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The challenges Indonesian oil palm smallholders face when replanting becomes necessary, and how they can be supported – a review

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Abstract

Three decades after the establishment of many smallholder oil palm plantations, large areas of oil palm will require replanting soon or are already overmatured. The process of replanting offers a unique opportunity to redesign plantations, close yield gaps, boost productivity and therefore secure income and livelihoods, but requires knowledge, inputs and financing. If postponed or done incorrectly, replanting could further exacerbate existing challenges in smallholder oil palm cultivation, both socioeconomic and environmental. In this review, we collect relevant literature on replanting of oil palm, especially in the realm of smallholder cultivation, to highlight the challenges smallholders will face when replanting. We find that access to inputs, finances and know-how differ greatly between groups of smallholders. This will likely affect smallholder's decisions when, how and what to replant. Information on replanting, proper training, access to high-quality seedlings as well as eligibility for public replanting funds will determine the success of smallholder replanting efforts in Indonesia but are distributed unevenly currently. We finish the review with recommendations for both policy-makers and researchers on how to overcome the challenges replanting holds and capitalize on the opportunity replanting offers rather than exacerbating existing issues.

Keywords: oil palm, replanting, smallholder, livelihood, Indonesia, Sumatera

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1. Introduction

Before the Indonesian government launched its transmigration programme in the 1980s, its palm oil production was practically non-existent. The cultivation area only covered 1.6 Mha (Wicke et al. 2011). As part of the programme, however, Indonesia's palm oil production grew rapidly, and the country is now the largest producer of the widely used oil (Statista 2021; Naylor et al. 2019). The transmigration programme did not only aim to relocate volunteers to fight overpopulation in some regions. But there was also the purpose of boosting the economy and reducing poverty by giving transmigrants land to cultivate oil palm in smallholding plantations (Rival and Levang 2014; Kunz et al. 2017; Schleicher et al. 2019).

These smallholders became an important pillar for Indonesia's palm oil production (Kubitza 2018; Naylor et al. 2019; Qaim et al. 2020). They now cultivate 41% of the Indonesian oil palm plantation area (Herdiansyah et al. 2020) and produce one third of Indonesia's palm oil (Statista 2021). In the 1990s the number of smallholder oil palm plantations skyrocketed (Naylor et al. 2019), particularly in rural regions, like Jambi province (Euler et al. 2015).

Despite oil palm's ambivalent reputation, its cultivation has been an overall success in terms of poverty reduction (Qaim et al. 2020). However, more and more smallholder plantations are about to reach or already have reached the end of their economic lifecycle, which is said to occur with palms older than 25 years (Corley and Tinker 2016). Literature agrees that around that age the economic productive cycle of an oil palm comes to an end, mainly because of two reasons: (1) the palm's height exceeds the 10-meter mark, which makes harvesting more difficult, thus increasing the harvesting costs; and (2) the palm's fruit production decreases (Corley and Tinker 2016; Ismail and Mamat 2002; Ferwerda 1955). Replanting, i.e. the replacement of old palms with new ones, becomes necessary. According to Mongabay Environmental News (2020a), already two-fifths of Indonesian smallholder plantations have reached that state. Other estimates say, that 30% (Glenday and Paoli 2015) to 50% – up to 2.4 Mha (Ompusunggu and Gunawan 2018) of Indonesian smallholder plantations will need replanting within this decade.

The replanting process offers the opportunity for smallholders to increase the productivity of their plantations, thus narrowing yield gaps to company-managed plantations (Lee et al. 2014; Woittiez et al. 2017). Higher productivity can also translate into higher incomes for smallholder households. Additionally, the replanting process could be used to redesign old plantations, making them more environmentally sustainable (Qaim et al. 2020). Besides these opportunities, replanting can represent a challenge to smallholders. Replanting is linked to high costs, and good management practices including pest control as well as correct fertilising become more crucial (Corley and Tinker 2016;

Nurfatriani et al. 2019; Goh 2005). While there are different methods of replanting (Corley and Tinker 2016), some may not be feasible for smallholders given high capital and information requirements.

Currently, there is little research on smallholders' replanting choices, the challenges they face and potential measures to support them. Yet, this knowledge is urgently needed to harness the opportunities offered by replanting large areas of oil palm in Indonesia and avoiding the exclusion of large parts of smallholder farmers from the oil palm sector in the future. In this review, we collect data from relevant studies, identify research gaps and offer policy recommendations concerning the difficulties and opportunities of smallholder-managed replanting.

In order to provide an overview of the subject and identify crucial research gaps, the review follows five guiding questions:

1. How much research has already been done on the topic of replanting, and what thematic emphases can be identified?
2. Are there different types of smallholders, and does their replanting situation look different?
3. What are different replanting techniques, and which are suited for smallholders?
4. Which impeding factors can be identified for smallholders?
5. How could smallholders be supported?

