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Insights from GAP Execution for Yield Intensification Among Independent Smallholder Farmer for Oil Palm

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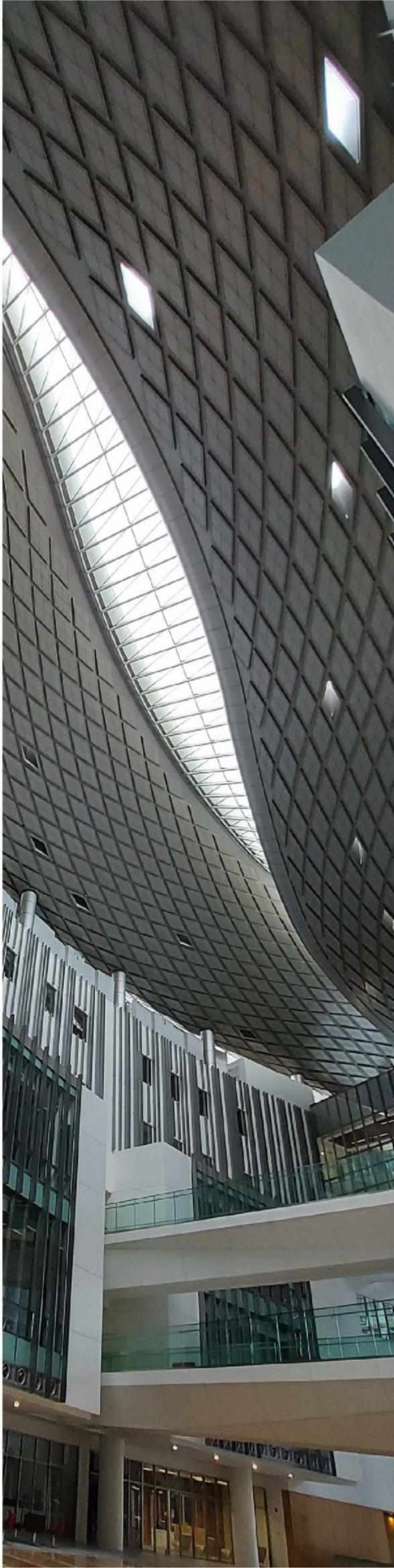

[ABSTRACT / EXECUTIVE SUMMARY]

Oil palm productivity today is well below its actual potential worldwide and much more so with Independent Smallholder (ISH) farmers. The national average oil yield in Malaysia remains at the 3 to 4 tons per hectare level, with growth in palm oil production in the last three decades having come mainly from increased area cultivated. The ISH sector contributes a total of 16.8% of the total area of palm plantations in Malaysia. This study looks at encouragement of Good Agricultural Practices (GAP) implementation to drive sustainable yield intensification in ISH farms, leading to better ISH livelihoods that alleviate their cost burden for certification to sustainable production standards that discourage deforestation and opening of new land for oil palm cultivation. In large plantations, decades of field experimentation have led to the development of GAP proven to drive yield improvement, but similar work is lacking for oil palm ISH. The GAP of large growers may also not be directly applicable or easily transferable to ISH whose farms are very small and discontinuous, and who have low capital and limited access to resources and knowledge. In this study, we set out to assess the impact of selected GAP that we considered most relevant for ISH in our project area, as well as the challenges faced by the participating ISH in implementing and sustaining the GAP in their farms. We measured the impact of the implemented GAP on fresh fruit bunch (FFB) yield and sales revenue in a group of ISH farms, called Learning Farms (LeFa), by comparison against a group of similar farms where normal practices of ISH continued. The status of implementation and maintenance of GAP in the LeFa was assessed in periodic field audits. Key insights were gained on the ability of ISH to implement the GAP. While GAP implementation was below par, the impact on FFB yield and sales revenue showed promise

Introduction to the research center.

The Center for Sustainable Small-owners (CSS) was established by funding from Procter & Gamble (P&G) in 2018 to deliver on its Ambition 2030 goals through the P&G smallholders initiative.

CSS aims to empower and improve the livelihoods of smallholders for oil palm through certification, compliance, training, and the implementation of sustainable and good agricultural practices.

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INSIGHTS FROM GAP EXTENSION FOR YIELD INTENSIFICATION AMONG INDEPENDENT SMALLHOLDER FARMERS FOR OIL PALM

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ABSTRACT

Oil palm productivity today is well below its actual potential worldwide and much more so with Independent Smallholder (ISH) farmers. The national average oil yield in Malaysia remains at the 3 to 4 tons per hectare level, with growth in palm oil production in the last three decades having come mainly from increased area cultivated. The ISH sector contributes a total of 16.8% of the total area of palm plantations in Malaysia. This study looks at encouragement of Good Agricultural Practices (GAP) implementation to drive sustainable yield intensification in ISH farms, leading to better ISH livelihoods that alleviate their cost burden for certification to sustainable production standards that discourage deforestation and opening of new land for oil palm cultivation. In large plantations, decades of field experimentation have led to the development of GAP proven to drive yield improvement, but similar work is lacking for oil palm ISH. The GAP of large growers may also not be directly applicable or easily transferable to ISH whose farms are very small and discontinuous, and who have low capital and limited access to resources and knowledge. In this study, we set out to assess the impact of selected GAP that we considered most relevant for ISH in our project area, as well as the challenges faced by the participating ISH in implementing and sustaining the GAP in their farms. We measured the impact of the implemented GAP on fresh fruit bunch (FFB) yield and sales revenue in a group of ISH farms, called Learning Farms (LeFa), by comparison against a group of similar farms where normal practices of ISH continued. The status of implementation and maintenance of GAP in the LeFa was assessed in periodic field audits. Key insights were gained on the ability of ISH to implement the GAP. While GAP implementation was below par, the impact on FFB yield and sales revenue showed promise

Keywords: Independent Smallholder, Yield Intensification, Good Agricultural Practices, nutrient management program

