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Review Article

An Overview of the Benefits and Advantages of Implementing Mechanisation in the Oil Palm Plantation: A Look at Fresh Fruit Bunch (FFB) Evacuation

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Abstract: The oil palm industry is labour-intensive to efficiently sustain the productivity of plantations. This article aims to review the benefits and advantages of mechanisation and introduce the types of machinery available to achieve it. The implementation of mechanisation in the oil palm plantation can help ease the dependence on human labour while avoiding diminishing field output. Fresh fruit bunch (FFB) evacuation involves the transportation of FFBs after harvesting from the field to the mill. The conventional methods for evacuation activities involve the use of wheelbarrows and lorries or tractors. The harvested FFBs will be evacuated using a wheelbarrow from the infield and placed on a platform before being hauled out of the plantation by tractor or lorry to the mill or collection point. New tractors attached with FFB grabbers and the systematic planting of oil palm in rows can help to reduce the amount of labour required and improve the quality of life for plantation workers. The Malaysian palm oil board (MPOB) has developed transport vehicles such as the Hydra-Porter, Grabber, and Beluga that are available to the industry. Optimising FFB evacuation in the oil palm plantation could improve FFB yields. Plantations that implemented the scissor lift trailer and FFB grabber combination could on average collect 27.5 tonnes of FFB a day.

Keywords: evacuation, fresh fruit bunches; labour; mechanisation; productivity; tractor, transportation.

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1. Introduction

The Malaysian oil palm planted area in 2021 was 5.74 million hectares with Sarawak and Sabah representing the bulk of planted area at 1.61 million hectares and 1.52 million hectares, respectively (Ghulam Kadir, 2022). The main activities found in oil palm plantations are fresh fruit bunch (FFB) harvesting, FFB evacuation, oil palm manuring, oil

palm replanting, oil palm nursery management, and pest and weed control. The operations of harvesting and evacuation of FFB account for 60% of the labour required to be done in any oil palm plantation (Shuib *et al.*, 2020). In line with the Industrial Revolution 4.0, the mechanisation and automation of oil palm plantations will further enhance the productivity of the sector (Bakri *et al.*, 2019).

Labour is an important aspect of the oil palm sector, as it involves a significant amount of manual labour, especially in the harvesting and processing of the fruits. In terms of plantation operations, growers would need to survey wide areas of land and harvest fruits with estimates putting the labour to land ratio at 1 labourer: 10.9 hectares of land (Lim *et al.*, 2021). The oil palm sector is a major employer in many countries, particularly in Southeast Asia, providing employment and income for millions of people. However, the labour practices in the oil palm sector have faced criticism, with concerns raised about poor working conditions, low wages, and exploitation of workers. There have also been reports of child labour and forced labour in the sector, particularly in countries where labour laws and protections are weak.

In response to these concerns, many companies and governments have taken steps to improve labour practices in the oil palm sector, through measures such as certification schemes, increased transparency, and efforts to improve working conditions and protect workers' rights (Kannan *et al.*, 2021). Some companies have also implemented programs to provide training and support to workers, to help improve their skills and increase their earning potential. It is important for the oil palm sector to address these issues, both for the well-being of workers and the reputation of the industry. The oil palm sector has the potential to provide important economic and social benefits, but only if it operates in a way that is sustainable and responsible and provides fair and decent working conditions for all workers involved.

The need for mechanisation in the oil palm sector is driven by a variety of factors, including increasing demand for palm oil, a shortage of labour, and the need to improve efficiency and productivity. As the demand for palm oil continues to grow, it is becoming increasingly important for the oil palm sector to find ways to increase productivity and efficiency, to meet this demand. Mechanisation can play a key role in this by reducing the reliance on manual labour and increasing the speed and efficiency of various processes, such as harvesting and processing the fruits (Nambiappan *et al.*, 2018).