We will first conduct a systematic literature review to identify and evaluate relevant studies on the subject. In section 3, we will provide information on Indonesian smallholder types, which is important to adequately assess opportunities and risks of the smallholder replanting process. Section 4 will discuss the necessity for replanting, the techniques and their feasibility for smallholders. In section 5 we focus on opportunities and constraints of replanting for smallholders. In section 6 we discuss the guiding questions and highlight areas of importance for future research. Finally, in section 7, we will provide policy recommendations and name fields of research.

2. Methodology and systematic literature analysis

2.1 Data acquisition and data selection

We used three databases for our systematic literature collection: ScienceDirect (SD), Web of Science (WOS), and Dimensions. According to Gusenbauer and Haddaway (2020) SD and WOS are suitable for systematic reviews. Dimensions was chosen because of its easy-to-handle surface and its elaborate search options. Gusenbauer and Haddaway (2020) consider Google Scholar unsuitable for primary

review searches. However, it is suitable as a supplementary source, which is why we used it to complement our systematic literature search. Furthermore, we used the snowballing method to expand the literature acquisition.

We searched for the terms “oil”, “palm”, and “replanting” in either the title, the abstract or the keywords. Non-English publications were excluded. We also excluded publications from further analysis, if at least one of the following factors applied to the abstracts: (1) research questions are not clearly stated; (2) the methodology is either unclear or not transparent enough; (3) the results are unclear, trivial or not related to research questions; (4) an obvious research bias was detected.

2.2 Systematic literature analysis

The search resulted in a total of 142 publications (see figure 1). 53 of the findings had to be excluded, because they were not relevant to oil palm replanting. Another 33 publications, mostly published in Malaysia, addressed the use of biomass that becomes available after replanting without discussing the replanting process itself. Another 18 studies were published on pest and disease control, 13 on environmental aspects of replanting, mainly about biodiversity loss during and shortly after land clearing. Six publications dealt with the replanting process. Two of them dealt with the optimization of the replanting process, two investigated replanting techniques, and two were about the optimal timing of replanting. None of them considered smallholder plantations. Only one study was found that investigated both, socioeconomic and environmental aspects of replanting.

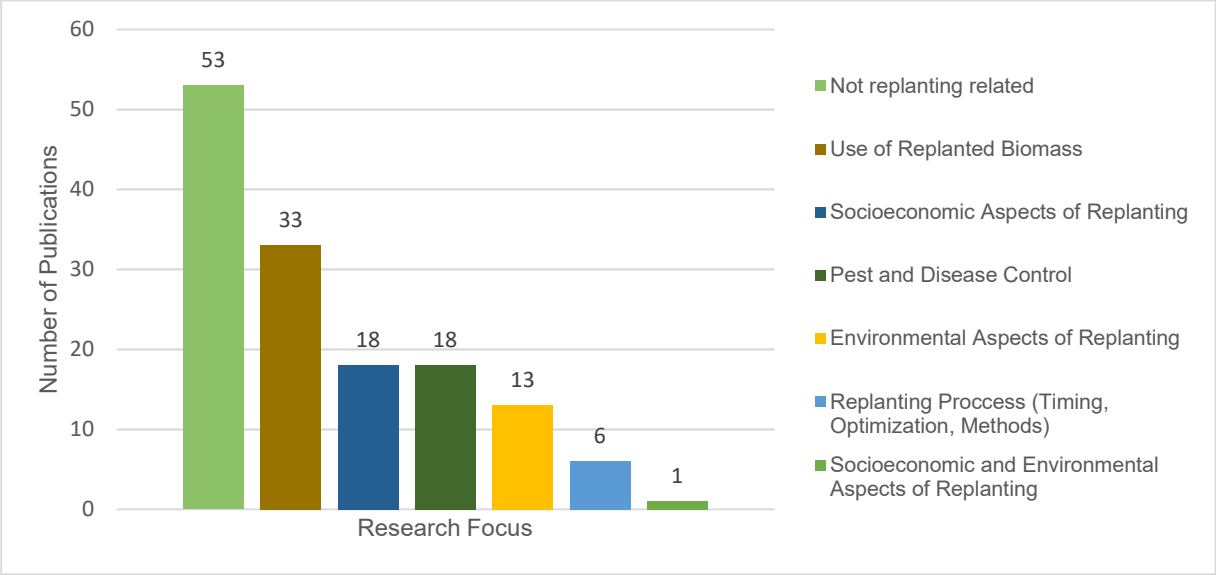

Figure 1: Number of publications on oil palm replanting and their research focus (SD, WOS, Dimensions)

Only 18 studies were related to socioeconomics aspects of replanting. These studies were mostly qualitative and based in Jambi province, Sumatra. 15 of them did not meet the quality criteria for this review. However, they partially contained important descriptive information. So, we used some of them as reference points where appropriate. The absence of high-quality studies on this subject clearly shows a lack of awareness of the importance of the replanting issue among the scientific community.

