Urgency to accelerate replanting of Indonesian oil palm: A review of the role of seed institutions

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Abstract. The achievement of expanding the area and volume of Indonesian palm oil production does not in line with the productivity. The productivity of Indonesian oil palm is inseparable from the age of the plants, most of which have exceeded their productive age. In addition, there are indications that the use of illegitimate seeds is relatively significant, causing yield gaps to potential productivity. Efforts to increase the productivity and sustainability of oil palm plantations have been carried out by forming a particular agency that collects and manages oil palm plantation funds. One of the programs to increase productivity and sustainability is the "Replanting of Smallholder Palm Oil (PSR)" with a grant scheme for participating farmers selected based on specific requirements. The progress of replanting realization is plodding. The target of 180,000 hectares per year cannot be realized. Accelerated breakthroughs without neglecting the primary mission of increasing productivity and sustainability are very urgent. This paper describes the results of a review on the importance of supporting seed institutional innovation for the acceleration of PSR towards increasing productivity and sustainability of Indonesian oil palm plantations.

Keywords: yield gaps, sustainability, illegitimate seed, institutional strengthening, oil palm

1. Introduction

Palm oil (Elaeis guineensis Jacq.) is a strategic commodity for Indonesia because of its significant contribution to foreign exchange earnings from export value and the fulfillment of raw materials for the food industry, especially the domestic cooking oil industry. Even in the last decade, palm oil is also projected as a raw material for renewable energy. In addition to the development of the biodiesel industry that has already been running, currently, a bio-hydrocarbon energy industry made from palm oil is being pioneered [1].

Since it was massively developed through the “Smallholders Nucleus Estate (PIR)” pattern that began in the 1980s, oil palm has attracted plantation investors in Indonesia. The area of Indonesian oil palm plantations has experienced higher growth for 30 years, reaching an area of 7.2 million ha in 2009 [2] and continues until the last decade, in 2011 reaching 8.99 million ha, increasing to 14.68 million ha in 2019 with a total fresh fruit bunch (FFB) production in 2011 of 157.33 million tons, increasing to 245.63 million tons in 2019[3]. The data shows that the productivity of Indonesian oil palm plantations decreased from 17.49 tons of FFB per ha in 2011 to 16.73 tons of FFB per ha in 2019. In the same period, the productivity of Malaysian oil palm plantations reached 17.26 to 20.33 tons of FFB per ha per year, and in 2019 it was still at the level of 18.98 tons per ha [3]. With the development of areas and production, in terms of total production, Indonesia took over Malaysia’s position as the world’s largest palm oil producer since 2012. However, in terms of productivity, Indonesian oil palm plantations are still lower than Malaysia’s.

The productivity of Indonesian oil palm plantations is still far below their potential productivity. The
potential productivity of high-yielding varieties released by the Palm Oil Research Center reaches 28.6 to 33.1 tons of FFB per ha per year with average productivity of 27.2 to 28.5 tons of FFB per ha per year [4]. Replanting at the age of 25 years is one of the strategic steps contributing towards reducing oil yield gaps [5].

This yield gap is not only caused by some of the plants having exceeded their productive age but also because of the maintenance of the plantations that are not carried out optimally due to farmers’ response to fluctuations in FFB prices. Plant performance greatly determines the productivity of oil palm plantations. The contribution of the influence of plant uniformity and fertilization factors to productivity reaching 31.5%, and 27.6%, respectively, should be monitored and observed further to increase the productivity of oil palm plantations [6]. In addition, various parties indicated that the low productivity was also caused by the use of poor-quality seeds, especially for smallholders. The proportion of smallholder oil palm plantations in Indonesia, reaching 40.79% of the total national area, has a significant effect on the overall performance of oil palm plantations [7].

