International Journal of Environmental Impacts
Vol. 8, No. 2, April, 2025, pp. 219-231
Journal homepage: http://iieta.org/journals/ijei

Strategies Inclusive Green Productivity for Environmental Sustainability in the Palm Oil Industry

Estiarty Haryani[1], Herdis Herdiansyah[1*], Tri Edhi Budhi Soesilo[1], Rosyani[2]

[1] School of Environmental Science, Universitas Indonesia, Central Jakarta, DKI Jakarta 10430, Indonesia
[2] Agribusiness Study Program, Jambi University, Muaro Jambi Regency, Jambi 36361, Indonesia

Corresponding Author Email: herdis@ui.ac.id

https://doi.org/10.18280/ijei.080202

Received: 17 October 2024
Revised: 27 December 2024
Accepted: 15 January 2025
Available online: 30 April 2025

Keywords:
Green Productivity, palm oil industry, strategy inclusive, sustainable agriculture, sustainable development

ABSTRACT

Palm oil is among the most important global commodities and contributes significantly in increasing state income; however, many palm oil industries are still not environmentally friendly. This study aimed to analyze the challenges and opportunities of adopting Green Productivity (GP) practices the industry of palm oil in Jambi, Indonesia. This study used a qualitative approach and comprehensive secondary data analysis, including academic publications, policy reports, and economic-social data. This research analyzed the relationship between socio-economic aspects and environmental sustainability, with a focus on smallholder farmers' livelihood strategies. Farmers face several challenges in implementing GP strategies, particularly in land legality, income diversification, and environmental management. These factors are critical for improving both industrial and environmental sustainability. Green Productivity offers a potential pathway for integrating environmental sustainability with increased productivity of the palm oil industry. The results emphasize the necessity for policy support to address the socio-economic challenges and promote sustainable practices. Moreover, it is emphasized that in Green Productivity, nature serves as unpaid labor.

1. INTRODUCTION

Palm oil constitutes a vital agrarian product that is influences the economies of producing nations like Indonesia and Malaysia which together account for a substantial share of global production. However, this growth in production has been accompanied by significant environmental consequences. The expansion of palm oil plantation has contributed to large-scale deforestation, loss of biodiversity, and increased carbon emissions. Raising concerns about the sustainability of palm oil production [1, 2].

Various efforts have been made to reduce forest conversion into palm oil plantations. RSPO (Roundtable on Sustainable Palm Oil) certification enhances sustainability in the palm oil industry. Research conducted in Indonesia and Malaysia show that RSPO certification has been ineffective in preventing deforestation for palm oil cultivation but has had a positive impact in reducing the conversion rate [3-5]. Reducing the conversion rate exerts an influence on the viability of palm oil production and subsequently on Green Productivity (GP) globally. World growth in 2011 [6] reports that the Indonesian palm oil industry faces criticism from several non-governmental organizations (NGOs) who campaign against this industry. This criticism is a response to plantation expansion which is considered to be taking place quickly and massively. This growth has been attributed to deforestation, increased carbon emissions, and a decline in biodiversity [7, 8]. In accordance with this, accusations concerning the unsustainability industry of palm oil have surfaced. Pierre [5] also stated that RSPO also encourages conservation and has a beneficial influence on the climate by diminishing the pace of tropical forest conversion.

Recent studies have shown that certified production processes such as ISPO, have contributed to reduced emissions and more efficient use of land, particularly by decreasing palm oil processing on peatlands and increasing the use of sustainable technologies like biogas. However, the effectiveness of these systems in fostering widespread adoption of Green Productivity practices among farmers remains uncertain, especially in terms of their socio-economic impacts. Considering these challenges, the agricultural sector plays a significant role in Indonesia's economic activities, contributing approximately 12.98% in 2018. The plantation subsector contributed 3.3% to the total GDP [9] These economic statistics underscore the critical importance of sustainable agricultural practices. The challenge lies in balancing economic growth with environmental stewardship.

The escalating environmental consciousness of European consumers which directs them to engage in consumption in accordance with eco-friendly principles, namely Green Chemistry, develops chemical process innovations that shift, reduce or renew traditional conventional chemical processes to be more friendly to the environment and humans without abandoning the principles of process optimization. production. The implementation of green chemistry is an important step towards sustainable development of policies and governance

are crucial for food exporting nations. The association with palm oil cultivation. Indonesia addresses to eco-conscious consumers through Indonesian Sustainable Palm Oil (ISPO). ISPO serves as a regulatory mechanism and a sustainability framework to actualize the tenets of the formal articulation of sustainable palm oil development is delineated in Presidential Regulation 44 of 2020, Republic of Indonesia. To mitigate the degradation of ecological resources and the surrounding ecosystem, whatever the coconut plantation business model Palm oil is essential for implementing effective production management principles. (good governance). implementation of sustainability standards through the implementation of good production governance, is basically an effort to internalize the costs of negative externalities resulting from risks from production activities so that environmental destruction can be minimized [10, 11] Environmental problems related to palm oil businesses include deforestation, biodiversity and climate change [3, 7, 12].

ISPO regulation is a Green Productivity initiative to overcome social and ecological problems concerning palm oil in Indonesia. Indonesian palm oil has been subject to significant critique owing to its adverse socio-ecological effects, particularly concerning ecological transformation, deforestation, and extensive alterations in land cover. Concerns regarding loss of biodiversity, land appropriation, and social conflict. Agrarian territorial dynamics between corporations and traditional communities are part of the ecological and agricultural challenges associated with palm oil cultivation in Indonesia. The execution of ISPO encounters numerous intricacies, particularly within local and regional governmental authorities.

In its application, ISPO provides some advantages and risks. For consumers, ISPO will be useful in guaranteeing environmental security. ISPO enhances market credibility for producers. Nevertheless, ISPO has the risk of being financially expensive for small farmers. In the meantime, for municipal and provincial authorities, ISPO not solely formulates directives but also promotes the procedure of socialization, education and guidance, or other technical assistance which necessitates substantial expenditures. The Indonesian government's readiness to carry out the ISPO accreditation procedure encounters multi-tiered impediments. Schouten and Glasbergen in 2011 [6] articulated that there exist challenges pertinent to the elucidation of the significance of sustainable palm oil accreditation which is not cohesive among diverse strata of governance. Regionalization policies have given rise to numerous interpretations among governmental entities of various tiers.

While mitigating effort such as RSPO and ISPO certifications already implemented to overcome these environmental impacts, the effectiveness of these frameworks in fostering both Green Productivity and social inclusion remains unclear. Other studies may focus on the environmental aspects, but the integration of socio-economic factors such as farmer livelihoods, education, and access to resources into sustainable palm oil production practices has not been fully explored. The role of Green Productivity practices in enhancing both environmental and economic outcomes in the palm oil industry needs further research.

This study aims to address this gap by investigating the relationship between Green Productivity practices and social inclusion in the context of the palm oil industry in Jambi, Indonesia. Specifically, the study will analyze the socio-economic factors such as income, education, and access to land that influence farmers' adoption of Green Productivity practices. Assess the effectiveness of ISPO along with RSPO in promoting both environmental sustainability and improved livelihoods among stakeholders. Then examine how the strategy of inclusivity can enhance the adoption of sustainable practices in terms of Green Productivity for contributing to both environmental and economic benefits.

As a result, there has been no significant enhancement in the sustainability effects of palm oil at local or regional tiers remain influenced by the evolving regulatory and policy frameworks established at the national government level. Diverse domains and levels of operational authority have resulted in miscoordination within scales of authority or function between organizations, particularly within sub-national contexts. Meanwhile, despite having extensive independence and greater authority to formulate resolutions and execute policies to the ratification of the Village Legislation, regional administration still has weak palm oil implementation and governance units. At the regional populace's subsistence tier, the circumstance remains still not advantageous. Deficiency of human capital and constrained capacity regarding technical, physical, and financial resources have resulted in small-scale agriculturalists possessing minimal prospects to address these demands, a governance occurrence that operates as sustainable palm oil governance. Furthermore, achieving better outcomes in sustainable palm oil requires attention to fundamental agronomic practices. It is crucial to consider the establishment of appropriate planting densities during the initial planting phase [13]. Improvement of palm oil using the implementation of Green Productivity will not run well without analyzing the income strategies by households involved in palm oil cultivation. The strategy can look deeper into the development of the concept of social inclusion [14] which is combined with the advancement of palm oil implementing sustainable Green Productivity so that this research finds in the literature review "green inclusive productivity" because productivity is not only in the amount of production but also in socio-economic impacts resulting from palm oil plantations.

2. METHODOLOGY

This study aims to explore inclusive Green Productivity strategies within the industry of palm oil in Jambi, Indonesia. Secondary data analysis is used to facilitate this process and is essential for analyzing and improving Green Productivity within this industry. This approach was selected for its validity, and the ability to replicate study findings. Additionally, it allows for the integration of various relevant studies and policies concerning Green Productivity in the palm oil industry.