The relevant studies from the systematic literature analysis, as well as the literature from the supplementary search are cited and analysed and the subsequent sections. A complete literature list from the systematic analysis is given in appendix A. The list is divided according to the foci of the studies.

3. A typology of Indonesian oil palm smallholders

In order to assess how the replanting process will affect smallholders and how they can be supported, it is important to address the heterogeneity in this socioeconomic group. In this context, we distinguish four different types of smallholder oil palm farmers (see table 1).

Scheme smallholders emerged first in the 1980s as part of the transmigration programme. They were usually given around 2 ha of land to cultivate oil palm and they received official land certificates (Gatto et al. 2015) – however, according to Indonesia's definition of smallholders, farmers can have 25 ha (Glenday and Paoli 2015). These land certificates prove ownership of land and are crucial as a collateral for bank loans and other subsidies. Furthermore, the transmigrant smallholders were supported by companies that provided know-how and training and facilitated access to input materials like fertilizer and seedlings (Rival and Levang 2014; Glenday and Paoli 2015; Jelsma et al. 2017; McCarthy 2010). Similar schemes took over, however, with less influence by the government (Rist et al. 2010; Jelsma et al. 2017). For example, the KKPA, (Kredit Koperasi Primer Anggota: Credit for Cooperative Primary Members) in which also local farmers were included. In this scheme, smallholders entrust a company parts of their land for large-scale oil palm cultivation. In turn, the company establishes a plantation for the smallholders. However, the smallholders have to bear the costs for the establishment of these plantations for which they have to take out loans (Feintrenie et al. 2010; Rist et al. 2010).

Type of Smallholder	Characteristics
Scheme smallholders	• Hold land certificates • Access to inputs, know-how and financing through company affiliation • Originally mainly transmigrants
Former plasma scheme, now independent	• Hold land certificates • Know-how and access to inputs established during company affiliation • Easier access to loans and funding • Often transmigrants
Independent, with no prior experience	• Often no official land certificates • Often sell FFB through middlemen • Limited access to financing, know-how and other resources • Often locals
Farmer groups/ farmer-managed cooperatives	• Coalition of independent farmers • Can provide financial aid • Simplify access to financing • Usually have legal documentation

Table 1: Types of smallholders in Indonesia (based on Glenday and Paoli (2015))

Beginning with Indonesia's decentralization policy in the mid-1990s, smallholders gradually started to cultivate oil palm independently, that is, with no formal affiliation to a company (Naylor et al. 2019). Additionally, former scheme smallholders started independent oil palm cultivation. They were able to keep their land certificates and draw on the established infrastructure (Euler et al. 2015). During that time, farmers with no prior experience also started oil palm cultivation. Some of them were migrants, many were locals (ibid.). Local farmers in particular faced quite a few challenges. One of the main drawbacks was that local farmers strongly relied on their customary laws (Indonesian: adat) with which they handle land access in their communities. This legal ambiguity led to the establishment of many smallholder plantations in state-declared forest areas, making these plantations *de jure* illegal. These plantations are formally located in contested land, making it nearly impossible for smallholders to attain official land certificates (Kunz et al. 2017; Riggs et al. 2016).

To compensate for lacking support and diversify financing possibilities (Schoneveld et al. 2019; Prokopy et al. 2008), smallholders can get organized in farmer groups or farmer-managed cooperatives. Some of the cooperatives provide financial aid. Usually, groups and cooperatives help to distribute tools, farming inputs and provide training. Some of them even established replanting funds through member contributions (Glenday and Paoli 2015; Anwar and Sunesti 2021; Syarfi et al. 2019b). An evaluation of their success proves difficult due to lack of information. Being a member in a farmer group is also a pre-requisite to apply for the state replanting fund PSR (Peremajaan Sawit Rakyat, see section 5.1) (BPDPKS 2019a; Nurfatriani et al. 2019).

Even though smallholder oil palm cultivation has reduced poverty (Qaim et al. 2020), there is still a potential to increase their productivity and thus ensuring smallholder livelihoods. Studies have shown that smallholders in general generate significantly lower yields when compared with large-scale company-managed plantations (Euler et al. 2016; Lee et al. 2014; Woittiez et al. 2017). According to Lee et al. (2014) the yield gap can be up to 40%. These studies have also shown that independent smallholders produce significantly less than scheme smallholders. In the study by Lee et al. (2014) the yield gap was 38%. Closing this yield gap will not only increase smallholders' income and improve their livelihood, but could also reduce further land-use changes.

