CYSENI 2015, May 27-28, Kaunas, Lithuania
ISSN 1822-7554, www.cyseni.com

WILL IMPROVED PALM OIL YIELDS SUFFICE TO THE DEVELOPMENT OF SUSTAINABLE BIODIESEL FEEDSTOCK IN INDONESIA?

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ABSTRACT

By the expansion of oil palm plantations, Indonesia has become a world leading producer of crude palm oil. However, Indonesia has also been largely criticized due to issues of land use change and deforestation. The country now promotes the use of palm oil for biodiesel production as part of policies to achieve renewable energy targets. Currently yields on palm oil plantations are far from optimal. Do new policies promoting biodiesel production address the issue of yields properly? This study analyses the driving forces for the expansion of palm oil plantations in Indonesia and the palm oil yields obtained in the country. Data is collected through a multi-disciplinary structured literature review of relevant palm oil publications from the last 15 years. We identify the policies that have been put in place and the strategies used to establish palm oil plantations in the past years. We look at the newly defined policies of the Indonesian government towards renewables and climate mitigation, in particular, targets for biodiesel production and fuel substitution. The idea is to verify whether the new policy will address the low yield issue. Presently, palm oil yields are much lower in Indonesia than in neighbouring Malaysia, also a major producer. Particularly, smallholders have lower yields than private and government estate plantations. Expanding production has been focused on covering new areas with palm oil plantations and less on developing farming methods. In earlier stages, the establishment of plantations included proper education of farmers and incentives to maintain production. Smallholders nowadays start palm oil production with little or no previous experience; still they favour oil palm over traditional crops. New policies have to address farming improvements to guarantee sustainable feedstock for biodiesel.

Keywords: Palm Oil, Oil Palm Plantations, Biofuel, Policy

1. INTRODUCTION

Palm oil has become an important crop globally not only for cooking but increasingly also for biofuel production. In fact, palm oil is one of the most interesting feedstocks for biodiesel production due to the high yields that can be achieved per hectare (ha) compared to other oil-crops [3]. In addition, palm oil production generates employment in rural areas. In 2011, the palm oil industry employed 3.7 million workers in Indonesia alone, and contributed to about 7% of the country's GDP [30]. In 2012, Indonesia produced 26 million tonne of crude palm oil1 of which 20

[1] Regarding palm oil in biodiesel production: Fresh fruit bunches (FFB) are harvested from oil palm trees from the age 2 to 4 years. These bunches contain the palm fruit from where the oil is extracted. The mesocarp in the palm fruit contains the oil from which crude palm oil (CPO) is derived using milling. The palm fruit kernel also contains a smaller amount of extractable oil. These two oils are then the basis for any further refined oil products. For producing fuel the refined oils are put in a process of esterification in which methanol is used to produce biodiesel and glycerol.

million tonne were exported [25]. However, they only achieved a yield of 3.7 tonne per ha [25], compared to Malaysia's 4.4 tonne per ha [35], and a maximum 6 tonne per ha [8].

Indonesia now has plans to expand the use of renewable energy in the country. As part of this effort, the government aims at developing the biodiesel industry and has set 30% biodiesel blending targets for 2020: the public service obligations (public transport), industry and for power generation. Biodiesel production was for 2012 2.2 million kilolitre in Indonesia of which 1.05 was domestically used, amounting to four percent of total diesel use [31]. If the targets are to be reached with domestically produced biodiesel without competing with current exports and food supply, an increase in palm oil production is required.

Palm oil production in Indonesia has been highly criticised in past years, and identified as a significant cause of land conversion and deforestation in the country [5,11,14]. Therefore, it is essential that measures are taken to make sure the development of the biodiesel industry and the shift towards bioenergy are achieved in a sustainable way. In this context, measures for increasing palm oil yields may constitute an important step. This paper addresses the conditions for improving the sustainability of palm oil production in Indonesia looking at the historic expansion, the issues with yield and role of policy in dealing with issues concerning lower yields.