Introduction

Palm oil is a sustainable alternative compared to other vegetable oils because it uses less land. If palm oil is replaced by another alterative, the same production requires seven to ten times land or as much as 240 million hectares of land (Bernama News, 2023). Not all palm oil production is unsustainable or harmful, efforts such as protecting high conservation peat lands, respecting land rights, and implementing environmentally friendly cultivation methods benefit the eco-friendly palm oil movement. In this realm, bad agriculture practices such as over and under-pruning, unkept tree circles, infrequent harvesting, and impairment of local ecosystems may lead to lower yield and environmental issues. As such maintaining farmers' livelihoods of farmers while preserving sustainability should become the ideal practice. These practices focus on a preserving the planet while maintaining farmers' quality of living. Sustainable and good agricultural practices (GAP) for oil palm production offer new aspects of plantation management with a potential for yield improvement. Hence, yield intensification can be the solution to addressing deforestation challenges to maintain their livelihoods.

GAP improves the quality management system for the ISH. As such, GAP offers some degree of management control that otherwise farmers need to invest their time and resources on. For example, the choice of fertilizer, pruning management, and environmental practices. Much research on sustainable certification on benefit focuses on the premium selling price (Brandi, 2017| Senawi, 2019 | Begum et al., 2018). The Center for Sustainable Small-owners (CSS) was established to improve the livelihoods of Independent Smallholder (ISH) of oil palm ensuring ethical and responsible production of oil palm with commitments to no deforestation, no new plantation on peatlands, and no exploitation (NDPE) in the supply chain. CSS has a two-pronged approach i.e. improving livelihoods through yield intensification while sourcing responsibly ensuring ethical and sustainable oil palm production and ensuring sustainability through certification and compliance while empowering communities through farmer associations to safeguard their interests. Hence, while certification is one of the main goals of this work, it is not the only focus. The overall is to improve the livelihood of ISH through improved crop yields while preserving the ecosystem through certification with implementation of sustainable and GAP. Hence, two questions can be raised: Can GAP implementation benefit ISH? What is the Best Management Practice for a yield intensification program?

ISH differs from schemed farmers in that ISH developed autonomously with minimal technical support and resources from or commitment to large oil palm companies (Hidayat et al., 2015). Schemed farmers usually performed better than ISH because of better access to market resources and have yields close to corporate farmers (Jelsma et al., 2019). Hence, higher constraints may encounter by ISH in implementing sustainable agriculture practices due to size factors and lack of access to market access and technical support. Many ISH farmlands are characterized by their small size, lack of organization, and scattered distribution, leading to management challenges in such programs to them. As such, the CSS aims to guide palm oil practice from weak sustainability (anthropocentric) to strong sustainability (ecocentric). Practicing sustainable agriculture practices away from traditional methods is viewed as a modernization process. Baker (2016) viewed modernization as the process of a society becoming more technically sophisticated away from conventional models. In CSS, this environmental modernization concept is conveyed in ISH commitments towards no deforestation, no new plantation on peatlands, and no exploitation (NDPE). Hence, the yield intensification program is aiding ISH to "take off" from traditional framing into sustainable framing with increasing their livelihood.

As the name implies, the yield or sustainable intensification (YI/SI) program seeks to increase production with the same area of palm oil land rather than through agriculture expansion. This paper provides insight into good agriculture practices by presenting a yield intensification program that contributes to sustainable agriculture practices. Good agriculture practices assist with monitoring and emending unsustainable practices in resorting and rehabilitating the local environment with numerous sustainable agriculture practices. The purpose of this program is to help ISHs to adopt good agricultural practices (GAP) with a commitment to sustainability. The program provides training on topics such as water conservation, soil management, and pest control.

Research Objective

The objective of this article is to provide a comprehensive review of management insights regarding the effective implementation of Good Agricultural Practices (GAP) in palm oil plantations among independent smallholders (ISH). The focus is on exploring how GAP can contribute to livelihood improvement and foster collaborative management practices among ISH and various stakeholders. GAP implementation contributes to better maintenance of natural resources to reduce the deterioration of the natural environment while simultaneously increasing yield. This approach aligns with the sustainable intensification paradigm, emphasizing the importance of balancing agricultural productivity with environmental sustainability. It is to show the result of agriculture practice that can fair consideration of environment without ferreting out much natural capital for economic gain, shifting from an anthropocentric to a biocentric perspective in the palm oil industry, while considering the livelihood of ISH. Hence, the objective of this paper is to discuss the implementation insights of a yield intensification program held by the Center for Sustainable Small-Owners (CSS) at the Asia School of Business with farmers in Johor. It studies the effectiveness of governing palm oil and whether such a yield intensification model can benefit farmers and its applications to a larger market.

Literature Review

There is a need for yield intensification program that CSS has been implementing. An agricultural intensification strategic is a sustainable alternative to agricultural land expansion. The need to increase production due to socioeconomic solutions to food security challenges and growing population demands has led to the adoption of agriculture intensification strategies. As such increasing the production of existing lands is a sustainable approach that can increase overall production while paying much attention to increasing environmental sustainability concerns (Garnett et al., 2013). Besides, Tilman et al. (2011) also stress the importance of agricultural intensification because it can increase production without clearing additional lands. Yield intensification offers an alternative way of agriculture expansion to meet the demand for increasing global crop demand (Tilman et al., 2011). These papers stress the roles of yield intensification in improving farmers' socioeconomic outcomes while preserving biodiversity. Many factors contribute to the yield gap between large and small palm estates. Rhebergen et al. (2018) identified that factors such as inadequate agronomy management, incomplete crop recovery, poor plantation management, and deficiencies in plantation establishment led to low yield among smallholders. Hence, an agricultural intensification strategy necessitates proper sustainable management, to address the challenge of poor agronomy management identified by Rhebergen et al. (2018). However, there is a lack of research on management strategy on agriculture intensification, especially in palm oil plantations. Hence, research on insights from

GAP implementation could fill this vital **literature gap** and contribute to deeper understanding proper agronomy management among smallholders.