The reference selected must cover publications from 2015 until the recent studies. Ensuring relevance to current palm oil industry practices and sustainability efforts. This study collects two main types of secondary data, quantitative data and qualitative secondary data. Quantitative data includes farmers' income, access to education, land access, and adoption of green technologies. Qualitative secondary data includes academic articles, government reports, and related documents on Green Productivity. The data is collected from the references from 2015 onward are prioritized and he collected data will be analyzed using descriptive statistics to provide broad understanding of the relationship between social

inclusion and Green Productivity adoption. These data sources provide in-depth insights into the socio-economic, environmental impacts, and conditions of communities surrounding palm oil plantation in addition to the execution of sustainable Green Productivity strategies. By linking the dataset, we can enhance the depth of analysis by providing comprehensive insights into service trajectories and policy impacts [15]. This study argues that strategy inclusivity is a key factor in improving Green Productivity in the palm oil industry. By ensuring better access to education, financial support, and technology. These practices contribute to environmental sustainability and economic prosperity. So that smallholder farmers can effectively adopt Green Productivity practices. This research also helps to understand the connection between social and economic aspects along with livelihood strategies of palm oil farmers along palm oil industry. Furthermore, it examines how Green Productivity practices, which combine industrial and environmental sustainability, can enhance productivity while recognizing the critical role that nature plays in this process.

This research focusing on Jambi, Indonesia. To investigate the research inquiry, the study used the literature analysis within the Green Productivity in the industry of palm oil. This provides comprehensive insight into the strategies to address these strategies. In the sense that some of the primary research considered is of this nature; configurative, focusing on the range and nature of the concepts discovered, not on completeness; and, following an inductive method, applying an iterative method that interprets specific examples to answer questions about experience and meaning to generate and explore theories used in Green Productivity sustainability research in the industry of palm oil.

3. RESULT

The objectives of this research encompass an examination of the socio-economic characteristics of palm oil farmers. Then the particular socio-economic profile is linked to Green Productivity, namely the income level of palm oil farmers (socio-economic); secondly, to examine the output and production number of palm oil smallholders in relation to social environment; third, connecting environmental sustainability in production in the palm oil industry. The study collected data on various socio-economic characteristics of farmers in the research areas, including their age group, education level, family size, and farming experience. These factors play a significant role in the adoption of Green Productivity practices.

Table 1. Distribution of farmer samples by socio-economic characteristics

Characteristic	Category	Percentage
Age Group	20-30 years	25%
	31-40 years	40%
	41-50 years	20%
	51+ years	15%
Education Level	High School	45%
	University	40%
	Post-Graduate	15%
Family Size	1-3 members	30%
	4-6 members	50%
	7+ members	20%
Farming Experience	1-5 years	25%
	6-10 years	45%
	11+ years	30%

Table 2. Impact of education on adoption rate, economic and environmental impacts in the palm oil industry

Source	Education Level	Adoption Rate of Green Productivity (%)	Economic Impact	Environmental Impact
Environmental Sustainability Practices Among Palm Oil Millers [2]	40% higher education adopt sustainable practices	40% higher adoption rate among educated farmers	15%-20% income increase for farmers who adopted sustainable practices	12%-15% reduction in emissions for educated farmers
Social Implications of Palm Oil Production [3]	Educated farmers are more proactive in attending training and adopting technologies	50% higher adoption rate for educated farmers	20%-30% reduction in input costs (fertilizer and water)	Waste Reduction: 15%-20%
Adoption of Sustainable Certification in West Borneo Palm Oil Farmers [4]	Higher education Increased awareness on sustainability issues	55%-60% adoption rate of sustainability certification	10%-15% income increase post-certification	CO_2 Emission Reduction: 10%-12%
Environmental and Social Impacts of Oil Palm Plantations [5]	Higher education levels correlate with higher adoption of new technologies	50%-55% adoption rate among educated farmers	15%-20% yield increase from adoption of sustainable techniques	Biodiversity Improvement: 10%-12%

From Table 1, the distribution of farmers by age group shows that the largest proportion of farmers are between 31-40 years (40%), followed by those in the 20-30 years age group (25%). Older farmers, those aged above 51 years, represent a smaller percentage (15%). This age distribution may influence the adoption of green practices, with younger farmers generally more adaptable to new technologies, while older farmers tend to have more traditional practices. The educational background of the farmers indicates that 45% have completed high school, while 40% have obtained a university degree. A smaller percentage, 15%, have postgraduate education. From the data, it can be concluded that higher education might correlate with higher adoption rates of Green Productivity practices, as farmers with higher education levels may have more access to information and resources related to sustainable practices. Most farmers have 4-6 family members (50%), followed by 30% with 1-3 members. Smaller percentage (20%) have 7+ family members. The family size distribution suggests that larger households may have more labor available to implement sustainable farming practices, such as agroforestry, but it could also imply more challenges in terms of land and resource allocation. Most farmers (45%) have 6-10 years of farming experience, while 30% have more than 11 years of experience. The remaining 25% have 1-5 years of farming experience. The adoption of Green Productivity could be influenced by the length of farming

experience, with more experienced farmers likely to have a deeper understanding of traditional farming methods. The rapid proliferation of oil palm plantation across Indonesia over the past decades has dramatically transformed rural landscapes, posing significant challenges to ecological systems and local community livelihoods. These transformative changes underscore the critical importance of understanding the complex interplay between agricultural expansion, environmental sustainability, and socio-economic dynamics [16]. These socio-economic characteristics should inform policy makers in the agricultural sector. For example, policies to enhance the adoption of Green Productivity practices could target younger farmers or those with lower educational levels. Additionally, policies that address the labor and resource constraints of larger households may help in scaling sustainable practices like agroforestry. In the future, farmers are expected to encourage improved farming practices and livelihood assessment [1]. The data in Table 2 provides further insights into how these factors influence the adoption rates of sustainable farming practices, economic benefits, and environmental outcomes in the palm oil. Examining the relationship will provide a better understanding of the dynamics that drive the implementation of green practices and the challenges.

From Table 2, it can be concluded that higher education correlates with higher adoption rates of Green Productivity practices. Educated farmers experience higher income increases and profitability from adopting sustainable practices. The income rise is particularly notable in those with higher educational levels. Farmers with higher education show impactful reductions in emissions and deforestation. This concise analysis highlights the key findings from the data and emphasizes how education, along with other socio-economic factors like age, family size, and experience, influence the adoption of sustainable farming practices, leading to positive economic and environmental outcomes.

This is succeeded by an examination of farmer profiles related to Green Productivity and finally, a framework is presented based on the strength of the correlation between socio-economic profiles. Palm oil plantation is Jambi will continue to grow due to the large area of secondary forest. In general, the development of palm oil agribusiness still has prospects, in terms of price prospects, exports and product development. Internally, the growth of the palm oil business is supported by the potential suitability and availability of land, productivity which can still increase and the further development of the downstream industry.

Table 3. Development of area and palm oil production in Jambi Province 2016-2021

Year	Land Area (Hectare)	Production (Tons)	Productivity (Tons/Hectare)
2016	736,095	1,910,028	2,50
2017	769,879	2,078,463	2,70
2018	1,032,145	2,691,270	2,61
2019	1,034,804	2,884,406	2,79
2020	1,083,746	2,639,894	2,44
2021	1,190,813	2,431,643	2,04

Source: Ministry of agricultural 2021 [17]

From Table 3, the quantity of land and palm oil production has risen every year starting 2016 until 2021. Efforts are needed to maintain the expansion of land utilization and palm oil production. The land area determines the amount of production that will be produced per year, by carrying out good maintenance on oil palm plantations. The area and production of palm oil in Jambi Province in 2016 was 736,095 Ha with production of 1,910,028 tones, the area and production of palm oil in the province in 2021, namely 1,190,813 Hectare and production of 2,431,643 tones.

Table 4 shows that the development of oil palm plants in Jambi Province has increased in every district in Jambi Province. For example, Tanjung Jabung Timur Regency with the largest land area, namely 201,302 Ha, followed by Tanjung Jabung Barat Regency with total area of 166,854 Hectare and next is Muaro Jambi Regency with a land area of 2021 is 86,088 Ha. The largest Fresh Fruit Bunches (FFB) production is Tanjung Jabung Timur Regency with production 390,324 tons, Merangin Regency with production of 248,596 tons and Muaro Jambi Regency with production of 196,321 tons in 2021.

Tanjung Jabung Timur Regency has the largest area and production of oil palm, namely 201,302 hectares or around 26% of the total area and production of 390,324 tons. Tanjung Jabung Timur Regency has quite a big effect on the palm oil industry.