2. METHODOLOGY

A literature search was carried out in 2015 between January the 15th through the 19th on the scientific databases Science direct and Wiley Online Library. Using a full text search for journals and books published between 2000 and 2015, by combination of keywords found in the appendix. Resulting in a total of 16054 non-unique hits of which 514 were relevant. Of these 106 sources were chosen as relevant to the topics: strategy, yield or policy, another 17 were collected by reference review. Policy documents from the official biofuel policy and the ISPO guidelines were then analysed against findings in literature for correlation or contradiction. Statistical data gathered from official documents released by the Indonesian Ministry of Agriculture [25].

3. INDONESIAN PALM OIL DEVELOPMENT STRATEGIES

Indonesian palm oil plantations have grown at an average rate of over 10 percent per year between 1967 and 1997, reaching 2.5 million ha. Though the increase per year decreases both palm oil, biodiesel production and plantation area are growing Figure 1 and Figure 2, adapted from [25].

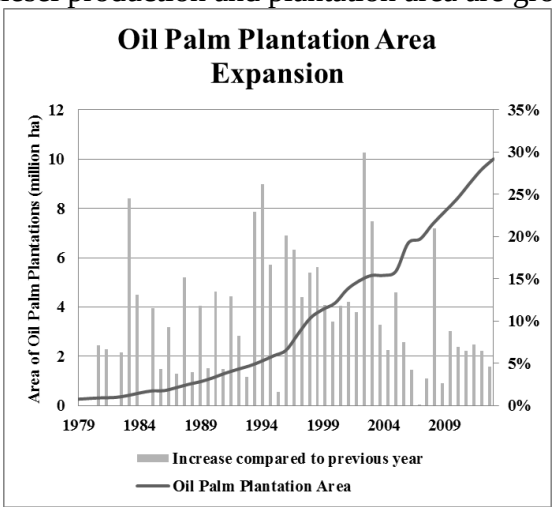

Figure 2 Oil Palm plantation area development and yearly percentage increases in Indonesia, 1979 to 2013.

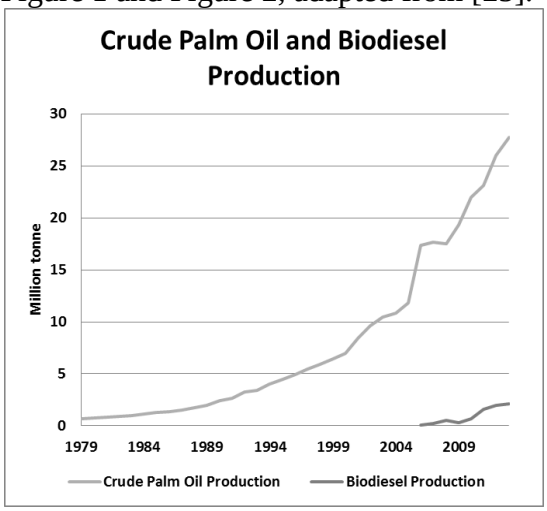

Figure 1 CPO and Biodiesel production development in Indonesia, 1979 to 2013.

3.1. Structure of the Indonesian Palm Oil Sector

There are typically three types of plantation owners in Indonesia: government estates, private estates, and smallholders. For distribution of land and production share Figure 3 [25]. Higher return on the land and increased profit per worker are the main financial appeals for farmers. The land return for palm oil is 10 times higher than rice per cycle; an oil palm plantation generates €2100 per hectare compared to €200 for rice paddy [11]. Together with the lower demand for workers compared to traditional crops, has been driving the expansion of palm oil plantations [6,28].

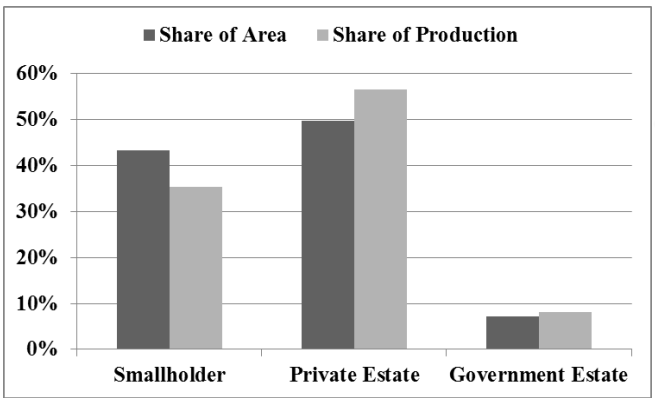

Figure 4 Distribution of occupied land for oil palm and production of CPO in Indonesia.