4. The replanting process

4.1 The necessity to replant

After the prime time of maximum yields, oil palms get less and less productive (see figure 2), until they reach the phase of economic unprofitability. This typically occurs 25 years after planting (Ferwerda 1955; Corley and Tinker 2016; Ismail and Mamat 2002). The harvesting process of oil palm fresh fruit bunches (FFB) still has a low degree of mechanization. Once the palm exceeds the height of 10 meters, harvesting becomes even more labour intensive. In combination with decreasing yields of the palms and increased need for fertilizer, oil palm production becomes economically unprofitable at this stage (ibid.).

Since the main expansion of Indonesian smallholder oil palm cultivation started in the 1990s, many farmers now have to deal with overmatured plantations. According to Mongabay Environmental News (2020a), two-fifths of the plantations are already 25 years or older. 30-50%, which would accumulate to 2.4 Mha, of the smallholder plantation area will need replanting within this decade (Glenday and Paoli 2015; Ompusunggu and Gunawan 2018). Already existing yield gaps are bound to increase if replanting is not conducted timely.

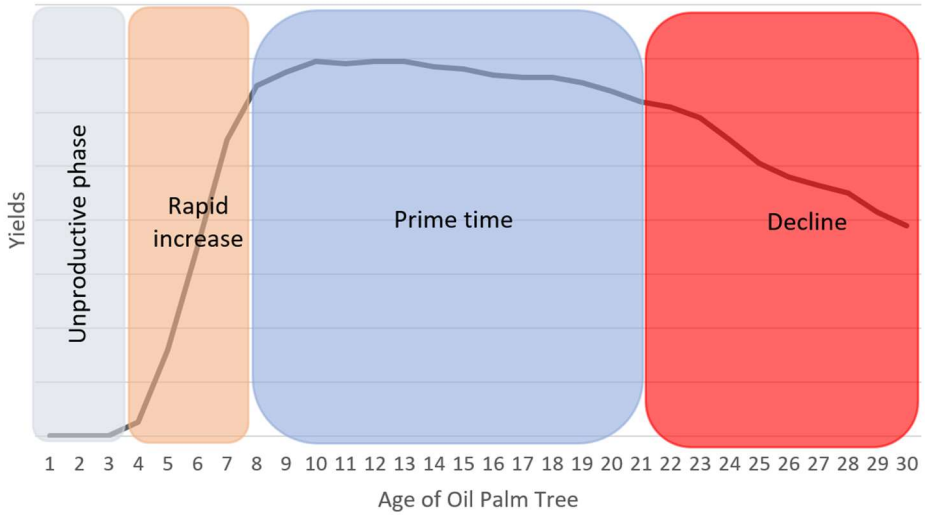

Figure 2: The productivity of an oil palm over time (schematic, based on USDA (2012))

Consequences of delayed replanting can already be observed in Malaysia. Here, the production cost of crude palm oil (CPO) has increased by more than 70% between 1997 and 2008. One of the main reasons for this increase was traced back to low productivity per area unit, to which progressively aging oil palms contributed substantially (Wahid and Simeh 2009). Despite a steady growth of the oil palm area, Malaysia's fresh fruit bunch (FFB) yield per hectare has shown a slight downward trend in the last 30 years, and the proportion of unprofitable old palms grows faster than the replanting rate can compensate (Kushairi et al. 2018; Wahid and Simeh 2010).

Another potential problem with delayed replanting is that a *replanting jam* might occur: if replanting is stalled to the point where it can no longer be deferred, many smallholders will replant large proportions of their plantations at the same time. This would increase the demand for replanting materials (seedlings, fertilizers, machinery, etc.), causing price increases, possibly even material shortages (see also Wahid and Simeh 2010). Another major issue is that oil palms produce no fruits in the first few years after plantation (see figure 2). The duration of the unproductive phase varies depending on environmental conditions, planting skills and seedling quality. But in general, productivity losses must be expected in the first 3-5 years (Schleicher et al. 2019). This could act as a deterrent, and start a vicious cycle, where decreasing yields impact farmers financial buffer, making replanting even more difficult. Even though the area under oil palm as well as production volumes are still increasing in Indonesia (Statista 2021), the Indonesian government expects a decline in crude palm oil (CPO) productivity from 2024, if replanting is not properly done (Ministry of Agriculture, 2020).

4.2 The different replanting methods

There are different methods to replant oil palm plantations. According to Corley and Tinker (2016), replanting should be a continuous process with a replanting rate of 4% of the plantation per year, in order to secure stable yields and incomes. However, the observed overageing of smallholder plantations suggests that this rate is not being met.