Another factor driving the need for mechanisation in the oil palm sector is the shortage of labour. In many countries, the oil palm sector is facing a shortage of workers, as many people are leaving rural areas to work in cities or abroad. This shortage is making it increasingly difficult for the sector to find enough workers to meet its needs, especially as demand for palm oil continues to grow. Mechanisation can help address this challenge by reducing the reliance on manual labour and allowing the sector to continue to meet demand, even as the supply of labour decreases.

Finally, the need for mechanisation in the oil palm sector is driven by the need to improve working conditions for workers and to reduce the environmental and social impacts of palm oil production. By reducing the reliance on manual labour and improving the efficiency and sustainability of production processes, mechanisation can help the oil palm sector to operate in a more responsible and sustainable manner, while also providing benefits to workers, communities, and the environment.

This paper seeks to outline the benefits and advantages of having mechanisation implementation in the oil palm plantation through collating information from multiple sources regarding the issue. Further case studies of mechanisation and automation implemented in the plantation can provide tangible results to be replicated in other estates.

2. FFB Evacuation and Mechanisation

FFB evacuation refers to the process of removing the bunches of fresh fruit from the trees in a palm oil plantation. This is typically done manually by workers using long poles or knives to cut the bunches from the trees. The bunches are then transported to a processing facility where they are further processed to extract the palm oil. This process plays a crucial role in the production of palm oil, which is one of the most widely consumed vegetable oils in the world.

Oil palm mechanisation refers to the use of machinery and equipment to perform tasks in the cultivation and harvesting of oil palms. This can include the use of tractors for land preparation, planting, and maintenance, as well as the use of specialised machinery for harvesting the fruit bunches. Mechanisation can improve the efficiency and productivity of oil palm operations and can also reduce the physical labour required for tasks such as planting and harvesting.

However, the mechanisation of oil palm cultivation and harvesting also has some drawbacks, such as the high cost of equipment, the need for skilled operators, and the

potential negative impact on local communities and labour markets. There is an ongoing debate over the use of mechanisation in oil palm cultivation, with some arguing that it is necessary to meet the growing demand for palm oil, while others argue that it can lead to environmental degradation and social injustice.

The information gathered in the article has been sourced from journals related to oil palm plantation, mechanisation and automation, and research and development into improving crop plantations.

3. FFB Evacuation Technologies

In the context of FFB evacuation technology, the Malaysian palm oil board (MPOB) has been involved in promoting and supporting the development and use of technology and mechanisation in this area, to improve efficiency, productivity, and sustainability in the oil palm sector. This includes conducting research on new technology, developing standards and guidelines for the use of machinery, and providing training and support to industry members on the use of these tools and techniques.

FFB evacuation technology refers to the use of machinery and equipment to automate the process of harvesting and transporting FFBs from oil palm trees to a mill for processing into palm oil. Some examples of FFB evacuation technology include:

- Mechanical Harvesters: These machines such as CANTAS are designed to automate the process of harvesting FFBs from oil palm trees, reducing the need for manual labour and increasing the efficiency and accuracy of the harvesting process (Jelani *et al.*, 2018).
- Specialised Transportation Vehicles: These vehicles are designed to transport FFBs from the plantation to the mill, including vehicles such as trailer trucks, dump trucks, and specialised tractors and trailers. These vehicles can be outfitted with grabbers to hoist FFB into the trailers (Hitam, 1992; Sarip *et al.*, 2019). Other innovations include different tractor designs like Hydraporter, Wakfoot, Beluga, and Rhyno (Ali & Mohamad, 2012; Muhamad & Aziz, 2018; Shuib & Hitam, 2003)

Figure 1. CANTAS EVO mechanical harvesting machine

Figure 2. The Wakfoot MK2 picking up FFB

Figure 3. The Beluga tractor dumping a load of FFB

Figure 4. The Rhyno tractor transporting FFB

Figure 5. The Hydraporter grabbing FFB

These technologies are designed to increase the efficiency and productivity of the FFB evacuation process while reducing labour costs and improving the quality of the FFBs. However, it's important to consider the potential challenges and impacts of FFB evacuation technology, such as the high initial cost of equipment and infrastructure and the impact on the local workforce, when implementing these technologies.