In the context of sustainable plantation development, the low productivity will need a wider area to meet the needs of food and domestic industry as well as export expansion targets. It has implications for the policy of conserving natural resources, especially forests. Along with a moratorium on area expansion for oil palm plantations [8], the Indonesian government launched the oil palm replanting program with a target of 2.4 million hectares of smallholder oil palm (PSR) [9]. One of the important factors to achieve this target is the availability of certified seeds of high-yielding varieties. This article presents a review of the performance of seed institutions to ensure the availability of quality seeds to the farmers and utilized to accelerate the realization of PSR.

2. Indonesian oil palm replanting: context and policy directions for sustainable plantations

2.1. Oil palm replanting in the context of sustainable plantations

The development of Indonesian oil palm plantations is not only economic oriented but has also led to the development of a sustainable plantation. This is indicated by the policy on plantation management and product development which is regulated by the establishment of an agency specifically mandated to manage funds collected from export receipts of palm oil products [10]. The replanting of smallholder palm oil is one of the main programs that are oriented towards sustainable plantations by imposing requirements for clarity on land status and recommendations for implementing standard operating procedures for cultivation as regulated in the RSPO/ISPO platform [11, 12], Minister of Agriculture Regulation No. 18/Permentan.KB.330/5/2016 concerning Guidelines for Oil Palm Plantation Replanting with the scope of a) oil palm replanting techniques, b) farmers institutional development, and c) supporting elements namely: mapping, environmental management statement letter, certification of land, ISPO, and plantation business registration certificate for cultivation (STD-B). An overview of Indonesian oil palm smallholders was presented by [13] that smallholders are closely linked to impacts on the environment, and in some geographies, can be major contributors to deforestation.

From a sustainability point of view, there are two things to balance. First, low productivity is a contributing factor to the expansion of smallholder oil palm plantations, where farmers tend to choose to plant more areas of less productive oil palm rather than intensify production. Second, increasing productivity and profitability does not always lead to more sustainable results because this is carried out in an effort to improve the economic status of farmers. Invoking smallholders in the PSR program, which is fully intensification-oriented, when the moratorium on the expansion of oil palm plantations is enacted, should be able to minimize the environmental impact as a result of uncontrolled area expansion. The PSR program in the context of sustainable plantation development can be viewed from two perspectives, namely efforts to improve crop performance to increase productivity through financial support to small farmers and efforts to improve the application of environmentally sound agricultural practices through training and mentoring. Both goals are rational and have the opportunity to be achieved [13].

2.2. Policy direction

Basically, the oil palm replanting policy is aimed at all oil palm plantations that have decreased productivity, either due to the age of the plants that have exceeded their productive age or due to the stress of biotic and
abiotic factors that cause generative impacts. However, what is specifically regulated through the replanting financing scheme is the replanting of smallholder oil palm plantations, including oil palm plantations managed by independent smallholders and plasma smallholders.

According to the guidelines for oil palm replanting as regulated in the Decree of the Director-General of Plantations 29/Kpts/Kb.1203/2017, the target for smallholder oil palm replanting is plasma plantations and independent plantations. The target for the replanting of plasma plantations is the PIR scheme, which was planned around the 1980s, which is technically unproductive. Meanwhile, the target for replanting of independent plantations is oil palm that has not used certified seeds (illegitimate), has not been accompanied by guidance and assistance, and the use of agro-input independently.

In addition to technical activities to replace unproductive oil palms, the replanting program also includes human resource development activities, including training and mentoring. The training relevant to the context of sustainable plantations is training on the implementation of the Indonesian sustainable plantation certification system (ISPO). In addition, technical cultivation training for planters also includes technical seedling [14]. This is in line with the PSR program, which is targeted to fulfill four elements, namely: legality, productivity, ISPO certification, and sustainability principles. In fulfilling the legal elements, smallholders who participate in this program must comply with the legal aspects of the land. The productivity element in this program is to increase productivity standards to 10 tons of FFB/ha/year with a plant density of <80 trees/ha. The element of ISPO certification is intended to ensure the principle of sustainability in this program, where program participants are facilitated to obtain ISPO certificates at the first harvest. To meet the principles of sustainability, the program is run based on environmentally friendly land management [15].

