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*Review Article*

# Mechanisation Technology for Small-Scale Oil Palm Plantations

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**Abstract:** Oil palm plantation is one of the main economic activities in Malaysia. Most of the activities in the plantations depend entirely on labour, especially foreign labour. Labour availabilities became more serious during post COVID-19 pandemic. To overcome the situation, technologies for plantation operations are required. Various technologies have been produced and introduced to the industry. However, not all technologies could be adopted by oil palm smallholders due to economies of scale. Thus, this paper provides an overview of mechanisation technologies suitable for smallholder adoption. Economic factors are the basis for the selection of the technology. However, there are several key factors to ensure the successful implementation of mechanisation practices by the smallholders. Among them are tools or machine maintenance and suitable work systems. The elements need to move in tandem to achieve the goal of using mechanisation.

**Keywords:** mechanization; smallholder; technology

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## 1. Introduction

Malaysia is the second-largest palm oil producer in the world, with a total planted area of 5.87 million hectares (Parveez *et al.*, 2021). Malaysia produced around 19.92 million metric tonnes of crude palm oil (CPO) in 2017 (Kushairi & Nambiappan, 2019). In addition, the Malaysian oil palm industry is one of the country's primary employment sectors, involving various stakeholders, including smallholders whose primary source of income is palm oil. The term small scale area refers to smallholders. Smallholders often own less than 40 hectares of land with land ownership or customary rights (Awang *et al.*, 2016).

There are three types of smallholders: independent, organised, and cooperative land ownership schemes. First, independent smallholders are oil palm growers who do not get direct support from the government or any organisation. Secondly, organised smallholders are oil palm growers who get funding from an organisation or government that provides agricultural input, technical advice, or finance, such as RISDA, FELCRA, and FELDA (Ali *et al.*, 2018) Finally, a cooperative scheme where a partnership between commercial plantation companies, local communities, and the government has been created. Each party had 60%, 30%, and 10% shares in the scheme. The scheme had been introduced especially in Sarawak as an initiative to develop rural land under Native Customary Rights (NCR). This project involves the Sarawak Land Development Board (SLDB), Sarawak Land Consolidation and Rehabilitation Authority (SALCRA), and Land Custody and Development Authority (LCDA) (Ali *et al.*, 2018).

The expansion of area by the smallholders was significant as it reflected almost 10% to 20% of the total planted area in the country. Smallholders' area was 538,490 hectares of land in Peninsular Malaysia in 2017 (Azman *et al.*, 2018). Thus, the contribution from the smallholders played a major role in national Fresh Fruit Bunches (FFB) production. Thus, the issues and challenges faced by them were a national concern. Among the issues and challenges were the difficulties of achieving optimal farm management practices, technology adoption, revenue generation, and access to high-quality fertilisers (Nagiah & Azmi, 2012). Most types of machinery that had been developed and built are for areas which are more significant than the average land area held by smallholders. It is undeniably, among other things, that the high cost of technologies makes it challenging for smallholders to acquire them. Thus, this paper aims to evaluate current technology available in the market for oil palm industry adoption and discuss ways to effectively implement mechanisation.

## 2. Scenario on Oil Palm Mechanisation Adoption

The current labour shortage requires the intervention of various parties to provide the best plan without leaving out the balance between productivity and operating costs. There are various ways to increase productivity by practising Good Agriculture Practice (GAP) and using mechanisation and automation. The mechanisation of oil palm cultivation has been associated with increased yields and enhanced fruit quality. It has been demonstrated that mechanisation reduces the time required to execute jobs, resulting in greater productivity and profits.

The government's efforts in dealing with the dependence on foreign labour coincide with the main objective of using mechanisation in the agricultural sector: reduce the workforce, reduce operating costs, increase productivity and increase operational efficiency in the fields. In line with this objective, the Malaysian Palm Oil Board (MPOB) has successfully developed various mechanisation technologies where some technologies have been successfully commercialised, such as aluminium harvesting poles (Giraffe and Hi-Reach), oil palm motorised cutters (C-kat and Cantas), unloading machinery Mechanical FFB (Grabber), FFB transport machinery (Beluga and Rhyno) and loose fruit picking machinery (Khalid & Shuib, 2014).