Table 4. Land area and production palm oil in each regency in the Province Jambi 2021

Regency	Land Area (Hectare)	Percentage (%)	Production (Tons)	Percentage (%)
Kerinci	94	0,01	54	0,0004
Sarolangun	44,218	6	100,097	7
Tebo	78,961	10	127,990	8
Tanjung jabung barat	166,854	22	115,376	8
Bungo	52,333	7	166,253	11
Batang hari	77,936	10	174,009	11
Muaro jambi	86,088	11	196,321	13
Merangin	64,125	8	248,596	16
Tanjung jabung timur	201,302	26	390,324	26
Total	771,997	100	1,519,044	100

Source: Ministry of agricultural 2021 [17]

Jambi Province is situated among the foremost ten palm oil generating provinces in Indonesia regarding both expanse and yield. Palm oil plantations developed rapidly in the 1980-1990 era when there was a phenomenon of transmigration from Java to Sumatra Island where most of the population cultivated palm oil plantations as a commodity to support the family economy. Palm oil plantations in Jambi Province are operated independently or in partnership with companies. The establishment of palm oil plantations has induced significant population mobility, transforming adjacent regions into hubs of rural economic development. This condition has led to an increase in the purchasing power of rural communities, especially for routine household needs and utility needs on palm oil plantation production [18].

Palm oil smallholders in Jambi Province are economically capable in increasing people's income as seen from the growth before and after the advancement of palm oil plantations. The area of palm oil plantations in Jambi Province based on ownership is dominated by smallholder plantations, while the development of state plantations tends to be stable, but smallholder plantations tend to increase. Based on data, around 75 percent of palm oil in Jambi based on control are smallholder farmers. The expanse of individual palm oil cultivation in 2017 was more than 500 thousand hectares. This

number will continue to increase by seeing the enthusiasm of the community for the palm oil plantation business [19].

The community's economic improvement continues to increase by working on plantations. Industry palm oil in Jambi province as a whole absorbs ± 1,414 people as workers, with a ratio of 75% men and 25% women. Palm oil does not yet have plasma but has guaranteed partnerships with independent farmers through the Created Share Value (CSV) program, which prioritizes the development of farmers around the plantation so that the resulting production increases and has better quality. Socially does not change women's social relations in domestic work, so that women around plantations can still work on plantations and in the domestic sector [19].

A total of 2,002 individuals constitutes the total size of palm oil smallholder. Further classification regarding family size shows that the majority are in the 5-8 range representing around 62%. Meanwhile, 79% of the full-time workforce in palm oil plantations are full-time non-family workers with an average of 2 full-time non-family workers, while the average full-time family workforce is estimated at one individual in household. The distance traveled by palm oil farmers from home to the plantation is an average of 2 km, the closest distance from the palm oil farmer's factory to the plantation is estimated to be 11 km and closest mean distance from the agricultural produce gathering location to the cultivation site is estimated to be 2 km.

Table 5. Summary of cost and revenue in palm oil productions

Cost/Revenue Category	Value (IDR/ha/year)	Description
Fertilizer Costs	IDR 70,925,000.00	Total cost of fertilizers (Urea, SP-36, KCL, Phonska)
Average Fertilizer Cost	IDR 1,773,125.00	Average cost per hectare per year
Herbicide Costs	IDR 40,541,000.00	Total cost of herbicides (Round-Up, Ally, Gram Oxon)
Average Herbicide Cost	IDR 1,013,525.00	Average cost per hectare per year
Labor Costs	IDR 42,430,383.33	Total cost of labour (fertilization, spraying, harvesting, etc.)
Average Labor Cost	IDR 1,060,759.58	Average cost per hectare per year
Other Costs (for Plasma Farmers)	IDR 14,370,000.00	Total cost for transportation, KUD, social funds, etc.
Average Other Costs	IDR 718,500.00	Average cost per hectare per year (only for plasma farmers)
Total Production Costs	IDR 179,337,942.86	Total costs (fixed and variable)
Average Total Costs	IDR 4,483,448.57	Average cost per hectare per year
Variable Costs	IDR 153,896,393.33	Total variable costs (fertilizer, herbicides, labour)
Average Variable Costs	IDR 3,847,409.58	Average cost per hectare per year
Total Production	368,200 kg	Total palm oil production per hectare per year
Average Production	9,205 kg	Average production per hectare per year

From Table 5, regarding total costs, comprising fixed and variable expenses, are pivotal for calculating net income, defined as total revenues with less total costs [20]. Furthermore, ending hunger does not stop at increasing productivity, but is also related to increasing incomes and strengthening markets so that people can access food when facing challenges that can hamper production [21]. Therefore, the next sub- section links the income of smallholder palm oil farmers to poverty alleviation. In this paradigm, comprehending the financial intricacies, including the comprehensive production expenses and the earnings of smallholder agriculturists, is imperative for achieving the overarching objectives of poverty reduction and food security. Given that the agricultural sector, especially palm oil cultivation, occupies a pivotal position within Indonesia's economic framework, addressing income inequalities and improving market accessibility is essential for combating hunger and poverty. These considerations align with the United Nations Sustainable Development Goals (SDGs).

Sustainable Development comprises 17 foundational pillars that encapsulate the collective aspirations of nations and global society towards achieving a more sustainable future as a UN member state, Indonesia has officially supported the UN Sustainable Development Goals over Presidential Regulation 59 of 2017, thereby aligning with the established objectives. In the 2030 agenda for Sustainable Development aims to actualize governmental pledges toward these objectives. Presidential Regulation 59 of 2017 is one of several policy documents facilitating the UN Sustainable Development Goals complement Indonesian Law 32 of 2009 pertaining to Environmental Safety and Management, underscoring the government's commitment to sustainable development. The objective encompasses that the utilization of natural assets must be in concordance and equilibrium with the role of the ecosystem. Consequently, developmental strategies, frameworks, and initiatives are supposed to be permeated with the imperative to conserve the natural environment and achieve sustainability objectives. Secondly, Presidential Regulation 2 of 2015 addresses the National Medium Term Development Plan for 2015-2019. Indonesia Road Map towards 2030 SGS delineates a strategic planning framework outlining the stages and objectives necessary for Indonesia to realize the Sustainable Development Goals in alignment with national development aspirations from 2017 to 2030.

Indonesian Sustainable Palm Oil (ISPO) constitutes a strategic endeavor commenced by Government of Indonesia throughout the Agricultural Ministry to enhance the status of palm oil in Indonesia within the international economic landscape. The framework advances the Indonesian President's pledge to mitigate greenhouse gas emissions and address ecological challenges. The execution ISPO is anticipated to bolster the advancement of Indonesian palm oil through an array of regulations and policies, particularly concerning various facets of the Triple Bottom Line, encompassing individuals, the environment, and financial gain. The policies instituted are not solely profit-centric, but also emphasize ecological and societal dimensions. This arises from the recurrent challenges linked to the enhancement of Indonesian palm oil, particularly concerning ecological and community concerns, governed by Presidential Regulation 44 of 2020 about the Indonesian Sustainable Palm Oil Accreditation Procedure. Presidential Regulation 44 constitutes a modality of actualization of the ISPO policy by acknowledging that Indonesian palm oil estates engage a significant workforce. For this rationale, Indonesia necessitates proficient, effective, equitable, and sustainable administration of palm oil estates to bolster national economic

progression and as a measure to reinforce ecologically sustainable Indonesian palm oil advancement in accordance with prevailing rules and protocols. The antiquated Sustainable Palm Oil Plantation certification procedure in Indonesia necessitates enhancement as it is no longer congruent with global advancements and legal stipulations.

The newly instituted ISPO Plantation Accreditation Procedure predicated by Presidential Regulation command perpetuates the primary objectives of ISPO, namely to a). ensure plus improve the managing and also progress of oil palm agricultural estate in accordance with ISPO standards and benchmarks; b). enhance the marketability and the competitive viability of Indonesian oil palm plantation outputs. domestically furthermore globally, c). accelerate the initiative for diminishing greenhouse gas emissions in accordance with the tenets of the Sustainable Development Goals. This statute is directed towards entities engaged in enhancing palm oil advancement in Indonesia, encompassing palm oil cultivators, enterprises, and other pertinent stakeholders. Initiatives undertaken as a demonstration of the administration's earnestness in tackling and resolving significant issues pertaining to Indonesian palm oil comprise the subsequent: Enhancing ISPO Certification administration by facilitating avenues for involvement, responsibility, and openness. ISPO certification is presently in the enhancement phase with the promulgation of additional regulations pertaining to ISPO protocols and stipulations. This amendment is encompassed in Presidential Regulation of the Republic of Indonesia 44 of 2020 and Ministry Regulation of Agriculture 38 of 2020. These dual statutes additionally establish novel frameworks that enhance the antecedent ISPO Certification.