In the PSR program, BPDPKS distributes financial assistance to smallholders participating in the PSR in the amount of IDR 30 million/ha/planter. There are three models of financing schemes that can be applied in this program based on the capacity of the smallholders. The first scheme is that the cost requirements are met from the BPDPKS assistance fund of IDR 30 million/ha/planter plus the smallholders’ savings funds. In the second scheme, the need for financing funds is met from two sources, namely utilizing BPDPKS assistance funds and People’s Business Credit (KUR) from planters. While in the third scheme, financing funds are obtained from three sources, namely BPDPKS assistance, planters’ savings, and KUR [15].

3. Indonesian oil palm replanting performance
For Indonesia, oil palm replanting is more of a sustainable plantation development policy to meet food and energy needs than a desire to maintain its status as the world’s largest palm oil producer. So far, fulfillment palm-based food needs have been fulfilled. Even with the existing production volume, Indonesia has become the world’s main exporter of palm oil. However, energy needs are still met from imports of fossil energy. In line with the success of developing biodiesel and bio-hydrocarbon technology, palm oil as renewable energy is the potential to substitute fossil energy and reduce the volume of imports. Replanting to overcome the problem of decreasing productivity of oil palm plantations as a result of a large number of old plantations certainly needs to be implemented immediately. The PSR program was introduced three years ago with a planned area target and financing mechanism.

3.1. Achievement of the replanting target.
The target area for replanting is 2.4 million hectares which are distributed into an annual target of 180,000 ha until 2020 has not yet been actualized. In 2021, acceleration efforts will be carried out, one of which is through PSR partnerships between 6 plantation companies that are members of the Indonesian Palm Oil Association (GAPKI) and one state-owned plantation company with 18 Cooperatives members of the Indonesian Palm Oil Farmers Association (APKASINDO) originating from 6 districts on the islands of Sumatra and Kalimantan, for 18,821 hectares of oil palm plantations. This area is only 10% of the PSR target in 2021 of 180,000 hectares [9]. Of course, the mobilization of participants from independent oil palm farmers is expected to meet 90% of the PSR target in 2021.

3.2. PSR financing scheme.
BPDPKS acts as the main funder of the PSR program. Financing schemes are periodically evaluated and developed in order to attract farmers’ interest and be able to meet both technical and administrative
requirements. Most recently, there are three choices of PSR financing schemes offered, which are a combination of financing sources from Palm Oil Plantation Fund Management Agency (BPDPKS), people business credit (KUR), and Farmer Savings. This paper does not review these aspects but focuses more on the innovative aspects of seed institutions.

3.3. Fulfillment of seed needs.
Seed requirements for oil palm replanting reach 150 ready-to-plant seeds per hectare. With a target area of 180,000 ha/year, 27 million ready-to-plant seeds are needed per year. Legal sources of germinated seeds in 19 seed-producing companies qualified as seed providers for the PSR Program [9], in addition to being obligated to meet the need for seeds in the right quantity, must also be of the right quality on time, and at a reasonable price. In terms of quantity, the PSR program only needs to be allocated 2,530% of the production capacity of 19 legal seed producers. Assuming that the need for seeds for new plantings is not significant due to the enactment of a moratorium on area expansion, the potential availability exceeds the amount required for PSR. Even with the capacity to provide sprouts by 19 producers, it is possible to increase the PSR target area to 500,000 hectares per year. In terms of price, because the seeds for PSR are a component of the financing package from BPDPKS, farmers participating in PSR are no longer affected by the difference in price to the price of illegitimate seeds. However, the aspect that still has the potential to reduce the performance of seed procurement is the supervision of the purity of the seeds provided by the company appointed as the provider. Physically, the differences between Tenera and Dura oil palm seeds are very difficult to detect. Farmers only know the difference between the two types when the plants have fruited. Detection at the seedling phase requires certain technologies that have not been adopted by oil palm seed quality control agencies in Indonesia.