Oil palm mechanisation technology can be categorised into several categories, namely special machinery for certain activities, utility machinery used for several purposes, farm equipment such as oil palm cutting machines and farm equipment that are installed on a machine such as a fertiliser spreader (Azwan *et al.*, 2019). According to the study by Norhajijah *et al.* (2021), the average percentage of mechanisation typically employed in oil palm plantation operations was 10.88%. Even though several mechanisation tools have been brought to the industry the degree of usage is still relatively low.

Mechanisation for oil palm smallholders is necessary due to several considerations, including reducing labour dependency and increasing productivity, allowing smallholder to increase their revenue. Wahid (2009) found that the mechanisation of oil palm plantations significantly increased productivity and profits for smallholders. In other words, mechanisation may facilitate labour and lower the possibility of accidents occurring when working on the plantation. This may subtly disassociate the 3D (Dirty, Dangerous, Difficult) phrase often attributed to the oil palm plantation industry.

## 3. Oil Palm Mechanisation Technologies for Smallholders

Although the machinery or mechanisation tools are not appropriate for smallholders, there are methods to make the machine more cost-effective for their use. It can also indirectly reduce smallholders' burden of owning machinery or machines. Mottaleb *et al.* (2017) found that when investing in technology and machinery for a small-scale plantation, the equipment needed to provide a high return on land and labour had to be "scale-appropriate." According to Edwards (2017), while deciding whether or not to use a new technology in an oil palm plantation, farmers must consider a few factors, including whether or not the technology's benefits outweigh its costs. Thus, several MPOB-created technologies considered amenable to adaptation by smallholders are included in this paper. Among the technologies suitable for

adaptation by smallholders are motorised oil palm cutters, sprayers and some small utility machinery (Shuib, 2011).

### *3.1 Oil Palm Motorized Cutter (CANTAS)*

Harvesting is the most crucial activity in the oil palm plantation. MPOB has undertaken extensive research to develop mechanised tools to improve the activity. CANTAS, an oil palm motorised cutter, is one of these. CANTAS have three main components: an engine, a telescopic pole, and a cutting head. CANTAS are used to harvest the oil palm bunches and cut the fronds. The machine has specific specifications and depends on the height of palm harvesting. CANTAS is able to increase harvesting productivity by up to 50% compared to manual methods (Jelani *et al.*, 2008). Since it was introduced to the industry, the improvement of the technology continues to be implemented by MPOB. The R&D focused on some issues raised by users, such as vibration and the overall weight of the machine. As such, CANTAS have gone through several evolutions, with the latest version being powered by batteries and known as CANTAS Elektro (Figure 1).


**Figure 1.** (a) Cantas; (b) Cantas Elektro

CANTAS Elektro is driven by an electric motor and a Lithium-Ion Polymer (LiPo) battery. The battery can last up to 2 h and 30 min on a single charge while an approximately 50 min is required for battery charging. One of the benefits of CANTAS Elektro is that it can reduce 40% of the vibration rate as compared to the earlier CANTAS version, which indirectly provides the user with improved comfort. In addition, the CANTAS Elektro has a maximum reach of 5 meters and a total weight of 7.2 kg, making it 1 kg less than the

CANTAS Petrol. According to the results of the tests conducted, the productivity of CANTAS Elektro is 7.11 t per machine in 8 h of work, depending on the skill level of the operators (Rizal *et al.*, 2022). CANTAS Elektro comprises three main components that make it easier for users to perform routine maintenance. Cooperation with well-known supplier companies is to ensure customers easily obtain replacement parts.