The ISPO authority previously exhibited deficiencies in executing its membership protocols, responsibilities, and functions. Enhancements are necessary to strengthen the ISPO Committee's reliability by activating the National Accreditation Committee (KAN) within the accreditation framework. KAN's involvement is pivotal in elevating ISPO certification standards, thereby facilitating a more autonomous process for issuing ISPO Certificates by Certification Bodies, with a focus on critical environmental issues. It is in line with the 4 variables in Green Productivity, namely social, economic and environmental. Implementing Green Productivity in palm oil has a major impact on productivity levels. This is in line with the explanation above regarding the costs that must be incurred by palm oil companies in the production process. The implementation of Green Productivity answers critical problems by enhancing initiatives to enhance the growth of palm oil, which necessitates addressing ecological concerns in addition to implementing a reliable, self-sufficient oversight framework, which will positively impact efforts to strengthen the sector.

Standardization is very important to apply both to the life and health of humans, animals and plants. Indonesian National Standards (SNI) will create standards for products or services with identical criteria for all Indonesian individuals and the global community who utilize or engage with domestic goods and services. SNI serves as the exclusive national criterion for all goods and services in Indonesia, with a standardization framework aligned with WTO ethical codes adopted as a national benchmark for palm oil operations, confirming that ISPO-compliant palm oil enterprises are economically viable, socially responsible, environmentally sustainable, and legally compliant. Therefore, if ISPO certification is implemented compulsorily and adequately, then all issues and obstacles pertaining to the execution of sustainable palm oil in Indonesia will be examined as articulated by Presidential Regulation 59 of 2017 regarding the implementation of Sustainable Development Goals (SDGs). Widespread ISPO accreditation exerts a significant positive influence on endeavors to bolster Indonesian palm oil improvement. ISPO official recognition, as delineated in Presidential Regulation of Indonesia 44 of 2020 concerning the Indonesian Sustainable Palm Oil Certification Procedure, is "Mandatory, Not Optional." This assertion is corroborated by the implementation guidelines outlined in the Indonesian Minister of Agriculture's Statute 38 of 2020, which governs the framework for ISPO authorization. Consequently, the execution of the Sustainable Development Goals regarding ISPO is achieved through the establishment of novel regulations that embrace the Sustainable Development Goals which emphasize the principle of sustainability. This statute will transition into an ISPO statute after the promulgation of Presidential Regulation 44 of 2020 pertaining to the Indonesian Sustainable Palm Oil Accreditation Framework and the regulation of Agricultural Ministry 38 of 2020 regarding the Certification of ISPO. The incorporation and execution of Sustainable Development Goals within diverse ISPO certification initiatives play a vital part in enhancing the palm advancement.

4. DISCUSSIONS

4.1 Socio-economic characteristics and Green Productivity

The findings of this study give clear highlights that it has clear correlation between education levels and the adoption of Green Productivity practices which aligns with existing research in agricultural sustainability [2, 4]. Farmers with higher education tend to have more access to information and resources that facilitate the adoption of technologies. However, the study also finds that younger farmers are more likely to embrace new practices, suggesting that age plays a role in adoption, a point that is less frequently emphasized in literature that mainly focuses on education or income levels. The data reveals that younger farmers (31-40) are more adaptable to new technologies. Reflecting the willingness to adopt Green Productivity practices. This finding is consistent with studies that younger generations are more open to change, especially when it comes to modern farming or certification programs. Conversely, older farmers tend to be more resistant to change, which may hinder the broader adoption of sustainable practices.

Higher education significantly correlates with higher adoption rates of sustainable farming practices, or this context is Green Productivity. Educated farmers have better access to training and awareness about economic and environmental benefits of sustainable practices [3]. While larger households may benefit from increased labor for agricultural practices. They simultaneously encounter land management challenges and resource limitations, necessitating further support for the management. Farmers who have 6-10 years of experience exhibit an advantageous blend of traditional knowledge and are open to innovation. Resulting in a high chance of adoption of Green Productivity.

The success of agricultural development, especially increasing people's income and providing basic food, will encourage the development of industry and services and accelerate change. The concept of Green Productivity plays a

critical role in shaping the future of palm oil production. It is an innovative approach that integrates environmental sustainability with productivity enhancement in organizational operations. It addresses global environmental challenges while improving organizational efficiency and competitiveness [6]. In palm oil, it refers to an integrated approach that aims to enhance productivity while simultaneously reducing environmental impacts. This concept is relevant in the palm oil industry, which faces significant environmental challenges due to its association with deforestation and degradation. Green Productivity involves optimizing production processes, utilizing waste products efficiently, and implementing sustainable practices to achieve a balance between economic and environmental factors to participate in sustainable development.

The adoption of Green Productivity has been shown to increase income by 10%-25% [2]. The increased income stems from better resource management, reduced input costs, and higher yields due to sustainable farming techniques. Policymakers should consider offering financial incentives or subsidies for education and training programs to support farmers in adopting Green Productivity, especially for those from less-educated backgrounds. Offering micro-credit schemes could also help farmers finance the transition to more technologies or further increase their economy. The study shows reductions in emissions and deforestation rates among educated and younger farmers who adopt Green Productivity. Educated farmers demonstrate a 12%-15% reduction in emission [2]. Governments could provide technical assistance for Green Productivity practices to enhance the sustainable development of the palm oil sector.

The role of green chemistry in sustainable development is also paramount. Green chemistry in the context of palm oil involves the development of environmentally friendly processes and materials derived from palm oil and its by-products. This approach aims to minimize environmental impact while maximizing the utility of palm oil resources. To further explore the role of green chemistry in sustainable palm oil production, it is essential to link this concept to the broader framework of creating shared value (CSV) in the palm oil industry. Creating shared value in Indonesia represent strategic approach that aligns business success with societal progress. It underscores the obligation of firms to create economic value while fulfilling societal demands, such as community enhancement and ecological sustainability. This methodology promotes stakeholder collaboration, including local population and governmental entities, to broaden the advantages of palm oil production beyond profit [7].

4.2 Farmers' livelihood structure on Green Productivity industry of palm oil

This research assumes that increased income dominance from palm oil plantations correlates with enhanced readiness for ISPO certification among farmer households. Meanwhile, the facts show that it is rare to find independent palm oil farmer households, whose livelihood structure is solely supported by a single source of income, palm oil alone.

Table 6 shows that contribution into total household income is 44.13% average ranging from the lowest is from Pelalawan District IDR 12,672,042/ha/year and the highest is from West Sulawesi IDR 30,666,620/ha/year. Palm oil constitutes an essential economic resource, necessitating thorough consideration the environmental and social obstacles associated with its production. Farmers also derive income from non-agricultural activities to complement their household income, such as construction work, employment in other sectors, and running small businesses [27]. Additionally, the need for financial support, price regulation, and adequate input supply are critical for sustaining and enhancing income levels [28]. Livelihood diversification for most farmers in rural areas is a household effort to survive, reducing the risk of crisis, while still trying to improve their welfare [29, 30]. With a diversified livelihood structure, the dominance of palm oil will greatly determine the encouragement of farmers to get involved in certification. It is commonly known that in farming households in rural areas of developing countries, there are typically three sources of sustenance, namely agricultural revenue, external employment earnings and non-agricultural income which are employed in such a manner as to sustain their survival and adapt to stressors or alterations in environmental circumstances [14, 31, 32]. In this study, sources of livelihood follow the pattern above, the analysis will be categorized into three primary foundations: palm oil cultivated area, usual agricultural practices, and non-agricultural livelihood activities.

Table 6. Percentage source of farmer income from palm oil in various locations

Location	Income (Ha/Year)	Contribution into Total Household Income	Year	Source
Muaro Jambi District	IDR 15,840,852	43.3%	2021	[22]
Tulang Bawang Regency	IDR 16,270,055	27.7%	2020	[23]
West Sulawesi	IDR 30,666,620	66%	2020	[24]
Pelalawan District	IDR 12,672,042	55.48%	2020	[25]
Siak Regency	IDR 24,373,057	28.17%	2023	[26]

A livelihood structure that is not dominated by income from palm oil is possible. It is predicted that if ISPO certification is applied to independent palm oil smallholders, the certification costs will burden other sources of income estimated cost of ISPO certification per hectare ranges from IDR 1,900,000-5,000,000 per Hectare [33]. This certification process requires significant costs for smallholders, while in fact the economic framework of palm oil farming households in various production centers is still weak. The average income of palm oil farmers from Table 6 is IDR 19,964,525/ha/year. Majority of oil palm farmers manage land area ranging from 2 to 5 hectares [34-36]. Which means that average income only IDR 831,855,208/ha/month. Financial support is a critical component of government assistance for ISPO certification. The government provides funds through programs like the PSR (Peremajaan Sawit Rakyat) to help smallholder farmers achieve certification [37, 38]. Technical support is also essential, as many smallholders lack the knowledge and resources to meet ISPO requirements [39]. Sustainable management in the agriculture sector enhances industrial development accelerating change [40]. On the context of developing palm oil plantations are critical for several reasons, starting from government control and policies [41] including its impact to positive environmental, social and economic impacts [42].