4. The role of seed institutions in accelerating PSR
One of the causes of the yield gap between existing conditions and the optimal potential of oil palm plantations is the use of illegal seeds, and it has been going on for decades. At the beginning of the development of oil palm plantations, the realistic consideration of using illegal seeds by farmers was the limited availability of legitimate seeds, which caused farmers’ access to physical seeds and technical information was relatively limited so that farmers were faced with only one choice, buying and planting seeds that are available in the market. More than 80% of the smallholders in North Labuhan Batu Regency, North Sumatra Province, obtained seeds from other planters and illegal traders. There are relatively few farmers who buy seeds from oil palm companies, production input shops, and nurseries (16.7%). This condition shows that the role of smallholders and illegitimate breeders is still relatively significant in providing seeds [16]. The use of illegal seeds by farmers is inseparable from the consideration of the price difference between illegal seeds and certified seeds [17]. The results of Agustira’s study in [18] showed that 14.90% of farmers chose to use illegitimate seeds because they were cheaper. The results of another study showed that the number of farmers who used uncertified/illegitimate seeds was relatively large (77.97%). This is because the price is much lower than the certified one, which is IDR 15,000 (USD 1.08) and IDR 40,000 (USD 2.89), respectively. In terms of price, all respondents were willing to pay for certified seeds, but only 29% were willing to pay (WTP) IDR 25,000 (USD1.81) or more for the difference in the average price between certified and uncertified seeds [16]. Illegal seed makers can sell seeds cheaply because the process of making them is very easy. Illegal seed production is carried out by taking oil palm bunches from any tree, peeling the seeds by curing them, then drying them. The germinated seeds are then packaged and accompanied by fake documents [19]. Farmers have not fully considered differences in productivity. At the same time, apart from having different prices and documents, the productivity of the uncertified seeds will also be different. Uncertified seeds will be 50% more lightweight than certified seeds. Their quality of oil content and shell thickness will also be different [20].

In addition to price considerations, accessibility factors also influence farmers’ decisions to use seeds. Other variables also have a real influence on farmers’ decisions to choose oil palm seeds, namely the age of farmers, length of farming, land area, and resistance to pests and diseases [21]. Agustira’s research results in [18] showed 30.29% of farmers chose to use illegitimate seeds because they faced problems with access to certified seeds.
The procurement of seeds for oil palm development programs financed by government agencies also does not fully address the problem of using illegal seeds. The mechanism for procuring seeds is through an auction process. It is possible that partners appointed as seed providers do not fulfill the commitments agreed in the seed procurement contract. On the quality control side, the supervisory function, especially related to seed purity, has also not run effectively due to limited resources at the institution that was given the mandate.

The problem of using illegal seeds also occurs in palm oil-producing countries other than Indonesia. The results of the study [22] concluded that up to 65% of smallholder farms in Cameroon were found to be planted with poor planting material distributed in the different Mendelian ratios. It was further stated that the source of this poor quality planting material for these farms was deduced to come from private nursery entrepreneurs and workers of industrial plantations. In Malaysia, an average of 10.7% of nontenera contamination occurs in smallholder plantations. Based on the results of a study on the purity of oil palm seeds in the country, it is estimated that 1% dura contamination could result in an additional cost of USD 45.6 million/year [23].

The review of seed institutions looks at the institutional aspects of two dimensions, namely the organizational dimension and the regulatory dimension.

4.1. Organizational dimensions

Formally, the process of providing oil palm seeds in Indonesia includes four stages, namely: (1) the production stage of sprouts, (2) the nursery stage, (3) the certification stage, and (4) the seed distribution stage. Stakeholders or organizations involved in the series of processes consist of (1) sprout producers, (2) seed producers and farmer groups that produce seeds, (3) seed certification centers, and (4) seed entrepreneurs (licensed). Outside of these formal organizations, there is an informal distribution of seeds involving Seed Reseller and Farmers selling seeds.