A sound agronomy management commences with governance framework or strategic orientation. In general, strategic orientation refers to the governance framework for the long-term focus and direction to guide the organization's decision-making process. Dzikriansyah et al. (2023) coined a greener version of strategic orientation as a set of practices to enable the organizational transformation to sustainable development. Green strategic orientation is associated with Green Supply Chain Management (GSCM). GSCM, defined by Srivastava (2007), is “integrating environmental thinking into supply-chain management, including product design, material sourcing, and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.” Besides, external factor plays a significant role for Indonesian SMEs in adapting GSCM (Dzikriansyah et al., 2023). Green strategic orientation fits into the definition on the aspect of “environmental thinking” in guiding decision-making process orienting toward ecological health and environmental management in the supply chain. Moreover, Syahza et al. (2020) emphasize the importance of aligning the certification process with strategies that address informality issues among Independent Smallholders (ISHs) to maximize value in the context of sustainable supply chains. The ISH’s “informality issues” indirectly implied ISHs should adhere to specific management procedures. Hence, the sustainable program offers by CSS could be the effective “external factor” that catalyzes environmental thinking and practice among ISHs.

One of the rationales of the research focus on sustainable transition in palm oil among ISH is due to international concern on deforestation. Hence, Malaysia has established the Malaysian Sustainable Palm Oil (MSPO) certifications to mitigate deforestation in the country and to answer called from the 2020 Amsterdam Declaration to promote sustainable palm oil production (Kannan et al., 2021). Signed by seven European countries, Amsterdam Declaration supports and helps private entities like smallholders to meet goals of eliminating deforestation from the production of agricultural commodities, especially palm oil and soybean production. Besides, the declaration emphasizes the need to effectively translate environmental commitments into tangible actions aimed at reducing deforestation (Ermgassen et al., 2020). Besides, implementing GAP among ISH is the one of the ambitious targets of

Malaysian government to improve the environmental quality of palm oil (Awang et al., 2016).

One crucial step in attaining MSPO and relevant certifications is the implementation of GAP. Farmers would receive training and access to the extent of their GAP in the process for MSPO certifications (Kannan et al., 2021). Smallholders benefit from such certification with new exposure to quality management principles and advanced farming knowledge. The certification helps farmers to adopt new technology and quality management systems (Aziz et al., 2021). Moreover, a survey from MSPO reveals that, among the seven MSPO principles, smallholders have poor achievement on Principle 6 “Best Practices” and 7 “Environment, natural resources, biodiversity, and ecosystem services” (Kannan et al., 2021). As such, CSS can fill the void in helping smallholders by educating them about industrial best practices, standards guidelines, and environmental epistemic values. This initiative through the CSS also answers the Amsterdam Declaration by effectively translating the NDPE commitment, into real action by safeguarding natural resources and promoting sustainable practices among ISHs.

Independent smallholders are assumed to have more management control over their farms and more bargaining power over the sale of their fruit. However due to limited technical, financial, and intuitional support, ISHs have challenges in attaining information on industry best practices, optimal farm management, and emerging technologies (Nagiah & Azmi, 2013). Smallholders also produce lower crops than the large and schemed farmers. Smallholders produced an average of 17 tonnes of FFB per hectare per year compared to the national average of 21 tonnes (Nagiah & Azmi, 2013). An alternative proposal for smallholders is to consider eco-centric farming management to improve market access and premium. However, smallholders encounter issues in meeting the management, marketing, and service delivery in the process of certification (Molenaar et al., 2011).

Smallholder encounters a challenge in complying with sustainability standards. Brandi et al. (2015) suggest that smallholder faces informational and financial challenges in transit to sustainability practices. Some smallholders reveal the lack of organization and the past mismanagement in cooperatives discourage continue involvement in sustainability practices. Many papers have highlighted that poor management practices pose a significant challenge to smallholder farmers, leading to lower productivity levels compared to commercial estates within the palm oil sector.

Euler et al. (2016) assert that poor management practices such as fertilizer and harvesting management as one of the leading determinants of yield gaps or the difference between the potential and realized yield. Besides, smallholders also encounter compliance challenges such as a lack of land registration documentation and proper administration (Jelsma et al., 2017).

Hypothesis Development

Much research has found that implementing GAP would benefit farmers. For example, GAP frequent harvest can improve yield. Similar yield intensification in Ghana harvests 29 cycles per year than the traditional 21 times per year also found to have increased larger harvest and larger recovery of palm oil bunches than the conventional method (Rhebergen et al., 2018). If the GAP implementation is effective, the control group should record a lower rate of yield improvement than the intervention group that implemented GAP. Hence, the predicted outcome is GAP implementation would improve the yield overtime because of improvement in crop recovery and better agronomic management (Donough et al., 2009).

Hypothesis 1: GAP is effective in driving FFB yield improvement.

Data

Data collected at CSS took place from 2019 to 2022 to record management practices among 168 ISH farms. CSS' team has collected data on field conditions, monthly FFB field, farm's gross margin, and agronomy conditions such as tree growth parameters, plant nutrients, and soil fertility status. When collecting the data, the team adopted field sampling protocols. There are four groups of farmers in four cohorts according to the date they commenced the program. In Cohort 1, 6 to 8 percent of the trees will be collected for agronomy data for sampling to quantify the impacts of GAP implementations (compared to the usual 1 percent sample size in large plantations). Between 10 to 20 trees per farm would be collected for GAP quantification. Below is the explanation of the parameters used for agronomy data collected.