Thus, independent palm oil farming households must be more intensive in using the combination of capital/assets they own to survive [14]. Independent palm oil farmer households aiming to enhance the economic impact of palm oil must resort to land expansion, which poses significant environmental hazards. Palm oil has become a vital product since it contains a tall net household item [43].

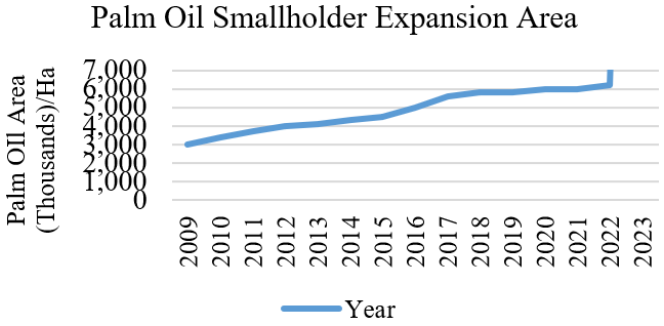

Figure 1. Palm oil smallholder expansion area
Source: BPS (2023)

Based on Figure 1, the significant expansion of palm oil smallholder plantations underscores the growing relevance of this sector within the agricultural framework. Starting from 3,061,400 hectares in 2009 there has been a consistent annual increase in the cultivated area, culminating in 6,291,000 hectares by 2023. This growth is indicative of several factors: economic incentives [40], global market demand [41], Environmental and social implications [42, 43], and future constraints [42]. The line graph derived from this data clearly depicts an upward trend, with significant acceleration observed in the latter half of the decade, particularly after 2015. This acceleration could be attributed to enhanced investment in infrastructure, better access to markets, and possibly more favorable policies supporting the cultivation. In Summary, the palm oil data underscoring the dynamic growth of this sector and its potential future impact on both local economies and global supply chains. It is fundamental consideration of the conditions faced by independent palm oil farmers. While expansion reflects positive trends, it also reveals emerging challenges, particularly for these smallholders.

Independent palm oil farmer households who want to expand, it is almost certain that the expansion they carry out will go into Forestry Cultivation Areas, which are not actually intended for plantation land. Thus, land occupation carried out by independent palm oil farmer households falls into the illegal category. The implementation of ISPO will certainly exclude land whose designation status is considered illegal. Two things are immediately apparent from this situation: (1) smallholders may exhibit a lack of enthusiasm for adopting ISPO due to their minimal income derived from palm oil (2) A considerable portion of land will be disqualified for ISPO certification due to its illegal status, which directly aligns with the primary objective of ISPO to eradicate unlawful territories from the legitimate and sustainable production framework, thereby ultimately enhancing the integrity of the global CPO market; consequently, this poses a substantial risk for agrarians, necessitating alternative strategies to bolster their well-being. As a substitute for expansion (extensification), independent palm oil farmers or smallholders are encouraged to undertake land intensification efforts where the productivity per hectare of independent palm oil plantations is increased (in accordance with Presidential Instruction no. 8/2018). This increase in productivity of palm oil can have implications for increasing the economic contribution in the livelihood structure.

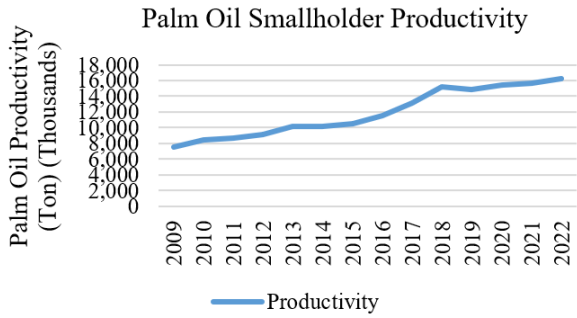

Figure 2. Palm oil smallholder productivity from 2009 – 2022
Source: Statistical of National Leading Estate Crops Commodity 2020-2022

Based on Figure 2 we can see that at the beginning of the period, in 2009 productivity was recorded at 7,517,716 tons/year. Over time, productivity steadily increased, reaching its peak in 2022 at 16,273,170 tons/year. The most notable increase occurred after 2016, where productivity surged from 11,575,542 tons/year to 13,191,189 tons in 2017, continuing to rise to 15,296,801 tons in 2018. Although there was a slight decline in 2019, productivity recovered and stabilized around 15 to 16 million tons in the subsequent years. Overall, this data highlights a positive development in smallholder palm oil productivity over the 14-year period, reflecting the success of improving plantation productivity. This productivity is also affected by external factors like climate and soil conditions [44], best management practices [45], and sustainable agronomic activities [46]. The willingness of independent palm oil farmer households to pursue ISPO certification is contingent upon specific enhancements in their operational readiness. are able to increase productivity per hectare of palm oil land they own, so that household income levels increase. However, external factors in the form of increases or decreases in prices Global palm oil remains a concern, because it has the potential to increase or decrease the contribution of household income from the palm oil sector to overall household income.

4.3 Sustainability of Green Productivity of palm oil

The notion of ecological sustainability in palm oil production is predominantly a marketing illusion, yielding advantages to a select few, while the industry dismisses any viable alternatives, attributing this to a perceived structural demand escalation for the commodity [6]. The persistence of power structures, characterized by corporate-state alliances, and dominant production methods such as extensive monocultures necessitate a committed and constructive engagement with the prevailing system (RSPO). Proposed interventions encompass diverse technical-managerial strategies, such as enhancing HCV standards [47], facilitating the increased commercialization of "certified sustainable palm oil." [48], involving more smallholders in certification schemes [31], develop more project-efficient smallholder programs [32] or limit future palm oil plantations. However, the success of previous programs was often inconsistent due to implementation problems such as poor management and difficult community relations [49]. Evaluating new strategies must consider the persistent gap between legal frameworks

and community rights [50]. Expansion of oil onto lots of hectares of existing “damaged land” is asserted to be available [51]. Beneficiaries of technical-administrative policy suggestions. These enterprises frequently exhibit characteristics of substantial corporations that exert control over the sector or nation [51]. For alternative sustainability. Rather, I contend that it is a beneficial point of departure that the authentic challenges reside within the disputed socio-ecological concerns of the palm oil. These may be categorized as human rights confrontations pertaining to territory, land reform, and traditional land entitlements (typically in opposition to the continued proliferation of extensive agricultural enterprises), conflicts involving small-scale cultivators and laborers within the industrial sector (concerning the characteristics and conditions of production), and ecological initiatives advocating for social equity and climate justice (encompassing the health ramifications of environmental contamination). There exist notable and pervasive ‘routine’ manifestations of resistance [33] and structured initiatives in all these domains. Although diverse movements articulate a cohesive alternative perspective for the industry of palm oil.

The impending path of sustainability can be articulated. by examining the challenges and requisites of diverse movements and interlinking them. The proliferation of palm oil is obstructed by territorial disputes [50, 51].

Table 7. Conflicts related to palm oil expansion in various villages

Location	Type of Conflict	Year	Source
Aceh Tamiang	• Relationship between corporate plantation and its workers, with primary issues revolving around labor entitlements regarded as merchandise within the oil palm plantation, such as wages, production processes, and management practices • Involving the act of unlawfully appropriating oil palm fruit within the corporate premises.	2024	[34]
Riau Province	• Land disputes among communities, governmental entities, and the private sector attributable to the industrial utilization of palm oil in forested regions of Riau, Indonesia. • Disputes encompass property rights, utilization entitlements, and ecological issues arising from the transformation of forested regions into palm oil production zones.	2024	[35]
Sungai Rotan District	Tension between PT Roempoen Enam Bersaudara and the Sungai Rotan community arises from the company's failure to fulfill its social responsibility concerning plasma plantation distribution. • Land ownership and social responsibility issues	2023	[36]
Jambi Province	• Land disputes, water contamination, habitat shortages, wildfires, flooding, and agricultural failures are sources of conflict. • The conflicts are mainly between indigenous communities and palm oil companies, highlighting issues such as land grabbing, inadequate-compensation, and degradation of natural resources	2023	[37]
East Kutai Regency, East Kalimantan	• Conflict related to expansion of oil palm plantation and its impact on the indigenous Dayak people’s ability to practice swidden agriculture • The conflict emerges from the administration’s approach to augment governmental territory for oil palm estates within Dayak ancestral domains, resulting in oppression, disenfranchisement, and the relegation of the Dayak community’s traditions.	2023	[52]

Table 7 illustrates the conflicts related to palm oil expansion in various villages. It shows the type of conflict, highlighting those issues with land rights and environmental concerns are ongoing and widespread.

Conflicts often emerge from the encroachment of palm oil companies into local communities and their resistance to the conversion of essential agricultural and sacred lands, compounded by disparities in power dynamics between smallholders and corporations, manifesting in issues such as land allocation, debt burdens, interest rates, and pricing mechanisms for palm fruit [32-39]. This distributional conflict is linked to deeper alienation resulting from the loss of productive control over agricultural processes, becoming "ghosts on our own land” [39].