Within 20 years of developing oil palm plantations, the demand for oil palm seeds has increased while the availability of quality oil palm seeds is still minimal. Until 2004 there were only three sprout producers, namely PPKS Medan, PT. London Sumatra, and PT. Socfindo. The high demand for seeds encourages the growth of the oil palm seed business. Until 2019, there were an additional 16 sprout-producing companies, so the number of producers who can play a role inprocuring seeds for the PSR program is 19 companies.

Based on information from the Directorate General of Plantations, from 2011 to 2019 for replanting and new planting activities, it has been recorded that the circulation of superior oil palm sprouts was 952,260,168 sprouts or equivalent to 4.76 million hectares of oil palm plantations [7]. This information reflects the germination capacity of providing an average of more than 100 million sprouts per year, equivalent to more than 500 thousand hectares of oil palm plantations with an estimated demand per hectare of an average of 200 sprouts (Figure 1). This estimate considers germination capacity, potential damage to seeds during the pre-nursery, nursery, and distribution process, and oil palm plantation population per hectare. With the support of the 19 oil palm seed producers with a production capacity of hundreds of millions of seeds per year, by positioning PSR as a national priority program accompanied by a moratorium on the expansion of oil palm plantations, mathematically the need for seeds to rejuvenate 200 thousand hectares of oil palm plantations per year can be met.
Oil palm farmers are not yet fully aware of the benefits of using certified seeds and the risks of using uncertified seeds. Oil palm replanting that is oriented towards increasing yields received by farmers needs to continue to encourage farmers’ awareness about the importance of using certified seeds. The results of the relevant research show that oil palm smallholders in West Kalimantan are adopting certified seed earned a higher yield of 66.34% than those who adopted non-certified seed and are also able to return all investment more quickly [24]. Therefore, efforts to increase the adoption of certified seeds need to be carried out continuously through strengthening the seed institution. An accommodative and market-oriented program can encourage institutional strengthening. Complementary roles between stakeholders, governments, private seed companies, and other partners will affect the performance of the seed system [25]. The capacity of the oil palm test station will also determine the performance of the seed system, especially in promoting certified seed production [24]. In addition, the government also needs to encourage local oil palm seed producers to carry out strict supervision and guidance.

The empowerment of seed producer communities to improve the performance of providing seeds for various commodities has been carried out in various countries. The development of a community seed bank model not only provides benefits in ensuring better availability and access but also increases knowledge and skills in managing seed production and distribution [26]. In the case of procuring palm seeds, increasing farmers’ access to sprout sources requires greater attention. On the other hand, policies and regulations are needed to facilitate guidance to strengthen their technical and managerial skills.

Mentoring and coaching need to reach all actors, both formal seed actors and informal actors. The development of an integrated seed sector aims to better link the informal and formal seed systems and balance the involvement of the public and private sectors. This is necessary to accommodate variations among the seed value chains so that seed programs and policies are more coherent with farmer practices [27]. In developing the palm oil agribusiness system, the linkage between the seed subsystem and the processing industry subsystem is also very necessary in order to create synergy between the subsystems.

Although, in practice, it is difficult to identify simple and clear indicators of the value and quality of planting material, the constant increase in commercial yields remains a key factor in achieving the sustainability of the palm oil industry [28]. In conditions where the technical efficiency of farmers in all best management practices is optimal, increased yields due to improved planting material will remain the main source of economic progress or sustainability.

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**Figure 1.** The institutional structure of oil palm seed production and distribution. Source: [9, 14] synthesized.
Interventions for smallholders of oil palm need to be holistic, accompanied by assistance and stricter enforcement of regulations. Intensification/replanting appears to be a more feasible approach to accommodating higher palm oil demand from a biodiesel policy [29]. However, holistic and systematic evaluations to address productivity, legality, and sustainability issues are needed to avoid unintended impacts. Interventions that are oriented towards increasing crop yields and farmers’ incomes need to be accompanied by more stringent actions in enforcing the moratorium rules and ISPO requirements to prevent land expansion [30].