The cost-effectiveness (CE) of a technology is the industry's priority. The lower the CE, the higher the probability of widespread technology adoption. Machines' CE was determined by comparing the initial investment over the total FFB harvested (Stanners, 1993) as shown in the following Equation 1:

$$Cost\ effectiveness\ (CE) = \frac{Tool\ or\ machine\ price\ (RM)}{Total\ bunches\ harvested\ (tonne\ FFB)} \quad (1)$$

CANTAS Elektro was currently selling for RM7500 per unit. Given that the average economic life of CANTAS Elektro's machines is two years and that the working days for 300 days annually, the CE is computed as follows:

$$\begin{aligned} CE\ of\ CANTAS\ Elektro \\ &= RM7{,}500 \div (7.11\ t\ FFB/day \times 300 day/year \times 2 yrs) \\ &= RM1.76/t\ FFB \end{aligned} \quad (2)$$

CANTAS Elektro is a reliable, easy to maintain and cost-effective harvesting tool, providing the smallholder with additional benefits such as increased productivity, better land-to-labour ratios, and opportunities to participate as a contractor harvester. All these factors make CANTAS Elektro a cost-effective harvesting solution for smallholders, with a cost-effectiveness of RM1.76/t. Additionally, given its two-year economic life and 300 working days per year, its cost-effectiveness improves its feasibility and returns.

### *3.2 Three-Wheeler Utility Machine*

MPOB and a local technology manufacturing company have collaborated to produce utility machinery. This machine has three wheels, is powered by a gasoline engine, and can transport up to 300 kg. The machine's modest size and compact design compared to other machines in the same categories make it easy to manoeuvre and suitable for various activities (Figure 2). This equipment is, therefore, appropriate for use by small oil palm planters. This machine can also be outfitted with an electric sprayer to apply herbicides (Azwan *et al.*, 2020). The study demonstrated that the installation of electronic tools for plantation activities boosts the efficiency of operations and can reduce the demand for foreign labour.

A simple chassis and adequate power machinery could meet smallholders' requirements. Besides farm activities, the machine could also be used for other economic activities by changing its back carrier type. It is easy to maintain, as most of the parts are available on the market like normal motorcycles. Farmers can afford the ownership cost, and female employees could also operate it. The vehicle was designed specifically for oil palm smallholders.

**Figure 2**. Three-Wheeled Utility Machine for Various Economic Activities of Smallholder

### *3.3 Motorcycle Trailer*

One of the technologies that smallholders might utilise is the motorcycle trailer. This system is employed for the conveyance of farm-related tasks. A motorcycle trailer may be hooked up to a motorcycle or an All-Terrain Vehicle (ATV). Improvements have been accomplished by designing a motorcycle trailer that can be changed into a wheelbarrow (Figure 3). Indirectly, this can boost the versatility of the motorcycle trailer itself, whether it is attached to the motorcycle or operated independently.

**Figure 3.** A motorcycle trailer with wheelbarrow functionality.

## 4. Key Success Factor of Mechanisation

It's undeniable that mechanisation helps increase productivity while decreasing labour requirements. This is due to the fact that mechanisation is frequently capable of doing tasks with incredible speed and efficiency compared to humans. They are also often able to work

for extended periods. Workers may require more time for other activities. However, adapting mechanisation for smallholders requires systematic planning to ensure it is more effective. Therefore, several guidelines and recommendations have been proposed for achieving ideal results when applying mechanisation tools. Various conditions must be met before deploying a tool, as determined by user feedback and observation. Effective mechanisation implementation necessitates the collaboration of three elements: men, machines, and systems (Jelani *et al.*, 2018). The element's specifics are as follows:

*4.1 Establish a Mechanisation Team.*

To successfully implement a mechanisation system, it is essential to have a strong team with a clear leader. Appointing a leader from inside the team, such as the Manager or a person with a higher ranking, is the first step in creating a successful team. The leader should provide clear instructions for every team member on machine management and use. It is also important to ensure that each group member's responsibilities are clear. Regular conversations should be held to build bidirectional communication and ensure that the team is on the same goal. A group for smallholders can be formed through collaboration between smallholders living near one another. According to Sarmila *et al.* (2018), the cooperative system has the potential to improve the effectiveness of the operation of the plantation system to the point where all participants stand to benefit from the enhancement.