The requisites and propositions presented by the Palm Oil Farmers Union (Palm Oil Farmers Union, SPKS, 2006) call for debt abolition and reasonable FFB prices. A sustainable alternative to small farmer capacity could be based on the independence of small farmers, who usually have a better agreement [53], regarding government programs that provide 100%. developing land for small farmers and interventions to ensure higher prices. From a livelihood standpoint, small-scale agriculture yields superior profits compared to extensive corporate palm oil operations, provided it enhances income distribution among a greater number of individuals per hectare [40]. The discourse neglects the long-term ecological and health repercussions of forest fires while advocating for a development paradigm centered on livelihoods and sustainability instead of mere economic growth. To achieve this, a restructuring of the state that prioritizes the interests of the working class over corporations is essential, alongside the formulation of new political strategies to address the palm oil sustainability gap.

4.4 Concrete policy recommendation to enhance Green Productivity practices

Based on the findings that younger farmers are more likely to adopt Green Productivity practices, policies should focus on enhancing youth engagement in palm oil. For example, they offer training programs, financial support, and mentoring to encourage their involvement in sustainable practices [17]. Addressing family size and labor challenges, the policies could assist with land consolidation, promote cooperative farming, or provide labor workforce insurance that can help optimize the use of labor in greater households. Additionally, programs that encourage involvement and training family members can be effective in boosting adoption rates. Providing incentives for educational advancement and supporting farmers in achieving sustainable certification (ISPO/RSPO) can foster stronger adoption of Green Productivity as well as providing access to agriculture extension services for those with lower educational levels [17].

To ensure the credibility of sustainability certifications, it is crucial for government to enforce stricter monitoring and compliance. There should also be mandatory transparency

requirements, with companies required to publish detailed annual reports on their Green Productivity performance, including deforestation rates and carbon emissions reductions [18]. Involving third party such as NGO is necessity, and government could give incentives to provide that facility. Additionally, green micro finance initiatives should be expanded to support smallholders in obtaining finance for Green Productivity practices. Systems like rewards and punishment should be boost enough to recognize and rewards farmers or companies that have effectively implemented Green Productivity practices. These awards could include ecological fiscal transfer or promotional support to reach a broader market.

The policy recommendations derived from these findings aim to support younger farmers, address the challenges of larger households, and foster sustainability. By focusing on education, resource management, and technological support, these policies can drive a more sustainability for the palm oil industrial ecosystem [19]. One limitation of the study is the data on adoption might be self-reporting biases from farmers, as they may overstate their level of adoption. The study focused on cross-sectional data, which might not fully capture long-term trends. Future studies should consider deeper research to track changes in adoption over time and assess the long-term impacts of education and policy interventions on Green Productivity. Further research could also investigate how local culture and community dynamics influence the adoption of Green Productivity practices [20].

4.5 Key challenges in ISPO implementation and connection to Green Productivity

The implementation of ISPO presents significant challenges for smallholder farmers in Jambi Province, key obstacles include economic dependency, where palm oil is not the primary source of income for many farmer households, which impacts their readiness to adopt ISPO. For example, in Sanggau only 34.04% of ISPO criteria have been implemented by farmers, highlighting significant gaps in knowledge and institutional support [22]. Land legality issues are prevalent, as many farmers lack formal land ownership and certificates, these are critical components of ISPO standards. The ambiguity surrounding seed provenance hinders the execution of ISPO for autonomous palm oil cultivators. Certified seeds often lack validation from authorized institutions. This research advocates for mentoring programs, land reforms, and support from plantation authorities to achieve ISPO certification. The study underscores the importance of integrating Green Productivity principles for balancing productivity and environmental sustainability. Implementing these strategies can allow independent farmers to boost productivity while protecting the environment, crucial for long-term sustainability. Farmers' unpreparedness in environmental management necessitates comprehensive reforms. Achieving ISPO certification requires overcoming economic risks and complex land legalization at multiple governance levels. Intensive mentoring is essential to raise sustainability awareness and facilitate the certification process while garnering stakeholder support. These findings bear significant implications for stakeholders and policymakers aiming to enhance sustainability in the palm oil sector. Effective land reform, capacity-building, and environmental training are vital for aiding independent farmers in obtaining ISPO certification and adopting sustainable practices. Additionally, this study enriches the global dialogue on sustainable palm oil production, advocating for stakeholder collaboration to help independent farmers in developing regions like Jambi meet global sustainability standards.

Stakeholder roles include government, private sector, civil society, and international organizations. The Indonesian government plays a pivotal role in regulating and promoting ISPO certification. It provides the necessary legal framework and support for smallholders to achieve certification [23]. This includes creating clear policies, providing financial incentives such as subsidies and tax breaks to support smallholders transitioning to ISPO-certified practices, and funding capacity-building programs to improve smallholders' knowledge of sustainable practices. Then, the government is responsible for monitoring and evaluating compliance with ISPO standards. Companies are responsible for implementing sustainable practices. They also assist in educating smallholders and facilitating their inclusion in certification schemes [24]. The private sector is critical in executing sustainable methodologies within the palm oil sector, encompassing waste management, diminishing emissions, and maximizing land utilization to fulfill ISPO certification. Corporations also contribute to CSR initiatives that benefit local communities. Moreover, companies can also aid smallholders by offering technical support, access to certified seeds, and financial alternatives to empower more sustainable agricultural practices. Civil society organizations are essential in promoting sustainable palm oil production and ensuring accountability from both government and private sectors regarding sustainable objectives. They provide education and training to smallholders on ISPO certification and Green Productivity. Facilitating an understanding of sustainability benefits. NGOs aid smallholders in navigating the certification process by offering guidance to technical and financial obstacles. Furthermore, they are instrumental in monitoring palm oil production, ensuring compliance with environmental and social standards, and identifying ISPO violations. Another stakeholder may involve is International Organizations like RSPO, align ISPO certification with global standards. Ensuring that Indonesia's palm oil industry addresses to international benchmarks. They provide technical assistance, funding, and research to foster adoption of sustainable practices. As is known, the food crop sector plays an important role in the economy and food security, as well as creating jobs and income for farmers [44].

To effectively tackle the challenges and opportunities associated with ISPO certification, collaboration among stakeholders—such as local governments, NGOs, and international organizations—is imperative. This cooperation enhances market traceability, linking ISPO-certified palm oil to global markets while fostering environmentally sustainable practices and meeting consumer demands for sustainability. ISPO implementation has resulted in substantial environmental benefits such as the reduction of emissions by 70.63 kg/ton CPO and significantly savings in diesel fuel and chemical fertilizer [25]. Companies adopting Green Productivity along ISPO to improve their environmental management performance, including enhanced wastewater treatment and reduced air emissions and noise levels. The adoption of Green Productivity methods such as anaerobic biogas reactors has further improved waste management and increased productivity, as seen in PT Bangun Tenera Riau [26]. If humans or stakeholders are not wise in managing the environment, the environment will be damaged, both in terms

of quality and quantity [45]. Other economic and social benefits are increased production of CPO and palm kernel oil (PKO), cost savings from improved waste management, and additional revenue from selling hazardous waste. This implementation also has positively impacted the social and economic conditions of local communities through CSR and labor, which increased community income and education [27]. Moreover, the collaboration between local governments, NGOs, and the private sector fosters a more transparent and accountable palm oil supply chain, ensuring that sustainability goals are met at every level—from farmers to consumers. This multi-stakeholder engagement not only drives Green Productivity but also supports the local economy and improves the overall social welfare in palm oil-producing regions. Harmonization of ISPO and RSPO can enhance traceability and sustainability, benefiting all stakeholders in the palm oil industry [18].

In the long run, the adoption of Green Productivity practices, such as efficient waste management, water use reduction, and energy optimization, not only improves environmental outcomes but also enhances the industry's resilience against fluctuating market conditions and increasing regulatory scrutiny. These measures ensure that the palm oil sector remains competitive while meeting both environmental and economic goals.

5. CONCLUSION

This inquiry studies the ecological and sustainability barriers connected to palm oil production, especially within Jambi, Indonesia. The results underscore the substantial environmental repercussions of palm oil cultivation, encompassing deforestation, loss of biodiversity, and heightened carbon emissions. Even with the creation of sustainability certifications like ISPO and RSPO, unfavourable outcomes continue to exist. Although these certifications have demonstrated a degree of effectiveness in enhancing land-use efficiency and curtailing emissions, they encounter significant obstacles including limited enforcement mechanisms, insufficient integration of smallholder farmers, and inconsistent application throughout the industry.

Moreover, the research delineates critical opportunities for alleviating environmental risks via Green Productivity methodologies. These methodologies encompass the advocacy for agroforestry systems, the execution of more effective land-use strategies, and the enhancement of water and waste management practices.