TABLE 1. AGRONOMIC DATA COLLECTED FROM PAIRS OF CORE LEARNING FARMS (LEFA) AND CHECK FARMS TO ASSESS THE IMPACT OF GOOD AGRICULTURAL PRACTICES (GAP)

Type of data	Tree growth status	Plant nutrient status	Soil fertility status
Parameters measured or determined[1]	a) Frond length b) Frond area c) Frond weight* d) Trunk height	(A) The concentration of N, P, K, Mg, Ca, and B was measured in leaf tissue of trees on mineral soil. (B) In addition, Cu, Zn, and Fe were measured in leaf tissue of trees on peat soil. (C) The concentration of K was measured in rachis tissue of trees on both soil types. Individual sample trees were sampled and combined into 1 composite sample per farm.	a) pH (in water) b) Organic carbon c) Total N d) Total and available P e) Exchangeable K, Mg, and Ca Soil samples were collected at 0-20 cm and 20-40 cm from within tree circles and under frond heaps at each sample tree. Samples for each depth-location combination were combined to give 4 composite samples per farm.
Time / Frequency of data collection	a) Baseline i.e., prior to GAP implementation b) Annual repeat	a) Baseline i.e., prior to GAP implementation b) Annual repeat	a) Baseline i.e., prior to GAP implementation b) Bi-annual repeat

Note: 1 – unless stated otherwise, all data sampling, measurement, and procedure observed the recommended method given in Fairhurst & Hárdter (2003) Appendices 3, 4, and 6.
Source: Ata et al., 2023

TABLE 2: TOTAL NUMBER OF ONBOARDING FARMERS FOR GAP IMPLEMENTATION

LI TARGETS	**FY 19-20**	**FY 20-21**	**FY 21-22**	**FY 22-23**	**FY 23-24**
NEW CORE PAIRS	9	10			
Cumulative Core	9	19	19	19	*19*
NEW PRIMARY		9	19	121	*82*
Cumulative Primary		9	28	149	*231*
Cumulative Core + Primary	**9**	**49**	**119**	**168**	***250***

Note: Core Learning Farms (LeFa) are intervention farms paired with control or check farms . Data collected from Core LeFa is compared in parallel against Check LeFa, which do not implement GAP as taught through the Core LeFa field days. There are Primary LeFas that like Core LeFa implement GAP but are not paired against a control or check farm.

In total, data from 168 ISHs have been collected with a scheduled collection of 250 ISHs by the year 2024. The number 168 is the cumulative of 19 Core and 149 Primary LeFa. Two groups of ISHs were classified for this research Core and Primary ISHs. Primary Learning Farms (Primary LeFa) are participating farms in GAP implementation. Sample agronomy data from Table 1 would be periodically collected. The purpose of Primary LeFa is to showcase the impact of GAP implementation. The detail of data collection is in *Appendix A*. Some data is collected in Core that was not collected in Primary LeFa. This data is baseline plant growth measurements and soil sampling.

Research Method

The program began by the establishment of an agronomy team to provide guidance to, and periodically progress and status of GAP implementation of Core and Primary LeFa. Periodic GAP field audits would be conducted to assessed GAP implementation. **This program would encourage, not directly execute, ISHs in adapting GAP for yield intensification and sustainable oil palm production**. The salient feature of this initiatives remains that ISH themselves have to exercise GAP. By adopting a non-coercive approach, the program encourages ISHs to embrace GAP voluntarily. Hence, it addresses the informality issue that Syahza et al. (2020) have identified where the data is analyzed according to the Intention to Treat protocol, widely used in Biostatistics and in the field of public health (Newell,1992). A fertilizer supply chain is established to support GAP related to optimal nutrient input use.

The main research method is quantifying the impact of GAP implementation. CSS designs a study to test the effectiveness of GAP implementation. There are three groups of farmers, Core, Check, and Primary LeFa. Core farms adapted GAP while check farms have the business-as-usual. Check farms are the controlled group that are not expose to GAP while core farms are exposed to GAP implementation. Primary LeFa implemented GAP. Prior to adopting GAP, farmers would receive a minimum of virtual and in-person briefings and field demonstrations.

CSS implements the following eight GAP according to Yield Making and Yield Taking processes. GAP implementation begins with the GAP selection process, which depends on the specific context and organization implementing the program. The selection process is in accordance with the following step in coordinating and connecting processes and human resources across the management process. The selection process has the following 7 steps element: research and understanding, development of GAP guidelines, stakeholder engagement, pilot testing, Training, and capacity building, evaluation and certification, and continuous improvement. The program aims to quantify GAP implementation, where was the program, and why this thing happen in the GAP context in formulating steps in addressing future issues that such a program can be replicated.

TABLE 3: GOOD AGRICULTURAL PRACTICES (GAP) RECOMMENDED FOR IMPLEMENTATION IN CORE AND PRIMARY LEARNING FARMS (LEFA).

	GAP
1	More frequent harvesting (i.e., 3X per month)
2	Avoid under-pruning (keep not more than 1-2 fronds below last bunch)
3	Avoid over-pruning (keep at least 32 fronds per tree)
4	Eradicate large trunk epiphytes that block harvesting
5	Keep tree circles clean of weeds and debris
6	Destroy *Ganoderma* fruit bodies and mound infected trees
7	Apply adequate and balanced nutrient inputs
8	Eradicate woody plants that compete with oil palms

Source: Ata et al., 2023

The pilot testing helps CSS quantify the impacts of GAP implementation thereby providing valuable insights into its effectiveness and identifying areas for improvement. In the pilot testing program, CSS grouped farmers into two groups. One group is check farmers, where farmers continue traditional practices without implementing GAP. Another group of farmers is core farms, which refer to Core Learning Farms (Core LeFa), where GAP replaced some traditional farming practices. In Core Learning Farms, standardizations and proper agronomy management practices were introduced. Standardizations implied the introduction of certain SOP in cultivating palm oil like agronomy management. Farmers are encouraged, there is no compulsion, to follow the planned method in the GAP Guidelines. By conducting small-scale trials and closely monitoring the outcomes, CSS can gather data on key performance indicators, such as yield improvement, cost-and-benefit results, the efficacy of GAP's implementation, and agronomy data. During the implementation phases, CSS agronomists have frequent engagements (stakeholder engagement) with farmers to gain corporation and valuable information from farmers. They have periodically assessed the progress of GAP implementation. Through these engagements, CSS can assess how well the implemented GAP strategies align with their objectives and whether they deliver the expected results.