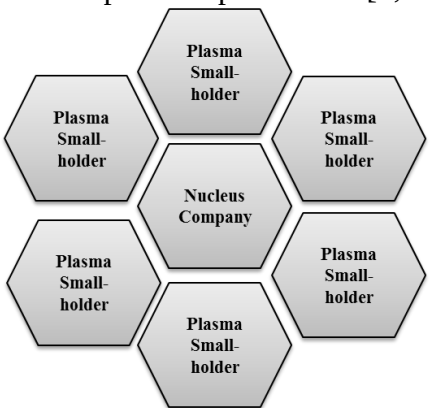

Figure 3 Schematic diagram of the NES-scheme

With a rural structure composed of many smallholders and in face of high initial investment requirements, various schemes, financial models and strategies have been employed to enable smallholders and companies to establish palm oil plantations. The initial capital requirements for palm oil production are large this includes the costs of labour to clear and plant the new crop, and fertilizers, herb- and pesticide application where the application of fertilizer and herb- and pesticide amount to over 60% of the initial cost [28]. The oil palm trees then start producing fruit around the third year after plantation at the earliest.

Smallholders are responsible for plantations below 50 ha [17] which, in turn, can be classified in: NES-smallholders (Nucleus Estate and Smallholder Scheme - NES, or Perkebunan Inti Rakyat – PIR in Bahasa Indonesia), and independent smallholders [9] who operate independently and sell their product to mills. The NES-type schemes offer financial and technological support to smallholders who want to enter the palm oil sector, schematic diagram in Figure 4. In the NES-schemes, an assigned agent, usually a private company prepares the land by clearing and planting trees, once it matures, hands it over to the smallholder. The name derives from a cell analogy, the estate company represents the nucleus and the smallholders constitute the surrounding plasma. By securing FFB delivery from the nucleus smallholders to the estate, palm oil investors were able to achieve the economies of scale required for the palm oil business. However, this also puts the smallholders in the hands of only one buyer for their product [21]. More companies in the same area would allow NES farmers to make use of the competition to negotiate more favourable deals for their FFB [11].

The plantations had since Indonesia's independence been nationalized and a first phase of the palm oil expansion was started in 1968 when the government, backed up by the World Bank, invested in state-owned plantation companies. In 1979, the first NES-scheme was launched, the plantations would be developed by private actors (the Nucleus) who would transfer a percentage of the developed plantations and technical information to the smallholders after the plantation had

matured [12]. Each plot was 2 ha and had access to a central processing facility for the fresh fruit bunch (FFB) [2]. The World Bank had been promoting these types of NES schemes elsewhere since the 1960's [9]. A bank was usually financing the cost of land clearing, land preparation, planting and applying fertilizers. This was a loan that would later have to be paid by the landholder. The Plasma would continue the development under direction of the Nucleus.

This type of scheme was carried on into new similar programs, the PIR-trans 1986-94 and Koperasi Kredit Primer untuk Anggota (KKPA) 1995-2000. For financing the expansion in the 1980s, policy was implemented to attract foreign capital by granting private companies concessions to develop oil palm plantations [21]. The PIR-trans scheme was run similar to the previous NES scheme, where a company instead represented the Nucleus and a bank or the state was financing the land preparation. In the PIR-trans scheme, many migrants (trans refers to transmigration) from more populous areas of Indonesia became smallholders and provided a cheap workforce in the new palm oil business[7,21]. The KKPA scheme remained in the eastern parts of Indonesia where large areas were being dedicated to oil palm plantations. In the KKPA scheme it was a local land owners instead of migrants would have their land converted into oil palm plantations in an agreement that they transferred one third of their land to the nucleus company.