4.2. Regulatory dimension

The Indonesian government has made efforts to regulate the oil palm seed system, for example, through the policy of issuing an Approval Letter for the Distribution of Oil Palm Seeds (SP2BKS), which is regulated in the Circular Letter of the Director-General of Plantations and finally, Circular Letter of the Director-General of Plantations 911/HK.330/E/7/2013 dated 12 July 2013 concerning Procedures for Supply and Distribution of Oil Palm Seeds. This regulation is given to plantation business actors, both plantation companies and farmers (plasma and independent), who want to order seeds in the form of sprouts from sprout seed producers. SP2BKS is also expected to be a control tool for the government in supervising the circulation of seeds through data collection on the number of circulating seeds, so the legality of SP2BKS is strengthened through the Decree of the Minister of Agriculture 321/Kpts/KB.020/10/2015 and revised again through the Decree of the Minister of Agriculture 76/KB.020/10/2017 [31]. In accordance with these provisions, the authority to issue SP2BKS is arranged in stages based on the number of sprouts needed as follows: 1) for the need for sprouts of 1-40,000 sprouts, the issuance of SP2BKS by the Head of the Office in charge of plantations in the Regency; 2) for the need for 40,001-200,000 sprouts, the issuance of SP2BKS by the Head of the Office in charge of plantations in the Province; 3) for needs more than 200,000 sprouts, the authority to issue SP2BKS to the Director of Plantation Seeds of Directorate General of Plantation. Plantation business actors who have obtained SP2BKS are required to report the realization of seed receipts from seed sprout producers and nursery progress on a regular basis.

In the previous chapter, it was discussed that the PSR program includes superior seeds as a component in the replanting assistance package for farmers so that PSR participating farmers are not directly related to fulfilling the requirements in SP2BKS. However, farmers as recipients of seed assistance have the potential to be affected by violations committed by seed providers related to seed purity and quality.

5. Technology implementation and the financial consequences

Knowledge about the parentage of families and individuals is crucial in oil palm breeding. This knowledge is related to progeny testing, namely a measurement in combining ability between dura and pisifera based on the performance of their tenera progeny. Pollination errors can lead to illegitimacy [32]. Illegitimacy can result in a 25-year reduction in the yield potential of oil palm plantations. Hence, genetic purity and good agricultural practices are equally essential to ensure the highest oil productivity of the oil palm industry.

Oil palm replanting is oriented towards increasing productivity. Therefore it is necessary to choose superior types of oil palm with high yields. Tenera type oil palm has been described as having higher yield potential and fruit characteristics favored by the palm oil processing industry compared to dura oil palm. Dura contamination can be identified and removed at or before the nursery stage [33]. Tenera type should be designated as planting material in the implementation of PSR. Supervision of seed purity for PSR needs to be tightened by conducting early detection using the latest accurate technology. In the short term, the strengthening of oil palm seed institutions needs to prioritize the application of early detection technology by using the services of technology patent owners accompanied by technology transfer to supervisory agencies for seed quality and distribution. In the long term, it can be considered to increase human resource capacity along with infrastructure support for independent implementation. The application of early detection technology for seed purity will result in additional costs in the series of seed preparation processes. If it is included in the cost of seed production, it will cause the unit cost to increase. The preferences of oil palm farmers regarding the cost consequences of seed purity testing vary widely. Some (29%) farmers are reluctant to pay for Dura marking services, indicating their perception that Dura is not the best type but is
still profitable due to its heavier weight. However, 71% of farmers are willing to pay for Dura marking services, varying in value from less than IDR 10,000 (USD 0.72) up to IDR 40,000 (USD 2.89) [16]. Associated with the replanting financing scheme in the PSR program, the additional cost of detecting seed purity can be considered as part of the cost assistance component from BPDPKS.