Results

Results show GAP implementation improved over time, especially on easy-to-implement, less complicated, and less costly practices. The farms that adopted GAP recorded higher yields as a group. In hindsight, the results endorse Hypothesis 1 that GAP is effective in driving FFB yield improvement. Core and Primary LeFa adopted GAP according to hands-on guidance from CSS personnel. Unlike large estates, smallholder farms have fewer standardized practices that they follow. In this context, ISH are encouraged to follow the prescriptions of GAP. This in turn introduced some control and uniform methods. For example, in the conventional system, each farmer may have his or her own method of managing his or her farm. With GAP, they follow uniform and standardized methods. This process of changing own-method with the control method, according to the GAP recommendation, fits into the paradigm of management disempowerment which is akin to losing the independence of the ISH. The management strategy from this yield intensification and GAP initiative is also about taking some of the independence away from these farmers i.e. reverting some autonomy and flexibility from farmers to be able to implement more sophisticated and sustainable farming methods uniformly, while receiving training through field days and in-class for certification qualification, where once again the farmers are certified as a group and not individually. The example is MPOB's MSPO certification and RSPO's RISS certification for independent smallholder farmers. The management practices in GAP implementation that farmers are encouraged to follow include fertilization management, pest and disease management, harvesting management, weed management, and prune management.

All Core and Primary LeFa fertilizing management are consulted by agronomists at CSS, where each hectare of the farm would receive 2.5 bags of fertilizers every 2 months. Hence, 15 bags of fertilizers in every year for every hectare. Furthermore, ISHs are recommended to have more frequent and scheduled harvesting. New Ganoderma management and pruning standard was introduced to the ISHs for improve yields and sustainability in their oil palm plantations. The GAPs are meant for, farmers to increase the yields, reduce the costs, and improve the sustainability of their operations. By following these rules and procedures, farmers can help to protect the environment and improve their farms' production.

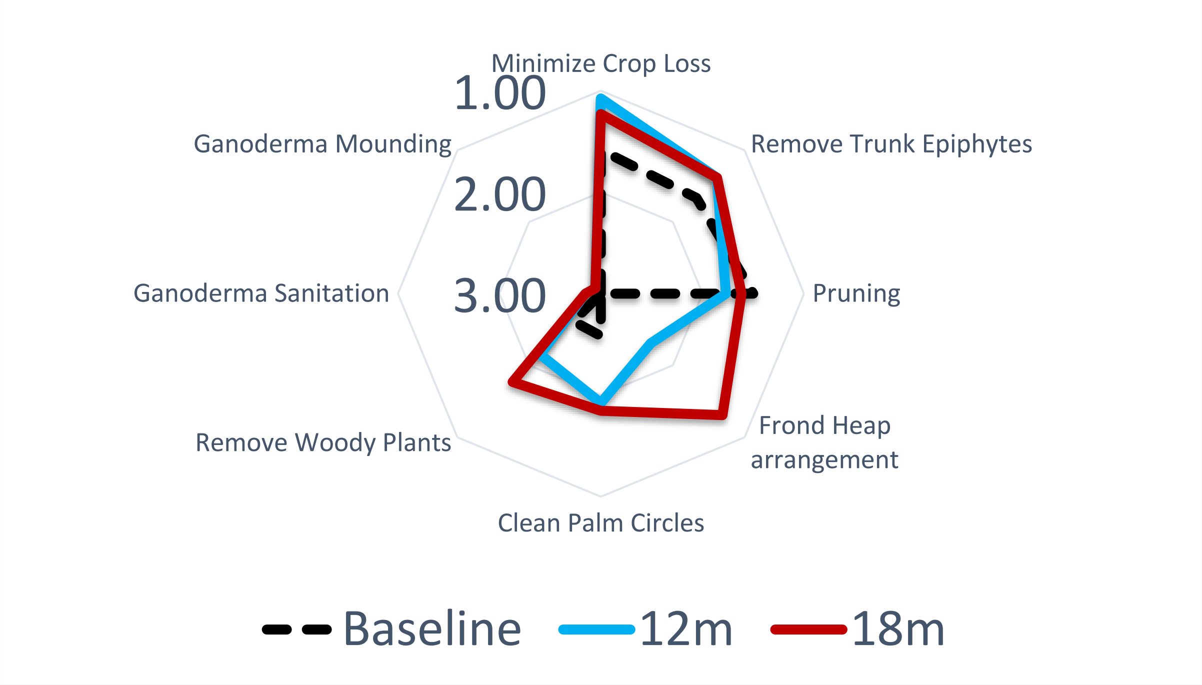

Figure 1: Core LeFa GAP Implementation Progress Report

Note: GAP Implementation of 13 Core LeFa in Cohort 1 and 2. The Outermost ring with score 1.0 = good, and medium rink of 2.0 = normal, and innermost ring with score 3.0 = poor. It is evaluated by the agronomists.