The conventional method to replant is the *felling and chipping* method in combination with prior poisoning of the palms. Poisoning the palm trunks accelerates their decay (Virdiana et al. 2020), which facilitates the next step: felling the palms. Companies usually use diggers and bulldozers to fell the old stand (Zulkifli and Khalid 2008). Among smallholders it is common to use chainsaws, which is cheaper but more labour-intensive and time-consuming. Next, the felled palms are chipped, either by heavy machinery or chainsaws. Even pulverisation with special machines is possible (Corley and Tinker 2016; Virdiana et al. 2020; Ooi and Heriansyah 2005; Bayona Rodríguez et al. 2015). The chipped material can be spread on the plantation and used as initial fertilizer (Corley and Tinker 2016). Yet, according to Ávila et al. (2014) the risk of pest infection of the new stand increases, if the residue material is not buried. Burying the residues is likely to increase the replanting costs, although Ávila et al. (2014) provide no information on that matter. Pulverisation reduces pest infection (Ooi and Heriansyah 2005), but is less suitable for smallholders, giving the necessity to use special machines.

If the whole plantation is felled and chipped all at once, income losses will be 100% in the first years (Novra et al. 2021). Partial replanting increases fixed costs, and could thus be unprofitable for smallholders with only one or two plots and small plantation sizes. Thus, income diversification becomes more crucial (Siswati et al. 2020). The use of heavy machinery is more efficient, but high fixed costs might prevent smallholders from using them. Through farmer groups and farmer-managed cooperatives machinery could be shared or rented, however, we found no studies to support this consideration. Also, we found no information on the toxicity of the poison used for the environment, nor on possible health risks for farmers.

An alternative replanting method is *underplanting*. The exact procedure varies, but in general the plantations can be fully replanted within three years. It is common to replant 50% of the plantation and then either the rest after 24 months, or 25% each in year 2 and 3. The old stand can be removed by either heavy machinery, chainsaws or by poisoning (Corley and Tinker 2016; SPKS 2016; Ooi and Heriansyah 2005). If done accordingly, short-term income losses can be reduced, and overall yields might even increase. Underplanting is, however, considered to be more difficult to implement. Initial shading from the old stand might hamper the development of the young palms, increasing the risk of pest infection and slowing down the growth of the new stand (Corley and Tinker 2016). The only study

we found on smallholder underplanting was by Ernawati et al. (2019). The study suggests that the acceptance of underplanting among smallholders in Jambi is considerably lower when compared to the conventional technique of felling and chipping. Maintenance costs were said to be higher due to the different age pattern of the palms. The income of smallholders who implemented this technique was also lower. Higher maintenance costs and lower incomes suggest that underplanting requires a higher level of management skills in order to maximize plantation yields and therefore profits.

Additionally, the replanting process could be used to re-design the new plantations to improve their productivity, for example by increasing the palm density (Ernawati et al. 2021) or selecting higher yielding varieties. The methods could also be complemented by biodiversity enrichment measures. Experimental studies have shown that integrating native trees into oil palm plantations can positively affect biodiversity and ecosystem services, while at the same time having little effect on oil palm yields (Teuscher et al. 2015; Gérard et al. 2017; Zemp et al. 2019). As these experiments were conducted on medium sized plantations, it is however unclear to what extent results can be applied to smallholder plantations.

5. Impeding factors in smallholder replanting

5.1 Replanting financing

During the productive phase, oil palm provides a relatively stable income for smallholder farmers (Mehraban et al. 2021). Income from oil palm cultivation can be up to ten times higher compared to rice cultivation (Rival and Levang 2014). At the same time, replanting can represent a substantial financial burden for smallholders. Replanting costs are estimated to be between 3,200€ and 3,800€ per hectare (Nurfatriani et al. 2019). These costs might further increase, if best management practices are not applied and/or if biodiversity enrichment measures are implemented. Studies on smallholder income are rare, but the four we found (see table 2), clearly indicate the necessity for longstanding savings before replanting can be financed. In the study by Ramadhana et al. (2021) smallholders generated an annual net income of 1,660€ with their oil palm plantations, while their household expenditures amounted to 1,500€. Lee et al. (2014) showed that income among independent smallholders can be significantly lower when compared with scheme smallholders. Furthermore, it takes years, sometimes up to 18 years, for smallholders to repay their loans for the initial plantation establishment (Rist et al. 2010). This further impedes their ability to invest in replanting.