6. Conclusions and policy implications
The acceleration of the replanting of Indonesian oil palm is very urgent because the total plantation area that has exceeded its productive age has reached 2.4 million ha. The delay in executing the Program of Smallholders Replanting (PSR) will have an impact on a drastic decrease in productivity, not only an impact on the decrease in production volume but also a potential impact on the sustainability of oil palm plantations. The role of seed institutions is very important in accelerating oil palm replanting, especially in providing seeds with adequate quantity and quality. The most important role is in controlling the purity of seeds to ensure the use of superior seeds of the tenera type by implementing early detection technology. The empowerment of seed-producing farmer groups that have been designed in the PSR implementation guidelines needs to be implemented proportionally to support the oil palm seed system. PSR is a national priority program directed to increase oil palm productivity to meet the demands of food and energy. The direction of PSR’s policy is to empower funds collected from the export value of palm oil products to increase benefits for the community and the ecosystem of oil palm plantations. The benefits for the community, especially small farmers, are financial assistance for replanting from the input side and increasing productivity which leads to an increase in income on the output and outcome side. Benefits for the oil palm plantation ecosystem are obtained from the obligation to implement good agricultural practices in accordance with the principles of sustainability (ISPO platform) for PSR participating farmers.

References
[1] Research Team PASPI 2020 Katalis Merah Putih: The Way to Achieve National Vision to National Energy Security through Palm Oil-Based Biohydrocarbon Palm O’ J. I 183–90
[2] GAPKI 2017 Sejarah Kelapa Sawit Indonesia 1
[3] FAO 2020 FAOSTAT
[4] PPKS 2018 Bahan Tanaman PPKS
[5] Danylo O, Pirker J, Lemoine G, Ceccherini G, See L, McCallum I, Hadi, Kraxner F, Achard F and Fritz S 2021 A map of the extent and year of detection of oil palm plantations in Indonesia, Malaysia and Thailand Sci. Data 8 4–11
[6] Hidayati J, Sukardi, Suryani A, Fauzi A M and Sugiharto 2016 Identifikasi Revitalisasi Perkebunan Kelapa Sawit Di Sumatera Utara J. Agroindustrial Technol. 26 255–65
[7] Directorate General for Estate Crops 2020 Statistical of National Leading Estate Crops Commodity 2019-2021
[8] Setkab 2018 Impres 8 Tahun 2018 1–13
[9] BPDPKS 2021 Percepatan Program Peremajaan Sawit Rakyat Melalui Kemitraan
[10] BPK 2015 Peraturan Presiden Republik Indonesia Nomor 61 Tahun 2015 Tentang Penghimpunan dan Penggunaan Dana Perkebunan Kelapa Sawit 6
[11] Setkab 2020 Sistem Sertifikasi Perkebunan Kelapa Sawit Berkelanjutan Indonesia Database Peratur. 22
[12] ZSL Indonesia 2013 Certification schemes Sustainable Palm Oil Platform
[13] Daemeter Consulting 2015 Overview of Indonesian Oil Palm Smallholder Farmers: A Typology of Organizational Models, Needs, and Investment Opportunities Daem. Consult. 21
[14] Ditjenbun 2017 Keputusan Direktur Jenderal Perkebunan Nomor: 29/Kpts/Kb.120/3/201 Tentang Pedoman Peremajaan Tanaman Kelapa Sawit Pekebun, Pengembangan Sumber Daya Manusia dan Bantuan Sarana dan Prasarana dalam Kerangka Pendanaan Badan Pengelola Dana Perkebunan Kelapa Direktorat Jenderal Perkebunan, Kementan
[15] BPDPKS 2020 Program Peremajaan Perkebunan Kelapa Sawit
[16] Chalil D, Basyuni M, Barus R and Putri L A P 2018 Smallholders’ willingness to pay for dura marking oil palm seeds E3S Web Conf. 52 1–6
[17] Pinem L J and Safrida 2018 Analisis Pengambilan keputusan Pembelian petani dalam Memilih Benih Kelapa Sawit Bersertifikat Dan Non Bserfifikat Di Kabupaten Labuhan Batu Utara J. fo Agribus. Sci. 2 1–8