4. Discussion

The evacuation of FFBs from the oil palm tree and to the palm oil mill is labour-intensive and a crucial part of the entire oil palm plantation operations. Ultimately, plantation operators and estate owners would need to conduct their own due diligence in implementing the mechanisation of FFB evacuation.

4.1 Cost-to-Productivity Comparison

The cost-to-productivity comparison of FFB evacuation methods depends on several factors that are outlined in Table 1 below. These methods would allow owners and operators to gauge their cost to benefit from the impact of the mechanisation approaches.

Table 1. Methods on the cost-to-productivity comparisons for FFB evacuation mechanisation

Method	Detail
Initial Investment	The initial investment in equipment and infrastructure for manual and mechanised FFB evacuation methods will differ, with mechanised methods typically requiring a higher initial investment.
Operating Costs	Operating costs, such as labour costs and maintenance costs, will also differ between manual and mechanised FFB evacuation methods, with manual methods

Method	Detail
	typically requiring higher labour costs and lower maintenance costs, while mechanised methods require lower labour costs and higher maintenance costs.
Productivity	The productivity of manual and mechanised FFB evacuation methods will also differ, with mechanised methods typically increasing the efficiency and accuracy of the evacuation process, leading to increased productivity.
Quality	The quality of FFBs produced through manual and mechanised FFB evacuation methods will also differ, with mechanised methods typically reducing the potential for damage to the FFBs and improving the quality of the FFBs. It is crucial that FFBs are evacuated from the plantation and reach the mill to avoid the deterioration of the fruits (Hadi *et al.*, 2021).

The overall cost-to-productivity comparison will depend on the specific circumstances of each operation and the balance between the initial investment, operating costs, productivity, and quality. In general, mechanised FFB evacuation methods can offer significant benefits in terms of increased efficiency and quality but may require a higher initial investment and ongoing maintenance costs. The determination of harvesting and evacuation routes can help to impact plantation productivity, but to date, there is no meaningful research being done in this area, which is a gap that can be looked into (Lim *et al.*, 2021). More machinery means higher energy costs and it is expected that out of the total energy needed to produce FFBs, about 2% is taken up by diesel and 10.8% by machinery (Azwan *et al.*, 2016). It's important to carefully consider these factors when choosing an FFB evacuation method to ensure optimal results for the operation.

4.2 Reliance on Foreign Workers

Reliance on foreign workers in the plantation industry is a common issue in many countries, particularly in the agriculture and horticulture sectors. According to MPOB estimates, more than 90% of labour dedicated to harvesting and collecting FFB is made up of foreign labour which shows the reliance on foreign workers to do the most essential job in the plantation. This reliance can result from several factors which are shown in Table 2 below.

Table 2. Factors that contribute to reliance on foreign workers

Factor	Detail
Labour Shortage	In some countries, there may be a shortage of local workers available for manual labour in the plantation industry, resulting in a reliance on foreign workers to fill this gap.
Lower Labor Costs	Foreign workers are often willing to work for lower wages than local workers, making them an attractive option for plantation owners looking to reduce labour costs.

Factor	Detail
Lack of Alternative Employment	In some countries, foreign workers may come from regions where there are limited alternative employment opportunities, making them more willing to work in the plantation industry for low wages.
Limited Immigration Options	In some countries, immigration policies may make it difficult for foreign workers to obtain visas for other forms of employment, resulting in a reliance on the plantation industry for work.