Beside the necessary investments for replanting, smallholders also have to cope with reduced income during the unproductive phase of the new stand. Depending on their replanting method, they lose their income from the plantation partially or completely for a few years. In two case studies conducted in Jambi Province, potential and actual household income losses during the non-productive phase were 75% and 71%, respectively (Novra et al. 2021; Yanita et al. 2021a). This would increase off-farm income dependency of smallholders and could lead to a long-term reallocation of labour.

Obviously, most smallholders will need financial support. In another case study from Jambi, 93% of the interviewed smallholders reported the need for financial aid (Syarfi et al. 2019b). Access to financing is a major problem for Indonesian smallholders, particularly for local smallholders, who often have no official land certificates, and are thus excluded from the formal banking sector. Consequently, many smallholders rely on informal credits at detrimental conditions (Krishna et al. 2017; Sahara et al. 2017; Glenday and Paoli 2015).

Study	Study area	Measurement	smallholder type	Income (€)
Rival and Levang (2014)	Sumatra	Annual income per ha	not specified	2,100
Lee et al. (2014)	Sumatra	Annual gross income per ha	not specified	1,200
		Annual gross income per ha	independent	720
Yanita et al. (2021a)	Sumatra	Annual net household income per ha	not specified	860
Ramadhana et al. (2021)	Sulawesi	Annual net household income per ha	not specified	1,900

Table 2: Income of smallholders

In 2015 the governmental Oil Palm Plantation Fund Management Agency (BPDPKS) was established to collect and distribute oil palm funds via the replanting programme PSR to support smallholders in their replanting efforts (BPDPKS 2019a). Even though the application procedure was simplified in 2019 (BPDPKS 2019b), the success of the PSR is still limited. Applicants have to prove that their plantation is not in dispute, and they have to hold official land certificates (ibid.), which continues to be a major burden for local smallholders. As they often used their customary laws to establish their plantations, and plantations are often located in state forest areas or other areas with contested land ownership, they are now unable to get land certificates. Applicants must further be members in a farmer group or cooperative. We did not find representative evidence on the prevalence of farmer groups and cooperatives, but in another Jambi-based case study, 35% of the farmers had no membership (Yanita et al. 2021a). Against this background, the requirement to be part of a farmer group or cooperative could be another obstacle in receiving state funding.

According to the SPKS (Indonesian Palm Oil Smallholders Union) many smallholders do not even know that the PSR exists (SPKS 2016). And those who know the programme seem to be overwhelmed by the application process (Syarfi et al. 2019b). Finally, even if a smallholder receives PSR funding, it is limited to 1,600€ per hectare and capped to 6,370€ in total (Nurfatriani et al. 2019). The rest of the costs must be paid with savings and/or bank loans, which, again, is a problem particularly for smallholders with no land certificates. Against this background, it is maybe not surprising that some smallholders state that they prefer keeping their non-profitable plantations and have no plan to replant (Syarfi et al. 2019b). So far, the BPDPKS has failed to reach its own replanting goals every year (see table 3) and between 2015 and 2019 only 5% of the agency's collected tariffs were distributed to the PSR (Mongabay Environmental News 2020b).

Year	Target (hectares)	Realization (hectares)
2017	20,780	13,211
2018	180,000	35,196
2019	180,000	88,339
2020	180,000	55,943

Table 3: The targeted replanting area and the actual area from 2017-2020 in Indonesia (Ministry of Agriculture, 2020)

5.2 Access to input materials and know-how

Large oil palm corporations with abundant land, financial, and human resources as well as technical know-how can make optimal decisions to maximize profits. On the contrary, smallholders have not only limited financial resources, but also often lack access to high-quality inputs (like fertilizer and seedlings), and know-how (Aguilar et al. 2021) for best management practices.

Smallholders typically only have access to low-quality fertilizer, and the use of it is often suboptimal. Furthermore, smallholders tend to use seedlings which are less productive, have inferior germination rates, and ripen irregularly, which increases harvesting costs. This is particularly common among independent smallholders. It has also been reported that some smallholders use seedlings from their own nursery grown from seeds from their current palms, which is often associated with low-quality seedling material (Jelsma et al. 2017; Soliman et al. 2016; Woittiez et al. 2017; InfoSAWIT.TV 2021). There is no evidence on smallholders' access to heavy machinery, but the fact that smallholders resort to the use of chainsaws for replanting indicates a lack of more efficient alternatives.

Another constraint are the knowledge gaps among smallholders (Kannan et al. 2017), again particularly among independent ones. While plasma smallholders can rely on their company's know-how and possibly can exchange knowledge with other scheme smallholders, independent smallholders often do not have a similar network. Especially local independent smallholders usually have no prior experience with oil palm cultivation (Jelsma et al. 2017). According to Jelsma et al. (2017), independent smallholders appear to rely on informal farmer groups and on their input suppliers for information.