3.2. Indonesian Financial Crisis

Companies were until the financial crisis in Indonesia of 1997 making large profits as a result of beneficial loans for establishing plantations, cheap workforce; high cost for CPO and windfall profits. Though Indonesia was going through an economic crisis, the palm oil sector was still profitable in 1997 and the government was encouraging foreign investors to invest in the business. As companies watched the Rupiah collapse they sought to sell their products outside the country, which led to high earnings, but reduced supply and increased prices for palm oil within Indonesia. Eventually, this led to an export ban as a way to protect domestic food supply, later replaced with high export taxes. Palm oil companies were eventually starting to report losses, which eventually slowed down the palm oil expansion in the country, Figure 1. The new government issued new policies for the palm oil sector at the end of the 1990's. The export tax was kept to protect the declining domestic supply, despite complaints from companies. Concession permits were withdrawn from estate companies that were not developing the plantation business. Maximum development area per company became limited to 20 thousand ha per lot, up to a total of 100 thousand ha in the whole country for one single company. This was meant to prevent the formation of monopolies. However, no limit was set for the total area used by conglomerates.

3.3. Post Crisis 2000's

Following the crisis, the government introduced five new schemes to encourage investor-farmer-cooperation. Since no financial support was provided, these schemes were less successful [21], and the expansion continued to slowdown Figure 1. Lower palm oil prices, changed market conditions, and reduced state support, reduced the investors interest to develop Indonesian palm oil [7]. A new governmental program was started 2005 and initiated in 2007, the Plantation Revitalization Program, it aimed at the development of 1.5 million ha of land. The program applied an organization similar to the previous nucleus model, developing smallholder plantations with the help of estate companies. Three banks are financing the program through the Credit Loan Program for Bio Energy Development and Plantation Revitalization (KPEN RP). This program has been criticized for not analysing and improving the situation for local landowners who had their land

converted often based on informal agreements and without any clear jurisdiction, or local governmental oversight [21].

More recently a movement of independent farmers has started opening up new plantations with the help of loans from local traders, often leading to the clearing of forested areas. Forest jurisdiction in Indonesia is not sufficiently clear on the rights to the forest on local level and there have been no sanctions for violations of the law. With a local interpretation of the forest belonging to the local community this is leading to conversion of forest into plantations, both by local farmers and migrants who want to cease the chance for a better life [1]. New migrants often clear the forested land before requesting a permit from the local village head, but this permit is not recognized by the local government. Land conversion that cannot easily be controlled by policy measures and the increasing employment in the sector, are threatening the long term sustainability of the palm oil business [4].

These strategies have resulted in large portion of independent and plasma smallholders but also a large amount of foreign owned companies with private estates. Malaysian private ownership and influence over Indonesian palm oil is especially strong [37].

4. INDONESIAN PALM OIL YIELDS

In 1997 the CPO yield in Indonesia was at 3.37 tonne per ha, as reported by Oil World via [7], for 2012 this number was 3.72 tonne per ha. In best conditions the FFB yield can reach 30 tonne per ha and year [8], this is equal to 6 tonne CPO per ha (low estimate of 20% CPO in FFB).

Figure 4 shows the trend of the last 5 years and the difference in yields among different owner types. The graph displays CPO yield and not FFB yield, as some factors described below will have an effect on the amount of extractable oil and also the available data presents CPO yield. Smallholders are even in the best performing regions producing a ton less per ha than the private estates [25]. If the smallholder yields were to reach the 4 tonne per ha equal to that of private estates it would have meant a production increase of 2 million tonne of CPO in 2012. This makes it not only of interest to biofuel development but to the economy of smallholders.