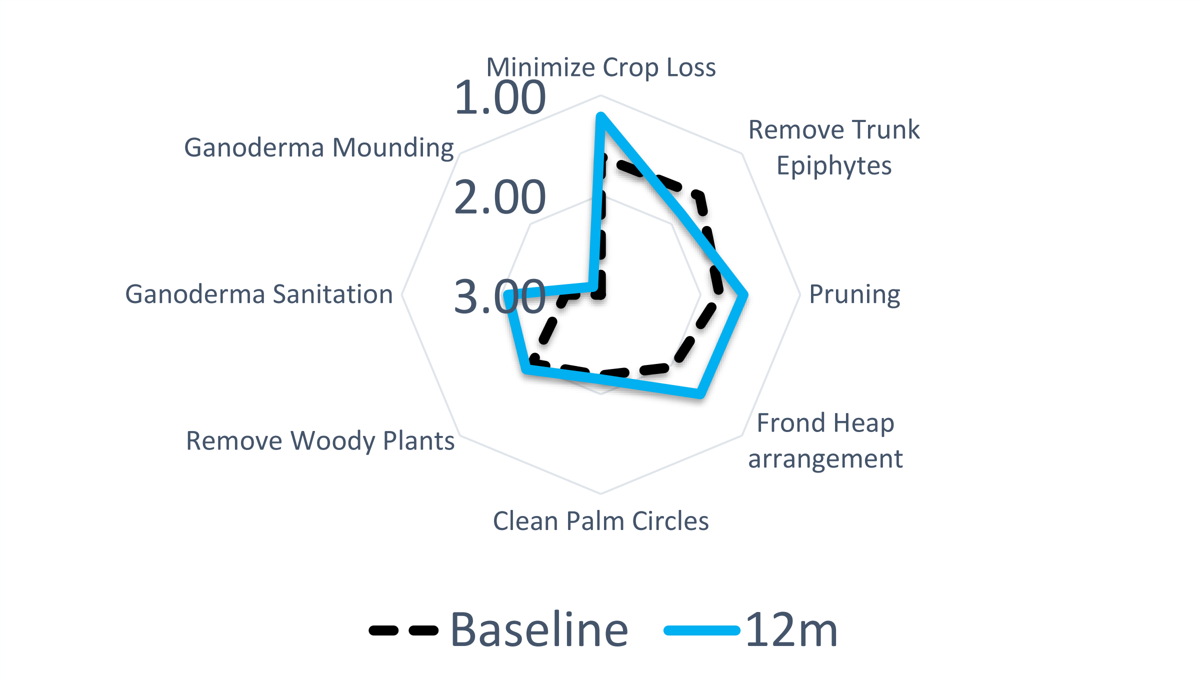

Figure 2: Primary Lefa GAP Implementation report

Note: GAP Implementation of 149 Primary LeFa. The Outermost ring with score 1.0 = good, and medium rink of 2.0 = normal, and innermost ring with score 3.0 = poor. It is evaluated by the agronomists.

CSS agronomists analyze the results of GAP implementation and quantified GAP based on a scale of 1 to 3. There is an overall improvement in GAP implementation in both Core and Primary LeFa 12 to 18 months after GAP implementation. The biggest improvement is at Frond Heap Arrangement and pruning management. Pruning management is to prevent under- and over-pruning. Frond Heap Arrangement is a mulching practice in oil palm. Farmers would stack the frond or leave and place it around the tree to optimize ground cover. The lowest improvement is Ganoderma mounding is the practice used in horticulture and arboriculture to prolong the productivity of Ganoderma infected trees disease. As such, such practice can extract more value from the affected trees. Hence, many trees score 3 to indicate no improvement because the trees did not suffer from Ganoderma fungus infection. It is a mistake in GAP field auditing that will be corrected in the future.

The above analysis yields one key insight from GAP implementation, the success of GAP implementation is partially correlated with the cost and complexity of the GAP to be implemented. All recommended GAPs are designed to be simple to implement, but some GAP such as the mounding of Ganoderma-infected trees needs more "steps" and costs including additional labor to implement, impeding the implementation of GAP. Here complexity implies the difficulty or ease of labor, time, and procedure in implementing GAP. Many farmers have limited manpower and knowledge base. Implementing a more complicated GAP might take more time and labor to implement. Consequently, farmers tend to prioritize practicing Good Agricultural Practices (GAP) that are simpler, less time-consuming with minimum additional resource or cost needed. This outcome provides valuable insights for developing agricultural methods that are less intricate and more user-friendly, aligning with the farmers' readiness level. For the more complex and resource intensive GAP, a robust support and training is necessitated to enhance GAP implementation. Besides, some farmers are better suited to adopt a collective approach to enhance resource efficiency because of their small and fragmented nature. One notable policy that facilitates this is the intervention in the form of a fertilizer supply chain based on a barter system of payment through deductions in fruit delivered to the collection center for fertilizer collection.

On analysis of yield improvement, farms that implemented GAP recorded higher yields than Check farms. Hence, this result supports Hypothesis 1. The reasons for yield improvement could be better farming techniques from GAP implementation, a more quality fertilizer, and improved agriculture management practices. In Cohort 1, Core LeFa demonstrated a 29 percent higher yield compared to Check Farms for the first 12 months. Subsequently, Core LeFa exhibited substantial yield gains of 72 percent and 53 percent in Year 2 and Year 3, respectively. After two years, Core LeFa achieved a cumulative yield gain of 49 percent, which further increased to 50 percent after three years. These results indicate that the targeted yield gain of 30-50 percent is attainable. The major driver of the observed yield gain would be fertilizing and harvesting management. For all cohorts i.e. for 19 Core LeFa and Check farm pairs, farmers who implemented GAP recorded 26 percent higher yields than Check farms one year after GAP implementation; the yield increased on average to 33 percent 18 months after implementation. Besides, in a sample of 23 Primary LeFa, the farms recorded a 25 percent increase in yield after implementing GAP for 12 months.

Discussion

FFB yield improvement has been part of the larger project under the Center of Sustainable Small-Owners at Asia School of Business. The program plans to propose

GAP with NPDE agenda to over 8000 small and independent smallholders. An important sustainability commitment for every ISH is the pledge to no deforestation, no new plantation on peatlands, and no exploitation (NDPE). The diffusion program is crucial in educating farmers to integrate sustainability principles into the framing. The diffusion of GAP offers tools for ISHs to understand and tackle issues such as agronomy challenges, fertilizing management, and knowledge access.