6. Discussion

6.1 The necessity for changes

The shortcomings mentioned in the previous section will have negative impacts on smallholders' ability to replant, but also affect their willingness to do so in the first place. Smallholders are usually not in the position to think about maximizing profits, but their decisions are made to satisfy and suffice (Cordaro and Desdoigts 2021). This "bounded rationality" (ibid.) may cause smallholders to inaccurately assess the process of replanting their plantations. Previous studies have shown that smallholders tend to be risk averse (Clough et al. 2016; Sarwosri and Mußhoff 2020). In the absence of proper knowledge about the replanting process and without access to affordable funding and quality input materials, risk averse farmers are likely to delay investments in replanting.

Studies have already shown that replanting is connected to high investment costs and potentially severe income losses. Underplanting is suitable to buffer income losses, but only if correctly implemented; otherwise it can have negative effects on income and plantation productivity. The concern of not being able to cope with the additional burden of replanting seems to be prevalent among smallholders, causing a delay of the replanting process (Napitupulu et al. 2021). This effect could be further amplified by the recent increase in crude palm oil (CPO) prices (Zainal et al. 2018; markets.businessinsider.com 2022) that might compensate for decreasing plantation productivity. Eventually, however, economic productivity will decrease and the associated income losses will threaten smallholders' livelihoods.

In another scenario, smallholders might be tempted to burn their old stand to reduce the clearing costs, which account for half of the replanting costs (Yanita et al. 2021b). Although burning leads to significant carbon dioxide emissions and is illegal since 2015, it is still practiced (Hartmann et al. 2018; Silvianingsih et al. 2020; Goldstein et al. 2020). Smallholders could also be tempted to clear new land areas to establish new plantations, which would lead to additional land-use changes, including

deforestation, as well as land conflicts. Smallholders could also be forced to sell their land and thus lose their main income source.

Farmer groups and cooperatives could be useful in the replanting process by providing financial, technical and material support. But farmer groups have been criticised for being inactive, and cooperatives for not being transparent enough. Groups and cooperatives often seem to be overwhelmed with their responsibilities (Yanita et al. 2021b; Syarfi et al. 2019a). Results by Jelsma et al. (2017) suggest that cooperatives and farmer groups only play a minor role as source for fertilizer, which makes it questionable how important they really are in terms of input material supply. Furthermore, there is no reliable evidence on how prevalent they are and how many members they have.

State efforts to accelerate replanting and to support smallholders have had limited success so far. The replanting programme does not distribute enough money to smallholders and they failed to reach their own replanting goals each year. One of the main problems is that the programme automatically excludes those who need the funding the most: mainly local, independent smallholders without land certificates. They have the lowest yields, lower income and the most limited access to finances and quality seedlings. Finally, the programme only offers financial aid (BPDPKS 2020a), but smallholders additionally need training in best management practices to increase productivity and to be able to establish more sustainable oil palm plantations.

6.2 Recommendations

Provide training, improve information flow

Replanting requires timely and thorough planning. Pest control becomes more important, the right use of fertilizer more crucial to optimize palm growth and reduce farm expenditures. In the past, training offers have proven to increase smallholders' knowledge on best management practices (Syahza et al. 2018; Mohd Ishak et al. 2020; Romero et al. 2019) as well as productivity of oil palm plantations (Elias et al. 2013). Proper training could support smallholders in their decision (Moser and Barrett 2006) to replant.

The BPDPKS suggests that smallholders should diversify their income sources during replanting, for example by cultivating other cash crops (BPDPKS 2020b) or pond fish farming (Siswati et al. 2020). If done properly, the additional income can compensate the income losses from replanting. Naturally,

such undertaking would require new investments, new skills, and the opening of new markets, for which support, information and training would be necessary.

Furthermore, smallholders need support regarding new plantation designs. Underplanting is better than replanting the whole plantation at once, but requires a higher level of management skills. Replanting offers the opportunity to make replanted plantations more environmentally sustainable, but it will also make plantation management more complex. Up to 2.4 Mha of smallholder plantations need replanting within this decade. This offers a unique chance to significantly improve oil palm's sustainability, using enrichment planting with native trees (Gérard *et al.* 2017) or alley cropping (Slingerland et al. 2019).

Once again, farmer groups and cooperatives can play an important role in providing and/or organizing training, information, and support. The little amount of data that exists, however, suggests that their potential is far from being exhausted.

Push the use of high-quality seedlings and facilitate access to markets

Information flow is crucial, but without practical support may prove useless. Smallholders, and particularly independent ones, do not have the same access to the oil palm supply chain as large-scale companies. With better seedlings, smallholders may be able to increase their oil fruit production by 30% (Jelsma et al. 2017). Therefore, policy makers should find ways to guarantee easy and affordable access to high-quality seedlings.