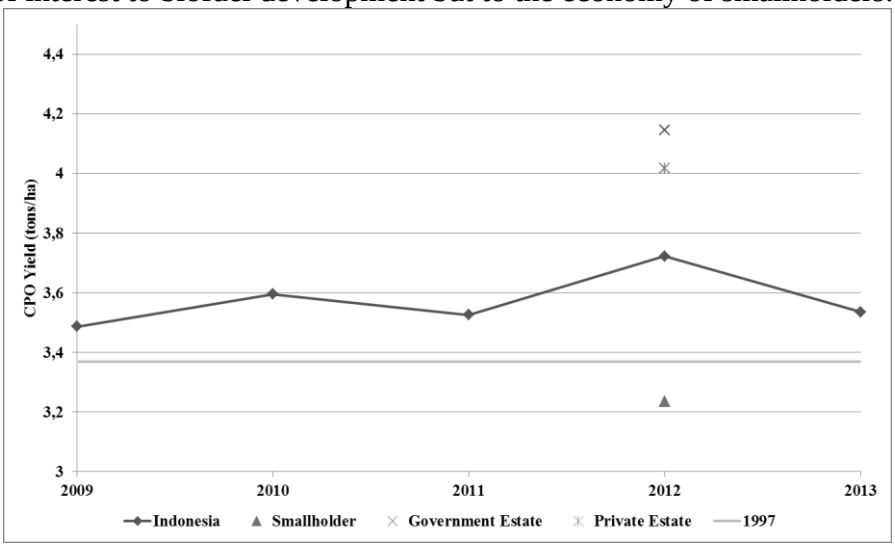

Figure 5 Average yield for recent years, 2009 to 2013 reported by Directorate General of Estate Crops[26,27], 1997 reported by Oil World[7].

The Indonesia Energy Outlook 2014 [31] suggests conversion of another 10 million ha of land for palm oil production, 7.3 million ha from undeveloped palm oil concessions and the

remaining 3.7 million ha from conversion of wetlands. The area occupied for palm oil production in 2012 was 9.6 million ha with 7 million ha of mature plantations [25]. Indonesia converted eight percent of their CPO into 2163 million litre biodiesel in 2012 [36]. Figure 5 display the potential increase of 18% more biodiesel if neighbouring Malaysia's 4,4 tonne per ha [35] were achieved, maintaining the use of 8% of the CPO production.

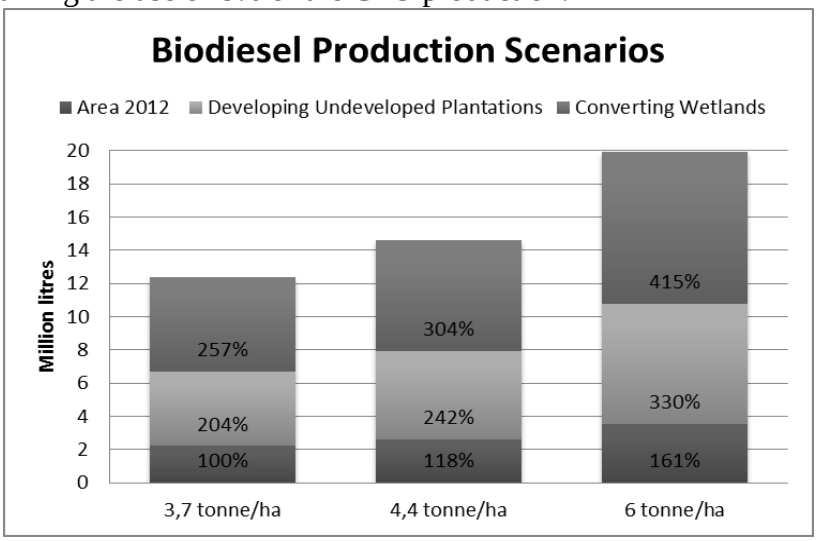

Figure 6 Potential Biodiesel production increase from yield increase and land expansion considering a maintained use of 8% of produced CPO.

4.1. Limiting Factors for Palm Oil Yield in Indonesia

Several factors have been identified and described below which influence the CPO yield of an oil palm plantation run by smallholders. These are identified from literature of Indonesian cases or general to plant growth. Smallholders outside the estate-like nucleus schemes may struggle to find adequate financing leading sometimes to the purchase of lower quality, locally produced, seedlings which results in lower yield and quality of the FFB [2,13]. The seedlings and the technical advice from a NES type system are advantageous for the smallholders, but seedlings may be unobtainable for them as companies reserve the supply for many years to come [11]. An incorrect or less than optimal planting pattern will affect the yield that can be obtained from each tree. During its life-time, the tree may be affected by factors which are maintenance related, such as pruning and pest or weed control and use of fertilizer. Smallholders may have difficulties in obtaining fertilizers due to the price or do not know where to obtain good planting material [29]. Noteworthy is that fertilizer and certified oil palm seedlings were an integral part of the agricultural policies during schemes prior to the financial crisis [29].