Reliance on foreign workers in the plantation industry can have both positive and negative impacts. On one hand, foreign workers can provide a source of labour that helps to meet the demand for manual labour in the plantation industry, improving productivity and contributing to the local economy. On the other hand, foreign workers may be subject to exploitation and abuse, and reliance on foreign labour can have a negative impact on local workers, who may see reduced employment opportunities and lower wages. The usage of machinery and mechanisation in the oil palm plantation can help reduce the reliance on foreign labour, especially in labour-intensive operations such as FFB evacuation.

4.3 Improving Worker Retention

Improving worker retention in the plantation industry is important for maintaining a stable and efficient workforce, reducing turnover costs, and improving overall productivity. Table 3 shows the strategies that can be used to improve worker retention in the plantation industry.

Table 3. Strategies to improve worker retention.

Strategy	Detail
Offer Competitive Compensation and Benefits	Providing competitive compensation and benefits packages can help to attract and retain workers in the plantation industry, particularly if these packages are in line with industry standards and are regularly reviewed and updated.
Provide Adequate Training and Development Opportunities	Providing adequate training and development opportunities can help workers grow and advance in their careers, making them more likely to stay with the company long-term.
Foster a Positive Work Environment	Creating a positive work environment that supports workers and encourages collaboration, teamwork, and open communication can help to increase job satisfaction and reduce turnover.
Address Health and Safety Concerns	Providing adequate health and safety support and resources can help to ensure that workers are safe and healthy in their jobs, reducing the risk of injury and illness and improving job satisfaction.
Provide Support for Work-Life Balance	Providing support for work-life balance, such as flexible schedules and paid time off, can help workers manage the demands of their jobs and personal lives, improving job satisfaction and reducing turnover.

By implementing these strategies and regularly assessing and adjusting them as needed, plantation owners and managers can work to improve worker retention in the plantation industry, creating a more sustainable and efficient workforce. A motivated workforce can be more easily influenced to take up mechanisation operations which helps improve their working conditions.

4.4 Benefits to FFB Evacuation Mechanisation

Mechanisation can bring several benefits to oil palm harvesting and FFB evacuation as shown in Table 4 below.

Table 4. Benefits from implementing FFB evacuation mechanisation.

Benefit	Detail
Increased Efficiency and Productivity	Mechanisation allows tasks to be completed more quickly and with greater precision, which can result in higher yields and lower costs.
Reduced Labor Costs	The use of machinery can reduce the need for manual labour, which can lower labour costs and improve working conditions for those who remain employed.
Improved Safety	Mechanisation can reduce the risk of accidents and injuries associated with manual labour tasks.
Improved Crop Quality	Mechanised harvesting can reduce fruit damage and bruising, resulting in higher quality crops.
Improved Sustainability	Mechanisation can help reduce the environmental impact of oil palm cultivation, by reducing the need for labour, fuel, and chemical usage.
Improved Traceability	Mechanisation can increase the traceability of the crop and improve the transparency of the supply chain.

It's important to note that, for these benefits to be realised, mechanisation must be implemented in an environmentally sustainable and socially responsible manner, with close attention to the impacts on local communities and labour markets. Plantation companies and estate owners play a pivotal role in realising mechanisation in the oil palm plantation as they deliberate and decide on the operations. There have been reports of plantations that can achieve an FFB collection of 27.5 tonnes a day just by implementing an optimised system of FFB evacuation using tractors with grabber and scissor lift trailers. The system is as outlined in the flow diagram in Figure 5 which when implemented properly can achieve the required results.