Even so, the investigation has its shortcomings. A notable limitation is the regional concentration on Jambi, which may not fully encapsulate the broader challenges encountered by other palm oil-producing regions within Indonesia. Additionally, while the manuscript recognizes the significance of certifications and regulations in fostering sustainability, it lacks an extensive quantitative analysis of their direct environmental impacts, particularly in the context of Jambi. This gap highlights the necessity for further empirical investigation to enhance understanding of the efficacy of these policies and practices in practical settings.

Future investigations should prioritize the execution of quantitative evaluations concerning the environmental ramifications of palm oil production, especially regarding greenhouse gas emissions, land-use alterations, and biodiversity decline across diverse regions of Indonesia. Furthermore, more comprehensive studies are required to assess the effectiveness of ISPO and RSPO certifications in mitigating environmental risks, with a specific focus on case studies that monitor progress over time. Research should also delve into Green Productivity practices at a more detailed level, identifying specific practices that can be scaled within the palm oil industry to optimize sustainability. Finally, examining the role of multi-stakeholder partnerships in surmounting barriers to sustainability and facilitating Green Productivity will be crucial in shaping forthcoming policies and industry standards.

This examination broadens the expanding knowledge base related to sustainable palm oil production and forms a stepping stone for later inquiries intended to lessen the environmental and social ramifications of the palm oil trade. By confronting the challenges and opportunities delineated, this study offers significant insights that could inform policy decisions and industry practices in the quest for a more sustainable palm oil sector in Indonesia.

ACKNOWLEDGMENTS

Our sincere thank delivering for the Cluster of Interaction, Community Engagement, and Social Environment, School of Environmental Science, Universitas Indonesia, who provided technical and substantial assistance to this research.

AUTHOR CONTRIBUTION

Conceptualization, E.H., H.H., T.E.B.S. and R.; methodology, EF and H.H.; format analysis, E.H. resources, E.H.; data curation, E.H.; visualization, E.H.; writing – original draft preparation E.H., H.H., T.E.B.S. and R.; writing-review and editing E.H., H.H., T.E.B.S. and R.; visualization, E.H., supervision, H.H., T.E.B.S. and R.; project administration, E.H. All authors have read and agree to the published version of the manuscript.

REFERENCES

[1] Abram, N., Meijaard, E., Wilson, K., Davis, J., Wells, J., Ancrenaz, M., Budiharta, S., Durrant, A., Fakhruzzi, A., Runting, R., Gaveau, D., Mengersen, K. (2017). Oil palm-community conflict mapping in Indonesia: A case for better community liaison in planning for development initiatives. Applied Geography, 78(5): 33-44. https://doi.org/10.1016/j.apgeog.2016.10.005

[2] Carlson, K.M., Heilmayr, R., Gibss, H.K., Noojipady, D.N., Burns, M.M.C. (2017). Effect of oil palm sustainability certification on deforestation and fire in Indonesia. Environmental Research Letters, 115(1): 121-126. https://doi.org/10.1073/pnas.1704728114

[3] Gaveau, D.L.A., Sheil, D., Husnayaen, Salim, S.M.A., Arjakusuma, S., Accrenaz, M., Pachero, P., Meijaard, E. (2016). Rapid conversions and avoided deforestation: Examining four decades of industrial plantation expansion in Borneo. Scientific Reports, 6(1): 32017. https://doi.org/10.1038/srep32017

[4] Rosa, J., Schimdt, J., De, P. (2020). Certified palm oil reduces greenhouse gas emissions compared to non-certified. Journal of Cleaner Production, 277: 124045.

https://doi.org/10.1016/j.jclepro.2020.124045
[5] Pierre, J. (2000). Debating Governance: Authority, Steering, and Democracy. Oxford University Press, USA.
[6] Schouten, G., Glasbergen, P. (2011). Creating legitimacy in global private governance: The case of the Roundtable on Sustainable Palm Oil. Ecological Economics, 70(11): 1891-1899. https://doi.org/10.1016/j.ecolecon.2011.03.012
[7] Liewellyn, G., Oullete-Kuntz, H., Emerson, E. (2023). Secondary analysis of large quantitative datasets (or doing research with other people's data). Journal of Intellectual Disability Research, 67(12): 112-122. https://doi.org/10.1111/jir.13101
[8] Direktorat Jenderal Perkebunan, Kementerian Pertanian. (2021). Statistik Perkebunan Unggulan Nasional. Jakarta: Kementerian Pertanian.
[9] Badan Pusat Statistik. (2018). Statistik Perkebunan Kelapa Sawit. Jakarta: Badan Pusat Statistik. https://www.bps.go.id/id/publication/2019/11/22/1bc09b8c5de4dc77387c2a4b/statistik-kelapa-sawit-indonesia-2018.html.
[10] Chichaibelu, B.B., Bekchanov, M., Braun, J., Torero, M. (2021). The global cost of reaching a world without hunger: Investment costs and policy action opportunities. Food Policy, 104(12): 102151. https://doi.org/10.1016/j.foodpol.2021.102151_34
[11] Ernawati, H.D., Saputra, A., Alamsyah, Z., Napitupulu, D.M.T., Yanita, M., Fauzia, G. (2021). Analysis of independent oil palm farming income after replanting in Muaro Jambi District. Earth and Environmental Science, 782: 1-9. https://doi.org/10.1088/1755-1315/782/3/032055
[12] Patra, R.S., Ismono, R.H., Nugraha, A. (2020). Struktur dan distribusi pendapatan serta tingkat kesejahteraan petani kelapa sawit rakyat di kabupaten Tulang Bawang. Jurnal Ilmu Ilmu Agribisnis (JIIA), 7(3): 354-360. https://doi.org/10.23960/jiia.v7i3.3773
[13] Astuti, N.S., Karim, I., Abdullah, M.A. (2020). Contribution of oil palm (Elaeis guineensis J.) plantations to farmers' income in West Sulawesi. Anjoro: International Journal of Agriculture and Business, 1(2): 45-51. https://doi.org/10.31605/anjoro.v1i2.892
[14] Feronika, I., Yusmini, Y., Yusri, J. (2020). Farm household income analysis of integrated cow oil palm system (SISKA) semi-intensive pattern in Pangkalan Lesung Sub-district Pelalawan District. Journal of Agribusiness and Community Empowerment (JACE): 3(1): 1-15. https://doi.org/10.32530/jace.v3i1.80
[15] Andriani, E. (2017). Income sources analysis of oil palm farmers. Agrisep, 16(2): 145-154. https://doi.org/10.31186/jagrisep.16.2.145-154
[16] Dharmawan, A.H., Nasdian, F.T., Barus, B., Kinseng, R.A., Indaryanti, Y., Indriana, H., Roslinawati, A.M. (2019). Kesiapan petani kelapa sawit swadaya dalam implementasi ISPO: Persoalan lingkungan hidup, legalitas dan keberlanjutan. Jurnal Ilmu Lingkungan, 17(2): 304-315. https://doi.org/10.14710/jil.17.2.304-315
[17] Hadi, S., Bakce, D., Muwardi, D., Septya, F. (2023). Strategi percepatan sertifikasi ISPO di perkebunan kelapa sawit swadaya. Analisis Kebijakan Pertanian, 21(1): 21-42. https://doi.org/10.21082/akp.v21n1.2023.21-42
[18] Anugwo, S.C., Egwue, O., Uke, P.C. (2022). Economic analysis of contract farming on oil palm production in Delta-State, Nigeria. Jonages, 2: 46-52. https://doi.org/10.36265/jonages.2022.020109
[19] Siswati, L., Insusanty, E., Susi, N., Nizar, R., Wahyudiono, A. (2023). Analysis of oil palm smallholder income during replanting in Siak Regency, Riau. Earth and Environmental Science, 1160(1): 012067. https://doi.org/10.1088/1755-1315/1160/1/012067
[20] Setiawan, I.R., Atmaja, J.J.E. (2023). Maximizing the income of oil palm farmers in Batu Betumpang Village Pulau Besar district, South Bangka Regency. Journal of Integrated Agribusiness, 5(1): 47-58. https://doi.org/10.33019/jia.v5i1.4083
[21] Lalita, R., Ismono, H.R., Prasmatiwi, F.E. (2019). Kajian sosial ekonomi dan tingkat kesejahteraan rumah tangga petani kelapa sawit di Kabupaten Tulang Bawang. Lembaga Penelitian dan Pengabdian kepada Masyarakat Universitas Lampung, 7(2): 195-202. https://doi.org/10.23960/jiia.v7i2.195-202
[22] Firawati, F., Safitri, D.F.A. (2022). Analisis pendapatan usahatani kelapa sawit di Kecamatan Kasimbar Kabupaten Parigi Moutong. Jurnal Pembangunan Agribisnis, 1(3): 29-35. https://doi.org/10.22487/jpa.v1i3.1516
[23] Barus, R., Chalil, D., Wibowo, R.P. (2024). ISPO introduction program for independent smallholders: Initial steps towards mandatory ISPO 2025. Jurnal Pengabdian Masyakarat Universitas Merdeka Malang, 9(2): 373-382. https://doi.org/10.26905/abdimas.v9i2.12657
[24] Rodhiah, I., Syarfi, I.W., Hasnah. (2019). The impact of ISPO certification on economic, social, and environmental aspect in the palm oil plantation. IOP Publishing, 336(1): 12-13. https://doi.org/10.1088/1755-1315/336/1/012013
[25] Novita, N. (2024). Socialization of Indonesia Sustainable Palm Oil (ISPO) certification obligations for smallholders palm oil plantation in West Pasaman District. Asian Journal of Community Services, 3(2): 245-262. https://doi.org/10.55927/ajcs.v3i2.8021
[26] Pirker, J., Mosnier, A., Kraxner, F., Havlik, P., Obersteiner, M. (2016). What are the limits to oil palm expansion? Global, 40: 73-81. https://doi.org/10.1016/j.gloenvcha.2016.06.007
[27] Furumo, P.R., Aide, T.M. (2017). Characterizing commercial oil palm expansion in Latin America: Land use change and trade. Environmental Research Letters, 12(2): 024008. https://doi.org/10.1088/1748-9326/aa5892
[28] Herdiansyah, H., Negoro, H.A., Rusdayanti, N., Shara, S. (2020). Palm oil plantation and cultivation: Prosperity and productivity of smallholders. Open Agriculture, 5: 617-630. https://doi.org/10.1515/opag-2020-0063
[29] Suharyanti, N.A., Mizuno, K., Nurfalah, L. (2024). Intensification model of smallholder oil palm plantation to achieving sustainability and prosperity, Riau Province, Indonesia. Earth and Environmental Science, 1308: 12-31. https://doi.org/10.1088/1755-1315/1308/1/012031
[30] Supriyanto, N. M., Arifin, A., Ruliyansyah, A., Pramulya, M. (2023). The portrait of agronomic activity of oil palm independent small holder in West Kalimantan Province, Indonesia. Earth and Environmental Science, 1165(1): 1-8. https://doi.org/10.1088/1755-1315/1165/1/012028
[31] Brandi, C., Cabani, T., Hosang, C., Schirmbeck, S.,