Palm oil has been a major contributor to farmers converting from rice [32] tempted by the higher profitability in palm oil. As the rice farmers converts from rice they lack the necessary skill in oil palm cultivation and some reported cases used fertilizer dedicated to food production in palm oil production [1]. Law No. 41 in 2009 state that land for food production may not be converted and should be conserved to protect food supply. Longer experience in cultivating oil palm has been seen as beneficial to achieve higher yields [6].

There are links between the government's performance and approaches for increased production, increasing plantation area as opposed to intensification. Higher quality government focuses on intensifying production and lower quality focuses on expanding the plantation area [19]. The expansion of palm oil has been increasingly aided by the decentralization of administration and

the decision making following the years after the financial crisis [20]. In Indonesia the expansion of production has led to land and forest being converted into oil palm plantations[11]. There is also an idea that increasing production by expanding the land can be done through family labour and as so requires no outside support [1].

The FFB trading system can be a reason for the yields [1]. Smallholders are granted favourable loans by local traders in exchange for their FFB deliveries. The local traders in turn get their money in loans from holders of district orders (traders with rights and a quota to sell to the mill). In turn they accept lesser quality FFB to make sure they fill their quota; this is disguised by either mixing the fruit or bribing the quality controller at the mill. Low quality and productivity stem from a lack in capital, knowledge and information among smallholders, as well as little interest from the farmers themselves in increasing the quality or productivity. With more mills and higher palm oil demand this is leading to a drop in FFB quality delivered to the mill.

4.2. Improvement Actions

The use of high quality seedling would improve yields by 47% from 2009's level [22]. Smallholders outside the estate-like nucleus schemes may struggle to find adequate financing leading sometimes to the purchase of lower quality, locally produced, seedlings which results in lower yield and quality of the FFB [2,13]. The seedlings and the technical advice from a NES type system are advantageous for the smallholders, but seedlings may be unobtainable for them as companies reserve the supply for many years to come [11]. During its life-time, a tree may be negatively affected by factors which are maintenance related, such as pruning and pest or weed control and use of fertilizer. Management and fertilization are issues that can be corrected on active producing plantations. By implementing best management practices (BMP) and a short harvest interval the FFB production could be improved in Indonesia [16].

Fertilizer cost is large part of the initial cost and around one third of the running costs for plantations until ten years of age and about half of the running cost for older plantations [18]. Compared to Malaysia, Indonesian labour cost is lower, whereas machine and building value depreciation is higher but the fertilizer costs are similar in the two countries [2].

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Implementing sustainable practices as the Roundtable for Sustainable Oil Palm (RSPO) can be beneficial to yield and could possibly be a 'low hanging fruit' for many. But it adds a cost that not all are willing to pay, especially smallholders [17]. Another obstacle is that as a large part of the market for palm oil, largely China and India may not be interested in the environmental benefits of certified plantations [15]. Indonesia is in these countries promoting the estate mandatory ISPO, while similar to RSPO certification, no results on improved yields have been presented yet.

Increasing yields can also be achieved by more modern mills and by quality control of the FFB [2]. To increase FFB quality a suggested solution is less mills that would increase competition among farmers to deliver higher quality FFB [1]. In contrast independent smallholders may require the opposite in regions where they instead have problems in accessing the oil palm mills and often receive a lower price for their FFB.

5. INDONESIAN BIOFUEL POLICIES

The Biofuels Integrated Policy is published by the Indonesian Department of Energy and Mineral Resources. It contains laws, regulations, decrees and policies related to biofuels in Indonesia. Three laws, in particular, affect plantation factors that could in turn influence yields. These are summarized below with relevant information to the topic. The relevant laws are Law Number 12 of 1992 Concerning Plant Cultivation System [33], Law Number 18 Concerning Plantation [34], and Law of the Republic of Indonesia Number 39 2014 about Plantations [23]. Only the articles and paragraphs within the law that are relevant to this topic of policy and yield have been reviewed. The law on plantations was updated in 2014 and therefore the newer version is also included. Indonesia has its own certification scheme, Indonesian Sustainable Palm Oil (ISPO), which is mandatory from the end of 2014 for all estate companies.