The policy implications of such paper are clear. GAP should promote to more ISH because it can improve yield and ISH's livelihood while maintaining the ecology health though the pledge to NDPE. It necessitates collaborative management practice among ISH and various stakeholder. One example is how CSS works with PERTANIAGA in empowering ISH to adopt and implement GAP practices in ensuring the success of GAP initiatives. PERTANIAGA is an ISH association owned entirely by ISH to connect ISH with local and international markets, and facilitate sustainable palm oil practices. On that note, policymakers should empower local organization to enhance sustainable practice and prioritize capacity building programs for ISH. Besides, efforts should focus on narrating and convincing farmers the benefit of GAP and sustainable management. Moreover, during the onboarding process of GAP, GAP that is more laborious and time-consuming should be allocated with more training time. GAP that is deemed important should have more persuasive narration in motivating ISH to adopt that GAP.

Conclusion

In conclusion, the implementation of Good Agricultural Practices (GAP) by CSS has yielded significant progress in improving yields, livelihoods, and sustainability in the Malaysian palm oil industry. This collaboration between CSS, ISHs, and farmers exemplifies how business and industry can address global challenges. CSS has been making significant progress in helping Malaysian farmers increase their yields, improve their livelihoods, and adopt sustainable agricultural practices. It has been a valuable resource for ISH. It is also an important example of how businesses, industry, and farmers can work together to combat the world's most pressing problems. CSS's work is helping in improving the lives of ISHs, spreading sustainability ideas to rural communities, making the palm oil sector more sustainable, and offering an innovative agriculture management model that can be implemented across the world. Such initiatives run in parallel with SDG 4.7. SDG 4.7 inculcates individuals such as farmers with sustainability skills. These sustainability skills are fundamental in maintaining sustainable production patterns in SDG 12 to ensure everyone has an awareness of sustainable information to live in harmony with nature.

Results show that easy to implement, economical, and less labor intensive with long-term benefits would enhance GAP implementation. Results from GAP implementation also asserts the benefit of standardization in palm oil operations, acting in the form of a group receiving training and eg. For certification thereby losing some of the independence that is enshrined in the ISH definition that some form of management disempowerment might benefit ISHs in the long run. A more controlled farming practice method like GAP is important. ISH that implements GAP records higher yield; thus, earns a higher income even before factoring in the benefit of seller premium. This shows that yield improvement could enhance the farmers’ livelihood. The success achieved by Core and Primary LeFa in terms of yield improvement demonstrates the feasibility of the targeted 30-50 percent gain, highlighting the benefits of standardized practices. The results of GAP implementation indicate that standardization practices have led to higher yields and improved profitability. CSS agronomists' guidance in fertilization and harvesting management has been a crucial driver of the observed yield gains. By following GAP, farmers have the potential to increase their incomes and improve the sustainability of their operations. However, it is essential to acknowledge the need for support and training to ensure successful implementation, especially considering the complexity of certain procedures.

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References

Ata, A., Donough, C.R., Ramachandran, V., Chua, S.T., Mansor, M.H., Teh, K.S., & Oberthur, T. (2023). *Supply Chain Driven Intervention to Improve Yield and Livelihood of Independent Smallholders for Oil Palm in Malaysia.* Manuscript summitted for publication.

Awang, A. H., Hashim, K., Ramli, Z., Lyndon, N., & Ali, M. N. (2016). The effects of technology transfer, good agriculture practices on the productivity of independent palm oil smallholders. *Journal of Economic & Management Perspectives,* 10(4), 300-304.

Aziz, N. F., Chamhuri, N., & Batt, P. J. (2021). Barriers and benefits arising from the adoption of sustainable certification for smallholder oil palm producers in Malaysia: a systematic review of literature. *Sustainability*, 13(18), 10009.

Baker, S. (2016) Sustainable Development**.** *Routledg*

Begum, H., Siwar, C., Alam, A. F., Choy, E. A., Ishak, S., & Alam, L. (2018). Enhancing sustainability amongst oil palm smallholders in Malaysia. *International Journal of Agricultural Resources, Governance and Ecology*, 14(1), 62-79.

Bernama News. (2023, June 14). MPOC: Palm oil industry can lead in sustainable agriculture practice. *The Star*. Retrieved from https://www.thestar.com.my/business/business-news/2023/06/14/mpoc-palm-oil-industry-can-lead-in-sustainable-agriculture-practice

Brandi, C. A. (2017). Sustainability standards and sustainable development–synergies and trade-offs of transnational governance. *Sustainable development*, *25*(1), 25-34.

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.

Donough, C. R., Witt, C., & Fairhurst, T. H. (2009). Yield intensification in oil palm plantations through best management practice. *Better Crops*, 93(1), 12-14.

Dzikriansyah, M. A., Masudin, I., Zulfikarijah, F., Jihadi, M., & Jatmiko, R. D. (2023).

The role of green supply chain management practices on environmental performance: A case of Indonesian small and medium enterprises. *Cleaner Logistics and Supply Chain*, 6, 100100.

Ermgassen, E. K., Ayre, B., Godar, J., Lima, M. G. B., Bauch, S., Garrett, R., ... & Gardner, T. (2020). Using supply chain data to monitor zero deforestation commitments: an assessment of progress in the Brazilian soy sector. *Environmental Research Letters*, 15(3), 035003.

Fairhurst, T., & Härdter, R. (2003). *Oil palm: management for large and sustainable yields*. Potash & Phosphate Institute.

Hidayat, K. N., Glasbergen, P., & Offermans, A. (2015). Sustainability certification and palm oil smallholders' livelihood: A comparison between scheme smallholders and independent smallholders in Indonesia. *International Food and Agribusiness Management Review*, *18*(1030-2016-83041), 25-48.