The team's main objective is to increase workers' productivity using mechanisation instead of conventional tools. This can be done by introducing modern machines and equipment, which can help to reduce labour and increase efficiency. The team should also focus on training and educating workers on the use of these machines so that they can use them safely and effectively. Finally, the team should also monitor the progress of the mechanisation system and make necessary changes to ensure it goes as planned.

*4.2 Machine*

Providing basic and extra machine operation needs is essential to ensure that the operation can be carried out efficiently and prevent significant problems from occurring when the equipment is in use. This includes spare parts, personal protective equipment (PPE) and machine replacement (recommended).

i. Spare parts are essential for the efficient operation of any machine. The availability of spare parts ensures that the machine can be repaired quickly and easily during a breakdown. With readily available spare parts, the machine may be able to operate to avoid operation being delayed or even cancelled.

ii. Personal protective equipment (PPE) is one of the important things for any machine's safe and efficient operation. PPE includes a safety helmet, gloves, and other protective clothing. These items are necessary to protect the operator from any potential hazards that may be present while operating the machine. Without PPE, the operator may risk injury. Therefore, it is important to ensure that the appropriate PPE is always available and used when operating the machine.

iii. Equipment or machine replacement is recommended for any machine's efficient operation. Over time, the machine may become worn or damaged due to wear and tear which may need to be replaced. With the equipment replacement, the machine may operate efficiently without posing a risk to the operator.

*4.3 Work System*

4.3.1 Work and Payment System.

i. The concept of payment systems has been studied extensively in economics. In particular, "equal payment" or "Gotong Royong" is based on sharing resources and labour equally among group members.

ii. Besides that, the concept of "payment according to the assignment" has also been studied in resource allocation and collective action (Ostrom, 1990). This system is based on rewarding individuals for their contributions to the group and is an effective way to increase motivation and productivity.

iii. Other than that, the concept of "incentives based on performance" has been studied in the context of organisational behaviour and motivation (Kreitner, 2001). This system is based on rewarding individuals for their performance.

The establishment of a more structured work and payment system is essential for any organisation or team management. Equal payment, payment according to the assignment, and incentives based on performance are all viable options that should be considered when designing and implementing a payment system.

4.3.2 Manage Machines and Machinery

Managing machines and machinery is essential to minimise disruptions to daily operations. Preparation before operation and post-operation activities must be conducted to ensure that machines and machinery are appropriately managed. Before the operation, the machine must be checked to ensure it is in good condition. Users and operators must also

comply with standard operating procedures (SOP) and perform periodic maintenance. Teams should also plan and set goals for the day.

After the operation, the condition of the machine/machinery should be checked. It should then be stored in the storage room. If the machine has a problem, a mechanic or expert should inspect the impairment and send the machine/machinery to the workshop for repair if it suffers severe damage.

The importance of managing machines and machinery to prevent disruptions to everyday operations. Proper management of machines and machinery can reduce downtime and improve operational efficiency.

#### 4.3.3 Monitoring

Monitoring and assessing their performance are important to ensure that machines function properly. This can be done through various methods, such as data collection, analysis of performance, and user feedback. By doing so, teams can identify areas for improvement and make necessary changes to ensure optimal performance. Monitoring and assessing a machine's performance can help improve its efficiency and reduce downtime.

## 5. Conclusion

The oil palm plantation is an important socio-economic sector of the country. Sustainability is the aspect of plantation operations that demands the most consideration. Adapting mechanisation technology suitable for smallholders can enhance the sustainability of operations. Additionally, several technologies can benefit smallholders. However, cost-effectiveness must be considered when deciding the application or selection of a technology and working system. Moreover, the sharing method and strategies can be adopted for a viable adoption. Three elements (men, machines and systems) significantly impact the efficiency of mechanised oil palm adaptation. The three elements of management of machinery, staff, and work procedures must be prioritised to ensure that technology is used efficiently. The elements can be used as a guideline or reference for smallholders to ensure that the technology employed provides benefits.

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