Law no. 12 1992 concerning plant cultivation system states that anyone can breed plants in order to achieve a better producing plant, and can even be rewarded for doing so, but the seedling must be approved by the government to secure quality standard and to be certified. Planting should be performed in a way to maximize growth and productivity by using appropriate planting techniques and seeds and maintenance should be performed to optimize growth and productivity. The government supervises distribution of fertilizer and tools to be used for cultivation, and is obliged to offer services regarding information that can aid in the development of cultivation.

In the recently updated law on plantations, law no. 39 from 2014 (as in the law of Plantations no. 18 from 2004) the core idea of plantations are: provide income, for the state and for the people, to provide work opportunities, fulfil the demands and to improve productivity and added value. Capacity building shall be provided officially, local, regional or national, for increasing the added value on plantations. Stricter rules are put in development of granted lands, at least 30% must be developed within 6 years of being granted the land or the state will recall the permit. The search for, or breeding of, improved seeds can now only be carried out by a legal person with the consent from the Minister of Agriculture. Priorities for crops are first to meet the domestic supply and raw materials for the industry before other demands. Mixing and falsifying quality that leads to unfair competition, in the steps of processing, distribution or marketing, is now not allowed and punishable. R&D shall respect local knowledge while also producing scientific knowledge and developing technology. Development of human resources has been targeted and is to be performed by a local or national authority; in order to develop and/or increase knowledge, skills, professionalism, independence and dedication of farmers.

As ISPO certification has become mandatory for estates in Indonesia, a summary of the relevant principles and criteria in the audit process [24] will be presented. The standards are based on Technical Guidelines Development Gardens Palm Oil (Pedoman Teknis Pembangunan Kebun Kelapa Sawit). The seeds have to be recognized by the government, certified and age and quality is monitored or the estate will be reported. Planting layout regarding amount of trees, distance and pattern should be according to best practice standards. Maintenance should be according to standard operating procedure for water use and weeding, and fertilization by analysis of soil and leaves. Pest control performed using a variety of techniques. Harvest according to standard operating procedure, including determining ripeness and crop rotation. In transportation protect the FFB from damage, contamination and fermentation, and timeliness to reach treatment facility. At the treatment facility there must be criteria for accepted FFB, the criteria must be open and rejection of non-complying. In the mill the machinery should be controlled and maintained to ensure that the FFB treatment will meet the expected quality. An ISPO certification that focuses on plasma farmers is being developed and contains a lot of the same criteria's.

6. DISCUSSION

Indonesia has had strategies that promoted company estate involvement with farmers but this has in many instances failed to produce high yielding plantations. As the involvement after the initial handover is not clearly described in literature there is a chance companies are only interested in payback of the loans handed out. Instead of focus should be placed on further developing their own and their plasma smallholders' plantations. This will be of importance if the country wants to avoid further deforestation or land conversion due to increased demand for palm oil from biodiesel production. As seen in Figure 5 the potential increase for biodiesel production by increased yield and even more so if further expansion is decided.

Phases of the palm oil production have factors which may be controlled and/or improved to achieve a higher yield, displayed in the improvement actions are marked as either addressed or not, the effectiveness of the policy is not evaluated. Many of the issues have been noted and have been included in the ISPO certification requirement, although fewer in related laws regarding plantations. Showing there are still many improvements that can be further explored and that deserve attention.

Table 1 Factors limiting in Indonesia palm oil yield, related policy and improvement actions, underlined actions are proposed in the policies.