For the initial phase of replanting, when the palms are unproductive, the BPDPKS suggests that smallholders should expand their income sources. For example, by using the felled trunks that can be used to produce brown sugar, or by selling them to the timber and furniture industry. Oil palm fronds could be used for craftsmanship (BPDPKS 2020b). Studies have shown how oil palm residues, like the trunks can be used as additional income sources (Fakhri et al. 2020; H`ng et al. 2011; Hambali and Rivai 2017). But again, political decision makers must facilitate access to these markets and establish an infrastructure in which the smallholders will be able to sell their goods. The same applies for other agricultural products that smallholder might produce as part of their income diversification.

Clarify the ambiguous land tenure regulations and reform the PSR

Indonesia has a long history of "legal and institutional pluralism" (Kunz et al. 2017) regarding land tenure regulations. The local use of customary laws was long tolerated (ibid.). Locals used them to regulate land access and land use in their communities – including establishment oil palm plantations. Many of these plantations are now located in state declared forests. The affected local smallholders have officially illegal plantations and cannot get land certificates. Without these, the smallholders are

excluded from bank loans. They must rely on informal loans at poor conditions, with direct consequences for their ability to save money and make investments. Therefore, clarifying ambiguous land tenure regulations is essential, not exclusively but also to support smallholder replanting.

Indeed, this is a huge task and unlikely to occur anytime soon. In the meantime, the PSR needs to be reformed to support smallholder replanting. Since those who do not have land certificates are the ones that need support the most, access to PSR funding should not be conditional on land certificates. Furthermore, the funding amount should be increased. Currently it only covers half of the expenses at maximum, with limited possibilities for other financing sources. Lastly, the funding programme should expand its responsibilities and organize training, for example, regarding best management practices, income diversification, etc., and provide or at least facilitate access to materials, particularly high-quality seedlings as well as machinery.

7. Conclusion and outlook

In this review, we collected relevant data on smallholder replanting of oil palm plantations, and identified the challenges Indonesian smallholders will likely face before, during and after replanting. This revealed several crucial research gaps that should be addressed in future studies. We also derived several policy recommendations.

Our review showed that up to 50% of smallholder oil palm plantations need to be replanted within this decade. When replanting becomes imminent, smallholders face several challenges, which past literature has not adequately addressed. The failure to engage in replanting will result in decreasing yields, entailing income losses and deteriorating livelihoods. As a consequence, some smallholders will likely be forced to sell their plantations, or will continue to work on plantations that are becoming less and less productive. Environmental deterioration is also likely, for example, if new land is cleared or old plantations are burned to save money. On the contrary, with proper support, smallholders' risk aversion of replanting could be reduced, leading to increased income, ensuring their livelihoods, and increase environmental sustainability of oil palm plantations. However, this can only happen when smallholders receive substantial support.

From a policy perspective, it is critical to address the issue of smallholder replanting, due to the expected environmental and socioeconomic implications, and to provide support measures. Smallholders need to receive training and information on why replanting is important, when and how it is done, and where they can get technical and financial support. Here, it becomes crucial that

sustainable replanting methods and measures are included in the training. It will be important to show the benefits of these sustainable measures to increase their acceptance among smallholders. Only then can the replanted oil palm plantations increase their environmental sustainability and ensure smallholders' income. Research can help to identify specific problems smallholders face when replanting occurs and based on these insights design proper training concepts. Making such trainings accessible to smallholder farmers should be a priority for policy makers. One way to achieve easy access is to reform the PSR programme by including such training measures. Furthermore, the different smallholder types need to be acknowledged in the process. Particularly the perspective and needs of local independent smallholders, who are typically most deprived of access to resources and information, have to be taken into account.

Policy makers should further facilitate access to materials, such as high-quality seedlings, funding schemes and new markets for income diversification. An efficient way to facilitate access to funding schemes is to reform the PSR, mainly by solving the issue of ambiguous land tenure regulations, making the application for the programme more appealing for smallholders. Research can help to determine how smallholders can be provided most effectively with access to supply chains and funding schemes, by analysing smallholder needs.

Farmer groups and cooperatives can function as mediator between individual smallholders and policy makers. They can provide support for smallholders in many ways. However, their potential has not been utilized so far. It seems that they often are not trusted by many smallholders. They need to have tangible tasks assigned to them by policy makers. These tasks need to be transparently communicated. Future research has to gather data on their prevalence and the difficulties they face. They should receive support in organizing and optimizing themselves.

Addressing the challenges associated with replanting can improve both socioeconomic and environmental conditions and help to transform the smallholder oil palm sector in Indonesia towards more sustainability.

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