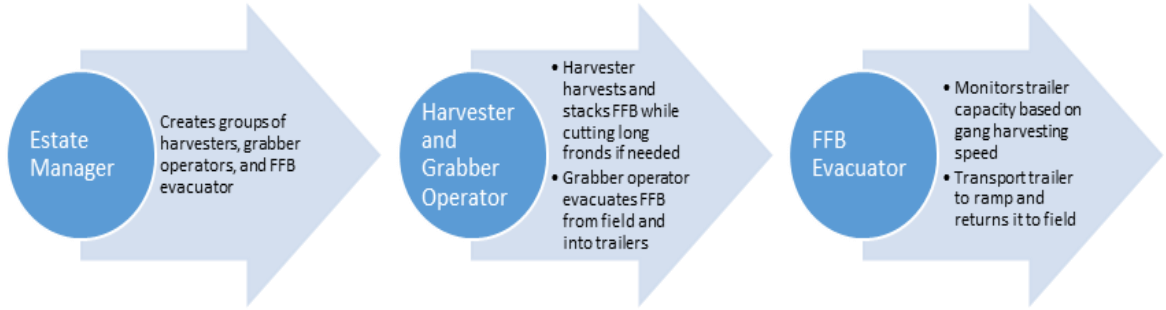

Figure 5. Operational flow diagram of an FFB evacuation gang in an oil palm plantation.

In general, the costs of mechanisation include the initial investment in machinery and equipment, as well as ongoing costs for maintenance, repair, and replacement (Shuib *et al.*, 2020). These costs can be significant and may make mechanisation infeasible for small or low-income operations. However, the benefits of mechanisation, such as increased efficiency and productivity, reduced labour costs, and improved safety, can offset these costs over time. Mechanisation can also increase the yield and quality of crops, which can result in higher revenues and profits.

It is important to conduct a cost-benefit analysis that considers all the factors and the long-term costs as well as the benefits of mechanisation. It is also important to consider the externalities, such as the impact on local communities and labour markets and the environmental impact.

4.5 Gaps to Implementing FFB Evacuation Mechanisation

Despite the benefits that are evident when mechanisation is introduced into FFB evacuation, there are currently gaps that hinder the implementation. These gaps are shown in Table 5 below.

Table 5. Gaps towards implementing FFB evacuation mechanisation.

Benefit	Detail
High Initial Investment	Mechanised FFB evacuation systems, such as mechanical harvesters and specialised transport equipment, often require a substantial initial investment. Many smallholders and smaller plantations may struggle to afford these machines.
Cost of Maintenance	Mechanisation equipment requires ongoing maintenance and repairs. The cost of maintaining and servicing these machines can be significant, and ensuring a reliable supply of spare parts can also be challenging in some areas.
Uneven Terrain and Infrastructure	Malaysian oil palm plantations can have diverse and uneven terrain. Mechanised equipment may not always be suitable for all types of terrain, and the lack of proper infrastructure (such as well-maintained roads) can hinder the deployment of mechanisation.

Benefit	Detail
Technology Adoption	The willingness of plantation owners to adopt mechanisation technology can vary. Some may be hesitant to invest in new equipment due to concerns about return on investment, while others may be more forward-thinking.
Data and Information Sharing	Access to data and information on best practices for mechanisation in oil palm plantations can be limited. Encouraging information sharing and knowledge transfer can help address this gap.
Scale and Size Variability	Not all plantations have the same scale or layout. The size and layout of plantations can affect the choice of mechanisation equipment, and there is no one-size-fits-all solution.

The gaps mentioned in Table 5 are the basic issues faced by the oil palm plantations even before attempting to adequately mechanise their operations to move FFB from the plantation. There is currently no one-size-fits-all solution and the reliance on foreign labour continues in most oil palm plantations.

5. Conclusions

Palm oil continues to be the leading vegetable oil used in the world and demand is ever increasing with the rise in world population. More than ever steps need to be taken to ensure there is a steady supply of palm oil for everyone. The oil palm plantation sector needs to be mechanised to achieve a competitive and uninterrupted supply of palm oil to buyers. FFB evacuation is one of the main and labour-intensive operations in the plantation and can be mechanised through the implementation of effective evacuation technologies and improving workforce integration. There are options provided by machinery companies and research organisations such as MPOB that can be utilised by the industry. There are still gaps in technologies such as evacuation route optimisation and Internet of Things (IoT) integration which can improve the operation. Further research can be conducted to explore those approaches in improving FFB evacuation efficiency.

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