Jelsma, I., Schoneveld, G. C., Zoomers, A., & Van Westen, A. C. M. (2017). Unpacking Indonesia's independent oil palm smallholders: an actor-disaggregated approach to identifying environmental and social performance challenges. *Land use policy*, *69*, 281-297.

Jelsma, I., Woittiez, L. S., Ollivier, J., & Dharmawan, A. H. (2019). Do wealthy farmers implement better agricultural practices? An assessment of implementation of Good Agricultural Practices among different types of independent oil palm smallholders in Riau, Indonesia. *Agricultural Systems*, *170*, 63-76.

Kannan, P., Mansor, N. H., Rahman, N. K., Peng, T., & Mazlan, S. M. (2021). A review on the Malaysian sustainable palm oil certification process among independent oil palm smallholders. *Journal of Oil Palm Research*, *33*(1), 171-180.

Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, P., ... & Godfray, H. C. J. (2013). Sustainable intensification in agriculture: premises and policies. *Science*, *341*(6141), 33-34.

Molenaar, J. W., Beekmans, A., & Pelders, P. (2011). Producer group models and certification: an exploration of various producer group models in the agricultural and forestry sectors. *ISEAL Alliance*

Mohd Suib, N. A. B., Salleh, N. H. M., Shukor, M. S., Chamhuri, N., Shahimi, S., Salleh, K. M., & Hashim, K. (2023). The Influence of Good Agricultural

Practice (GAP) on the Productivity and Well-Being of Malaysian Sustainable Palm Oil (MSPO)-Certified Independent Smallholders in Malaysia. *Agriculture*, *13*(5), 990.

Nagiah, C., & Azmi, R. (2013). A review of smallholder oil palm production: challenges and opportunities for enhancing sustainability-a Malaysian perspective. *Journal of Oil Palm, Environment and Health (JOPEH)*, *3*.

Newell, D. J. (1992). Intention-to-treat analysis: implications for quantitative and qualitative research. International journal of epidemiology, 21(5), 837-841.

Ramachandran, V., Donough, C., Soontat, C., Ratnam, M., Mohamad, R., Azahar, S., Hashim, A., The, K, S., Mansor, H., Oberthür, T., Ata, A. (2023). *Improving Livelihoods for Independent Smallholders by Yield Intensification through Good Agricultural Practices.* Manuscript summitted for publication.

Tilman, D., Balzer, C., Hill, J., & Befort, B. L. (2011). Global food demand and the sustainable intensification of agriculture. *Proceedings of the national academy of sciences*, *108*(50), 20260-20264.

Rhebergen, T., Fairhurst, T., Whitbread, A., Giller, K. E., & Zingore, S. (2018). Yield gap analysis and entry points for improving productivity on large oil palm plantations and smallholder farms in Ghana. *Agricultural Systems*, *165*, 14-25.

Senawi, R., Rahman, N. K., Mansor, N., & Kuntom, A. (2019). Transformation of oil palm independent smallholders through Malaysian sustainable palm oil. *Journal of Oil Palm Research*, *31*(3), 496-507.

Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, *9*(1), 53-80.

Syahza, A., Irianti, M., & Nasrul, B. (2020, October). What's Wrong with Palm Oil, Why is it Accused of Damaging the Environment? *Journal of Physics: Conference Series* (Vol. 1655, No. 1, p. 012134). IOP Publishing.

Appendix A

Comparative Activities Between Different Farm Categories	Period/ frequency	Core LeFa	Check Farm	Primary LeFa
Benchmarking performance				
Check farm - maintain current practices to quantify GAP impact in Core LeFa			ü	X
Historical FFB data - compare before & after GAP implementation	Prior 2 years		ü	ü
Performance metrics & data collection				
Farm mapping - baseline palm population, farm shape & area	At start	ü	ü	ü
Plant sampling (leaf, rachis) - baseline	At start	ü	ü	ü
Soil sampling - baseline	At start	ü	ü	ü
Plant growth measurements - baseline	At start	ü	ü	Ideal
Farm mapping - annual update (or when major change occurs)	Annual	ü	ü	ü
Plant sampling (leaf, rachis) - repeat annually	Annual	ü	ü	ü
Soil sampling - every 2nd year to track changes	Biennial	Ideal	Ideal	X
Plant growth measurements - repeat annually	Annual	Ideal	Ideal	Optional
Farm mapping - end of project final farm status	At end	ü	ü	ü
Plant sampling (leaf, rachis) - end of project	At end	ü	ü	ü
Plant sampling (trunk) - end of project	At end	Optional	Optional	X
Soil sampling - end of project	At end	ü	ü	Ideal
Plant growth measurements - end of project	At end	ü	ü	Optional
Farm audits - every quarter to assess farm conditions	Quarterly	ü	ü	ü
FFB production records - every collection date	Every occasion	ü	ü	ü
GAP implementation & records				
Harvesting frequency		ü	X	ü
Pruned fronds arrangement pattern		ü	X	ü
Fertilizer program - annually		ü	X	ü
Fertilizer supply - as per annual program		ü	X	ü
Fertilizer application - as per annual program		ü	X	ü
Weeds management - as needed		ü	X	ü
Pests & diseases management - as needed		ü	X	ü
Soil conservation - as needed		ü	X	ü
Water management (drainage/conservation/erosion control/etc.) - as needed		ü	X	ü
Farm input records* (diary of activities & details) *Details of fertilizer(s), harvesting, agrochemicals used		ü	ü	ü
Learning/diffusion activities				
Field Days for Primary LeFa managers & prospective LeFa		ü	X	X
Field Days/Visits for potential Early Adopters		X	X	ü
Informal visits/knowledge exchange between farmers		X	X	X

ü must be implemented
X not required
Ideal - adds useful management &/or interpretative information, or helps raise yield
Optional - fills information gap, but can forego if implementation resources lacking
Source: Ramachandran et al., 2023