Parameter Group	**Identified factors limiting yield in Indonesia**	**Source**	**Related Indonesian Policy**	**Actions for improvement (Addressed)**
Agricultural Practices	Wrong planting pattern or distance between trees. Both low and high tree density reduce FFB output per ha.	[28]	ISPO	SOP (standard operating procedure) for planting.
	Use of uncertified seed or seed of lower quality. Due to availability, lack of knowledge or financial constraints	[2,11, 28]	Law no. 12 1992 Article 11, 12, 13. Law no. 39 2014 Article 26, 27. ISPO	Stricter breeding control. Increase certified seedling supply.
	Improper fertilizer application due to knowledge or financial constraints. Affect tree and fruit growth.	[1,28, 29]	ISPO	Capacity building for benefit of fertilizer. Policy development for oil palm fertilizer.
	Pesticide: Pests and diseases affect leaf area, root and stem and can decrease growth or kill the tree	[8]	ISPO	Pesticide. GMO.
	Lack of experience and knowledge in oil palm cultivation.	[1,6]	Law no. 39 2014 Article 88, 89.	Knowledge transfer from authorities and estates.
Management Practices	Management practices for cultivation; harvesting, pruning and maintenance.	[10,16,28]	ISPO	Training in BMP. Applying BMP.
	Behaviour of farmers and decentralized administration; focus on land expansion rather than intensification for increased production.	[1,19, 20]	-	Central directions for expansion and focus on developing concessions.
	Poor quality of FFB delivered to palm oil mills. Due to high demand for FFB, lack of or indulgent quality control and/or poor farming practices.	[1]	Law no. 39 2014 Article 77. ISPO	BMP for harvest. Quality monitoring and control at mill.
	Long transportation or retention time of FFB causing free fatty acid build up and reduced oil yield.	[22]	ISPO	Infrastructure development. SOP for harvest and transportation. Decrease retention time.

Environmental Factors	Natural environment: Light, carbon dioxide, temperature. Affect tree and fruit growth.	[8]	-	-
	Local environment: soil type, nutrient and water availability. Affect tree and fruit growth.	[8]	ISPO	Choice of location. Fertilizer application. GMO.

Agricultural practices related to start up such the planting pattern and seedlings are of little issue in estate companies and plasma smallholders but especially quality seedling for independent smallholders need improvement. Only increasing quality control may affect the demand side therefore increasing the supply of seedlings could ensure that more plantations acquire quality trees.

Fertilizers are one of the most important and costly factors for oil palm cultivation. Easier access would most likely be beneficial to yields in Indonesia but as recognized in the ISPO certification, the application procedure of fertilizer is important. It can be damaging to soils which in turn affect the sustainability for biofuels, as fertilizer production has a high environmental and energy impact. This makes a subsidies policy volatile regarding risk and benefit. In order to make fertilization an effective measure, farmers need to understand the benefits of applying it and the proper application of fertilizers to not damage the soils. As of now little is done toward fertilizers and smallholders who cultivate a large portion of the land, intensification will benefit these farmers' income and change their behavior method towards increasing production. For example there is a policy regarding rice fertilizer in Indonesia and a similar one could be developed for palm oil production.

In terms of FFB quality delivered to mills better management may improve harvesting timing leading to better fruit and less retention time which causes deterioration of the oil. BMP bring several benefits to a plantation and should be an integral part of biofuel policies to ensure good practices and reducing the loss of potential palm oil.

The ISPO certification is a good step for securing more sustainable feedstock for the biodiesel production in Indonesia. It targets many problem areas regarding yield and with similar measures that have been suggested in the literature. As ISPO became mandatory further steps should be taken to ensure that biodiesel is produced from sources holding the certification and those criteria is upheld. But it must also be redirected toward smallholders who hold a great part of the land but with a low output Figure 3 and Figure 5, which require a different approach then estate companies.

7. CONCLUSION

As Indonesia targets higher biofuel blending targets the potential benefits of increasing the yield for the main biodiesel feedstock cannot be overlooked. Not only does it provide significant potential on current land, it can also reduce the requirement on converting additional land by intensifying on currently occupied land and if expanding there are advantages in terms of biodiesel potential if aiming for high yielding plantations. The biofuel policy will need to target fertilizer especially among smallholders and the use of best management practices in all plantations to realize the potential in current and future plantations. Strengthen the knowledge exchange and focus on capacity building between estate companies and research institutions with each other and other farmers. Higher yields are possible and if achieved it will be a step towards a more sustainable biodiesel feedstock as the Indonesian oil palm plantations realize their true potential.

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Appendix

Keyword 1	Keyword 2	Keyword 3	Keyword 4	Keyword 5
Indonesia	Oil Palm	Estate	Development	Driver
Indonesia	Oil Palm	Estate	Expansion	Driver
Indonesia	Oil Palm	Plantation	Development	Driver