Westermann, L., Wiese, H. (2015). Sustainability standards for palm oil: Challenges for smallholder certification under the RSPO. The Journal of Environment & Development, 24(3): 292-314. https://doi.org/10.1177/1070496515593775
[32] Zen, Z., Barlow, C., Gondowarsito, R., McCarthy, J.F. (2016). Interventions to promote smallholder oil palm and socio-economic improvement in Indonesia. NUS, Singapore, pp. 78-108.
[33] Dewi, G., Acciaioli. (2016). Opposition to Oil Palm Plantations in Kalimantan: Divergent Strategies, Convergent Outcomes.NUS Press, Singapore, pp. 327-353. https://doi.org/10.2307/j.ctv1xz0km.8
[34] Nazaruddin, M., Nasution, A.A., Kamil, A.I., Arifin, A., Aulia, F. (2024). Conflict and resistance in oil palm corporation; An analysis of corporate relations, Labor, and the 'Ninja' Phenomenon at Aceh Tamiang. In Proceedings of International Conference on Social Science, Political Science, and Humanities (ICoSPOLHUM), 4: 00006-00006. https://doi.org/10.29103/icospolhum.v4i.374
[35] Yuslaini, N., Maulidiah, S. (2024). Governing sustainability: Land use change impact on the palm oil industry in Riau Province, Indonesia. Jurnal Ilmu Pemerintahan, 14(1): 115-130. https://doi.org/10.26618/ojip.v14i1.14304
[36] Nugraha, W. (2023). Konflik perkebunan kelapa sawit antara PT roempoen enam bersaudara dengan masyarakat dalam mendukung keamanan wilayah. Indonesian Journal of Social Development, 1(1): 1-7. https://doi.org/10.47134/jsd.v1i1.1874
[37] Herdiansyah, H., Mamola, R., Rokhim, R. (2023). Palm oil cluster resilience to enhance indigenous welfare by innovative ability to address land conflicts: Evidence of disaster hierarchy. Open Agriculture, 8(1): 20220206. https://doi.org/10.1515/opag-2022-0206
[38] Sudirman, S. (2023). The regime of truth, partnerships, and palm oil expansion in East Kalimantan, Indonesia. Jurnal Ilmu Sosial dan Ilmu Politik, 27(1): 46-59. https://doi.org/10.22146/jsp.72270
[39] Colchester, M., Jiwan, N. (2006). Ghosts on our own land: Oil palm smallholders in Indonesia and the Roundtable on Sustainable Palm Oil. Forest Peoples Programme and SawitWatch, Bogor.
[40] Euler, M., Schwarze, S., Siregar, H., Qaim, M. (2016). Oil palm expansion among smallholder farmers in Sumatra, Indonesia. Journal of Agricultural Economics, 67(3): 658-676. https://doi.org/10.1111/1477-9552.12163
[41] Pascafitra, A., Arisa, E.A., Aldiansyah, M.R., Arimbi, N.A., Syarif, H.A., Antriyandarti, E. (2024). Model of agricultural development and transformation in Siwal Village, Baki District, Sukoharjo Regency, Central Java Province. Kemakmuran Hijau: Jurnal Ekonomi Pembangunan, 1(1): 31-38. https://doi.org/10.61511/jekop.v1i1.2024.773
[42] Nahriyah, M. (2024). Manajemen berkelanjutan dalam perkebunan kelapa sawit. Peatland Agriculture and Climate Change Journal, 1(1): 35-51. https://doi.org/10.61511/pacc.v1i1.2024.725
[43] Arista, N.I.D., Natalia, C.E., Sinaga, I.L., Lestari, W., Undari, D., Andryan, R., Alimatul, M.M. (2024). The potential of circular economy in the oil palm plantation to industry. Journal of Sustainability, Society, and Eco-Welfare, 1(2): 94-110. https://doi.org/10.61511/jssew.v1i2.2024.311
[44] Klau, M.V.B., Nurwiana, I.N., Pellokila, M.R. (2023). Analisis fungsi keuntungan usahatani kacang hijau (Phaseolus ra-diatus L.) di Kabupaten Malaka Provinsi Nusa Tenggara Timur. Holistic: Journal of Tropical Agriculture Sciences, 1(1): 69-86. https://doi.org/10.61511/hjtas.v1i1.2023.226
[45] Supangkat, S. (2023). Analisis hubungan Sistem Manajemen Lingkungan (SML) ISO 14001 dengan perilaku peduli lingkungan. Journal of Character and Environment, 1(1): 47-71. https://doi.org/10.61511/jocae.v1i1.2023.252
[46] Supriyanto, N.M., Arifin, A., Ruliyansyah, A., Pramulya, M. (2023). The portrait of agronomic activity of oil palm independent small holder in West Kalimantan Province, Indonesia. IOP Conference Series, 1165(1): 1-8. https://doi.org/10.1088/1755-1315/1165/1/012028
[47] Edwards, D.P., Laurance, S.G. (2012). Green labelling, sustainability and the expansion of tropical agriculture: Critical issues for certification schemes. Biological Conservation, 151: 60–64. https://doi.org/10.1016/j.biocon.2012.01.017
[48] Laurance, W.F., Koh, L. P., Butler, R., Sodhi, N.S., Bradshaw, C.J., Neidel, J.D., Vega, J.M. (2010). Improving the performance of the roundtable on sustainable palm oil for nature conservation. Conservation Biology, 24: 377–381. https://www.jstor.org/stable/40603362.
[49] Zen, Z., Barlow, C., Gondowarsito, R. (2005). Oil palm in Indonesian socio-economic improvement: A review of options. Working Papers in Trade and Development, Canberra.
[50] Colchester, M., Fay, C. (2007). Land, forest and people: Facing the challenges in South-East Asia. Rights and Resources Initiative, Listening, Learning and Sharing, Asia Final Report.
[51] Obidzinski, K., Andriani, R., Komarudin, H., Andrianto, A. (2012). Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia. Ecology and Society, 17(1): 170125. https://www.jstor.org/stable/26269006.
[52] S. Sudirman. (2023). The regime of truth, partnerships, and palm oil expansion in East Kalimantan, Indonesia. Jurnal Ilmu Sosial dan Ilmu Politik, 27(1): 46-59. https://doi.org/10.22146/jsp.72270
[53] R. Cramb, P. Sujang. (2013). The mouse deer and thecrocodile: Oil palm smallholders and livelihood strategies in Sarawak, Malaysia. Journal of Peasant Studies, 40(1): 129-154. https://doi.org/10.1080/03066150.2012.750241

NOMENCLATURE

ISPO	Indonesian Sustainable Palm Oil
RSPO	Roundtable Sustainable Palm Oil
NGO	Non-Governmental Organization
CPO	Crude Palm Oil