[18] Edy Suprianto, Anbar Kurniawan, M. Akmal Agustira, Ratna Nur khoiry S R 2017 Oil Palm Program for Smallholders: Planting Materials Perspectives

[19] LRPI 2005 Benih Kelapa Sawit Palsu: Penghambat Peningkatan Produktivitas 9–10

[20] BPDPKS 2018 Illegitimate Oil Palm Seeds Found in East Kutai, Farmers Need to be Careful

[21] Pinem L J and Pratiwi M 2020 Faktor-Faktor Pendorong Petani Dalam Memilih Benih Kelapa Sawit (Elaeis guineensis) Bersertifikat Dan Nonsertifikat Agrimor 5 1–4

[22] Nchu W A and Koona P 2020 Using Oil Palm Segregation Genetics to Decipher Illegitimate Seed Distribution Channels to Smallholder Farmers in Cameroon Agrotech J. 5 52–62

[23] Ooi L C L, Low E T L, Abdullah M O, Nookiah R, Ting N C, Nagappan J, Manaf M A A, Chan K L, Halim M A, Azizi N, Omar W, Murad A J, Lakey N, Ordway J M, Favello A, Budiman M A, Van Brunt A, Beil M, Leininger M T, Jiang N, Smith W S, Brown C R, Kuck A C S, Bahrain S, Hoynes-O’Connor A, Nguyen A Y, Chaudhari H G, Shah S A, Choo Y M, Sambanthamurthi R and Singh R 2016 Non-tenera contamination and the economic impact of SHELL genetic testing in the Malaysian independent oil palm industry Front. Plant Sci. 7 1–13

[24] Kariyasa I K 2015 Financial Feasibility Analysis of Oil Palm Certified Seed Adoption in West Kalimantan Province J. Agro Ekonomi. 33 141–59

[25] Dawit Tsegaye Sisay, Verhees F J H M and van Trijp H C M 2017 Seed producer cooperatives in the Ethiopian seed sector and their role in seed supply improvement: A review J. Crop Improv. 31 323–55

[26] Vernooy R, Sthapit B, Otieno G, Shrestha P and Gupta A 2017 The roles of community seed banks in climate change adaptation Dev. Pract. 27 316–27

[27] Louwaars N P and De Boef W S 2012 Integrated seed sector development in Africa: A conceptual framework for creating coherence between practices, programs, and policies J. Crop Improv. 26 39–59

[28] Baskett J P C, Jacquemard J C, Durand-Gasselin T, Suryana E, Zaelanie H and Dermawan E 2008 Planting material as key input for sustainable palm oil J. Oil Palm Res. 102–14

[29] Halimatussadiah A, Nainggolan D, Yui S, Moeis F R and Siregar A A 2021 Progressive biodiesel policy in Indonesia: Does the Government ’ s economic proposition hold? Renew. Sustain. Energy Rev. 150 111431

[30] Jelsma I and Schoneveld G C 2016 Mewujudkan petani kecil sawit mandiri yang lebih produktif dan berkelanjutan di Indonesia: Pandangan dari pengembangan tipologi petani kecil (Bogor)

[31] Ditjenbun 2017 Keputusan Menteri Pertanian No. 76/KPTS/Kb.020/10/2017 Tentang Perubahan atas Lampiran Keputusan Menteri Pertanian Nomor 321/Kpts/Kb.020/10/2015 Tentang Pedoman Produksi, Sertifikasi, Peredaran dan Pengawasan Benih Tanaman Kelapa Sawit

[32] Corley R H V. 2005 Illegitimacy in Oil Palm Breeding – A review J. Palm Oil Res. 17 64–9