more land, and also have more formally titled land. Partly, this may be explained by being supported by the government or companies. Another reason are the lower labour requirements in case of oil palm, which allow the farmer to expand agricultural activities without hiring additional labour. The lower labour requirements have also been identified as a major reason for smallholders to grow oil palms. We further showed that returns to land are higher for rubber than for oil palm. Due to the differences in labour requirements, the returns to labour are, however, higher for oil palm than for rubber. The higher returns to labour and the fact that oil palm smallholders appear to employ excess labour in cultivating addition oil palm plots make oil palm cultivation more profitable, and thus attractive. Crop choice seems also to be affected by farmers' risk preferences. We showed that oil palm farmers are neither risk-averse nor risk-loving, rather, they appear to be risk-neutral. This risk neutrality seems also to be in line with farmers' appreciation of the relatively short time period before oil palm yields and an income can be generated. A risk neutral farmer would probably be more inclined to choose oil palm, which will guarantee an earlier cash inflow. In addition, oftentimes risk can be reduced when oil palm is cultivated because of the availability of contract farming arrangements with private companies that provide, among others, credit and extension services.

However, in this paper we also identified constraints of oil palm cultivation, and thus factors that prevent smallholders to cultivate oil palm. By econometrically estimating the production functions of oil palm and rubber, we found that rubber is highly labour intensive, as discussed, whereas oil palm is capital-intensive. Qualitative interviews support this finding. For many farmers, who lack access to formal credit, the high investment costs associated with palm oil production pose a considerable barrier. Moreover, the high agricultural expertise required negatively affects the decision to cultivate oil palm. In many cases rubber cultivation, which has been an established crop for many decades, seems to be the more viable and secure choice.

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